EFFECT OF IRRIGATION AND VARIETIES ON THE GROWTH AND YIELD OF RAPESEED

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF IRRIGATION AND VARIETIES ON THE GROWTH AND YIELD OF RAPESEED"** 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 **SADIA SULTANA**, Registration No. **27619/00764** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 27.6.07
Place: Dhaka, Bangladesh

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Supervisor

Dedicated

To

MY BELOVED PARENTS

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EFFECT OF IRRIGATION AND VARIETIES ON THE GROWTH AND YIELD OF RAPESEED

ABSTRACT

The study was carried out at the Sher-e- Bangla Agricultural University farm, Dhaka during November 2006 to March 2007 to evaluate the effect of irrigation and variety on growth, yield attributes and yield of rapeseed. The treatment comprised of three levels of irrigation viz. no irrigation, one irrigation at 20 DAS, one irrigation at 35 DAS, two irrigations at 20 and 35 DAS, and three irrigations at 20, 35 50 DAS, and three varieties viz. SAU Sarisha-1, Kalyania and Improved Tori-7. The experiment was laid out in a split plot design with three replications. Three irrigations (at 20, 35 and 50 DAS) increased economic yield with higher values of harvest index as the yield attributes like branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1} and 1000 seed weigh were higher. The seed yield with three irrigations were 111.93% and 10.73% higher than no irrigation and two irrigations, respectively. The variety SAU Sarisha-1 showed its superiority by producing 1.4 % and 45.94 % higher yield than Kalyania and Improved Tori-7, respectively. This variety (SAU Sarisha-1) also showed higher branches plant^{-1}, seeds siliqua^{-1}, 1000 seed weight, biological yield and harvest index. In most of the cases interaction of three irrigations with SAU Sarisha-1 performed best in respect of grain yield as well as other studied parameters. The highest seed yield (1827.0 kg ha^{-1}) was found in the interaction of three irrigation with SAU Sarisha-1. This was achieved due to the maximum number of branches plant^{1}, seeds siliquae^{-1} and 1000 seed weight in this interaction. The yield attributes was also supported with appreciable production of dry matter.

LIST OF CONTENTS

CONTENTS *(Contd.)*

CONTENTS *(Contd.)*

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

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

Chapter I
Introduction

A' 38

CHAPTER I

INTRODUCTION

Rapeseed and mustard are important oil crops which come from the Cruciferae family. It is widely grown as oilseed crops in Bangladesh and currently ranked as the world third important oil crop in terms of production and area. Domestic production of edible oil comes from rapeseed – mustard, groundnut and sesame. Edible oil plays a vital role in human nutrition. Edible oil is a high-energy component of food and meeting the calorie requirements of human nutrition. In Bangladesh the annual oil seed production is 3,76,000 metric tons of which rapeseed covers 62% of the total edible oil (MOA, 2006). Each gram of oil supplies 9 kcal energy, whereas 4 kcal energy comes from 1-gram carbohydrate or protein (Stryer, 1980).

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 and it contains 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. Worldwide the total annual production of *Brassica* is 44.41million tons of seed from an area of 27.24 million hectares (FAO, 2004). 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).

Bangladesh has been facing acute shortage of edible oil for the last several decades. On the basis of RDA, Bangladesh requires 0.29 million tons of oil annualy to meet the demand of her people (FAO, 1998). But one-third of total requirement of oil is meeting by local production of rapeseed and mustard (BBS, 2004). Rapeseed-mustard is grown more or less all over Bangladesh, but more particularly in the districts of Comilla, Tangail, Jessore, Faridpur, Dinajpur, Pabna, Kushtia, Rajshahi, Rangpur, Kishoregonj, Dhaka (BBS, 2001). Major rapeseed and mustard growing areas in Bangladesh is presented in Appendix I. Bangladesh Agricultural Research Institute (BARI), Bangladesh Agriculture University, Bangladesh Institute of Nuclear Agriculture (BINA) and Sher-e-Bangla Agricultural University (SAU) have released a number of new high yielding varieties of rapeseed/mustard for farmer's cultivation. The yield of HYV's ranges from 1.4 to 2.1 t ha^{-1} (BARI, 2002). But the yields in farmer's field are still low compared to their potentialities due to lack of proper management practices. So there is a scope to increase the yield level of HYVs with proper management practices like spacing, irrigation, seed rate, fertilizer application etc.

Irrigation is a vital factor for proper growth and development of these crops in dry season (Roy and Tripathi, 1985). The crop essentially requires water ranging from 60 to 69 mm through out its life cycle (Rahman, 1989, Sarkar *et al.*, 1989). Mondal *et al* . (1988) reported that one irrigation at flowering and another at siliquae development stages gave the highest yield (2.56 t ha^{-1}). In recent years some promising varieties have been released which are growing with irrigation facilities in Bangladesh. But the information regarding irrigation on the yield of rapeseed is still unlimited.

In view of the limited information on the problems mentioned above a field study on rapeseed containing the different varieties and irrigation time were conducted with the following objectives :

i) to find out the optimum number of irrigation for getting higher yield,

ii) to evaluate the yield performance of different rapeseed varieties and

iii) to study the combined effect of variety and irrigation on the growth and yield of rape seed.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Rapeseed is an important oil crop in Bangladesh which can contribute to a 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.

2.1 Effect of irrigation

In strict sense *Brassica* is an irrigated crop (Andrews, 1972). Performance of *Brassica* is geatly affected by irrigation. Seed yield of *Brassica* are greatly affected by water stress during flower initiation and siliquae filling stage (Richard and Thurling, 1978).

Singh *et al.* (2002) tested four *Brassica spp.* (*Brassica carinata, Brassica napus, Brassica juncea and Brassica campestris*) under 2 moisture regimes, i.e. normal irrigation (3 irrigations at branching, bolting and siliquae filling stages) and limited irrigation (one irrigation at branching stage). Results revealed that growth, development and yield of all *Brassica* spp. were adversely affected under limited water conditions. This clearly indicates that yield expression of *Brassica* spp. differs under varying soil water regimes. .

2.1.1 Plant height

Saran and Giri (1988) reported that plant height of rapeseed was found to be highest when one irrigation at 30 DAS was applied. But two irrigations applied at 30 and 60 DAS produced taller plant than under rainfed condition. There was a positive relation between irrigation levels and plant height of mustared.

Siag *et al.* (1993) found a relationship between irrigation levels and plant height of toria. In an experiment, plant height was increased with the increasing levels of irrigation. Plant height was greater with 2 irrigations at branching and siliqua development stage and it was the highest compared to one irrigation at branching stage and without irrigation.

2.1.2 Dry weight of plants

Maini *et al*, (1965) observed that one irrigation at flowering stage was enough to increase the yield of dry matter in *Brassica campestris* .

Singh *et al.* (1972) noticed that one irrigation at flowering stage of rapeseed was better than two irrigations (one at fowering and one at fruiting stage).

Dalal *et al.* (1963) suggested for one irrigation at the blooming stage in brown sarson (*Brassica campestris* var. *Sarson).*

Saran and Giri (1988) stated that dry matter of mustard was significantly increased with the increasing levels of irrigation and the highest dry matter accumulation was found with two irrigations. In some cases, at the time of harvest dry matter was found to be the highest with one irrigation.

Patel *et al.* (1991) found a significant difference in case of dry matter accumulation in mustard with the application of irrigation. One irrigation produced more dry matter, which was significantly higher than that was produced without irrigation.

Tomer *et al.* (1992) conducted an experiment with no irrigation, one irrigation (at pre-flowering) and two irrigations (one at pre-flowering and one at fruiting). They observed a significant increase in dry matter with irrigation application and the maximum dry mater was recorded with two irrigations while one irrigation and control (no irrigation) produced lower dry matter per plant.

Paul and Begum (1993) showed that total dry weight of different irrigation treatments at successive stage of growth of rapeseed was significant except the first sowing (38 DAS). The plant receiving continuous irrigation throughout the growing period had the highest dry weight while rainfed plant had the lowest total dry weight. Among the remaining treatments, irrigation at 50% flowering stage proved to be the most important single irrigation treatment. Two irrigations also increased dry matter production.

Mahal *et al.* (1995) conducted a field experiment during the Rabi seasons of 1987 and 1988 at Ludhiana, India. Toria was irrigated at 50, 60 or 70% depletion of available soil moisture. The dry matter of leaves, stems and siliquae of mustard increased with irrigation at lower depletion levels.

Raut *et al.* (1999) studied the effects of irrigation (at pre-flowering and siliqua-setting stages, pre flowering + 50% flowering +siliquae setting stages, pre-flowering +50% flowering + seed-filling stages, and pre-flowering + 50% flowering + siliquae-setting + seed filling stages) on the dry matter production and yield of Indian mustard cv. Pusa Bold. They concluded that irrigation at pre-flowering + 50% flowering + siliquae-setting + seed-filling stages gave the highest dry matter production at 30 and 60 days after sowing (DAS) but irrigation at pre-flowering + 50% flowering + seed-filling stages gave the highest dry matter production at 90 DAS and at harvest as well as the highest grain yield .

Giri (2001) reported that dry matter per plant of rapeseed was not significantly increased with irrigation treatments. He conducted two experiments to find out the effect of irrigation on growth and yield of mustard. In 1995-1996 total dry matter production was higher with two irrigations at flowering and siliquae development stage than the dry matter produced irrigation with one irrigation at flowering stage. But in 1996-1997, one irrigation produced higher dry matter production than two irrigations ,but those dry matter productions were not significantly different.

2.1.3 Number of branches plant^{-1}

Clarke and Simpson (1978) observed in an analysis of yield components of rapeseed from field trial that irrigation scarcely affected the number of branches plant^{-1}.

Joarder *et al.* (1979) cultivated mustard cv. Rai 7, Laha 101 and Rai 5 cultivated under irrigated or rainfed condition and observed that irrigation increased the number of primary and secondary branches plant^{-1}.

Prasad and Eshanullah (1988) reported that number of primary branches plant^{-1} of mustard were significantly increased with the increase of irrigation levels. They found the maximum number of primary branches plant^{-1} with two irrigations at 30 and 60 DAS which was followed by one irrigation at 30 DAS and without irrigation, respectively.

Rathore and Patel (1989) stated that the number of branches plant^{-1} of mustard increased with the increases of irrigation frequency.

Patel *et al.* (1991) conducted an experiment with mustard by applying irrigation for evaluation of branches plant^{-1} and found that one irrigation produced significantly higher number of branches plant^{-1} compared to unirrigated control.

Tomer *et al.* (1992) concluded that branches plant^{-1} of rapeseed were significantly increased with irrigation application and branches plant^{-1} were highest with two irrigations compared to one irrigation or without irrigation (control). They also reported that branches per plant^{-1} were highest when two irrigations were applied at preflowering and fruiting stages. When one irrigation was applied at preflowring stage, it produced lower branches plant^{-1}. The least number of branches was produced at control treatment.

Singh *et al.* (1994) conducted a field trial with *Brassica juncea* irrigated at 50% flowering, at 50% flowering + 50% siliquae development, or given no post sowing irrigation. They found the maximum branching with increased irrigation level.

Giri (2001) showed that branches plant^{-1} increased with the increasing irrigation level in mustard plant. He also observed that when one irrigation was applied it produced more branches plant^{-1} compared to that of two irrigations. But the difference was not significant.

2.1.4 Number of siliquae plant^{-1}

Clarke and Simpson (1978) conducted two years field experiment with rapeseed in Canada at Saskatoon and reported that irrigation increased the number of siliquae plant^{-1}.

Sharma and Kumar (1989b) found in experiment with mustard that the number of siliquae plant^{-1} increased with increasing irrigation frequency, while irrigation was applied with zero and one level at the rosette or at siliquae formation stage.

Giri (2001) stated that in case of two irrigations at flowering and siliquae formation stage 277 siliquae were found in mustard followed by 324 siliquae plant^{-1} with one irrigation at flowering stage.

Tomer *et al.* (1992) conducted an experiment to observe the effect of irrigation teratments viz. no irrigation, one irrigation (at pre-flowering stage) and two irrigation (one at pre-flowering and one at fruiting stage). Maximum number of siliquae were found plant^{-1} when two irrigations were applied. One irrigation and without irrigation produced lower siliquae plant^{-1}.

Patel *et al.* (1991) reported that one irrigation produced higher siliquae plant^{-1} while minimum was produced plant^{-1} in without irrigation.

2.1.5 Number of seeds siliqua^{-1}

Clarke and Simpson (1978) found the increasing number of seeds siliqua^{-1} with irrigation application than rainfed condition.

Joarder *et al.* (1979) conducted an experiment with mustard cv. Rai 7, Laha 101 and Rai 5 cultivated under irrigated or rainfed condition and observed that irrigation increased the number of seeds siliqua^{-1} and therefore, increased yield plant^{-1} and yield ha^{-1} by 65 and 59% compared to the rainfed treatments, respectively.

Prasad and Ehsanullah (1988) carried out a field trial in 1984-85 and found an increasing trend of seeds siliqua^{-1} in mustard with irrigation application.The number of seeds siliquae^{-1} were found when irrigation was applied at 30 and 60 DAS followed by irrigation at 30 DAS and without irrigation which produced lower seeds siliqua^{-1} .

Sharma and Kumar (1989a) conducted an experiment of *Brassica juncea* cv. *Krishna* with two irrigation levels. They observed that number of seed siliquae^{-1} was higher when irrigation was applied at irrigation depth and cumulative pan evaporation ratio of 0.6. Number of seed siliqua^{-1} was lower with irrigation to a ratio of 0.4 or without irrigation.

Tomer *et al.* (1992) reported that seeds siliqua^{-1} were significantly increased with irrigation application. Maximum numbers of seeds siliquae^{-1} were found when two irrigations were applied (one at pre-flowering stage and one at fruiting stage). A siliqua produced 12.36 seeds on an average when two irrigations were applied while one irrigation and without irrigation produced 10.81 and 8.02 seeds siliquae^{-1}, respectively.

Siag *et al.* (1993) found that two irrigations given either at branching and siliqua development or at branching and flowering stages of rapeseed showed a significant increase in siliquae plant^{-1}. The highest number of siliqua (261) was found with two irrigations at branching and siliquae development stages.

2.1.6 . Weight of 1000-seed

Clarke and Simpson (1978) reported that under field conditions irrigation scarcely affected 1000-seed weight of mustard. The seed yield was positively correlated with 1000-seed weight of mustered.

Saran and Giri (1988) concluded that one irrigation applied at 30 DAS on rapeseed produced similar 1000-seed weight that found in two irrigations at 30 DAS and 90 DAS. The lowest weight of 1000-seed was found in without irrigation .

Prasad and Ehsanullah (1988) reported that irrigation significantly increased the 1000-seed weight of rapeseed. They found maximum weight of 1000-seed from the application of two irrigations at 30 and 60 DAS. The lowest weight of 1000-seed was found in rainfed condition (without irrigation) which was also lower than the application of one irrigation at 30 DAS.

Sarker and Hassan (1988) observed increased 1000-seed weight with increasing levels of irrigation applied on rapeseed.

Sharma and Kumar (1989a) found that 1000-seed weight was higher, when irrigation was applied at irrigation depth and cumulative pan evaporation ratio of 0.6 and that was lower with irrigation to a ratio of 0.4 or without irrigation.

Tomer *et. al.* (1992) reported that maximum weight of 1000-seed was found when one irrigation was applied during pre-flowering stage and another one during fruiting stage of mustard. Least weight of 1000-seed was found in without irrigation treatment.

2.1.7 Grain yield

Singh and Yusuf (1979) reported that seed yield of brown Sarson (*Brssica campestris* var. *Dichotoma*) was curvilinearly related to irrigation levels reaching a maximum yield, and yield response to nitrogen was greater with irrigation than without irrigation.

Singh (1983) found in an experiment with mustard (*Brassica juncea*) grown with a pre-sowing irrigation in the Rajastan arid zone of India that irrigation at the pre-flowering stage increased the yield of mustard. But the irrigation given at siliquae formation stage did not further increase seed yield.

Roy and Tripathi (1985) stated that the growth characters and yield of *Brassica juncea* were significantly increased with irrigation at IW: CPE (Irrigation water depth: cumulative pan evaporation ratio) of 0.6 compared to irrigation at IW: CPE ratio of 0.4.

They found yield was positively associated with number of branches plant^{-1} and siliquae plant^{-1}, number of seeds siliqua^{-1} and 1000 seed weight.

Singh and Srivastava (1986) observed a significant increase of seed yield of mustard (*Brassica juncea*) with irrigantion. They found the seed yields of *Brassica juncea* with single irrigation at the flower bud stage and two irrigations at the flower bud stage + the siliquae formation stage were 430 and 610 kg ha^{-1}, respectively, compared with 330kg ha^{-1} without irrigation.

Reddy and Sinha (1987) observed in an experiment with *Brassica juncea* in Rabi seasons of 1983-1985 that irrigation at IW and CPE ratio of 0.6 and 0.3 (three and one irrigation respectively) gave maximum seed yield compared to that of rainfed crops.

Hoque *et al.* (1987) observed that yield increase was highly significant for two irrigations applied on rapeseed, one at the early vegetative stage and the other at the initial siliquae formation stage.

Katole and Sharma (1988) conducted a field experiment on clay loam soils with rapeseed to study the effect of irrigation schedule and found that yield was highest with two irrigations, one at branching and other at siliquae development stage.

Prasad and Eshanullah (1988) pointed out in an experiment in 1983-1985 with *Brassica juncea* that two irrigations (with six cm irrigation) at irrigation water depth and cumulative pan evaporation ratio of 0.8 or at 30 and 60 day after sowing gave maximum seed yield compared to one irrigation and without irrigation. Seed yield was minimum with no irrigation treatment.

Sarker and Hassan (1988) made an experiment with *Brassia juncea* at two locations in Bangladesh. They irrigated the crop at one to six levels commencing 20-25 day after sowing and obtained maximum seed yield at BINA farm with three levels of irrigation and that at RARS Ishurdi farm with five levels of irrigation.

Sharma and Giri (1988) reported that *Brassica juncea* grown with 0-80 kg N ha^{-1} under rainfed conditions or with 1-2 irrigations gave similar seed yield during two consecutive growing seasons.

Sharma and Kumar (1988) studied an irrigated mustard (*Brassica juncea)* with 60 cm irrigation at irrigation water depth and cumulative pan evaporation ratio of 0.4 or 0.6 (one and two irrigations respectively) and reported that seed yield were higher in 1984-1985 and 1985-1986 compared with respective yield under rainfed conditions.

Mondal *et al.* (1988) conducted a field trials in the Rabi (winter) season of 1980-1982, *Brassica juncea* cv. T-59 was sown in the 1^{st} week of November and given 1-4 irrigation treatments (at preflowering, flowering, early siliquae or late siliquae developmental stages). The result revealed that maximum yield was obtained with 1 irrigation at flowering, intermediate with 2 irrigations at that yield was obtained flowering and late siliqua stages and minimum with 3 irrigations applied at preflowering, early and late siliqua stages.

Hasan *et al.* (1988) conducted a field experiment in 2 locations in Bangladesh, mustard (*Brassica juncea*) was given no irrigation(I_0), 1 irrigation at 25 days after sowing (I_1), or I_1, together with later irrigation when IW: CPE (irrigation water depth and cumulative potential evaporation ratio) reached at 0.2, 0.4, 0.6 or 1.0. They observed that the highest seed yield resulted from irrigation at I_1 and 2 irrigations when IW: CPE was 0.4

at 1 location, whereas at the other location the highest seed yield recorded from irrigation at I_1 and 4 irrigations when IW:CPE was 1.0.

Sharma and Kumar (1989b) stated that *Brassica juncea* cv. *Krishna* was unirrigated or given 1 irrigation at the rosette stage with or without 1 irrigation at siliquae formation. They observed that the average seed yield was higher with irrigation and lower for unirrigated treatment.

Rathore and Patel (1989) reported that mustard (*Brassica juncea*) gave highest seed yield with 3 irrigations at branching and 50% flowering and seed filling, followed by 2 irrigations at branching and 50% flowering, and one irrigation at late branching.

Parihar and Tripathi (1989) gave irrigation to mustard (*Brassica juncea)* with six cm irrigation and found that average yields were varied for irrigation depth and cumulative pan evaporation ratios of 0.4, 0.6 and 0.8, respectively.

Lal *et al.* (1989) irrigated mustard cv. Varuna with one to three levels at different growth stages in one of their experiment. They found that application of one level of irrigation at flowering stage gave the highest seed yield. Addition of irrigation did not improve seed yield . Seed yield was lowest under rainfed condition.

Sarkar *et al.* (1989) reported that mustard irrigated at flowering stage produced the highest seed yield and this was followed by the plants irrigated at vegetative and siliquae filling stages.

Siag and Verma (1990) concluded that mustard (*Brassica juncea*) yield increased with irrigation frequencies at different growth stages.

Tomer and Singh (1990) studied the effects of 0, 1 or 2 irrigations on the yield of *Brassica juncea* cv. *Varuna*. They found that increasing irrigation levels increased seed and oil yield.

In another experiment on mustard, Sharma and Kumar (1990) observed that one or two levels or irrigation produced the maximum seed yield in 1984-1985 and 1985-1986. Yields were obtained lower with without irrigation in those years.

Rarihsr (1990) found in an experiment with mustard that the seed yield land yield components were greater while irrigation was applied at irrigation depth and cumulative pan evaporation ratio of 0.6.

Sharma (1991) conducted two experiments on mustard (*Brassica juncea*) cv. Varuna in the Rabi seasons of 1986-1987 on clay loam soil at Mandsaur, Madhya Pradesh of India and found that I irrigation at 15 or 30 days after sowing or 2 irrigations at 15 + 30 or 30+ 60 days after sowing, i.e. increasing irrigation frequency elevated seed yield over no irrigation.

Ghatak *et al.* (1992) reported that mustard was irrigated at flowering (Ifl), irrigated at branching (Ibr)+ Ifl, or Ibr +Ifl + irrigation at seed development (Isd), i.e. with increased level of irrigation produced greater seed yield compared to be control (rainfed).

Tomer *et al.* (1992) conducted an experiment to find out the effect of irrigation levels on the growth and yield of mustard (*Brassica juncea*). They worked with three irrigation treatments viz no irrigation, one irrigation (at pre- flowering stage) and two irrigations (one at pre-flowering and another at fruiting stage). They concluded both levels of irrigation significantly increased the seed yield over no irrigation.

Tiwari and Chaplot (1993) carried out a field experiment on the effect of irrigation levels on mustard (*Brassica juncea* cv. Varuna) which was irrigated at vegvetative, flowerig , siliqua development or seed filling stage corresponding 3, 6, 9, or 12 weeks after sowing (WAS) or at various combinations of these dates. Seed yield increased with increase in irrigation frequency. The highest mean seed yield was obtained from irrigating the crop at 3, 6 and 9 WAS.

Sharma and Singh (1993) conducted an experiment with *Brassica juncea* cv. Pusa Bold which was not irrigated, irrigated at the rosette stage (28-30 days after sowing DAS), siliquae formation stage (55 DAS) or rosette + siliquae formation stage. One irrigation at the rosette stage gave appreciable yield compared with one irrigation at siliquae formation stage and unirrigated treatments .

Gill and Narag (1993) observed in an experiment with Gobhi sarson that all growth parameters and yield significantly increased , while irrigation was applied at 20 days after sowing under cumulative pan evaporation of 80 mm.

Padman *et al* (1994) conducted a field experiment during the winter season of 1987-1989 at Udaipur, Rajshthan, India. They observed that seed yield of *Brassica juncea* increased with increasing levels of irrigation .

Mahal *et al* (1995) reported that maximum seed yield were recorded with 2 irrigations (at 3-4 weeks and at 9-10 weeks after sowing) in consecutive two years experiment .

Samadder *et al* (1997) studied the *Brassica juncea* cv .Bhagirathi with non irrigated condition and irrigation at flowering or at flowering + seed formation stages and found that seed yield was highest with 2 irrigations .

Singh *et al* (1997) reported that the stages most sensitive to water strecs were the seedling stage followed by the flowering stage . Decreased in seed yield varied from 22.13 to 36.57% when irrigation was withheld at seedling and flowering stages, 17.98 to 32.43 % when withheld at seedling and seed development stages compared to irrigation applied at all these stages . However, early water stress from flowering to seed development stages decreased the yield by 4.83 to 15.46% compared with irrigation at all 3 stages.

Raut *et al* (1999) conducted a field experiment in Akola, Maharashtra, India , during the Rabi season of 1996-97 to study the effects of irrigation (at preflowering and siliquae-setting stages, preflowering+ 50% flowering+siliqua-setting stages, preflowering+ 50% flowering +seed-filling stages, and preflowering+ 50% flowering + siliqua-setting stages) on yield of Indian mustard cv. Pusa Bold . They reported that Irrigation at 50% flowering + seed-filling stages the highest grain yield (15.99 q ha^{-1})

2.1.8 Stover yield

Stover yield was found to be higher with the application of irrigation in the mustard (Patel *et al.*, 1991). They found maximum biomass with one irrigation compared to unirrigated control.

2.1.9 Biological yield

Bhargava (1991) demonstrated that biological yield, harvest index and siliquae productions $plant^{-1}$ were positively correlated with higher seed yield of rapeseed and mustard but number of seed per siliqua was negatively correlated.

2.1.10 Harvest index

Srivastava *et al.* (1988) observed in an experiment with mustard (*Brassica juncea*) cv. Varuna that two irrigation at pre-flowering and seed development stages gave higher harvest index. They also observed that irrigation at pre-flowering stage gave higher harvest index value than those of irrigation at seed development stage or without irrigation . However, information was very scarce regarding to the effect of irrigation on harvest index of rapeseed.

2.2 Effect of variety

Varietal prformance 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.

2.2.1 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 and Rahman (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) 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 height was in Narenda (175 cm) which was similar with AGA-95-21 (166 cm) and Hyola-51 (165 cm). They also found the shortest variety as Tori-7.

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

2.2.2 Dry weight

Thuriling (1974) reported that in *Brassica campastris* 85% of the PDM was accumulated after anthesis whereas, *B napus* it was only 50%.

Chauhan and Bhargave(1984) noticed that in rapeseed and mustard more than 90% of the TDM was accumulated during the reproductive period and one third of TDM was partition into seed yield.

2.2.3 Number of branches plant^{-1}

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

Jahan and Zakaria (1997) reported that the local varieties Tori-7 and Sampad produced the highest number of primary branches plant^{-1} (4.07) which was at par with BLN-900. The minimum number of primary branches plant^{-1} (2-90) was found in Jatarai which was similar to those found in Hhole-401 and BARI Sarisha-8 .

Hossain *et al.* (1996) stated that the varieties were statistically different with respect to number of primary branches.

2.2.4 Number of siliqua 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 statistically similar 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 siliqua plant^{-1}.

Mondal *et al.* (1992) found that the maximum number of siliqua plant^{-1} (136) was found in the variety Tori-7and the lowest number of siliqua plant^{-1} (45.9) was found in SS-75.

2.2.5 Number of seeds siliqua^{-1}

Jahan and Zakaria (1997) found the 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 of seeds siliqua^{-1} (18.0) was found in tori-7and which was at par with that in sampad (20.0), BARI Sarisha-7 (20.5) and BARI Sarisha-8 (21.6).

2.2.6 Weight of 1000 seed

Mondal and Wahhab (2001) reported that the weight of 1000 seed varies from variety to variety and even 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*).

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

Karim *et al.* (2000) stated that the varieties showed significant difference in weight of thousand seeds. They found the 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 record the highest thousand seed weight (3.43 g) in Hyda-401 and the lowest (2.1. g)was in Tori-7 .

2.2.7 Grain yield

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

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

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

Mendham *et al.* (1990) observed that seed yield differed in the species of *B. napus* due to varietals differences.

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

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

2.2.8 Stover yield

BARI (2000) reported that in case of poor management, Isd-local gave the highest stover yield (3779 kg ha^{-1}) and lowest (1295 kg ha^{-1}) was found in Nap-248. In case of medium management, the highest stover weight (6223.3 kg ha^{-1}) from PT-303. Under high management conditions, the highest stover yield (6400 kg ha^{-1}) was obtained from Rai-5 and that of lowest(4413.3 kg ha^{-1}) was recorded from Tori-7.

2.2.9 Biological yield

The biological yield of plant at final harvest measured in terms of total dry weight is 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).

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.

2.2.10 Harvest index

Robertson *et al.* (2004) stated that Indian mustard had a lower havest index. Islam *et al.* (1994) showed that varieties had significant harvest index (%) of mustard.

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

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHOD

A field experiment with variety and irrigation level was conducted in the Rabi season (November, 2006 to March, 2007) to evaluate the three rapeseed varieties viz. SAU Sarisha-1, Improved Tori-7 and Kalyania in respect of growth and yield performances.

3.1 Experimental site

The research work was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November 2006 to March 2007. The experimental field is located at $90^0 22'$E longitude and $23^0 41'$N latitude at an altitude of 8.6 meter above sea level . The land was medium high and well drained.

3.2 Climate

Cold temperature and minimum rainfall is the main feature of the rabi season. Monthly total rainfall, air temperature and average sunshine hour of the site during the experimental work have been shown in Appendix II .

3.3 Soil

The soil of the experimental site belongs to the agro-ecological region of 'Madhupur Tract' (AEZ No. 28). It was Deep Red Brown Terrace soil and belongs to "Nodda" cultivated series. The soil was silty clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47 - 5.63. The physical and chemical characteristics of soil have been presented in Appendix III.

3.4 Experimental materials

Three oil seed varieties - SAU Sarisha-1, Improved Tori-7 and Kalyania were used as experimental materials. SAU Sarisha-1 was released by Sher-e-Bangla Agricultural University, Dhaka-1207. Seeds of SAU Sarisha-1 were collected from SAU, Improved Tori-7 and Kalyania were collected from Oil Seed Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

3.5 Experimental treatments

The factors and treatments of this experiment have been presented below-

Factor A: Irrigation level- 5

i. No irrigation (Control)
ii. Irrigation at 20 days after sowing (I_1)
iii. Irrigation at 35 days after sowing (I_2)
iv. Irrigation at 20 and 35 days (I_3)
v. Irrigation at 20,35 and 50 days after sowing (I_4)

Factor B: Variety- 3

i. SAU Sarisha-1(V_1),
ii. Improved Tori-7(V_2) and
iii. Kalyania(V_3)

3.6 Experimental design and layout

The experiment was laid out in a two factor Split plot design with three replications. Irrigation was given in main plot and variety was in sub-plots. Each replication was divided into 5 equal main plots randomly. Further each main plot was also divided into 3 sub plots. Thus the total number of plots were 45. The size of each plot were 3 m x 2 m

($6m^2$). The distance between two adjacent unit plots was 0.75 m and distance between two replications was 1 m.

3.7 Crop Husbandry

3.7.1 Land preparation

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

3.7.2 Fertilization

The experimental plots were fertilized with the recommended dose of 300, 180, 100, 180, 5 and 10 kg ha^{-1} of Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum, Zinc Oxide (ZnO) and Boric acid, respectively. During final land preparation, one half of the urea and total amount of other fertilizers were applied and incorporated into soil. Rest of the urea was top dressed on 8 December 2006 during first weeding at 28 days after sowing (DAS).

3.7.3 Germination test:

Germination test was performed before sowing the seed in the field. Filter paper were placed on petridishes and the paper were socked with water. Seeds were distributed at random in petridish. Data on emergence were collected on percentage basis by using the following formula:

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

3.7.4 Sowing of seed:

Seeds were sown in lines continuously and line to line distance was maintained 30 cm. Seeds were placed 2 cm depth and then rows were covered with loose soil properly .The seed rate was used as 7.5 kg for SAU Sarisha-1, 8 kg for Improved Tori-7 and Kalyania.

3.7.5 Weeding and thinning

The experimental plots were found to be infested with different kinds of weeds, viz. Bathua (*Chenopodium album* L.), Bermuda Grass (*Cynodon dactylon*), Nut sedge (*Cyperus rotundus* L.), Biskatali (*Polygonum hydropiper* L.) etc. Weeding was done two times manually with "nirani"on 27 November and 12 December. Thinning was done in all the unit plots on 29 November with care maintaining a constant plant population in each row. Finally plants were kept at 5 cm distance in rows.

3.7.6 Irrigation

First irrigation was given at 30 November 2006(20 DAS) in the plots according to treatments. The second irrigation was given at 15 December, 2006(35 DAS) and in the plots as required by the treatments and the third irrigation was given at 30 December, 2006(50DAS). Irrigation was done by check basin method. Control plots were maintained with no irrigation.

3.7.7 Pest and disease management

The crop was sprayed with Malathion 60 EC to prevent infestation of aphids at siliquae formation stage. Dithane M-45 was also applied immediately after irrigation to prevent soft rot of plants.

3.8 Harvesting and processing

At maturity when 80% of the siliquae turned straw yellowish in colour, the experimental crop was harvested. The sub-plots under the main plots without irrigation and Tori-7 were harvested on 1 February, 2007 (82 DAS), the sub-plots under the main plots with one irrigation and Kalyania were harvested on 8 February 2007 (90 DAS), the sub-plots under the main plots with two and three irrigations and SAU Sarisha-1 were harvested on 18 February,2007 (100 DAS). Harvesting was done in the morning to avoid shattering. Four linear meters were harvested from the centre of each plot at ground level with the help of a sickle. The harvested plants from each plot were bundled separately, tagged and brought to a clean cemented threshing floor. The crop was sun dried by spreading them over the floor and seeds separated from the siliquae by beating the bundles with bamboo sticks.

The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield were recorded and converted into kg ha^{-1}. The biological yield was calculated as the sum of the seed yield and stover yield.

3.9 Sampling and data collection

Five sample plants were selected and marked in each plots. All the growth data were collected from the pre selected five plants in each plots. For taking yield characters data, ten sample plants were collected at random from each plot. The selected plants of each plot were at the ground level with the help of sickle. The parameters studied in this experiment were as follows-

i) Plant height (cm) at 15days intervals starting from 15 DAS

ii) Dry weight of plants (g) at 15days intervals starting from 15 DAS

iii) Number of branches plant^{-1}

iv) Number of siliquae plant^{-1}

v) Number of seeds siliqua^{-1}

vi) Weight of 1000-seed (g)

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

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

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

x) Harvest index (%)

3.9.1 Plant height (cm)

The height of five plants from each plot were measured with a meter scale from the ground level to the top of the plants and height was expressed in cm. The height were taken at 15, 30, 45, 60 and 75 DAS.

3.9.2 Dry weight of plant (g)

The dry weight of five plants were measured with the help of a digital electric balance and mean weight was calculated to obtain dry weight plant^{-1}.

3.9.3 Number of branches plant^{-1}

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

3.9.4 Number of siliquae plant^{-1}

Number of total siliquae of pre selected ten plants from each plot was noted and the mean number was recorded. The number of siliquae plant^{-1} were counted and the mean was recorded.

3.9.5 Number of seeds siliqua^{-1}

The number of seeds were counted randomly taking 10 siliquae per treatment and mean value was taken.

3.9.6 Weight of 1000-seed (g)

The weight of thousand seeds were measured by counting 1000 seeds randomly from each plot and finally expressed dry weight basis.

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

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

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

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.

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

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

Biological yield = Grain yield + Stover yields (dry weight basis)

3.9.10 Harvest index (%)

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

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

3.10 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 at 5% level of significance.

Chapter IV

Results and Discussion

CHAPTER IV

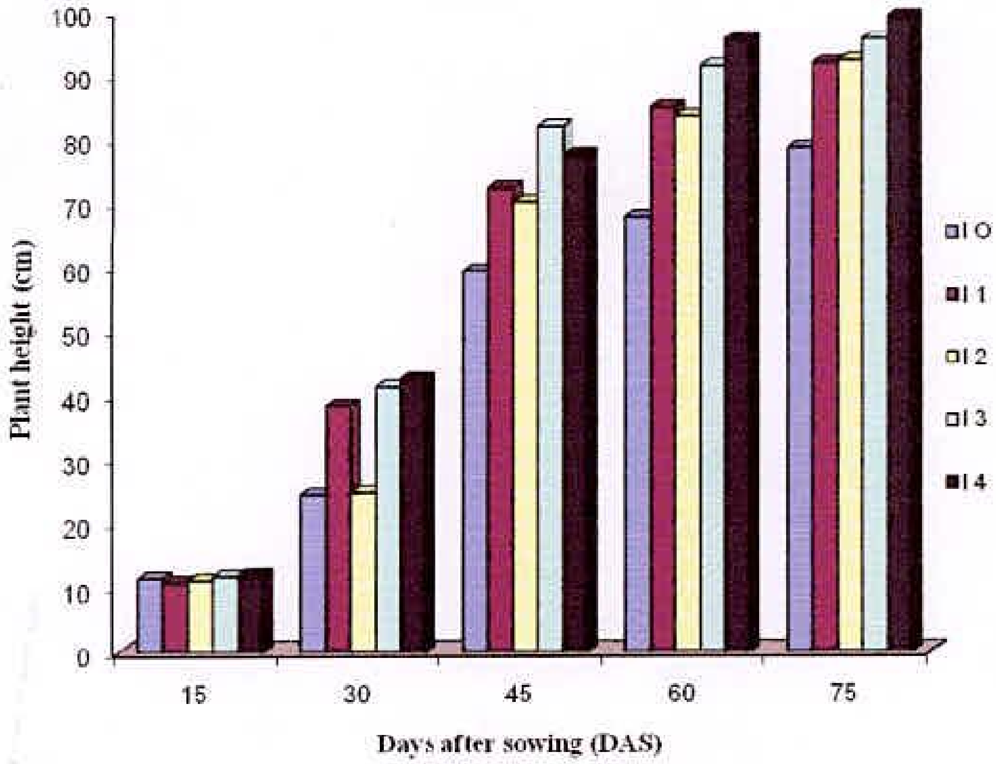
RESULTS AND DISCUSSION

The experiment was conducted to study the performance of irrigation and variety on growth, yield attributes and yield of rapeseeds. The results of the present investigation have been presented, discussed and compared as far as possible with the results of other research.

4.1 Plant height (cm)

4.1.1 Effect of irrigation

Significant variation was found among the irrigation levels on plant height of rapeseed which started from 15 DAS to onwards (Fig. 1). At 30 DAS I_1, I_3 and I_4 irrigation produced taller plant compared to I_2 (one irrigation at 35 DAS). The treatment I_3 (two irrigations at 20 and 35 DAS)showed significantly the tallest plant at 45 DAS and it was followed by I_4 (three irrigation at 20 and 35 and 50 DAS). The treatment I_4 (three irrigations at 20 and 35 and 50 DAS) showed significantly the tallest plant at 60 DAS and 75 DAS followed by I_3 (two irrigations at 20 and 35 DAS). The controll treatment I_0(no irrigation) produced the shortest plant throughout the growth period. The result corroborates with the findings of Sarker (1994) and Siag *et al.* (1993) who observed maximum plant height in the irrigation application treatment during branching and siliquae +development stages.



Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at 20 and 35 DAS

I_4= Irrigation at 20,35 and 50 DAS

Fig. 1 Effect of irrigation on plant height at different growth stages of rapeseed ($LSD_{0.05}$=.828, 4.08, 2.16, 1.55, 5.20 at 15,30,45,60 and 75 DAS respectively).

4.1.2 Effect of variety

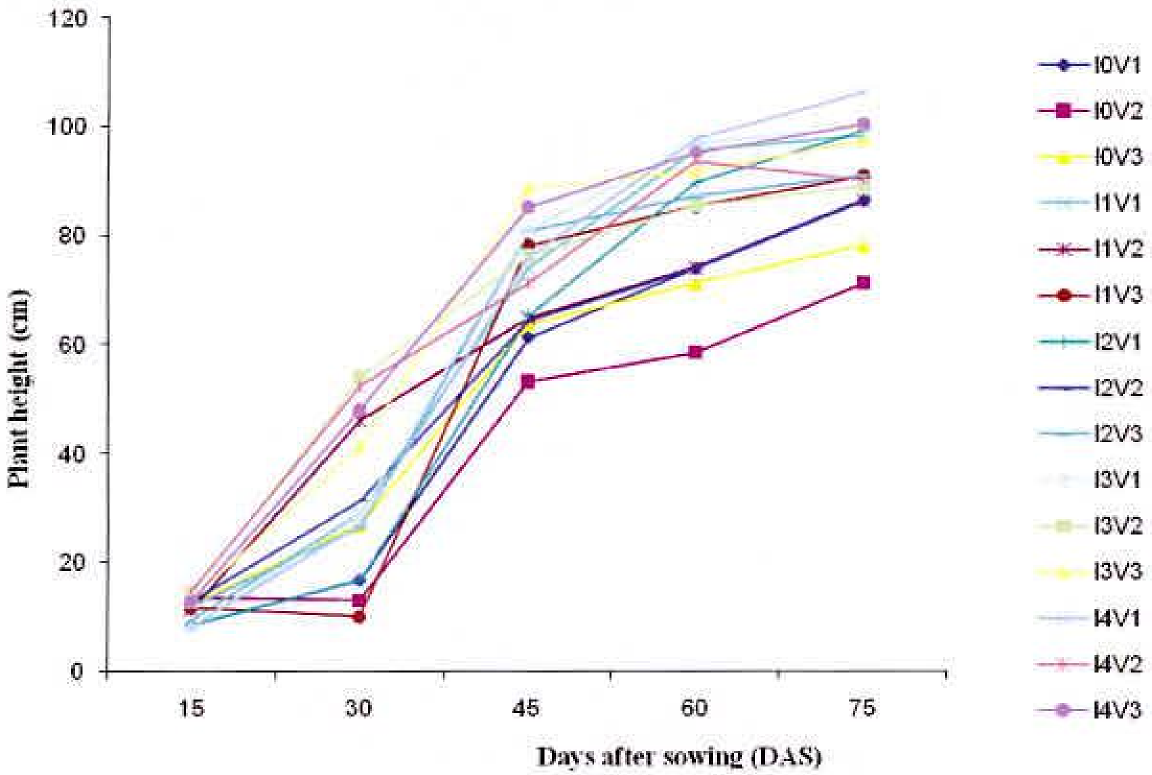
The plant height of the varieties was different at different days after sowing (DAS)(Table 1). At 15 and 30 DAS, the highest plant stature, produced by the variety Tori-7, were highly significant and different from those of SAU Sarisha-1 and Kalyania. At 45 DAS, the plant height of the variety Kalyania was significantly highest and different from those of Tori-7 and SAU Sarisha-1 (60.02 and 72.52, respectively). At 60 and75 DAS the highest plant statures were produced by the variety SAU Sarisha-1 followed by Kalyania and Tori-7. It is interesting to note that initially SAU Sarisha-1 showed the shortest plant after 45 DAS the height of this variety increased rapidly up to 75 DAS.

Table 1 Effect of variety on plant height at different growth stages of rapeseed

Variety	Plant height(cm) at different days after sowing (DAS)				
	15	30	45	60	75
SAU Sarisha-1	8.57	23.66	71.52	90.76	98.03
Improved Tori-7	13.29	42.82	66.02	77.10	84.69
Kalyania	12.33	37.58	79.33	86.15	91.62
LSD(0.05)	0.520	3.164	1.672	1.198	4.026
CV(%)	6.41	12.04	3.09	1.89	5.89

4.1.3 The interaction effect of irrigation and variety

The interaction effect of irrigation and variety had a significant effect on the plant height (Fig. 2). Significant differences of plant heights were found in every stages of growth except at the early stage (15 DAS). This was due to slow growth rate and also for the reason of no irrigation was applied before 15 DAS. Maximum plant height was observed in the interaction of I_4V_1 (three irrigation and SAU Sarisha-1). The lowest plant height was found with I_0V_1 (control condition and Tori-7) interaction. The plant response in terms of height to the combined treatment was found higher in the middle growth stage (from 30 to 60 DAS) because of better growth. The maximum plant height (106.3cm) at harvest was obtained from the treatment I_4V_1 (three irrigations x SAU Sarisha-1)which was at per with I_4V_3 (three irrigations x Kalyania), I_3V_1(two irrigations x SAU Sarisha-1), I_3V_3(two irrigations x Kalyania) and I_2V_1(one irrigation at 35 DAS x SAU Sarisha-1).



Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at20 and 35 DAS

I_4= Irrigation at 20, 35 and 50 DAS

V_1=.SAU Sarisha-1

V_2= Improved Tori-7

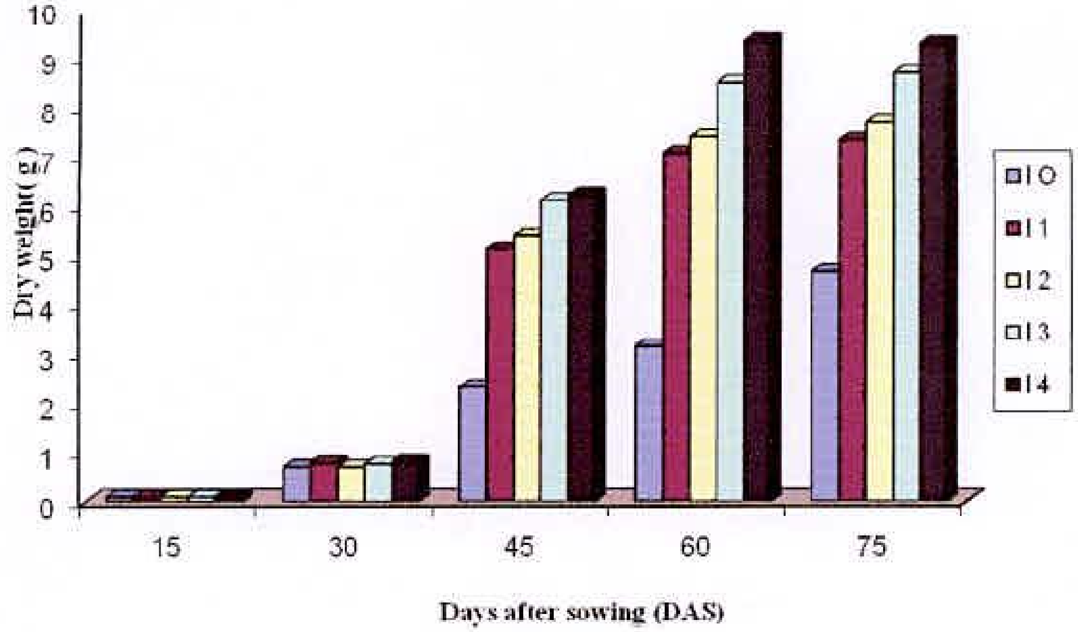
V_3=. Kalyania

Fig. 2 Interaction effect of irrigation and variety on plant height at different growth stages of rapeseed ($LSD_{0.05}$= 1.33,7.07,3.34,2.68,9.00 at 15,30,45,60 and 75 DAS respectively).

4.2. Dry weight

4.2.1 Effect of irrigation level

Significant variation was found in total dry matter plant^{-1} with different level of irrigation at all growth stages except two early growth stages (15 and 30 DAS). Distinct differences were observed in dry matter production after 30 DAS when irrigations were initiated at 20 DAS (Fig. 3). The total dry matter production was increased with each increment of irrigation levels. The lowest dry matter in the early growth stages of plant was due to internal moisture deficient that made the plants to have lower height and failed to increase growth parameter due to lower net assimilation rate. This adversely affected the dry matter accumulation in plants. Wright *et al* (1988) expressed the similar observation in respect of dry matter. Application of three irrigation produced the highest number of branches which might have contributed in the accumulation of highest dry matter at latter growth stages (45, 60 and 75 DAS). Saran and Giri (1988) noticed similar observation of dry matter accumulation in rapeseed plant with increasing irrigation levels.



Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at20 and 35 DAS

I_4= Irrigation at 20, 35 and 50 DAS

Fig. 3 Effect of irrigation on dry weight of rapeseed ($LSD_{0.05}$=*NS, NS, 0.48,0.82,0.92 at 15,30,45,60 and 75 DAS respectively).
***NS=Not Significant**

4.2.2 Effect of variety

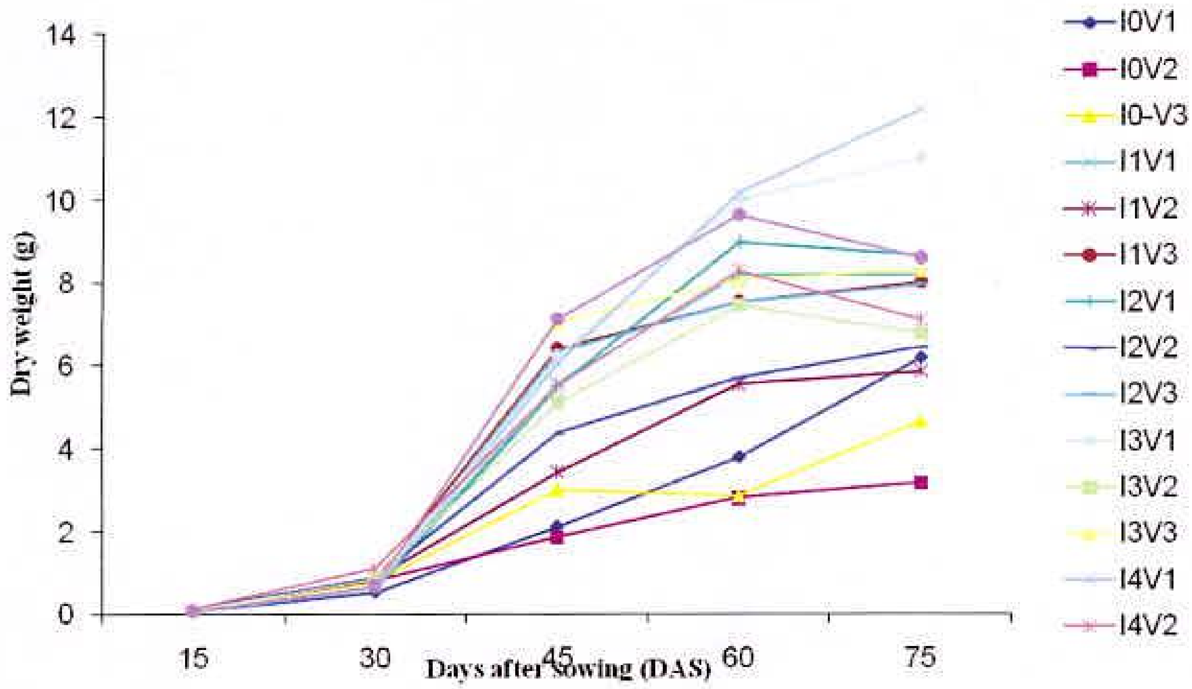
The dry weight among the varieties was different at different DAS(Table 2). At 15 and 30 DAS, the highest dry weight was produced by the variety Improved Tori-7 than SAU Sarisha-1 and Kalyania. At 45 DAS, the plant height of the variety Kalyania was significantly highest than other two varieties. At latter growth stages (60 and 75 DAS) the highest dry matter was found in SAU Sarisha-1 followed by Kalyania and lowest was observed in Improved Tori-7 variety.

Table 2 Effect of variety on dry weight of rapeseed

Variety	Dry weight (gm) at different days after sowing (DAS)				
	15	30	45	60	75
SAU Sarisha-1	0.07	0.62	5.09	8.21	9.23
Improved Tori-7	0.11	0.91	4.05	5.95	5.86
Kalyania	0.082	0.73	5.96	7.12	7.50
LSD (0.05)	0.0334	0.085	0.375	0.634	0.709
CV(%)	8.71	15.03	9.96	11.94	12.58

4.2.3 Interaction effect of irrigation and variety

The interaction effect of irrigation and variety exerted significant effect on the dry weight plant^{-1} for all growth stages except 15 DAS (Fig. 4). At 60 and 75 DAS maximum dry weights were observed in the interaction of I_4V_1 (three irrigations x SAU Sarisha-1) which was at par with I_3V_1 (two irrigations x SAU Sarisha-1). The lowest dry weight was found in the interaction of I_0V_2 (control condition x Improved Tori-7) at 60 and 75 DAS.



Here,

I_0= Control	V_1=.SAU Sarisha-1
I_1= Irrigation at 20 DAS	V_2= Improved Tori-7
I_2= Irrigation at 35 DAS	V_3= Kalyania
I_3= Irrigation at 20 and 35 DAS	
I_4= Irrigation at 20, 35 and 50 DAS	

Fig. 4 Effect of irrigation and variety on dry weight at different growth stages of rapeseed ($LSD_{0.05}$=NS ,0.190, 1.42, 1.56, 1.56 at 15,30,45,60 and 75 DAS respectively).
***NS=Not Significant**

4.3. Number of branches plant^{-1}

4.3.1 Effect of irrigation level

From the study it was found that irrigation exerted significant influence on the number of branches plant^{-1}(Table 3). The maximum number of branches plant^{-1} (6.26) was found from a plant subjected to three irrigations, one at 20 DAS, one at 35 DAS and another at

50 DAS. The lowest numbers of branches plant^{-1} (2.89) was found from control treatment. The maximum increase 116.6% of branches plant^{-1} was observed with three irrigations (at 20, 35 and 50 DAS) compared to unirrigated control treatment. Branch number was also increased with the application of one irrigation at 20 DAS over control but the rate was lower than three irrigations. In case of one irrigation (at 20 DAS) the rate of increase was 52.60% and in case of one irrigation (at 35 DAS) the rate was 95.50% . The same thing was also happend in case of two irrigations (at 20 and 35 DAS). Similar finding was reported by Joarder *et al.* (1979) that irrigation increased primary and secondary branches plant^{-1}.

4.3.2 Effect of variety

Number of branches plant^{-1} differed significantly due to varieties (Table 4). SAU Sarisha-1 produced the highest number of branches plant^{-1} (5.43) which was significantly higher than Kalyania (4.80) and Improved Tori-7 (4.40). Numerical value indicated that SAU Sarisha-1 produced 23.36% and 13.10% higher branches plant^{-1} than Improved Tori-7 and Kalyania, respectively.

4.3.3 Interaction effect of irrigation and variety

Numbers of branches plant^{-1} was significantly increased by the interaction effect of irrigation and variety (Table 5). The maximum number of branches plant^{-1} (7.12) was found from the interactions between two irrigations (at 20 and 35 DAS) and three irrigations (at 20, 35 and 50 DAS) with SAU Sarisha-1. The lowest number of branches plant^{-1} (2.38) was found from the interaction between without irrigation × Improved Tori-7. It revealed that the plants of SAU Sarisha-1 produced higher number of branches plant^{-1} by possing sufficient moisture.

4.4Number of siliquae plant^{-1}.

4.4.1 Effect of irrigation level

Irrigation showed significant variation in producing siliquae plant^{-1}(Table 3). In general, application of irrigation at different leves increased the production of siliquae plant^{-1} over control (no irrigation). Three irrigations (at 20, 35 and 50 DAS) produced the highest number of siliquae plant^{-1} (124.10) followed by two irrigations (at 20 and 35 DAS) and one irrigation (at 35 DAS). The lowest number of siliquae plant^{-1} was found in control treatment which was 63.73, 57.97, 48.24 and 40.36% lower than three irrigations, two irrigations, one irrigation at 35 DAS and one irrigation at 20 DAS, respectively. The results were partially supported by Clarke and Simpson (1978) and fully supported by Sharma and Kumar (1989a) in that irrigation increased siliquae plant^{-1}.

Table .3 Effect of irrigation on yield character of rapeseed

Irrigation level	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Seed siliqua^{-1} (no.)	Weight of 1000 seed (g)
I_0	2.89	45.01	16.48	2.05
I_1	4.41	75.47	16.38	2.30
I_2	5.65	86.96	16.67	2.49
I_3	5.86	107.10	17.52	2.61
I_4	6.26	124.10	19.89	2.91
LSD (0.05)	0.391	4.190	1.562	0.185
CV(%)	8.07	4.95	9.30	8.13

Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at 20 and 35 DAS

I_4= Irrigation at20,35 and 50 DAS

4.4.2 Effect of variety

Siliquae plant^{-1} varied significantly due to varieties (Table 4). The result revealed that Kalyania produced the highest number of siliquae plant^{-1} (94.96) which was significantly higher than SAU Sarisha-1 and Improved Tori-7 (89.97 and 78.28, respectively). Similar observation was also reported by Islam *et al.* (1994) that siliquae plant^{-1} varied from variety to variety.

4.4.3 The interaction effect of irrigation and variety

Significant difference was found due to the interaction of irrigation and variety (Table 5). Three irrigation with SAU Sarisha-1 (I_4V_1) produced the highest number of siliquae plant^{-1} (140.20) which was 288.36% higher than that of no irrigation × SAU Sarisha-1 interaction (I_0V_1). The lowest number of siliqua plant^{-1} (36.13) was found from the treatment I_0V_1. The result agreed with the findings of Andrews (1972) who observed the positive effect of irrigation water towards siliquae formation.

4.5 Number of seeds siliqua^{-1}

4.5.1 Effect of irrigation level

Number of seeds siliqua^{-1} was significantly affected by irrigation level. The number of seeds siliqua^{-1} was increased with the increased number of irrigation (Table 3). Significantly the highest number of seeds siliqua^{-1} (19.89) was found with three irrigations (at 20, 35 and 50 DAS) while the lowest number of seeds siliqua^{-1} was found with control and one irrigation (at 20 DAS). Seeds siliqua^{-1} was increased with the increased irrigation level due to the supply of adequate soil moisture which helped to produced the longer siliqua and have more number of seeds. That reported by Prasad and Ashanullah (1988), Sarker and Hassan (1988), Sharma and Kumar (1989b) and Dobariya and Mehta (1995).

4.5.2 Effect of variety

Seeds siliqua^{-1} varied significantly among the varieties (Table 4). SAU Sarisha-1 showed the highest seeds siliqua^{-1} (18.20) followed by Improved Tori-7 (17.06). The lowest seeds siliqua^{-1} (16.91) was found in Kalyania. SAU Sarisha-1 showed 7.63 and 6.68% higher seeds siliqua^{-1} over Kalyania and Improved Tori-7, respectively. The present study were consistant with the findings of Jahan and Jakaria (1997).

Table 4 Effect of variety on yield characters of rapeseed

Variety	Branches plant^{-1} (no)	Siliqua plant^{-1} (no)	Seed siliqua^{-1} (no)	Weight of 1000 seed (gm)
SAU Sarisha-1	5.435	89.97	18.20	2.585
Improved Tori-7	4.405	78.28	17.06	2.335
Kalyania	4.807	94.96	16.91	2.492
LSD (0.05)	0.303	3.245	1.210	0.1439
CV(%)	8.07	4.95	9.30	7.83

4.5.3 Interaction effect of irrigation and variety

Irrigation and variety interact significantly each other in producing seeds siliqua^{-1} (Table 5). The highest number of seeds siliqua^{-1} (20.93) was found when three irrigations were applied with SAU Sarisha-1 followed by I_4V_1 (three irrigation × SAU Sarisha-1) and I_3V_1 (two irrigation × SAU Sarisha-1).

4.6 Weight of 1000 seeds

4.6.1 Effect of irrigation

Irrigation levels had significant effect on 1000 seed weight(Table 3). Three irrigations (at 20, 35 and 50 DAS) produced the heighest 1000 seed weight (2.90 g) which was significantly superior to one irrigation applied at 20 DAS (2.299) and one irrigation at 35 DAS (2.49), respectively. The lowest 1000 seed weight (2.04g) was produced by without irrigation (control). The result was supported by Sarker and Hassan (1988), Sharma and Kumar (1990), Rahman (1994), and Sarker *et al.* (2000).

4.6.2 Effect of variety

Weight of 1000 seed differed significantly among the varieties (Table 4). The result revealed that SAU Sarisha-1 had the highest 1000 seeds weight (2.58g) which was statistically higher from that of Kalyania (2.49g) and Improved Tori-7(2.33g). However, 1000 seed weight was statistically at par with SAU Sarisha-1 and Kalyania. Similar findings were reported by Mondal and Wahhab (2001) that weight of 1000 seeds vary from variety to variety.

4.6.3 The interaction effect of irrigation and variety

Interaction effect of irrigation and variety was found significant in producing 1000 seed weight (Table 5). The highest weight of 1000 seed (3.09g) was found from the combination of three irrigations (at 20, 35 and 50 DAS) with SAU Sarisha-1. The lightest seed (1.93g) was found from the treatment combination of no irrigation and Improved Tori-7 (I_0V_2). However, the combination of the all varieties with no irrigation treatment were found statistically similar in respect of seed weight.

Table 5 Interaction effect of irrigation and variety on yield character of rapeseed

Irrigation × Variety	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Seed $siliqua^{-1}$ (no.)	Weight of 1000 seed (g)
I_0V_1	3.09	36.13	16.87	2.03
I_0V_2	2.38	41.43	16.02	1.93
I_0V_3	3.20	57.46	16.55	2.18
I_1V_1	5.31	78.13	16.74	2.37
I_1V_2	4.00	62.13	15.91	2.10
I_1V_3	3.92	86.13	16.50	2.42
I_2V_1	6.53	88.53	16.82	2.48
I_2V_2	5.19	76.25	16.31	2.38
I_2V_3	5.22	96.10	16.89	2.62
I_3V_1	7.12	106.90	19.63	2.95
I_3V_2	4.80	102.60	18.23	2.51
I_3V_3	5.66	111.90	14.70	2.36
I_4V_1	7.12	140.20	20.93	3.09
I_4V_2	5.64	109.00	18.85	2.75
I_4V_3	6.02	123.20	19.90	2.88
LSD (0.05)	0.6773	7.256	2.705	0.3217
CV(%)	8.07	4.95	9.30	8.13

Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at 20 and 35 DAS

I_4= Irrigation at20, 35 and 50 DAS

V_1=.SAU Sarisha-1

V_2= Tori-7

V_3=. Kalyania

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

4.7.1 Effect of irrigation

Seed yield varied significantly due to irrigation level (Table 6). In general irrigation application increased seed yield over control (no irrigation). Maximum seed yield (1517.0kg ha^{-1}) was found from three irrigations (at 20, 35 and 50 DAS) which was statistically higher than the yield obtained from the controll as well as other irrigation treatments. The lowest seed yield (715.8 kg ha^{-1}) was found in unirrigated control condition. In control condition, high mortality of seedlings reasulting from shortage of soil moisture might have drastically reduced the yield. Samui *et al.* (1986) and Malavia *et al.*(1988) reported similar reasults in rapeseed in respect of seed yield. Under no irrigation treatment internal moisture deficit led to lower plant height, failed to increase in growth parameters and reduced the net assimilation rate, which adversly affected yield components and thus yield was reduced. Three irrigations (at 20, 35 and at 50 DAS) significantly increased the seed yield due to favorable growth condition with maximum production of dry matter due to adequate moisture. The present result was in agreement with those obtained by Sarma and Kumar (1989b) and Joarder *et al.* (1979) who reported that irrigation increased seed yield of rapeseed.

Table 6 Effect of irrigation on yield and harvest index of rapeseed

Irrigation level	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index(%)
I_0	715.8	1469.0	2185.0	32.80
I_1	1016.0	1997.0	3013.0	33.72
I_2	1151.0	2138.0	3283.0	35.03
I_3	1370.0	2181.0	3561.0	38.68
I_4	1517.0	2208.0	3726.0	40.44
LSD (0.05)	63.48	208.0	234.1	2.024
CV (%)	5.70	10.78	7.69	5.80

Here,

I_0= Control I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS I_3= Irrigation at 20 and 35 DAS

I_4= Irrigation at20, 35 and 50 DAS

4.7.2 Effect of variety

Grain yield of rapeseed among the varieties was significantly different from one another (Table 7). The variety SAU Sarisha-1 produced seed yield of 1296 kg ha^{-1}, which was significantly highest than those of Kalyania (1278.0 kg ha^{-1}) and Improved Tori-7 (888.7 kg ha^{-1}). Again the yield of Kalyania differed significantly from that of Improved Tori-7. The result was in conformity with the findings of Islam *et al.* (1994) who indicated the yield variation due to varietal differences.

4.7.3 Interaction effect of irrigation and variety

Interaction effect of irrigation and variety exerted significant variation in respect of grain yield (Table 8). Among the interaction treatments I_4V_1 (three irrigation × SAU Sarisha-1) produced the highest seed yield (1827.0 kg ha^{-1}) which was 224% higher than the lowest yield (563.2 kg ha^{-1}) by I_0V_2 (no irrigation × Improved Tori-7). The lower yield of I_0V_2 compared to other studied varieties might be due to the limitation of varietal genetical makeup.

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

4.8.1 Effect of irrigation

Application of irrigation at different levels increased stover yield (ranged 1997.0-2208.0 kg ha^{-1}) over control. Significant variation was found in stover yield at different irrigation levels (Table 6). Three irrigations (at 20, 35 and at 50 DAS) produced the highest stover yield (2208.0 kg ha^{-1}) followed by 2 and 1 irrigations. It is interesting that irrigation applied treatment helped to produce tallest plant, more number of branches $plant^{-1}$ and number of siliquae $plant^{-1}$ which ultimately increased stover yield. The treatment no irrigation produced the lowest stover yield (1469.0 kg ha^{-1}). Patel *et al.* (1991), Sarker *et al.* (2000), and Sarker *et al.* (2001) reported similar views in respect of stover yield that irrigation increased stover yield .

4.8.2 Effect of variety

Stover yield for different varieties of rapeseed under study differed significantly from one another (Table 7). Kalyania produced the higher stover yield (2159.0 kg ha^{-1}) which was statistically at par with SAU Sarisha-1 (2156.0 kg ha^{-1}) and higher than Improved Tori-7 (1681.0 kg ha^{-1}). Kalyania and SAU Sarisha-1 out yielded (in respect of stover yield) 478 and 475 kg ha^{-1} over Improved Tori-7. The result was confirmatory with the findings of Chakraborty *et al.* (1991) and Saran and Giri (1987) that the dry matter production in crops was importantly determined by varietal characteristics.

Table 7 Effect of variety on yield and harvest index of rapeseed

Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
SAU Sarisha-1	1296.0	2156.0	3454.0	37.10
Improved Tori-7	888.7	1681.0	2570.0	34.37
Kalyania	1278.0	2159.0	3437.0	36.92
LSD (0.05)	49.18	161.10	4.39	1.568
CV(%)	5.70	10.78	7.69	5.80

4.8.3 Interaction effect of irrigation and variety

Interaction of irrigation and varietiy showed significant variation in producing stover yield (Table 8). The table showed that the interaction treatment I_4V_1 (three irrigation × SAU Sarisha-1) produced significantly highest stover yield (2911.0 kg ha^{-1}) where as the interaction treatment I_0V_2 (no irrigation × improved Tori-7) produced the lowest stover yield (1179.0 kg ha^{-1}). The result also showed that interactions of SAU Sarisha-1 and Kalyania with all irrigation level showed higher amount of stover yield than Tori-7.

4.9 Biological yield

4.9.1 Effect of irrigation level

Irrigation levels showed significant variation in biological yield (Table 6). The control treatment produced the lowest biological yield (2185.0 kg ha^{-1}). Three irrigations (at 20, 35 and at 50 DAS) showed the highest (3726.0 kg ha^{-1}) biological yield followed by two irrigations (at 20, and 35 DAS) 3561.0 kg ha^{-1}. Three and two irrigations produced 70.53 and 62.97% higher biological yield than control (no irrigation treatment).

4.9.2 Effect of variety

Like grain yield SAU Sarisha-1 produced the highest biological yield (3454.0 kg ha^{-1}) which was statistically similar with Kalyania (3437.0 kg ha^{-1}). Improved Tori-7 (2570.0 kg ha^{-1}) produced the lowest biological yield (Table 7). The difference between SAU Sarisha-1 and Improved Tori-7, and Kalyania and Improved Tori-7 were 884 and 867 kg ha^{-1}, respectively.

4.9.3 Interaction effect of irrigation and variety

Interaction effect of irrigation and variety influenced the biological yield significantly (Table 8). The treatment I_4V_1 (three irrigation × SAU Sarisha-1) produced the highest biological yield (4238.0 kg ha^{-1}) followed by I_3V_1 (two irrigation × SAU Sarisha-1) (3950.0 kg ha^{-1}) and I_4V_3 (three irrigation × Kalyania) (3927.0 kgha^{-1}). The lowest biomass was found from the treatment of I_0V_2 (1442.0 kg ha^{-1}).

Table 8 Interaction effect of irrigation and variety on yield and harvest index of rapeseed

Irrigation × Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
I_0V_1	746.1	1546.0	2292.0	32.70
I_0V_2	563.2	1179.0	1442.0	32.34
I_0V_3	838.0	1682.0	2520.0	33.35
I_1V_1	1086.0	2131.0	3217.0	33.81
I_1V_2	797.2	1664.0	2461.0	32.51
I_1V_3	1164.0	2195.0	3359.0	34.83
I_2V_1	1247.0	2344.0	3570.0	34.89
I_2V_2	899.6	1770.0	2669.0	33.87
I_2V_3	1308.0	2300.0	3610.0	36.32
I_3V_1	1573.0	2347.0	3950.0	40.92
I_3V_2	1068.0	1898.0	2966.0	36.10
I_3V_3	1469.0	2299.0	3768.0	39.01
I_4V_1	1827.0	2411.0	4238.0	43.16
I_4V_2	1115.0	1897.0	3012.0	37.05
I_4V_3	1609.0	2317.0	3927.0	41.11
LSD (0.05)	110.00	360.30	405.50	3.51
CV (%)	5.70	10.78	7.69	5.80

Here,

I_0= Control

I_1= Irrigation at 20 DAS

I_2= Irrigation at 35 DAS

I_3= Irrigation at 20 and 35 DAS

I_4= Irrigation at 20,35 and 50 DAS

V_1=.SAU Sarisha-1

V_2= Tori-7

V_3=. Kalyania

4.10 Harvest index

4.10.1 Effect of irrigation level

Irrigation level had significant effect on harvest index (Table 6). Among the five irrigation levels three irrigations (at 20, 35, and 50 DAS) gave the highest harvest index (40.44%) Which was statistically at par with two irrigations at 20 and 35 DAS (38.68%). The lowest value of harvest index (32.80%) was obtained from the treatment I_0 (control). The result corroborates with the findings of Sarker (1994) who observed irrigation application gave higher harvest index over control.

4.10.2 Effect of variety

SAU Sarisha-1 exhibited the highest value (37.10 %) of harvest index (37.10 %) and Improved Tori-7 showed the lowest value (34.37 %). SAU Sarisha-1 and Kalyania showed statistically similar values of harvest index.. The results in respect of harvest index was in agreement with the findings of Islam *et al.* (1999) who observed the harvest index varied markedly among varieties.

4.10.3 Interaction effect of irrigation and variety

Significant interaction effect between irrigation and variety was observed in respect of harvest index. Interaction of I_4V_1 (three irrigation × SAU Sarisha-1) produced the highest harvest index (43.16%) followed by I_4V_3 (three irrigation × Kalyania). The treatment I_0V_2 (no irrigation × Improved Tori-7) produced the lowest harvest index (32.34%).

Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the field of the Sher-e-Bangla Agricultural University farm, Dhaka to find out the effect of irrigation level and variety on growth, yield attributes and yield of rape seed. The results are summarized below.

Significant variation was found in plant height for irrigation levels. In respect of plant stature three irrigations gave the tallest plant. SAU Sarisha-1 produced the tallest plant and Improved Tori-7 gave the shortest plant among the varities. Maximum plant height was found from the interaction of three irrigation (at 20, 35 and 50 DAS) × SAU Sarisha -1.

Dry weight was greatly influenced by irrigation. The control (no irrigation) treatment produced the lowest dry weight plant^{-1} for all growth stages. Three irrigations produced the highest dry weight at 60 and 75 DAS. Among the varieties SAU Sarisha-1 produced the highest dry weight at 60 and 75DAS. The interaction of three irrigation with SAU Sarisha-1 showed the maximum dry weight and lowest dry weight was observed in the interaction of one irrigation with SAU Sarisha-1 at 15 DAS.

Three irrigations produced the highest number of branches plant^{-1} which was significantly superior to the control and one irrigation. Maximum number of branches plant^{-1} was observed in SAU Sarisha-1 and the lowest in Improved Tori-7. On the other hand interaction of three and two irrigations with SAU Sarisha-1 produced the highest and similar number of branches plant^{-1} (7.111) under the study.

Siliquae plant^{-1} was highest (124.1) with three irrigations (at 20, 35 and 50 DAS) and that of lowest with no irrigation. Kalyania produced the highest (94.96) and Improved Tori-7 produced the lowest (78.28) number of siliquae plant^{-1}. Three irrigation × SAU Sarisha-1 interaction produced the highest number of siliquae plant^{-1} (140.2) that followed by the interaction between three irrigations and Kalyania.

Number of seeds siliqua^{-1} was significantly affected by irrigation, variety and their interaction. Three irrigations produced the highest number of seeds siliqua^{-1} whereas control and one irrigation produced comparatively lower number of seeds siliqua^{-1}. SAU Sarisha-1 produced the highest number of seeds siliqua^{-1}. Treatment combination of three irrigations with SAU Sarisha-1 produced highest number of seeds siliqua^{-1}.

Thousand seed weight was higher with the increasing of irrigation. Three irrigation produced highest weight of seeds, whereas no irrigation produced the lowest seed weight. In case of variety, SAU Sarisha-1 produced the highest weight of 1000 seed and Improved Tori-7 produced the lowest. Interaction of three irrigations × SAU Sarisha-1 produced the highest weight of 1000 seeds.

Seed yield (kg ha^{-1}) varied significantly among the irrigation levels, varieties and their interactions. Three irrigation produced the highest seed yield whereas control treatment produced the lowest yield ha^{-1}. SAU Sarisha-1 produced the highest seed yield (1296.0 kg ha^{-1}) followed by Kalyania (1278.0 kg ha^{-1}) . Treatment combination of three irrigations with SAU Sarisha-1 produced the highest seed yield (1827.0 kg ha^{-1}) which was 224% higher than the lowest yield (563.2 kg ha^{-1}) produced by Improved Tori-7 with control.

Among the irrigation treatments, three irrigation produced the highest stover yield and the variety Kalyania produced the highest stover yield. Treatment combination of three irrigations with SAU Sarisha-1 produced the highest stover yield (2411.0 kg ha^{-1}).

Irrigation levels, varieties and their interaction showed significant variation in biological yield. The control treatment produced the lowest biological yield (2185. kg ha^{-1}) and three irrigations (at 20, 35and 50 DAS) produced the highest biological yield (3726.04 kg ha^{-1}). The interaction effect showed that three irrigation coupled with SAU Sarisha-1 produced the highest biological yield (4238.0kg ha^{-1}) and no irrigation x Improved Tori-7 showed the lowest (1442.0 kg ha^{-1}) biological yield.

Among the five irrigation levels, three irrigation gave the highest harvest index (40.44%) SAU Sarisha-1 produced the highest harvest index (37.10%). Interaction of three irrigations × SAU Sarisha-1 produced the highest harvest index (43.16%) .

From the present study, it may be concluded that irrigation levels influence the growth, yield and yield components of rape seed varieties. Among the irrigation levels, three irrigation (at 20, 35, and 50 DAS) followed by two irrigations (at 20 and 35 DAS) and among the varieties SAU Sarisha-1 and the interaction between three irrigation × SAU Sarisha-1 were found to be most promising.

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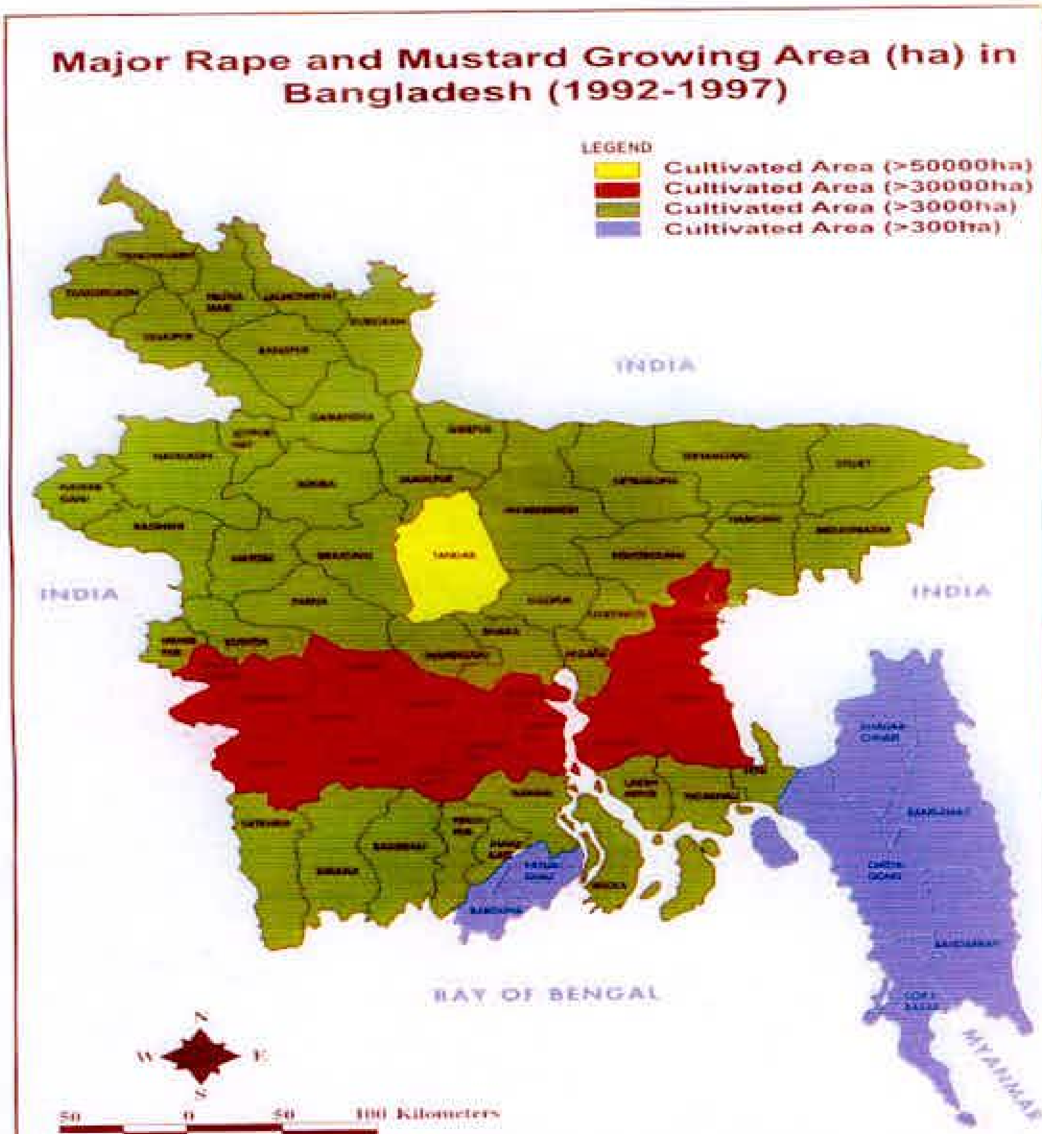
Appendices

APPENDICES

Appendix- I. 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 II. Monthly Temperature, Rainfall, and Relative humidity of the experiment site during the period from November 2006 to March 2007.

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sun shine (hr)
		Maximum	Minimum	Mean			
2006	November	29.7	20.1	24.9	65	5	178.72
	December	26.9	15.8	21.2	68	Nil	170.97
2007	January	24.6	12.5	18.55	66	Nil	175.40
	February	27.1	16.8	21.95	64	Nil	158.68
	March	31.5	19.6	25.55	47	160	255.01

Source: Bangladesh Metrological Department (climate division), Agargon, Dhaka-1207

Appendix- III: Physical and Chemical characteristics of initial soil (0-15 cm depth) before seed sowing

A. Physical composition of the soil

Soil separates	(%)	**Method employed**
Sand	36.90	Hydrometer method (Day, 1995)
Silt	26.40	-do-
Clay	36.66	-do-
Texture class	Silty clay loam	-do-

B. chemical composition of the soil

SI.	Soil characteristics	Analytical data	method employed
1	organic carbon (%)	0.82	Walkly and Black, 1947
2	Total N (kg/ha)	1790.00	Bremner&Mulvaney, 1995
3	Total S (ppm)	225.00	Bardsley and Lancster, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg /ha)	54.00	Bremner, 1965
6	Available P (kg/ha)	69.00	Olsen and Dean 1965
7	Exchangeable K (kg/ha)	89.50	pratt, 1965
8	Available S (ppm)	16.00	Hunter , 1984
9	Ph (1:2.5 soil to water)	5.55	Jeckson, 1958
10	CEC	11.23	Chapman, 1965

Source: Soil Research Development Institute(SRDI)

Appendix-IV. Means square values for plant height of rapeseed at different days after sowing (DAS).

Sources of variatin	Degrees of freedom	Means square				
		15 DAS	30DAS	45DAS	60DAS	75DAS
Replication	2	8.531	15.974	2.983	4.005	88.559
Irrigation	4	1.923	570.32	659.999	1004.38	541.862
Variety	2	93.344	1425.09	671.358	724.283	668.004
Irrigation x Variety	8	2.490	35.935	20.742	39.752	8.510
Error	28	0.736	17.890	4.995	2.564	28.971s

Appendix-V. Means square values for plant dry weight of rapeseed at different days after sowing (DAS).

Sources of variation	Degrees of freedom	Means square				
		15 DAS	30DAS	45DAS	60DAS	75DAS
Replication	2	0.000	0.002	0.493	1.720	0.812
Irrigation	4	0.001	0.018	22.748	51.178	28.595
Variety	2	0.009	0.298	13.884	19.133	42.560
Irrigation x Variety	8	0.000	0.026	0.489	0.889	1.808
Error	28	0.002	0.013	0.252	0.718	0.898

Appendix-VI. Means square values for yield attributes of rapeseed.

Sources of variation	Degree of freedom	Branches plant^{-1} (No.)	Siliquae plant^{-1} (No.)	Seeds siliquae^{-1} (No.)	1000 seed weight (g)
Replication	2	0.180	4.820	0.348	0.072
Irrigation	4	16.937	8274.816	19.430	0.942
Variety	2	8.158	1099.536	7.446	0.238
Irrigation x Variety	8	0.474	204.080	4.151	0.077
Error	28	0.164	18.824	2.616	0.037

Appendix-VII. Means square values for yield, harvest index of rapeseed.

Source of variation	Degrees of freedom	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index(%)
Replication	2	9070.123	12295.283	50359.171	1.839
Irrigation	4	877110.056	849043.635	3305138.726	97.261
Variety	2	793675.685	1132718.30	3829976.886	34.855
Irrigation x Variety	8	33805.128	9305.545	59721.121	5.308
Error	28	4322.326	46404.432	58780.526	4.394