GROWTH YIELD AND ECONOMICS OF BARI SARISHA 14 AS INFLUENCED BY DIFFERENT MANGEMENTS UNDER IRRIGATED AND NON IRRIGATED CONDITION

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JUNE, 2013

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REGISTRATION NO.: 06-01852

A Thesis
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

SEMESTER: JANUARY- JUNE, 2013

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH YIELD AND ECONOMICS OF BARI SARISHA 14 AS INFLUENCED BY DIFFERENT MANAGEMENTS UNDER IRRIGATED AND NON IRRIGATED CONDITION"** 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 bonafide research work carried out by **UMMA MALIHA MOMTAJ, Registration No. 06-01852**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

Dated: June, 2013
Dhaka, Bangladesh

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ACKNOWLEDGEMENT

All praises goes to Almighty Allah, the Supreme Ruler of the universe who enabled the author to complete the present piece of work.

The Author would like to express her heartiest gratitude, sincere appreciation and immense indebtedness to her supervisor **Professor Dr. Md. Jafar Ullah,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his scholastic guidance, careful planning, valuable suggestions, continuous encouragements and all kinds of support and help throughout the period of research work and preparation of the manuscript.

Heartiest gratitude is due to the respectable **Professor Dr. Md. Hazrat Ali,** Co-supervisor Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his valuable suggestions, kind co-operation and dynamic guidance throughout the study and research works.

The Author expresses her sincere respect to, **Professor Dr. A. K. M. Ruhul Amin,** Chairman**,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his valuable advice, encouragement, proper assistance and support during the period of research works.

The Author wishes to record deep appreciation to her other course teachers, Department of Agronomy for their co-operations and constant encouragement.

The Author also wishes to acknowledge her indebtedness to the Farm Division of SAU and other staff of the Department of Agronomy for their co-operation in the implementation of research works.

The Author is also thankful to **Md. Arif Hossain** for his constant encouragement.

At last but not the least, the Author feels indebtedness to her beloved parents whose sacrifice, inspiration, encouragement and continuous blessing, paved the way to her higher education. The Author is also grateful to her brothers and sisters and other members of the family for their forbearance, inspirations, sacrifices and blessings.

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2012 to February 2013 to evaluate growth yield and economics of BARI Sarisha 14 as influenced by different managements under irrigated and non irrigated condition. In this experiment, the treatment consisted of two irrigations viz. no irrigation and with irrigation; and seven different management practices viz. all management, all management without row, all management without mulching, all management without weeding, all management without fertilizer, all management without insecticide, all management without fungicide. The experiment was laid out in two factors split plot design with three replications. Results showed significant variations among the treatments in respect of majority of the observed parameters. The highest yield per hectare (0.86 tones) was obtained from irrigation with all management practices. The highest benefit cost ratio (BCR) (1.65) was obtained in the treatment combination of irrigation with all management along with without mulching and without weeding.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
Wt.	=	Weight
Lsd	=	Least Significant Difference
^{0}C	=	Degree Celsius
mm	=	Millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

CHAPTER 1

INTRODUCTION

Rapeseed (*Brassica rapa* var. sarson) belongs to Brassicaceae family, which also includes cabbage, broccoli, cauliflower etc. It is originated from Asia Minor, but now is cultivating as a main commercial oil crop in Canada, China, Australia, India including Bangladesh. It was reported that Rapeseed is a popular crop in crop rotation, which increases cropping intensity since it enhances yields of wheat and barley, and breaks disease cycles in cereal grains.

Rapeseed is the major oilseed crop in Bangladesh covering about 70 % of the total production. The area and production of rapeseed of our country was about 0.481 million hectares and 0.536 million tons, respectively with an average yield of 0.92 tha^{-1} during 2009-2010 (BBS, 2011). The present domestic edible oilseed production is 267 thousand tons, which meets only one third of national demand. Domestic production of edible oil almost entirely comes from rapeseed and rapeseed occupying only about 2% area of total cropped area in Bangladesh (BBS, 2002). The annual oil seed production of 0.41 million tons of which the share of rapeseed-rapeseed is 0.21 million tons, which comes about 52% of the total edible oil seed production. Rapeseed covers about 61.2% of the total acreage under oil seed and 52.6% of the total oil seed production in Bangladesh (BBS, 2005). The yield of this crop in Bangladesh is much lower compared to other countries.

Bangladesh is deficit in edible oil, which costs valuable foreign currency for importing seeds and oil. Annually country is producing about 2.80 lac m tons of edible oil as against the requirement of 9.80 lac m tons thus import oil is regular phenomenon of this country (BBS, 2010). Both the acreage and production of the crop have been decreasing since 1990 mainly due to ingression of cereal crops like-rice, maize, wheat etc. Delayed harvest of transplanted aman rice and wetness of soil are another reason which hinders rapeseed cultivation in rabi season (BARI, 2008).Chemical fertilizers have contributed significantly towards the pollution of water, air and soil. So the current trend is to explore the possibility of supplementing chemical fertilizers with organic ones which are ecofriendly and cost effective.

Although intensive use of inorganic fertilizers and pesticides has been an important tool in the drive for increased crop production. In fact more fertilizers consumption is a good indication of agricultural productivity but depletion of soil fertility is commonly observed in soils. Due to heavy use of chemical herbicides, pesticides and intensification of agricultural production during the past few decades has led to other harmful effects like nitrate in the ground water, contamination of fooding materials, eutrophication, stratospheric changes etc. High agricultural inputs are unlikely to be sustainable for very long unless the inputs are correctly judged in terms of both their quality and quantity. Organic Farming seems to be more appropriate as it considers the important aspects like sustainable natural resources and environment. It is a production system, which favors maximum use of organic materials like crop residues, FYM, compost, green manure, oil cakes, bio-fertilizers, bio-gas slurry etc. to improve soil health from the different experiment, microbial fertilizers like Rhizomic, Azotobacter, Blue green algae, Azolla etc. have increased the yield and also played important role for minimizing the harmful effect of pesticides and herbicides. Organic farming is a practical proposition for sustainable agriculture if adequate attention is paid to this issue. There is urgent need to involve more and more scientists to identify it.

Fertilizer is the depending source of nutrient that high yielding varieties of Rapeseed are very responsive to fertilizers especially nitrogen (Gupta *et al.*, 1972; Ali and Rahman, 1986; Sharawat *et al.*, 2002 and Patel *et al.*, 2004). Nitrogen (N) is the key element for proper growth and yield of plants. It supports the plant with rapid growth, increasing seed and fruit production and yield of rapeseed (Sinha *et al.*, 2003; Shukla *et al.*, 2002; Meena *et al.*, 2002; Zhao *et al.*, 1997 and Allen & Morgan, 2009). Previous reports showed that N has significant effect on plant height, branches plant^{-1}, siliquae plant^{-1} and other growth factors and yield of rapeseed (Allen and Morgan, 1972; Mondal and Gaffer, 1983). It was also reported that N significantly increased leaf area as well as rate of photosynthesis etc and the use of N either @250 $kgha^{-1}$or @180 kg ha^{-1} produced higher seed yield (Hossain & Gaffer 1997; Singh & Prasad 2003). The oil content of rapeseed seed significantly decreased with increasing levels of N up to 80 kg ha^{-1} whereas oil content increased with increasing levels of phosphorus. In addition, the deficiency of N causes stunted or slow growth, slender fibrous stems and the classic yellowing of the leaves which reduces the seed yield of crops including rapeseed (Ozer, 2003). Separately, excessive use of N increases the vegetative growth thus food production may be impaired and delayed maturity (Maini *et al.,* 1959; Singh *et al*., 1972).These results suggest that the optimum dose of N for Rapeseed plant growth, seed production and oil content of Rapeseed is needed to analyze.

The frequency of irrigation and the amount of water required depend on such factors as cultivar, soil type, season, amount of rainfall and diseases; therefore, it is difficult to give definite recommendation. Over irrigation, as well as under irrigation may lower yields. Efficient water management thus plays a vital role in Rapeseed production. This can be achieved by adopting improved irrigation practices. Although both timing and the amount of water applied affect irrigation efficiency, timing has greater effect on the yield and quality of a crop. Therefore, a judicious irrigation schedule is needed to avoid over or under irrigation and for profitable Rapeseed cultivation.

In view of the importance of this crop, attention has to be given to increase its production in order to meet the huge shortage of edible oil in the country. Very few research works have been conducted in our country regarding the growth yield and economics of BARI Sahrisha-14 as influenced by different management under irrigated and non irrigated condition.

Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

1. To find out the influence of different managements under irrigated and non-irrigated on the growth, development and yield attributes of rapeseed.
2. To assess the economic profitability as a consequence of adapting different management practices in growing rapeseed.

CHAPTER 2

REVIEW OF LITERATURE

Rapseed is an important oil crop in Bangladesh which can contribute to a large scale 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 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 greatly 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 carinala*, *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 mustard 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 mustard.

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 growth and siliquae development stage and it was the highest compared to one irrigation at growth 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 mustard was better than two irrigations (one at flowering and one at fruiting stage).

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

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 preflowering) 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 mustard 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 siliquae 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 mustard was not significantly increased 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 observed 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 per plant

Clarke and Simpson (1978) observed in an analysis of yield components of mustard from field trial that irrigation scarcely affected the number of branches per plant.

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 per plant.

Prasad and Eshanullah (1988) reported that the numbers of primary branches per plant of mustard were significantly increased with the increase of irrigation levels. They found the maximum number of primary branches per plant 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 per plant 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 per plant and found that one irrigation produced significantly higher number of branches per plant compared to unirrigated control.

Tomer *et al.* (1992) concluded that branches per plant of mustard were significantly increased with irrigation application and branches per plant were highest with two irrigations compared to one irrigation or without irrigation control. They also reported that branches per plant were highest when two irrigations were applied at pre-flowering and fruiting stages. When one irrigation was applied at pre-flowring stage, it produced lower branches per plant. 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 per plant increased with the increasing irrigation level in mustard plant. He also observed that when one irrigation was applied it produced more branches per plant compared to that of two irrigations. But the difference was not significant.

2.1.4 Number of siliquae per plant

Clarke and Simpson (1978) conducted two years field experiment with mustard in Canada at Saskatoon and reported that irrigation increased the number of siliquae per plant.

Sharma and Kumar (1989) found in an experiment with mustard that the number of siliquae per plant 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 per plant with one irrigation at flowering stage.

Tomer *et al.* (1992) conducted an experiment to observe the effect of irrigation treatments 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 was found when two irrigations were applied. One irrigation and without irrigation produced siliquae per plant.

Patel *et al*. (1991) reported that one irrigation produced higher siliquae per plant while it was produced per plant in without irrigation.

2.1.5 Number of seeds per siliquae

Clarke and Simpson (1978) found the increasing number of seeds per siliquae 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 per siliquae and therefore, increased yield per plant and yield per ha 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 siliquae^{-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 siliquae^{-1}.

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

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

Siag *et al.* (1993) found that two irrigations given either at branching and siliquae development or at branching and flowering stages of mustard showed a significant base in siliquae plant. The highest number of siliquae (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 mustard.

Saran and Giri (1988) concluded that one irrigation applied at 30 DAS on mustard occured 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 mustard 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 mustard.

Sharma and Kumar (1989) 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 (*Brassica campestris* var. Dichotorna) was curvili nearly 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 rapeseed (*Brassica juncea*) grown with a pre sowing irrigation in the Rajasthan 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 1W: CPE (Irrigation water depth: cumulative pan evaporation ratio) of 0.6 compared to irrigation at 1W: CPE ratio of 0.4. They found yield was positively associated with number of branches $plant^{-1}$ and siliquae $pant^{-1}$, number of seeds per siliquae and 1000 seed weight

Singh and Srivastava (1986) observed a significant increase of seed yield of rapeseed (*Brassica juncea*) with irrigation. 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 respectively compared with 330kg ha without irrigation.

Reddy and Sinha (1987) observed in an experiment with *Brassica juncea* in Rabi seasons of 1983-1985 that irrigation at 1W 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 mustard, 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 mustard 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 *Brassica 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 that at RARS Iswhurdi farm with five levels of irrigation.

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

Sharma and Kumar (1988) studied an irrigated rapeseed (*Brassica rapa* var. sarson) with 60 cm irrigation at irrigation water depth and cumulative pan evaporation ratio of 0 4 or 0 6 (one I 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 1St week of November and given 1-4 irrigation treatments (at pre flowering, flowering, early siliquae or late siliquae developmental stages). The result revealed that maximum yield was obtained with one irrigation at flowering, intermediate with 2 irrigations at that yield was obtained flowering and late siliquae stages and minimum with 3 irrigations applied at pre flowering, early and late siliquae stages.

Hasan *et al.* (1988) conducted a field experiment in 2 locations in Bangladesh, mustard was given no irrigation (I_o), I irrigation at 25 days after sowing (I_1), or I_1, together with later irrigation when 1W: 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 1 and 2 irrigations when 1W: CPE was 0.4. at 1 location, whereas at the other location the highest seed yield recorded from irrigation at 1 and 4 irrigations when 1 W:CPE was 1.0.

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 and 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 1 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 in mustard (*Brassica campestris* cv. Varuna) which was irrigated at vegetative, flowerig, siliquae 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 rapa* var. sarson 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, Rajasthan, 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 the *Brassica campestris* 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 stress were the seedling stage followed by the flowering stage decreased in seed yield varied from 22.13 to 36. 57% when irrigation was with held 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 pre-flowering and siliquae setting stages, pre-flowering+ 50% flowering+ siliquae-setting stages, pre-flowering+ 50% flowering +seed-filling stages, and pre-flowering+ 50% flowering+ siliquae-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 were positively correlated with higher seed yield of mustard and mustard but number of seed per siliquae was negatively correlated.

2.1.9. Harvest index

Srivastava *et al.* (1988) observed in an experiment with mustard (*Brassica juncea*) 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 mustard.

2.2 Effect of nitrogen (N) on mustard:

Nitrogen is an essential macronutrient. High yielding mutants / varieties of mustard are very responsive to nitrogen (Ali and Rahman, 1986 and Gupta *et al.,* 1985). Nitrogen is essentials for cell division and expansion, chloroplast development, chlorophyll concentration and enzyme activity (Gardner *et al*., 1985).

A field experiment was carried out by Mozaffari *et al.* (2012) at Qazvin-Iran during 2009-2010 to assess the effect of different levels of nitrogen (N0, N75, N150 and N225 kg ha^{-1}) and potassium (K0, K45, K90 and K135 kg ha^{-1}) on yield and some of the agronomical characteristics in Mustard (*Brassica juncea*). The results showed that increased amount of nitrogen and Potassium up to 225 kg N ha-1 and 135 kg K ha^{-1} respectively had a positive and significant ($p<0.01$) effect on thousand seed weight (TSW), seed yield (SY) and seed oil yield (SOY).

A field experiment was conducted by Gupta *et al.* (2011) during the rabi season of 2003-2004 and 2004-2005. They reported from their field experiment that higher dose of nitrogen 120 kg N/ha produced maximum oil yield.

A field experiment was conducted by Patel *et al.* (2004) during the rabi season of 1999-2000 in Gujarat, India to investigate the effects of irrigation schedule, spacing (30 and 40 cm) and N rates (50, 75 and 100 $kgha^{-1}$) on the growth, yield and quality of Indian mustard cv. GM-2. In combination treatments, 3 irrigation + N at 100 kg/ha + spacing of 45 cm resulted in a significant increase in yield. Growth, yield attributes and seed yield increased with increasing N levels, while oil content decreased with increasing rates. The highest benefit cost ratio was also obtained with N at 100 kg ha^{-1}.

A field experiment was conducted by Sinsinwar *et al.* (2004) during the 1999/2000 and 2000/01 rabi seasons in Bharatpur, Rajasthan, India to determine the best cropping sequence and N fertilizer application rate (0, 30, 60 and 90 kg ha^{-1}) of Indian mustard cv. RH-30 under brackish water situation. The cropping sequences comprised: pearl millet + black gram followed by Indian mustard : pearl millet + pigeon pea followed by Indian mustard; black gram followed by Indian mustard; cluster bean followed by Indian mustard; and fallow followed by Indian mustard. The cropping sequences did not affect the growth, yield and yield components (i.e. plant height, number of primary and secondary branches per plant, number of siliquae per plant), 1000-seed weight and seed yield in both years. The seed yield of Indian mustard significantly increased with each increment of N fertilizer up to 60 kg ha^{-1}, beyond which the increase was marginal. On an average, the increase in seed yield compared to the control was 33.3 and 83.8% with 30 and 60 kg Nha^{-1}, respectively. The Indian mustard seed equivalent yield was significantly highest in pearl millet + black gram followed by

Indian mustard (3190 kgha^{-1}) cropping sequence during 1999/2000. In 2000/01, the Indian mustard equivalent yield of pearl millet + black gram followed by Indian mustard was highest (2435 kgha^{-1}).

Singh *et al.* (2004) reported that nitrogen application did not affect the oil content in mustard but oil yield and chlorophyll content were increased up to 90 kg N ha^{-1} over the control. Nitrogen application increased the seed yield of mustard. Nitrogen and sulfur content both in seed and straw and total N and S uptake enhanced due to application of 90 kg N ha^{-1}over its preceding rates. The increased nitrogen and sulfur content enhanced the total uptake of nitrogen and sulfur.

Prasad *et al.* (2003) stated that N at 30 kgha^{-1} + P at 20 kgha^{-1} + Zn at 5 kgha^{-1}, and N at 60 kgha^{-1} + P at 30 kgha^{-1} + S at 20 kgha^{-1} produced the highest growth, yield and productivity and also good cost benefit ratio.

An experiment was conducted by Tripathi and Tripathi (2003) in Uttar Pradesh, India in 1994- 95 and 1995-96 to investigate the effects of N levels (80, 120, 160 and 200 kg ha^{-1}) on the growth, yield and quality of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and at 60 days after sowing. Results showed that all the yield characters except number of branches increased with increasing N levels up to 160 Kg Nha^{-1}. The number of branches per plant increased up to 200 Kg Nha^{-1}. Net returns were maximum (Rs. 19 901ha^{-1}) at 160 Kg N ha^{-1} because seed yield was also maximum at this N rate. The benefit: cost ratio increased up to 160 Kg Nha^{-1}, with a maximum of Rs. 209 earned per rupee investment.

Field experiments were conducted by Abdin *et al.* (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V1) and rape cv. Pusa Gold (V2). The treatments comprised: Ti (S0:N50 + 50); T2 (S40:N50 + 50 for V1 and S40:N50+25 + 25 for V2); and T3 (S20 + 20:N50 + 50 for V1 and S20 + 10 + 10:N50 + 25 + 25 for V2). Split application of S and N (T3) resulted in a significant increase the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 t $ha^{-1}$for V1 and 3.06 t ha^{-1} for V2 under T3. The average oil yield under T3 was 1.71 t ha^{-1} for V1 and 1.42 t ha^{-1} in V2. The oil and protein contents in the seeds of V1 and V2 also increased with the split application of S and N. It may be concluded from these results that the yield and quality of mustard can be optimized with the split application of 40 kg S/ha and 100 kg N/ha during the appropriate phenological stages of crop growth and development.

Khan *et al.* (2003) observed that cycocel at 400 ppm + 60 kg N ha^{-1} and ethrel at 200 ppm + 80 kg N ha^{-1} enhanced leaf photosynthetic rate, water use efficiency, leaf area and leaf dry mass 80 days after sowing. The highest stem, pod and plant dry mass were noted 120 days after sowing. At maturity, pod number and seed yield increased.

Singh and Prasad, (2003) stated that among the N rates, 120 $kgha^{-1}$gave the highest seed yield (20.24 $quintalha^{-1}$), straw yield (12.22 $quintalha^{-1}$), stick yield (43.52 $quintalha^{-1}$), and net profit (12 975 $rupeesha^{-1}$). The highest cost benefit ratio (0 85) was obtained with 180 kg N/ha. [1 quintal=100 kg].

Singh *et al.* (2003) stated that N at 120 kg/ha produced 4.51 higher number of branches, 48.03 higher siliquae number, 2.09 g siliquae weight, 2.05 g higher seed per plant and 2.55 q ha^{-1} higher seed yield compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the yield and yield attributes significantly. The basis of N application did not significantly affect the performance of the plants.

Singh (2002) found that application of N and P increased the length of siliquae, number of siliquae per plant, seeds per siliquae, seed yield and 1000-seed weight of mustard. However, the significant increase in yield and yield components was recorded in 60, 90 and 120 kg N ha^{-1} and 30, 45 and 60 kg Pha^{-1}treatments. The maximum seed yield was recorded from application of 45 kg P/ha (11.43 and 13.85 qha^{-1} in 1999 and 2000, respectively) and 120 kg N ha^{-1} (12.98 and 13.83 q ha^{-1} in 1999 and 2000, respectively). The oil content also increased with the application of N and P, but was not significant.

Kader *et al.*(2003) observed that the effects of row spacing (30, 45 or 60 cm) and N rate (60, 120 or 180 kg ha^{-1}) on the yield of Indian mustard cv. Basanti were studied. N was applied at sowing (50%) and after the initial irrigation (50%). They found among the N rates, 120 kg ha^{-1} gave the highest seed yield (20.24 quintal ha^{-1}), straw yield (12.22 quintal ha^{-1}), stick yield (43.52 quintal ha^{-1}), and net profit (12975 rupees ha^{-1}). The highest cost benefit ratio (0.85) was obtained with 180 kg N ha^{-1}. [1 quintal=100 kg].

Field experiments were conducted by Jamal *et al*, (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian mustard cv. Pusa Jai Kisan (V1) and rape cv. Pusa Gold (V2). The treatments comprised: Ti (S0:N50 + 50); T2 (S40:N50 + 50 for V1 and S40:N50+25 + 25 for V2); and T3 (S20 + 20:N50 + 50 for V1 and S20 + 10 + 10:N50 + 25 + 25 for V2). Split application of S and N (T3) resulted in a significant increase the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 tha^{-1} for V1 and 3.06 t/ha for V2 under T3. The average oil yield under T3 was 1.71 t ha^{-1} for V1 and 1.42 tha^{-1} in V2. The oil and protein contents in the seeds of V1 and V2 also increased with the split application of S and N. It may be concluded from these results that the yield and quality of mustard can be optimized with the split application of 40 kg S/ha and 100 kg Nha^{-1} during the appropriate phenological stages of crop growth and development.

Ozer (2003) studied two cultivars (Tower and Lirawell) of mustard with four levels of nitrogen (0, 80, 160 and 240 kg N/ha). He observed that adequate N fertilization is important in increasing siliquae number per plant and 1000-seed weight in summer oilseed rape. He suggested that the rate of 160 kg Nha^{-1} will be adequate for the crop to meet its N requirements.

Singh and Prasad (2003) reported that 120 kg N ha^{-1} gave the highest seed yield (20.24 q ha^{-1}). But the highest cost benefit ratio (0.85) was obtained with 180 kg N/ha.

Kumar and Singh (2003) conducted an experiment during rabi season with different levels of nitrogen for Indian Mustard (*Brassica juncea*). They reported that the maximum seed yield (24.51 q ha^{-1}) was observed with 150 kg N ha^{-1}.

Singh and Meena (2003) conducted a field experiment to determine the effect of N fertilizers (20, 40, 60, 80 and 100 kg N ha^{-1}) on the oil and protein yield of Indian mustard cv. Varuna. Results showed that 40 kg N ha^{-1} gave the highest oil content (39.61%).

Meena and Sumeriya (2003) canied out a study to evaluate the effect of nitrogen (0, 30, 60 and 90 kg/ha) on oil content of mustard (*Brassica juncea*). Application of 60 kg N/ha gave the maximum oil content (37.04%) compared to no nitrogen application.

Sharawat *et al.* (2002) observed that the yield and oil content generally increased with the increase in N and S rate. N at 120 kg ha^{-1} resulted in the highest number of siliquae per plant (397. 25), weight of siliquae per plant (33. 32 g), number of seeds per siliquae (14.80), seed yield per plant (368.75 g), 1000-grain weight (17.33 g), seed yield per ha (17.33 quintal) and oil content (38.39%).

Saikia *et al.* (2002) stated that dry matter and seed yield affected by different level of N.

Sharma and Jain, (2002) reported that the application of 80 kg N ha^{-1} resulted in the highest number of branches (24.4) and siliquae (260.9) per plant, number of seeds per siliqua (15.3), 1000-seed weight (5.85 g), and seed yields (1649, 2217, and 1261 kg ha^{-1}).

Shukla *et al.* (2002) conducted an experiment to observe the effect of nitrogen for Indian mustard (*Brassica juncea*). They found that maximum number of siliquae per plant, maximum siliquae length, maximum number of seeds per siliquae, maximum 1000-seed weight and maximum seed yield per hectare was obtained with the application of 120kg N ha^{-1}. Singh *et al.* (2002) also reported that growth characters and length of siliquae increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

Abadi *et al.* (2001) indicated that N had significant effect to increase the number siliquae per plant of mustard up to 120 kg Nha^{-1}.

BARI (1999) performed trial in two different regions of Bangladesh, at Joydebpur & Ishwardi to find out the effect of N on the yield of mustard. The experiment was conducted with 3 levels of nitrogen 0, 120, 160 kg ha^{-1} and plant height was found 87.78, 113.94, 106.46 cm, respectively at Joydebpur and 90.79, 118.46. 113.69 cm at Ishwardi. The highest plant height was found in both the location at 120 Kg N ha^{-1}.

BARI (1999) reported 22.7, 42.0, 45.6 and 48.0 siliquae per plant of mustard with o, 80, 120 and 140 N kg ha^{-1} respectively.

BARI (1999) reported yields of mustard 493.3, 833.3, 940.0 and 993.7 kg ha^{-1} showed with four levels of nitrogen (0, 80,120, kg ha^{-1}) respectively.

Singh *et al.* (1998) reported that seed and oil yields as well oil component values were increased with increasing nitrogen rates (0, 40, and 80 kg Nha^{-1}).

2.3 Effect of Boron (B) on Mustard:

Hossain *et al.* (2011) reported that the grain B concentration increased from 19.96 µg/g in B control to 45.99 µg/g and 51.29 µg/g due to application of 1 kg and 2 kg Bha^{-1}, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.

Hussain *et al.* (2008) reported from two years experiment that 1-1.5 kg boron ha^{-1} should be applied along with recommended fertilizers produced higher seed yield. BARI sarisha-11 and BARI sarisha-8 performed better and highly response to boron than BARI sarisha-9.

Mollah *et al.* (2005) conducted an experiment to find out the suitable doses of Boron for yield of mustard varieties. Three doses of boron fertilizer viz, 0.1.0 and 2.0 kg ha^{-1} were used on five varieties of mustard. He reported that application of 1.0 to 2.0 kg B ha^{-1} significantly influenced on the seed yield of mustard varieties under the test over control.

CHAPTER 3

MATERIALS AND METHODS

The experiment was undertaken during rabi season (November to February) of 2012-13 to growth, yield and economics of bari sahrisha-14 as influenced by different management under irrigated and non irrigated condition.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{0}22^{\prime}$ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28 (Appendix I).

3.2 Climatic condition

The experimental area under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, October-March and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season April-September. Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment were collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, presented in Appendix II.

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture having pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in Appendix III.

3.4 Materials

3.4.1 Seed

A newly developed, moderately salinity tolerant and high yielding variety of mustard, BARI Sarisha 14 developed by the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur was used in the experiment as a planting material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur. Before sowing germination test was done in the laboratory and percentage of germination was over 95%.

3.4.2 Fertilizers

The recommended doses of Urea, TSP, MP, Gypsum, $ZnSO_4$ and cowdung were added to the soil of experimental.

3.5 Methods

3.5.1 Treatments

Factor A: 2 Irriation (I)

I_0 = no irrigation

I_1= irriation

Factor B: 7 Managements

T_1 = all management

T_2= all management without row

T_3= all management with out mulching

T_4= all management without weeding

T_5= all management without fertilizer

T_6= all management without insecticide

T_7= all management without fungicide

3.5.2 Design and layout

The two factors experiment was laid out following split plot design with three replications. The total plot number was 14 × 3 = 42. The unit plot size was 3 m × 2.5 m = 7.5 m^2. The distance between block to block is 1 m and distance between plots to plot is 0.5 m and plant spacing is 30 cm × 5 cm.

3.5.3 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 16 November, 2012. According to the lay out of the experiment the entire experimental area was devided into blocks and subdivided into plot for the sowing of mustard seed. In addition, irrigation and drainage channels were prepared around the plot.

3.5.4 Fertilizer application

In this experiment fertilizers were used according to BARI and under as follows:

Fertilizers	**Rate of application per ha.**
Urea	300 kg
TSP	180 kg
MP	110 kg
Gypsum	180 kg
ZnSO4	5 kg
Boric Acid	10 kg
Cowdung	10 ton

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid required per plot were calculated. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days of sowing (DAS)

3.5.5 Sowing of seed

Sowing was done on 17 November, 2012 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg/ha. After sowing; the seeds were covered with the soil and slightly pressed by hand.

3.5.6 Thinning and weeding

The optimum plant population, 60 plants/ m^2 was maintained by thinning excess plant at 15 DAS. The plant to plant distance was maintained as 5 cm. One weeding with khurpi was given on 25 DAS.

3.5.7 Irrigation

Irrigations were given as per treatment.

3.5.8 Crop protection

A preventive measure were applied asper treatment

3.5.9 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

3.5.10 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyse the yield and yield contributing characters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. After collecting sample plants, harvesting was started on February 15 and completed on February 180, 2013. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.5.11 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into yield kg/ha.

3.6 Data collection

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. No. of leaves per plant
3. No. of branches per plant
4. No. of inflorescences
5. Total dry mater
6. No. of siliqua per plant
7. No. of seed per silliqua
8. Yield (t/ha)
9. Stover yield
10. Biological yield
11. Harvest index (%)

3.6.1 Plant height (cm)

Plant height was measured five times at 10 days interval such as 20, 30, 40, 50 and 60 DAS. The height of the plant was determined by measuring scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

3.6.2 Number of leaves per plant

Number of leaves per plant was counted five times at 10 days interval such as 20, 30, 40, 50 and 60 DAS of mustard plants. Mean value of data were calculated and recorded.

3.6.3 Number of branches per plant

The number of branches per plant was counted five times at 10 days interval such as 20, 30, 40, 50 and 60 DAS of mustard plants. Mean value of data were calculated and recorded.

3.6.4 Number of siliquae on the main inflorescence

The number of siliquae of main inflorescence from ten plants were counted and calculated as per plant basis.

3.6.5 Total dry matter (TDM)

The total dry matter was calculated from summation of leaves, stem, and inflorescen dry weight plant^{-1}.

3.6.6 Number of siliqua plant^{-1}

Number of siliqua was counted from randomly selected ten plants after harvest and averaged them to have number of siliqua plant^{-1}.

3.6.7 Number of seeds siliqua^{-1}

Total number of seed was counted from the selected 20 siliqua and averaged them to have number of seeds siliqua^{-1}.

3.6.8 Yield (t ha^{-1})

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

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

Straw obtained from each unit plot was sun-dried and weighed carefully. The dry weight of straw of central 3m^2 area was used to record the final straw yield plot^{-1} which was finally converted to kg ha^{-1}.

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

Grain and straw yields were altogether regarded as biological yield. The biological yield was calculated with the following formula-

Biological yield (kg ha^{-1}) = Seed yield + Stover yield.

3.6.11 Harvest index (%)

Harvest index is the ratio of economic yield to biological yield and was calculated with the following formula-

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

3.7 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of organic manure and plant spacing. All input cost included the cost for lease of land and interests of running capital in computing the cost of production. The interests were calculated @ 15.5 in simple rate. Analysis was done according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (TK)}}{\text{Total cost of production per hectare (TK)}}$$

3.8 Data analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values were separated using least significant difference (LSD) test at 5% level of significance. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

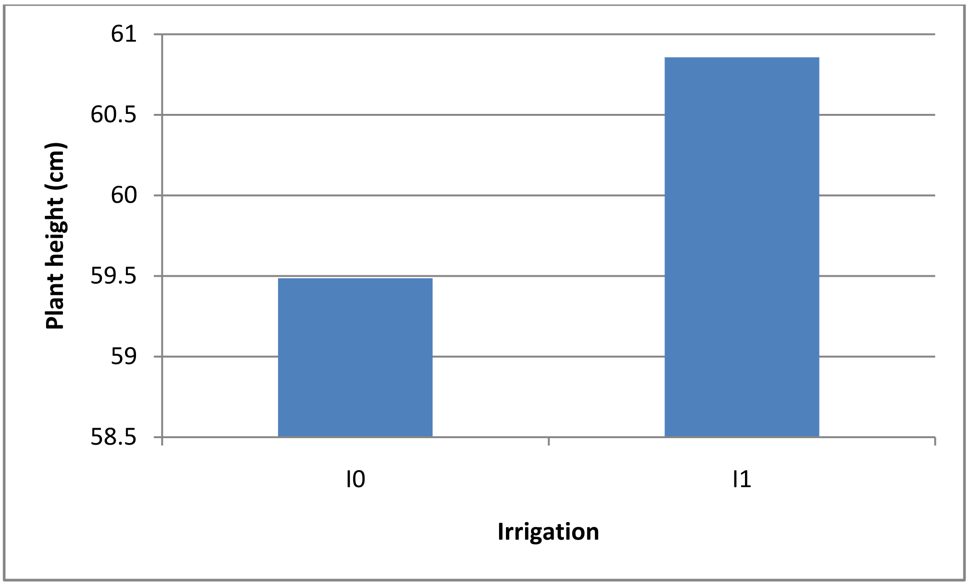
The results obtained with irrigation and different management practices and their combination are presented and discussed in this chapter. Data about growth, yield contributing characters of mustard have been presented in both Tables and Figures.

4.1 Plant height

Irrigation affected the height of mustard plant significantly (Fig. 1). The taller plant (60.85 cm) was recorded with I_1(irrigation). In contrast, the shorter plant (59.48 cm) was recorded from I_0 (no irrigation).The result corroborates with the findings of Siag *et al*. (1993) who observed maximum plant height in the irrigation application treatment during branching and siliquae development stages.

There were significant differences among the different management practices in respect of plant height (Fig. 2). The tallest plant (63.27 cm) was produced with T_1 (all management practices) and the shortest plant (56.80 cm) was obtained in T_2 (all management without row). These findings are in agreement with those of Singh *et al*. (2003). Similar findings were reported by FAO (1999), Ali and Ullah (1995), Shamsuddin *et al.* (1987), Ali and Rahman (1986) and Hassan and Rahman (1987). All together, these results suggest that higher doses of N increase mustard plant height.

The combined use of irrigation and management practices had significant effect on plant height (Table 1). The tallest plant (65.40 cm) was obtained in I_1T_1 (Irrigation with all management practices) treatment combination, whereas the shortest plant (54.00 cm) was observed in I_0T_2 (irrigation with all management without row) treatment combination.



I_0 = no irrigationI_1= irrigation

Fig. 1 Effect of irrigation on plant height of rapeseed

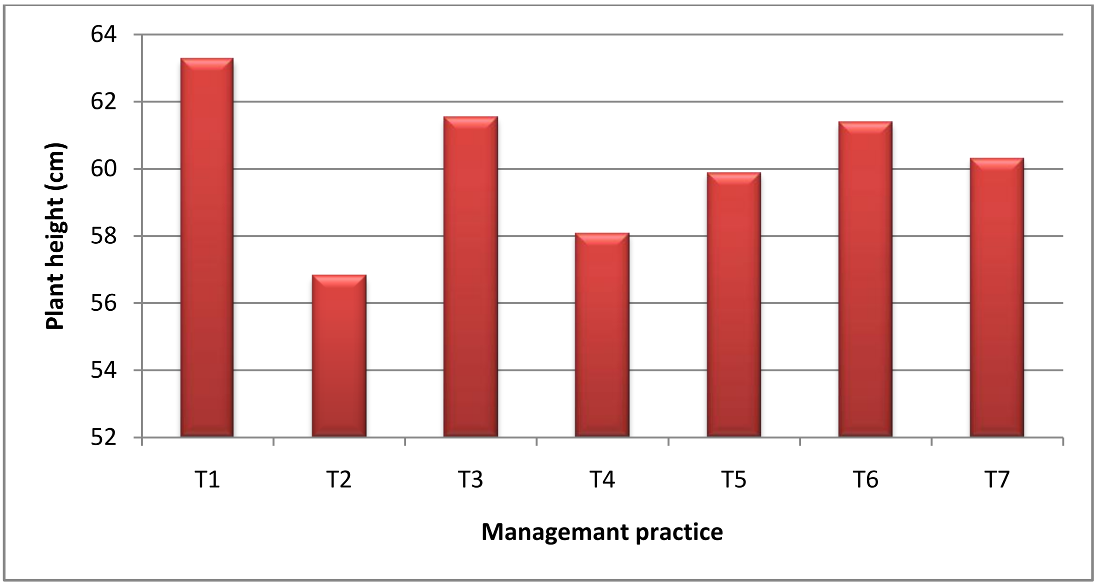


Fig. 2 Effect of management practices on plant height of rapeseed

T_1 = all management,T_2= all management without row, T_3 = all management without mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

Table 1. Combined effect of irrigation and management practices on plant height of rapeseed

Treatment	Plant height (cm)
I_0T_1	60.20 abc
I_0T_2	54.00 c
I_0T_3	64.13 ab
I_0T_4	59.73 abc
I_0T_5	59.93 abc
I_0T_6	57.33 abc
I_0T_7	61.07 abc
I_1T_1	65.40 a
I_1T_2	59.60 abc
I_1T_3	62.40 abc
I_1T_4	56.40 bc
I_1T_5	59.80 abc
I_1T_6	62.87 ab
I_1T_7	59.53 abc
SE	2.48
CV (%)	7.15

I_0 = no irrigation I_1= irrigation

T_1 = all management,T_2= all management without row, T_3 = all management withouts mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

4.2 Number of leaves plant^{-1}

A good number of leaves indicate better growth and development of crop. It is also possibly related to the yield of mustard (Table 2). Greater the number of leaf, greater the photosynthetic area which may result in higher seed yield. The maximum number of leaves plant^{-1} (14.68) was produced by I_1 and without I_0 treatment produced the lower number of leaves plant^{-1} (12.86).

Number of leaves plant^{-1} was significantly influenced by management practices (Table 2). The all management practices (T_1) had the highest number of leaves plant^{-1}(15.00). The lowest number of leaves plant^{-1}(11.40) was obtained from the all management without fertilizer (T_5). So, fertilizer has important role on increasing number of mustard leaves. These indicated that number of leaves plant^{-1} increased with N and those were in consistent with Patil *et al*., (1997).

A significant variation in the number of leaves plant^{-1} was found between the irrigation and management practices (Table 2). The highest number of leaves plant^{-1} (17.87) was found in combined use of no irrigation and all management practices treatment, whereas the lowest number of leaves plant^{-1} (9.87) was found in irrigation and all management without fertilizer treatment.

4.3 Number of branches plant^{-1}

The irrigation showed variation in the number of branches plant^{-1} (Table 2). The maximum number of branches plant^{-1} (3.77) was produced by I_1 treatment. No irrigation (I_0) produced the minimum number of branches plant^{-1}(3.49). Similar finding was reported by Joarder *et al.* (1979) that irrigation increased primary and secondary branches plant^{-1}.

Table 2. Number of leaves plant^{-1}, number of branches plant^{-1} and total dry matter weight of mustard plant as influenced by irrigation and management practices and their interactions

Treatment	Number of leaves plant^{-1}	Number of branch plant^{-1}	Total dry matter weight (g)
Irrigation			
I_0	12.86	3.49	6.09
I_1	14.68	3.77	6.48
SE	1.33	0.43	0.24
Management practices			
T_1	15.00 A	4.37 a	6.74 A
T_2	13.23 ab	4.17 a	5.79 A
T_3	14.90 A	3.83 ab	6.43 A
T_4	13.83 ab	3.83 ab	6.46 A
T_5	11.4 B	2.47 b	6.25 A
T_6	14.67 A	3.63 ab	5.79 A
T_7	13.33 ab	3.1 ab	6.53 a
SE	0.88	0.46	0.52
Interaction effect of irrigation and management practices			
I_0T_1	15.27 abc	4.87 ab	5.23 bc
I_0T_2	12.20 cde	3.00 bcd	5.17 c
I_0T_3	12.13 cde	3.07 bcd	6.96 a
I_0T_4	14.33 ad	2.27 d	6.97 a
I_0T_5	9.87 E	2.67 d	5.57 abc
I_0T_6	14.53 ad	3.47 bcd	7.21 a
I_0T_7	11.67 cde	2.73 cd	6.19 abc
I_1T_1	17.87 A	5.73 a	7.27 a
I_1T_2	16.60 ab	4.60 abc	6.40 abc
I_1T_3	14.53 ad	4.60 abc	5.89 abc
I_1T_4	13.33 be	3.07 bcd	5.96 abc
I_1T_5	10.60 de	3.47 bcd	6.01 abc
I_1T_6	14.80 abc	3.80 bcd	6.27 abc
I_1T_7	15.00 abc	3.47 bcd	6.86 ab
SE	1.24	0.56	0.49
CV (%)	15.62	26.56	26.36

T_1 = all management,T_2= all management without row, T_3 = all management withouts mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

The effect of management practices was significantly influenced on number of branches plant^{-1} (Table 2). The highest number of branches plant^{-1}(4.37) was obtained from T_1 (management practices) and the lowest number of branches plant^{-1}(2.47) was obtained from T_5 (all management without fertilizer).

The interaction between irrigation and management practices was found significant on the number of branches plant^{-1}(Table 2). The maximum number of branches plant^{-1}(5.73) was obtained in I_1T_1 treatment combination, whereas the lowest number of branches plant^{-1}(2.27) was obtained in I_0T_4.

4.4 Total dry mater

Total dry matter is the material which was dried to a constant weight. Total dry matter (TDM) production indicates the production potential of a crop. A high TDM production is the first prerequisite for high yield. TDM of leaves, stem and inflorescences of plants data were measured. It was evident from Table 2 that variation was found in the total dry matter. The higher total dry matter (6.48 g) was found with I_1treatment and lower (6.09) with I_0treatment. The total dry matter production was increased with increased of irrigation. Wrighter *et al.* (1998) expressed the similar observation in respect of dry matter.

TDM was not significantly affected by different management practices (Table 2). The minimum TDM was observed in T_2 treatment. Among all the management treatments, all management (T_1) achieved the maximum TDM.

The interaction of irrigation and management practices had significant effect on TDM production (Table 2). The treatment combination of I_1T_1 recorded the highest TDM (7.27 g). The lowest TDM (5.17) was found in I_0T_2 combination.

4.5 Number of siliquae on the main inflorescence plant^{-1}

The irrigation showed variation in the number of inflorescencesplant^{-1} (Table 3). The maximum number of inflorescences (4.60) was produced by I_1 treatment whereas I_0 treatment produced the minimum number of inflorescences (4.19).

There was significant difference among the management practice treatments in the number of inflorescences (Table 3). As evident from Table 3, the maximum number of inflorescences (5.20) was produced from T_1. The minimum number of inflorescences (3.33) was produced in T_5 treatment.

A significant variation was observed among the treatment combinations in number of inflorescences. The maximum number of inflorescences (6.47) was found in I_1T_1 treatment combination, whereas the minimum number of inflorescences (3.13) was found in I_0T_5 (Table 3).

Table 3. Number of inflorescences, number of siliquae, number of effective siliquae plant^{-1} and number of seeds siliquae^{-1} of mustard as influenced by irrigation and management practices and their interactions

Treatment	Number of inflorescences plant^{-1}	Number of siliquae plant^{-1}	Number of effective siliquae plant^{-1}	Number of seeds siliquae^{-1}
Irrigation				
I_0	4.19	14.18	7.28	26.05
I_1	4.60	15.49	7.69	27.19
SE	0.54	1.97	0.56	0.67
Management practices				
T_1	5.20 A	17.27 a	9.00 a	27.98 a
T_2	4.17 Ab	11.73 c	5.96 c	26.80 ab
T_3	4.70 Ab	16.00 ab	8.35 ab	25.42 b
T_4	4.63 Ab	13.93 abc	6.43 bc	25.64 ab
T_5	3.33 B	16.60 a	6.78 bc	26.31 ab
T_6	4.63 Ab	15.33 ab	7.82 abc	26.73 ab
T_7	4.10 Ab	12.98 bc	8.05 abc	27.34 ab
SE	0.29	1.44	0.68	1.28
Interaction effect of irrigation and management practices				
I_0T_1	4.80 Bcd	15.60 bc	6.83 abc	28.05 a
I_0T_2	3.93 Cde	11.40 f	5.27 c	25.32 c
I_0T_3	3.87 Cde	17.73 ab	7.41 abc	23.28 d
I_0T_4	5.00 Bc	14.87 bcde	7.12 abc	25.62 bc
I_0T_5	3.13 E	17.60 ab	6.57 abc	26.10 abc
I_0T_6	4.47 be	15.27 bcd	9.23 a	26.12 abc
I_0T_7	3.73 Cde	14.27 cdef	8.53 abc	27.85 a
I_1T_1	6.47 A	19.33 a	9.29 a	28.28 a
I_1T_2	3.53 De	12.07 def	6.65 abc	27.92 a
I_1T_3	5.53 ab	14.27 c-f	8.81 ab	27.55 ab
I_1T_4	4.27 be	13.00 c-f	5.73 bc	25.67 bc
I_1T_5	3.53 de	15.20 bcd	6.99 abc	26.52 abc
I_1T_6	4.80 bcd	15.40 bc	8.77 ab	27.33 abc
I_1T_7	4.47 be	11.70 ef	7.57 abc	26.83 abc
SE	0.42	2.04	0.96	1.81
CV (%)	16.37	7.37	12.23	11.81

T_1 = all management,T_2= all management without row, T_3 = all management withouts mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

4.6 Number of siliquae plant^{-1}

Number of siliquae plant^{-1} is one of the most important yield contributing characters of mustard. The irrigation showed variation in the number of siliquae plant^{-1}(Table 3). The maximum number of siliquae plant^{-1}(15.50) was produced by I_1 and I_0 produced the minimum number of siliquae plant^{-1}(14.18). The results were partially supported by Clarke and Simpson (1978) and fully supported by Sharma and Kumar (1989) who stated that irrigation increased siliquae plant^{-1}.

There was a significant difference among the management practices in the number of siliquae plant^{-1}(Table 3). The maximum number of siliquaeplant^{-1}(17.27) was produced in T_1 treatment and the minimum number of siliquae plant^{-1}(11.73) was produced in T_2 treatment.

A significant variation was found in the treatment combinations of irrigation and management practices on number of siliquae plant^{-1}(Table 3). The maximum number of effective siliquae plant^{-1}was found in I_1T_1, whereas the minimum number of effective siliquae plant^{-1}was found in I_0T_2 treatment combination.

4.7 Number of effective siliquae plant^{-1}

Number of effective siliquae plant^{-1} is one of the most important yield contributing characters in mustard. The irrigation showed variation in the number of effective siliquae plant^{-1}(Table 3). The maximum number of effective siliquae plant^{-1} (7.69) was produced by I_1 and I_0 produced the minimum number of effective siliquae plant^{-1} (7.28).

There was a significant difference among the management practices in the number of effective siliquae plant^{-1} (Table 3). The maximum number of effective siliquae plant^{-1} (9.00) was produced in T_1 treatment and the minimum number of effective siliquae plant^{-1} (5.96) was produced in T_2 treatment.

A significant variation was found in the treatment combinations of irrigation and management practices on number of effective siliquae plant^{-1}. The maximum number of effective siliquae plant^{-1} (9.29) was found in I_1T_1, whereas the minimum number of effective siliquae plant^{-1} (5.27) was found in I_0T_2 treatment combination.

4.8 Number of seeds siliquae^{-1}

The irrigation showed variation in the number of seeds siliquae^{-1} (Table 3). The maximum number of seed siliquae^{-1} (27.16) was produced by I_1, whereas I_0 produced the minimum number of seeds siliquae^{-1} (26.05). Seeds siliquae^{-1} was increased with the irrigation due to the supply of adequate soil moisture which helped to produce the more siliquae having more number of seeds. This phenomena is reported by Prasad and Eshanullah (1988), Sarker and Hassan (1988) and Sharma and Kumar (1989).

There was a significant difference among the management practices in the number of seeds siliquae^{-1}(Table 3). The maximum number of seeds siliquae^{-1} (27.98) was produced in T_1 treatment. The minimum number of seeds siliquae^{-1} (25.42) was produced in T_2.

Number of seeds siliquae^{-1} indicates a significant variation among the treatment combinations of irrigation and management practices (Table 3). The maximum number of seeds siliquae^{-1} (28.28) was obtained in I_1T_1 treatment combination, whereas the minimum number of seeds siliquae^{-1} (23.28) was found in I_1T_3 treatment.

Table 4. Seed yield, stover yield, biological yield and harvest index of rapeseed as influenced by irrigation and management practices and their interaction

Treatment	Seed yield (tha^{-1})	Stover yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
Irrigation				
I_0	0.45	1.33	1.78	24.97
I_1	0.73	1.74	2.47	29.59
SE	0.03	0.11	0.14	0.53
Management practices				
T_1	0.66 A	1.66 ab	2.31 A	27.19 b
T_2	0.62 ab	1.53 c	2.15 A	27.82 b
T_3	0.66 A	1.73 a	2.39 A	26.23 bc
T_4	0.64 A	1.58 bc	2.22 A	27.90 b
T_5	0.46 B	0.90 d	1.37 b	35.25 a
T_6	0.52 ab	1.68 ab	2.20 A	22.37 d
T_7	0.56 ab	1.67 ab	2.23 A	24.17 cd
SE	0.08	0.12	0.17	2.8
CV (%)	11.92	10.20	11.44	9.17
Interaction effect of irrigation and management practices				
I_0T_1	0.49 de	1.47 fg	1.96 bcd	24.79 c
I_0T_2	0.49 de	1.29 h	1.78 cd	25.68 bc
I_0T_3	0.48 de	1.39 fgh	1.87 bcd	24.65 c
I_0T_4	0.42 E	1.49 f	1.92 bcd	21.71 c
I_0T_5	0.35 E	0.84 j	1.19 d	33.85 ab
I_0T_6	0.48 de	1.47 fg	1.95 bcd	21.98 c
I_0T_7	0.42 E	1.37 gh	1.79 cd	22.08 c
I_1T_1	0.81 ab	1.85 cd	2.66 ab	29.59 abc
I_1T_2	0.75 abc	1.77 d	2.52 abc	29.97 abc
I_1T_3	0.83 A	2.08 a	2.91 A	27.81 bc
I_1T_4	0.86 A	1.66 e	2.52 abc	34.09 ab
I_1T_5	0.57 cde	0.97 i	1.54 d	36.65 a
I_1T_6	0.57 bcde	1.88 bc	2.45 abc	22.76 c
I_1T_7	0.71 abcd	1.96 b	2.67 ab	26.25 bc
SE	0.075	0.03	0.24	4.09
CV (%)	11.92	10.20	11.44	9.17

T_1 = all management, T_2= all management without row, T_3 = all management withouts mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

4.9 Seed yield (t ha^{-1})

The different dose of irrigation had effect on the yield of seed per hectare (Table 4). The maximum yield of seed per hectare (0.73 t) was obtained from I_1 treatment, whereas the minimum yield of seed hectare^{-1} (0.45 t) was obtained from I_0. In control condition, high mortality of seedlings resulting from shortage of soil moisture might have drastically reduced the 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 adversely affected yield components and thus yield was reduced. The present result was in agreement with those obtained by Sharma and Kumar (1989) and Joarder *et al*. (1979) who reported that irrigation increased seed yield of mustard.

The total yield of mustard varied significantly due to the application of different management practices (Table 4). The highest yield of seed (0.66 t ha^{-1}) was obtained from T_1 while T_5 gave the lowest (0.46 t ha^{-1}) yield.

The combined effect of irrigation and management practices was significant on yield of seed hectare^{-1} (Table 4). The highest yield of seed hectare^{-1} (0.86 tones) was obtained from I_1T_1 treatment combination. The lowest yield of seed hectare^{-1} (0.35 tones) was obtained from I_0T_5 treatment.

4.10 Stover yield (t ha^{-1})

The different dose of irrigation had the effect on the stover yield per hectare (Table 4). The maximum yield of stover hectare^{-1} (1.74 t) was obtained from I_1 treatment, whereas the minimum yield of stover per hectare (1.33 t) was obtained from I_0.It is interesting that irrigation helped to produce tallest plant, more number of branches plant^{-1} and number of siliquae plant^{-1} which ultimately increased stover yield. Patel *et al.* (1991), Sarkar *et al.* (2000), and Sarker *et al*. (2001) reported similar views in respect of stover yield that irrigation increased stover yield.

The total stover yield of mustard varied significantly due to the application of different management practices (Table 4). The highest yield of stover (1.73 t) was obtained from T_3 while T_5 gave the lowest (0.90 tha^{-1}) yield.

The combined effect of irrigation and management practices was significant on yield of seed $hectare^{-1}$ (Table 4). The highest yield of stover $hectare^{-1}$ (2.08 tones) was obtained from I_1T_3treatment combination. The lowest yield of seed $hectare^{-1}$ (0.84 tones) was obtained from I_0T_5 treatment.

4.11 Biological yield (t ha^{-1})

Irrigation had effect on the biological yield $hectare^{-1}$. The maximum biological yield $hectare^{-1}$ (2.47 t) was obtained from I_1 treatment, whereas the minimum biological yield hectare (1.78 t) was obtained from I_0 (Table 4).

The biological yield of mustard varied significantly due to the application of different management practices (Table 4). The highest biological yield (02.38 t ha^{-1}) was obtained from T_3 while T_5 gave the lowest (1.37 tha^{-1}) yield.

The combined effect of irrigation and management practices was significant on biological yield $hectare^{-1}$ (Table 4). The highest biological yield per hectare (2.91 tones) was obtained from I_1T_3treatment combination. The lowest biological yield per hectare (1.19 tones) was obtained from I_0T_5 treatment.

4.12 Harvest index (%)

The irrigation had significant effect on the harvest index of mustard. The maximum harvest index (29.59 %) was obtained with $I_{1,}$ and the minimum harvest index (24.96 %) was obtained from I_0 treatment (Table 4).

The harvest index varied significantly due to the application of different management practices (Table 4). The highest harvest index (35.25 %) was obtained from T_5 while T_6 gave the lowest (22.37 %) harvest index.

The combined effect of irrigation and management practices was significant on harvest index (Table 4). The highest harvest index (36.65 %) was obtained from I_1T_5 treatment combination. The lowest harvest index (21.71 %) was obtained from I_0T_4treatment.

4.13 Cost and return analysis

The cost and return analyses were done and have been presented in table 5. Materials, non materials and overhead costs were recorded for all the treatments of unit plot and calculated on hectare^{-1} basis (yield), the price of mustard at the local market rate was considered.

The total cost of production ranges between Tk. 34580.00 and 24440.00 hectare^{-1} among the different treatment combinations. The variation was due to different cost of different types of management practices. The highest cost of production of Tk. 34580.00ha^{-1} was involved in the treatment combinations of irrigation and all management practices (I_1T_1), while the lowest cost of production tk 24440.00 ha^{-1} was involved in the combination of no irrigation and all management without fertilizer (I_0T_5) (Table 5). Gross return was obatined from the different treatment combinations range between Tk 56157.50 and Tk. 23082.00 ha^{-1}.

Among the different treatment combinations irrigation with all management practices (I_1T_1) gave the highest return Tk. 56157.50 ha^{-1} while the lowest net return Tk. 23082.00 was obtained from the treatment combination of no irrigaton with all management without fertilizer(I_0T_5).

The benefit cost ratio (BCR) was found to be the highest (1.65) in the treatment combination of irrigation with all management without mulching(I_1T_3). The lowest BCR (0.90) was recorded from the combination of no irrigation with all management without fungicide (I_0T_7). Thus it was apparent that irrigation with all management practices (I_1T_1) treatment gave the highest yield (0.86 t/ha) and the highest return (Tk. 56157.50).

Table 5. Cost, benefit and benefit cost ratio of rapeseed as influenced by different managements.

Treatments	Cost Tk ha^{-1}	Benefit TK ha^{-1}	Benefit cost ratio
I_0T_1	32580.00	33220.50	1.02
I_0T_2	31660.00	32695.50	1.03
I_0T_3	31160.00	32489.50	1.04
I_0T_4	30280.00	29112.50	0.96
I_0T_5	24440.00	23082.00	0.94
I_0T_6	31620.00	32362.50	1.02
I_0T_7	31620.00	28374.50	0.90
I_1T_1	34580.00	56157.50	1.62
I_1T_2	33660.00	49537.50	1.47
I_1T_3	33160.00	54760.00	1.65
I_1T_4	32280.00	52930.00	1.64
I_1T_5	26440.00	36754.75	1.39
I_1T_6	33620.00	38960.00	1.16
I_1T_7	33620.00	42702.00	1.27

I_0 = no irrigation I_1= irrigation

T_1 = all management,T_2= all management without row, T_3 = all management without mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide

CHAPTER5

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season during November 2012 to February 2013 to find out the growth yield and economics of BARI Sarisha14 as influenced by different managements under irrigated and non irrigated condition. In this experiment, the treatment consisted of two irrigation levels viz. I_0 = no irrigation, I_1= irrigation, and seven different management practices viz. T_1 = all management, T_2= all management without row,T_3 = all management without mulching, T_4= all management without weeding, T_5= all management without fertilizer, T_6= all management without insecticide, T_7= all management without fungicide. The experiment was laid out in two factors split plot design with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect of majority of the observed parameters.

There is difference between irrigation and non irrigation in respect of almost all parameters. The taller plant (60.85 cm) was recorded with I_1 (irrigation). The maximum number of leaves plant^{-1} (14.68), number of branches plant^{-1}(3.77), total dry matter (6.47 g), number of inflorescence (4.60) were produced withI_1 (irrigation). The maximum number of siliquae plant^{-1}(15.50), number of effective siliquae plant^{-1} (7.69), number of seed siliqua^{-1}(27.16were produced by I_1 (irrigation). The different dose of irrigation had effect on the yield of seed hectare^{-1}. The maximum yield of seed per hectare (0.73 t) was obtained from I_1 (irrigation), treatment, whereas the minimum yield of seed per hectare (0.45 t) was obtained from I_0. The maximum biological yield per hectare (2.47 t) was obtained from I_1 (irrigation) treatment. The maximum harvest index (29.59 %) was obtained with $I_{1.}$

Plant height, number of leaves, branches plant^{-1}and number of inflorescences plant^{-1}showed statistical difference in response of application of management practices. However, the tallest plant of rapeseed (63.27 cm) was produced with T_1 (all management practice). The maximum number of leaves plant^{-1}(15.00), number of branchesplant^{-1}(4.37), total dry matter, number of inflorescences (5.2) was produced from T_1 (all management). Statistically the maximum number of siliquae plant^{-1}, number of effective siliquae plant^{-1} (9.00), and number of seeds siliquae^{-1} (27.98was obtained from T_1 treatment. The highest yield of seed (0.66 t ha^{-1}) was obtained from T_1 while T_3 gave the lowest (0.46 t ha^{-1}) yield. The highest yield of stover (1.73 t ha^{-1}) was obtained from $T_{3.}$ The highest harvest index (35.25%) was obtained from T_5.

The combinations of irrigation and management practices had significant effect on almost all parameter. The tallest plant (65.40 cm) was found in I_1T_1 (irrigation with all management practice) treatment combination. The maximum number of leaves plant^{-1}(17.87), number of branches plant^{-1} (5.73) and number of inflorescences (6.47) were found in I_1T_1 (irrigation with all management practices) treatment combination. The maximum number of siliquae plant^{-1}, number of effective siliquae plant^{-1} (7.69), number of seeds silliquae^{-1} (28.28) was found in I_0T_1. The highest yield of seed hectare^{-1} (0.86 tones) was obtained from I_1T_1 (irrigation with all management practices) treatment combination. The lowest yield of seed hectare^{-1} (0.35 tones) was obtained from I_0T_5 treatment. The highest biological yield hectare^{-1} (2.91 tones) was obtained from I_1T_7 treatment combination. The highest harvest index (36.65 %) was obtained from I_1T_5 treatment combination.

The benefit cost ratio (BCR) was found to be the highest (1.65) in the treatment combination of irrigation with all management without mulching (I_1T_3). The lowest BCR (0.90) was recorded from the combination of no irrigation with all management without fungicide (I_0T_7). Thus it was apparent that irrigation with all management practice (I_1T_1) treatment gave the highest yield (0.86 t ha^{-1}) and the highest return (Tk. 56157.50).

Considering the above results, it may be summarized that growth, seed yield contributing parameters of rapeseed are positively correlated with irrigation and management practices. Therefore, the present experimental results suggested that the combined use of irrigation with all management practices would be beneficial to increase the seed yield of mustard variety BARI Sarisha14 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required further to substantiate with different varieties of rapeseed and mustard.
3. It needs to conduct more experiments with irrigation and management practices whether can regulate the growth, yield and seed quality of rapeseed BARI Sarisha14.

REFERENCES

Abadi, G. R. N.; Khodabandeh, N.; Aeshi, N. and Paigambari, A. (2001).Effect of nitrogen application and irrigation on yield and yield components in two mustard cultivars. *Indian J. Agric. Sci.* **32**(4): 765-772.

Abdin, M. Z.; Khan, N.; Khan, I.; Israr, M. and Jamal, A. (2003). Nitrogen and sulphur interaction in relation to yield and quality attributes of mustard-mustard. Centre for Biotechnology, Faculty of Science, Flamdard University, New Delhi, India. **5**(3/4): 35-41.

Ali, M. H. and Rahman, A. M. (1986).Response of nitrogen in TS-72 (Kalynia) cultivar of *Brassica campestris*. *Bangladesh J. Agric*. **11**(3): 85-86.

Ali, M. H. and Ullah, M. J. (1995).Effect of different levels and methods of nitrogen application on growth and yield of mustard (*Brassica campestris* L.)*Ann. Bangladesh Agric*. **5**(2): 115-120.

Allen, E. J. and Morgan, D.G. (1972).A quantative analysis of growth and yield variation of oilseed mustard and mustard. *J. Agric. Sci., Camb*. **103**: 249-252.

Allen, E. J. and Morgan, D.G (2009).A quantitative analysis of the effects of nitrogen on the growth, development and yield of oilseed rape. *J. Agri. Sci.***78**, 315-324.

Andrews, J. E. (1972). Research Branch Report. Canadian Agricultural Research Station, Lethbridge, Atlanta. p. 309.

BARI (Bangladesh Agricultural Research Institute). (2008). Annual Report for 2007-2008.Gazipur-1701, Bangladesh. pp. 1- 385.

BARI (Bangladesh Agricultural Research Institute). (1999). Annual Report. Joydebpur, Gazipur 1701, Bangladesh.

BBS (Bangladesh Bureau of Statistics).(2002). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Ministry Planning, Govt. Peoples Rep. Bangladesh, Dhaka.

BBS (Bangladesh Bureau of Statistics).(2005). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Ministry Planning, Govt. Peoples Rep. Bangladesh, Dhaka

BBS (Bangladesh Bureau of Statistics).(2010). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Ministry Planning, Govt. Peoples Rep. Bangladesh, Dhaka

Bhargava, S. C. (1991). Physiology.In: Oilseed *Brassica* in Indian Agriculture. Eds. U. L. Chopra and Shyan Prakas. Haranand Publications and Vikas Publish Pvt. Ltd. pp. 161-197.

Clarke, J. M. and Simpson, G.M. (1978). Influence of irrigation and seeding rates on yield and yield components of *Brassica napus* cv. Tower. *Canadian I. Plant Sci.* **58** (3): 73 1-737.

Dalal, J. L.; Lobana, K. S. and Singh, A. (1963). Improved agricultural practices and manuring for higher yields of Brassica oil seeds in the Punjab. *Field Crop Abst.***16**(4): 264-65.

FAO (Food and Agricultural Organization) and UNDP (United Nations Development Programme).(1988). Land Resources Appraisal of Bangladesh for Agricultural Development Report 2, Agro-eco. Reg. Bangladesh. pp. 472-496.

FAO (Food and Agriculture Organization).(2004). FAO Production Year Book. Food and Agriculture Organization of United Nations, Rome 00100, Italy. **57**:113.

FAO (Food and Agriculture Organization).(1999). FAO production year book. Food and Agricultural Organization of the United Nations, Rome, Italy. **51**: 125-27.

Gardner, F.; Pearce, R. B. and Mitchell, R. L. (1985). Physiology of Crop Plants Lowa St. Univ. Press pp. 112-114.

Ghatak, S.;Sounda, G. and Jana, P. K. (1992).Effect of irrigation and nitrogen on seed and oil content of Indian mustard (*Brassica juncea). Indian J. Agric. Sci.* **62**(10): 668.

Gill, M. S. and Narag, R. S. (1993). Yield analysis in rabi season (*Brassica najus* sub sp. olefera var. annua) to irrigation. *Indian J. Agron*. **38**(2):257-265.

Giri, G. (2001). Effect of irrigation and nitrogen on the performance of Indian mustard (*Brassica juncea*) and sunflower (*Helianthus annuits*) under two dates of sowing. *Indian J. Agron*. **46** (2): 304-308.

Gomez. K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research (2nd Edn.). John Willey and Sons, Singapore, pp. 28-92.

Gupta, T. R.; Pathak, P. K. and Bhan, S. (1972). Effect of NPK on yield, nutrient uptake and quality of tori. *Indian J. Agron*. **17**: 81-91.

Gupta, T. R.; Saini, J.S. and Gangasaran.(1985). Rai response to fertilizer. *Indian J. Agron*.**33**(3) : 342-343.

Gupta,V.; Pratap, V.; Bhadauria, S. and Aarwal R.L. (2011). Effect of Nitrogen and split dosees of Potassium on quality aspects of *Brassica spp. Afric. J. of Agri. Res.***6**(2):pp. 285-288.

Hasan, A. A.; Sarkar, A. A. and Hamid, M. A. (1988). Development of water use management practices for different crops using nuclear techniques and small scale irrigation structures. Workshop on the evaluation of the research activities under PL-480 Programme (Title 3) for 1986-87 at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during 23 April. pp. 11-12.

Hassan, A.A. and Rahman.A.(1987). Effect of various combinations of water supplies and nitrogen rates on growth and yield of mustard. *Thai. J. Agric. Sci.* **20**: 17-35.

Hoque, M. R.; Ahmed, M. U. and Rahman, M. A. (1987).Irrigation scheduling for optimum yield of mustard. *Bangladesh J. Agric. Sci.* **14**: 31-34.

Hossain, A. and Gaffer, M. A. (1997). Influence of nitrogen on yield of mustard. *Bangladesh J. Agric*. **15**(4): 72-80.

Hossain, M.A.; Jahiruddin, M.andKhatun, F. (2011). Effect of Boron on Yield and Mineral Nutrition of Mustard (*Brassica napus*) *Bangladesh J. Agril.Res*. **36**(1) : 63-73.

Hussain, M. J.; Sarker, M.M.R.; Sarker, M. H.; Ali M. and Salim M.M.R. (2008). Effect of Different Levels of Boron on the Yield and Yield Attributes of Mustard in Surma-Kushiara Flood Plain Soil (AEZ 20). *J. Soil. Nature*. **2**(3): 06-09.

Jamal, A.; Abdin, M. Z.; Khan, I.; Israr, M.; Jamal, A.; Khan, N. and Khan, I. (2003). Nitrogen and sulphur interaction in relation to yield and quality attributes of mustard-mustard. Centre for Biotechnology, Faculty of Science, Hamdard University, New Delhi, India.**5**: 3-41.

Joarder, 0.L.; Paul, K. and Goose, S. K. (1979).Effect of irrigation and fertilizer on mustard (*Brassica juncea*). *Expt. Agric*. **15**(3): 299-302.

Kader, P.; Singh, G. K. and Prasad, K. (2003).Studies on the effect of row spacingand nitrogen doses on the yield of and profit from Indian mustard.Progressive Agriculture. C.S. Azad University of Agriculture and Technology, Kanpur, India. **3**: 1-2, 146-147.

Katole, N.S. and Sharma, O. L. (1988). Effect of irrigation and nitrogen schedule and nitrogen level on seed yield, consumptive use and water use efficiency of mustard (*Brassica juncea). Indian J. Agron.***36**: 147-149.

Khan, N.; Singh, A.; Khan, S. and Samiullah, M. (2003).Interactive effect of nitrogen and plant growth regulators on biomass partitioning and seed yield in mustard. Department of Botany, Aligarh Muslim University, Aligarh, India.**5**(3&4): 64-71.

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

Mahal, S. S.; Gill, M. S. and Narang, R. S. (1995). Effect of irrigation and nitrogen levels on growth and yield of toria (*Brassica campesiris* L.). *Res. Dev. Rep*. **12**(1-2): 24- 29.

Maini, N. S.; Saandhu, J. S. and Johal, K. S. (1965). Effect of sowing date, spacing, irrigation and nitrogen levels on the grain yield and growth of toria(*Brassica campestris*). *Field Crop Absi.***18**(10): 48.

Maini, N. S.; Singh, G. and Singh, K. (1959). Response of some Brassica crops to nitrogenous manures in the Punjab. *Indian Oilse. J*. **3** (2): 105-108.

Meena, B. S. and Sumeriya, H. K. (2003). Influence of nitrogen levels, irrigation and interculture on oil and protein content, soil moisture studies and interaction effects of mustard (*Brassica juncea* . Czern and Coss). *Crop Res. Hisar*.**26**(3): 409-413.

Meena, B. S.;Sarma. G. L. and Sharma, R. P. (2002). Effect of nitrogen, irrigation and interculture on yield attributes and yield of mustard (*Brassica juncea* L. Czern and Coss). *Res. Crops.* **3**(1): 37-39.

Mollah, M. R. A.; Khatun, M. R.; Islam, M. J.; Rahim, M. A. and Khalequzzaman,K. M. (2005). Effect of boron fertilization on yield of mustard varieties. IJSAT.**1**(4):77-81.

Mondal, S. S.;Nayak, R. L. and Jayaram, D. (1988).Effect of irrigation on yield attributes and yield of mustard (*Brassica juncea*). *Indian Agricul.* **32**(4): 263-266.

Mondol, M. R. A. and Gaffer, M. A. (1983).Effect of different levels of nitrogen and phosphates on yield and yield contributing characters of mustard. *Bangladesh J. Agril. Res.***8** (1): 37-93.

Mozaffari, S.N.; Delkhosh, B. and Rad, A. S. (2012)**.**Effect of nitrogen and potassium levels on yield and some of the agronomical characteristics in Mustard*(Brassica juncea*). *Indian J. Sci. Technol*. **5**(2). ISSN: 0974- 6846.

Ozer, H. (2003).Sowing date and nitrogen rates effect on growth, yield and yield components of two summer mustard cultivars. *European J. Agron*. **19**(3): 453-463.

Padman, D. R.;Porwal, B. L. and Patel, J. C. (1994). Effect of levels of irrigation, nitrogen and jalashakti on growth and yield of Indian mustard (*Brassica juncea*). *Indian. J. Agron.* **9**(4): 599-603.

Patel, B. R.; Singh, D. and Gupta, M. L. (1991).Effect of irrigation and intercropping on gram and mustard. *Indian J. Agron*. **36**(2): 283 -284.

Patel, R.H; Sharma, V. and Usadadia, V.P.(2004). Influence of irrigation schedule, spacing and nitrogen on growth, yield and quality of mustard. Department of Agronomy, Gujarat Agricultural University. India. **5**(2/3): 290-293.

Patil. B.N.; Lakkineni, K. C. and Bhargava, S. C, (1997). Ontogenic changes in growth and assimilate distribution as influenced by nitrogen supply in mustard. *J. Agron. Crop Sci.* **17**(1): 15-21.

Paul, N. K. and Begum, F.A. (1993).Effect of irrigation at specific developmental stages on growth and yield of mustard. *Bangladesh J. Agri*. **18**: 77-79.

Prasad, K.; Chaudhary, H.P. and Uttam, S. (2003). Effect of nitrogen, phosphorus, sulphur and zinc on growth, yield attributes and yield of mustard under rainfed condition. Bhartiya-Krishi-Anusandhan-Patrika.Chandra Shekhar Azad University of Agriculture & Technology, Kanpur - 2 (U.P.), India. **18**(3/4): 124-129.

Prasad, U. K. and Eshanullah, M. (1988). Effect of irrigation and nitrogen on yield and yield attributes of mustard. *Indian J. Agron*.**33**(1): 47-51.

Rarihsr, S. S. (1990). Effect of nitrogen and irrigation on mustard (*Brassica juncea*). *Indian J. Agron*. **36**: 156-159.

Rathore, A.L. and Patel, S.L. (1989).Effect of irrigation and nitrogen on mustard. *Hayana J. Agron*. **5**(2): 148-151.

Raut, R. F.; Hamid, A.; Hadole, S. S.; Jeughale, G. S. and Sajid, M. (1999). Dry matter and grain yield of mustard as influenced by irrigation and sulphur levels. *Ann. Plant Physiol*. **13**(2): 118-122.

Reddy, B. N. and Sinha, M. N. (1987).Effect of irrigation and fertilization on yield and economics of Indian mustard. *J. Oliseed Res*. **4**(2): 202-210.

Richard, R. A. and Thurling N. (1978).Variation between and within species of mustard (*Brassica campestris* and *Brassica napus*) in response to drought stress.*Australian. J. Agric. Res*. **29**: 469 -77.

Roy, R. K. and Tripathi, R. S. (1985). Effect of irrigation scheduling and fertility levels on the yield, yield attributes, water use efficiency and nutrient concentration of mustard. *Ann. Agric. Res.* **6**(1): 1-11.

Russel, D.F. 1986. MSTAT-C Package Programme. Dept. of Crop and Soil Science, Michigan State University, USA.

Saikia, U. S., Chopra, U. K, Singh, A. K. and Goswami, B. (2002).Stimulation of biomass and seed yield of Indian mustard (*Brassica juncea*) under different levels of nitrogen. *Ann. Agric. Res*. **23**(4): 685-691.

Saran, G. and Giri, G. (1988). Influence of irrigation and time of nitrogen application on mustard (*Brassica juncea*). *Indian J. Agron*. **33**(2): 154-158.

Sarker, G.; Salam, M.A.; Islam, M.A.; Islam, M.R. and Sultana, R. (2001). Adaptibility of BINA mustard, Boro rice and mungbean mutant varieties in different saline habitats. A study report. GOLDA project, CARE-Bangladesh. pp.1-6.

Sarker, G.; Salam, M.A.; Islam, M.S.; Sultana, R and Roy, R. (2000).Effect of variety and moisture regimes on the yield and yield component of mustard in saline soil.A study paper.GOLDA project, CARE-Bangladesh.Pp.1-6.

Sarker, A. A. and Hassan, A. A. (1988).Irrigation scheduling to mustard using pan evaporation. *Thai J. Agric. Sci*. **21**(4): 3 11-321.

Shamsuddin, A. M.; Islam. M. A. and Asaduzzaman, S. M. (1987). Effect of nitrogen on yield and yield contributing characters of mustard at different levels. *Bangladesh J. Agric. Sci.***14**(2): 165-167.

Sharawat, S.; Singh, T. P.; Singh, J. P. and Sharawals, S. (2002). Effect of nitrogen and sulphur on the yield and oil content of Varuna mustard (*Brassica juncea* L.).*Prog. Agric.* **2**(2): 177.

Sharma, D. K. and Kumar, A. (1990). Effect of nitrogen on yield, uptake, recovely and nitrogen use efficiency of mustard under different irrigation scheduling . *J. indian Soc. Sci*. **38**(2): 229-232.

Sharma, D. K. and Kumar.A. (1989). Effect of irrigation and nitrogen on growth, yield, consumptive use and water use efficiency of Indian mustard (*Brassica juncea* sub sp.juncea). *Indian J. Agric. Sd*. **59**(2): 127-129.

Sharma, D. K. and Kumar.A. (1989).Effect of irrigation on growth analysis, yield and water use in Indian mustard (*Brassica juncea*). *Indian J. Agric. Sci.* **59**(3): 162- 165

Sharma, G. and Giri, G. (1988). Influence of irrigation and time of nitrogen application on mustard *(Brassica juncea*). *Indian J. Agron*. **33**(2): 154-158.

Sharma, G. and Kumar, A. (1988).Effect of irrigation scheduling and nitrogen on yield and N uptake of mustard. *Indian J. Agron*. **33**(4): 436-441.

Sharma, P. P. and Jam, N. K. (2002). Nitrogen requirement on indian mustard *(Brassica juncea*) under different crop sequences. *Indian J. Agril. Sci*. **72**(2): 101-103.

Sharma, R. K. (1991). Effect of limited irrigation and fertilizer on mustard yield. *J. Oilseeds Res*. **8**(2): 234-23 6.

Sharma. D. K. and Singh, K. N. (1993). Effect of irrigation on growth, yield and evapotranspiration of mustard (*Brassica juncea)* in partially reclaimed sodic soils. *Agric. Water Manag*. **23**(3): 225-232.

Shukla, R. K.; Kumar, A.; Mahapatra, B. S.;Basanth, K.; Kumar, A. and Kandpal, B. (2002). Response of promising varieties of mustard (*Brassica napus*) to nitrogen and phosphorus fertilizer on the Tarai region of Uttaranchal.*Ann. Agril. Res*. **23**(4): 630-633.

Shukla.R. K.; Kumar, A.; Mahapatra, B. S.; Kandpal, B.; Kumar, A. and Kandpal, B. (2002). Integrated nutrient management practices in relation to morphological and physiological determinants of seed yield in Indian mustard (*Brassica juncea*). *Indian J. Agril. Sci.* **72**(11): 670-672.

Siag, R. K. and Verma, B. L. (1990).Effect of irrigation schedules on growth and yield of mustard. *Indian J. Agron*. **35**(4): 395-399.

Siag, R. K.; Kumar, S.; Verma, B. L. and Singh, V. (1993).Effect of irrigation schedule on yield, water use and oil content of toria (*Brasica napus* var. napus).*Indian J. Agron*.**38**(1): 42-44.

Singh, A. and Meena, N. L. (2003).Effect of nitrogen and phosphorus levels on the oil and protein yield of mustard (*Brassica juncea*). *Ann. Agric. Res*. **24**(2): 368-371.

Singh, B. N. and Srivasrava, S. P. (1986).Effect of irrigation and nitrogen fertilization on growth and yield of mustard in mid hills Meghalaya. *Indian J. Agron*. **13**(2): 135- 138.

Singh, B. P.; Yadava, T. B. and Bhola, A. L. (1972).Effect of irrigation and fertility levels on seed yield and quality of raya *(Brassica juncea*).*Field Crop Abst*.**25**(3): 584.

Singh, B.; Singh, B. P. and Faroda, A.S. (1994). Physiological parameters of Brassica species as affected by irrigation and nitrogen management of Aridisols. *Indian J. Agron*. **39**(3): 426-431.

Singh, D.; Jain, K.K. and Sharma, S.K. (2004).Quality and nutrient uptake in mustard as influenced by levels of nitrogen and sulphur. *J. of Maharashtra Agricul. Univer*. Department of Agronomy, College of Agriculture, Bikaner, India.**29**(1): 87-88.

Singh, G. K. and Prasad, K. (2003).Studies on the effect of raw spacing and nitrogen doses on the yield and profit from Indian mustard. *Progress. Agric*. **3**(1/2): 146-147.

Singh, M. P.; Paandey, U. N.; Lal, R. K. and Chaturvedi, G. S. (2002).Respons of Brassica species to different irrigation regimes.*Indian J. Plant Physiol*. **7**(1): 66- 69.

Singh, O.K.; Kedar,Prasad.; Prasad, K. (2003). Effect of row spacings, nitrogen levels and basis of N application on yield attributes and yield of mustard. Crop Research Hisar. C. S. Azad University of Agriculture & Technology, Kanpur, India. **25**: 3, 427-430.

Singh, P.C. (2002).Effect of different levels of nitrogen and phosphorus on yield, yield components and oil content of mustard. *J. Livi. Worl.* S.D.J. Post Graduate College, Chandeshwar, Azamgarh (U.P.), India. **9**: 1,1-4.

Singh, R. P.; Singh, Y. and Singh, Y. (1998). Performance of rainfed Indian mustard (*Brassica juncea*) varieties at varying levels of nitrogen. *Indian J. Agron*. **43**(4):709-712.

Singh, S. D. and Yusuf.M. (1979).Effect of water, nitrogen and row spacing on yield and oil content of brown sarson. *Canadian. J. Plant Sd*. 59(2): 457-444.

Singh, S.; Singh, N. P. and Bandyopadhyay, S.K. (1997) .Effect of limited irrigation on seed production.oil yield and water use by Indian mustard. *Ann. Agric. Res*. **18**(3): 265-269.

Singh, V. (1983).Response of mustard to irrigation and fertilization. *Madras Agric. J*. **70**(1): 15-18.

Sinha, S.; Nayak, R. L. and Mitra, B. (2003).Effect of different levels of nitrogen on the growth of mustard under irrigated and rainfed conditions. *Env. Ecol.* **21**(4): 741-743.

Sinsinwar, B.S.; Kumar, A.; Premi, O.P.; Singh, F. (2004).Production potential and nitrogen requirement of Indian mustard. *J. Oil seeds Res*. National Research Centre on Mustard-Mustard, Sewar, Bharatpur, Rajasthan, India.**21**(1): 175-177.

Srivastava, G. K.;Tomar, S. S. and Tomar, G. S. (1988).Effect of irrigation and nitrogen schedules on harvest index of mustard. Res. Dev. Rept., Madhya Pradesh, India, **5**: 1-2.

Tiwari, R. C. and Chaplot, P. (1993). Response of mustard to irrigation schedules. *Intl. J. Trop.Agric*. **11**(3): 178-181.

Tomer, S. and Singh, S. (1990). Influence of varying levels of irrigation and fertilizers on yield, nutrient uptake, water use efficiency and quality of mustard *(Brassica juncea* cv. Varuna). *Ann. Agric. Res*. **11**(3-4): 241-248.

Tomer, S.; Tomer, S. and Singh, S. (1992).Effect of irrigation and fertility levels on growth, yield and quality of mustard (*Brassica juncea*). *Indian J. Agron.* **37**(1): 76-78.

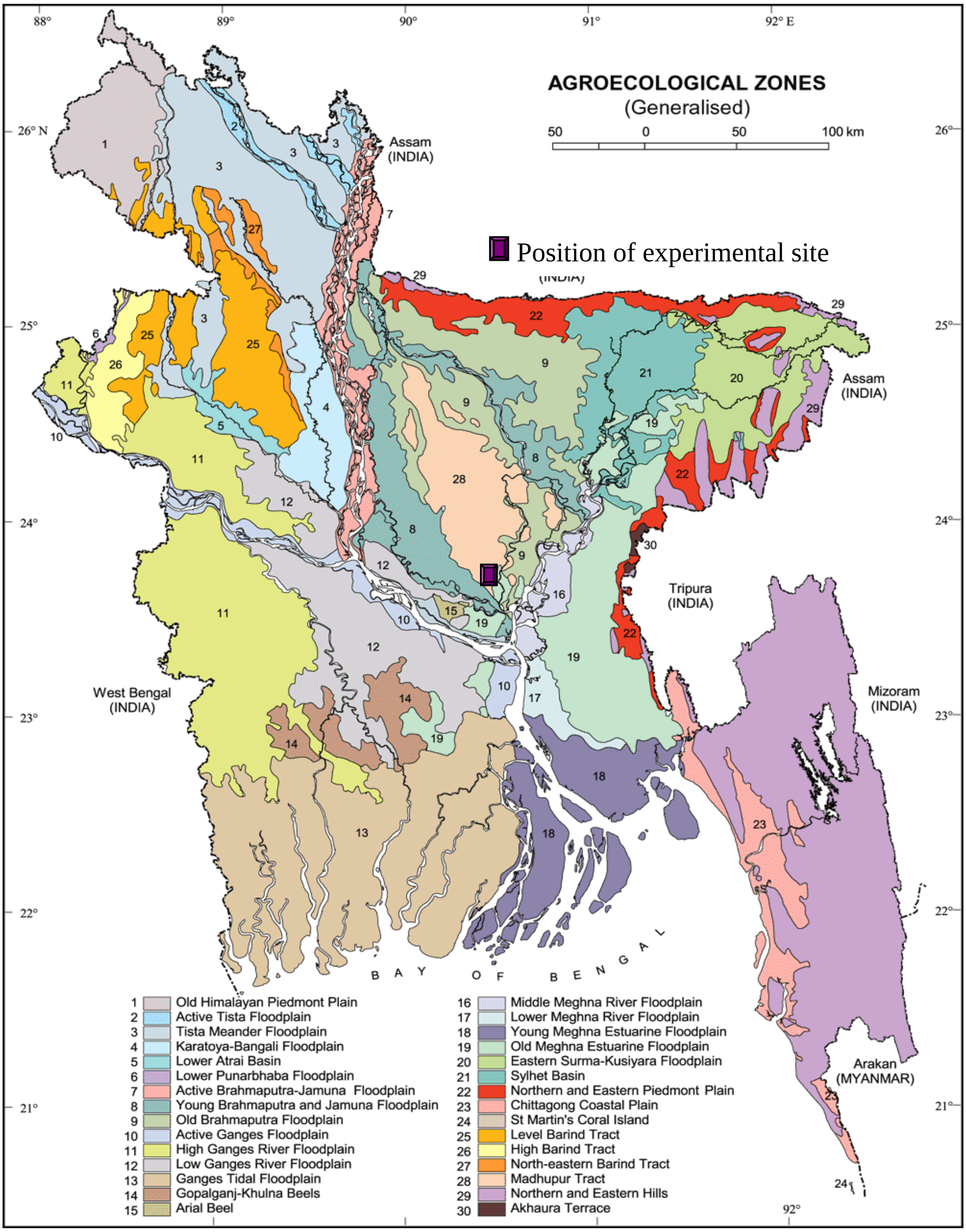
Tripathi, A.K. and Tripathi, H.N. (2003). Influence of nitrogen levels on growth, yield and quality of Indian mustard. *Farm-Sci. J*. C.S. Azad University of Agriculture & Technology, Kanpur, India.**12**(1): 7 1-72.

Wrighter, G. C.; Smith, C. J. and Woodroofe, M.R. (1998). The effect of irrigation and nitrogen fertilizer on mustard (*Brassica juncea)* production on South-easter Australia, I. growth and seed yield. *Irrigation Sci.* **9:**1-13.

Zhao, F. J.; Withers, P. J. A.; Evans, E. J.; Monaghan, S. E.; Shewry, P. R. and Mogarth, S. P. (1997). Nitrogen nutrition and important factor for the quality of wheat and mustard. *Soil Sci. Plant Nutri*. **43**: 1137-1142.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during 2012-2013

Month	Air temperature (°C)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November	26.98	14.88	71.15	00
December	25.78	14.21	68.30	00
January	25.00	13.46	69.53	00
February	29.50	18.49	50.31	00
March	33.80	20.28	44.95	00

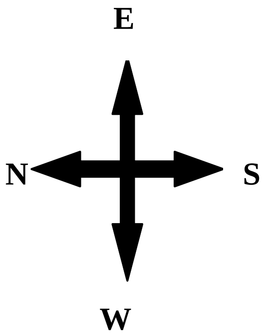
Source: Bangladesh Mateorological Department (climate and weather division), Agargaon, Dhaka.

Appendix III. Chemical properties of the soil of experimental field before seed sowing

CHARACTERISTICS	VALUE
pH	5.70
Organic matter (%)	2.35
Total N (%)	0.12
K (me/100 g soil)	0.17
P (Mg/g soil)	8.90
S (Mg/g soil)	30.55
B (Mg/g soil)	0.62
Fe (Mg/g soil)	310.40
Zn (Mg/g soil)	4.82

Source: Soil Resource Development Institute (SRDI), Krishi Khamar Sharak, Dhaka

Appendix IV. Layout and design of the experimental plot



R_1		R_2		R_3	
I_1	I_0	I_1	I_0	I_1	I_0
T_2	T_1	T_2	T_1	T_2	T_1
T_3	T_7	T_3	T_7	T_3	T_7
T_5	T_2	T_5	T_2	T_5	T_2
T_1	T_3	T_1	T_3	T_1	T_3
T_4	T_6	T_4	T_6	T_4	T_6
T_7	T_5	T_7	T_5	T_7	T_5
T_6	T_4	T_6	T_4	T_6	T_4

Unit plot size:
3m × 2.5m

Factor A: Irrigation
I_0- no irrigation
I_1- irrigation

Factor B: Managements
T_1 = all management
T_2= all management without row
T_3 = all management without mulching
T_4= all management without weeding
T_5= all management without fertilizer
T_6= all management without insecticide
T_7= all management without fungicide

Appendix V. Analysis of variance of the data on plant height, Number of leaf plant^{-1}, number of branch plant^{-1} and total dry matter weight of mustard plant as influenced by irrigation and management practices

Source	Degrees of freedom	Plant height	Number of leaves plant^{-1}	Number of branch plant^{-1}	Total dry matter weight (g)
Replication	2	901.357	109.547	8.289	8.075
Factor (irrigation)	1	19.749	34.744	0.857	1.581
Error	2	208.837	36.952	3.86	1.18
Factor (Management)	6	28.77	9.693	2.548	0.805
AB	6	26.715	17.582	3.593	2.075
Error	24	18.515	4.625	0.929	2.743

Appendix VI. Analysis of variance of the data on Number of inflorescences, number of siliquae, number of effective siliquae plant^{-1} and of seeds siliquae^{-1} of mustard as influenced by irrigation and management practices

Source	Degrees of freedom	Number of inflorescences plant^{-1}	Number of siliquae plant^{-1}	Number of effective siliquae plant^{-1}	Number of seeds siliquae^{-1}
Replication	2	10.458	53.324	2.272	10.53
Factor (irrigation)	1	1.761	18.269	1.761	12.926
Error	2	6.035	80.827	6.481	9.495
Factor (Management)	6	2.121	24.496	7.427	4.923
AB	6	2.743	7.864	2.863	5.274
Error	24	0.518	12.458	2.736	9.877

Appendix VII. Analysis of variance of the data on Seed yield, stover yield, biological yield and harvest index of mustard as influenced by irrigation and management practices

Source	Degrees of freedom	Seed yield	Stover yield (tha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.44	1.256	3.176	91.066
Factor (irrigation)	1	0.833	1.72	4.951	224.717
Error	2	0.021	0.235	0.39	5.872
Factor (Management)	6	0.033	0.493	0.708	99.16
AB	6	0.017	0.064	0.08	20.186
Error	24	0.036	0.086	0.175	50.397