EFFECT OF IRRIGATION AND WEEDING ON THE YIELD COMPONENTS AND YIELD OF MUSTARD (SAU Sarisha-3)

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CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF IRRIGATION AND WEEDING ON THE YIELD COMPONENTS AND YIELD OF MUSTARD (SAUSarisha-3)**" 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 **MD. TONMOY KIBRIA**, **Registration No. 05-1596,** 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:

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2011 to February 2012 to study the effect of irrigation and weeding on the yield components and yield of mustard (SAU sarisha-3). In the experiment, the treatment consisted of four irrigation viz. I_0 = no irrigation, I_1=one irriation at 20 DAS (just before flowering), I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS (during siliqua formation), I_3=Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS (during seed maturation stage) and three different weeding viz. W_0=No weeding (Control), W_1= One weeding at 10 DAS, W_2= Two weeding, 1st at 10 DAS + 2nd at 20 DAS. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) (factorial) with three replications. Results showed that significant variations occurred among the treatments in respect of majority of observed parameters. Tallest plant (101.00 cm), maximum branches per plant (7.70), siliquae per plant (138.8), seeds per silliqua (20.06) and seed yield (1.98 t/ha) was produced by two irrigations. Tallest plant (102.10 cm), maximum branches per plant (7.90), siliquae per plant (131.50), seeds per silliqua (20.02) and seed yield (1.88 t/ha) was produced by two weedings. Shortest plant (98.49 cm), minimum branches per plant (7.17), siliquae per plant (111.9), seeds per silliqua (19.37) and seed yield (1.34 t/ha) was produced by no irrigations. Shortest plant (97.73 cm), minimum branches per plant (7.16), siliquae per plant (117.50), seeds per silliqua (18.82) and seed yield (1.60 t/ha) was produced by no weedings. The combinations of irrigation and weeding had significant effect on almost all parameters. Highest yield of seed per hectare (2.88 t) was obtained from two weedings and two irrigations treatment combination (I_2W_2). The control combination of irrigation and weeding (I_0W_0) produced the lowest seed yield per hectare (1.28t).

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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 I

INTRODUCTION

Mustard *(Brassica campestris*) belongs to the family Cruciferae, is an important oil crop in Bangladesh. It is originated from Asia Minor, but now is cultivating as a main commercial oil crop in Canada, China, Australia, and India including Bangladesh. It was reported that mustard 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 (Mondal and Wahhab, 2001).

Mustard oil is not only rich source of energy (about 9 k cal/g) but also rich in soluble vitamins A, D, E and K. The National Nutrition Council (NNC) of Bangladesh reported that recommended dietary allowance (RDA) per capita per day should be 6 g of oil for a diet with 27000 k cal. On RDA basis, the edible oil need for 150 millions peoples is 0.39 million tons of oil equivalent to 0.82 million tons of oilseed (NNC, 1984). Mustard seeds contain 40-45 % oil and 20-25 % protein (Mondal and Wahhab, 2001).

Mustard is the main cultivable edible oil seed corp of Bangladesh. Mustard is the most important popular oil crop which is grown in rabi season in Bangladesh. Mustard covers the land area of 216800 hectares in Bangladesh and produces about 183500 metric tons of oil seeds (BBS, 2007). Bangladesh occupies the 5th place in respect of total oil seed production in the world and mustard occupies the first position in respect of area and production among the oil crops grown in Bangladesh (BBS, 2010).

Mustard is the major oilseed crop in Bangladesh covering about 70 % of the total production. The area and production of mustard of our country was about 0.481 million hectares and 0.536 million tons, respectively with an average yield of 1.11 t/ha during 2010-2011 (AIS, 2012). The present domestic edible oilseed production is 267 thousand tons, which meets only one third of national demand. Therefore, Bangladesh has to import a large quantity of edible oil every year at the cost of huge amount of foreign exchange worth BDT 11000 million during 2005-2006 fiscal years (Anon., 2006).

The area and production of oilseeds are gradually declining due to (i) low yield potential of oilseed varieties (ii) high infestation of diseases and pests, compared to other crops (iii) instability of yield due to micro-climatic fluctuation (iv) expansion of irrigation facilities and more profitable crops are available in place of mustard in the cropping patterns. Most oilseeds crops respond positively with high management, yet they cannot compete with other high value crops. Usually, farmers do not allocate their good piece of land and also they do not follow modern cultural practices for oil crops. So, their yields are low.

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 on the frequency and amount of water to be given. Over irrigation, as well as under irrigation may lower yields. Efficient water management thus plays a vital role in mustard 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 mustard cultivation.

A significant number of farmers are still using broadcasting methods of seed sowing which causes uneven distribution of seed. The seeds at the bottom receive more moisture in comparison to those in the top, which may produce uneven emergence of seedlings and also uneven maturity of plants. Ultimately it creates a difficult situation for harvesting. This can easily be overcome by maintaining proper row spacing.

Weeds are most serious pests of mustard reducing the growth and yield of crop. Modern agricultural practices contribute mostly on protection of the crop against competition from weeds. Weeds reduce yield by competing with crop plants for space, light, nutrients and carbon dioxide etc. There are different views about the intensity of weed losses but it is established fact that weeds cause great losses to crops, depending upon the degree of weed infestation, duration of weed competition, and soil and climatic conditions (Mansoor *et al*., 2004).

Karim (1987) estimated that weeds caused a yield loss of 28% of total food crops, 33% in cereals, 14% in pulses, 27% in oil seeds and 33% in rice crops. There is no specific way to control weeds of all types because of different kinds of social, economical and environmental factors influence the choice of control method to be used. Quarshi *et al*. (2002) reported that weed could be controlled by manual, cultural and chemical methods. Although weed management practices like hand weeding and herbicide application are effective in weed control but are uneconomical due to higher costs (Cheema *et al*., 2003). Moreover the chemical weed control method is hazardous for health and causes environmental pollution.

The experimental evidences on the effect of irrigation and weeding on the yield components and yield of mustard (SAU sarisha-3) is not available. So, to find out the frequency of irrigation at different growth stage along with proper time of weeding (manual) for optimum growth and yield of mustard is needed to be examined. The present study was therefore, undertaken with the following objectives.

i. To find out required irrigation management in mustard cultivation for maximum yield.

ii. To determine the weeding effect on the growth and yield of mustard.

iii. To study the combining effect of irrigation and weeding on the growth and yield of mustard.

CHAPTER II

REVIEW OF LITERATURE

Rapseed is an important oil crop in Bangladesh which can contribute to a large extent in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings about irrigation and weed control method have been reviewed in this chapter.

2.1 Effect of irrigation on crop performance of mustard

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 siliqua 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 siliqua filling stages) and limited irrigation (one irrigation at branching stage). Results revealed that growth, development and yield of all *Brassica* spp. were adversely affected under limited water conditions. This clearly indicates that yield expression of *Brassica* spp. differs under varying soil water regimes.

2.1.1 Plant height

Saran and Giri (1988) reported that plant height of rapeseed was found to be highest when one irrigation at 30 DAS was applied. But two irrigations applied at 30 and 60

DAS produced taller plant than under rainfed condition. There was a positive relation between irrigation levels and plant height of mustared.

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

2.1.2 Dry weight of plants

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

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

Dalal *et al*. (1963) suggested for one irrigation at the blooming stage in brown sarson (*Brassica campesiris* var. Sa,-son,).

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.* (1990) 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 rapeseed was significant. 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 irrgation treatment. Two irrigations also increased dry matter production

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

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

Giri (2001) reported that dry matter per plant of rapeseed was not significantly increased by irrigation treatments. He conducted two experiments to find out the effect of irrigation on growth and yield of mustard. In 1995-1996 total dry matter production was higher with two irrigations at flowering and siliqua development stage than the dry matter produced 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 rapeseed 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 number of primary branches per plant of mustard was 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.* (1990) concluded that branches per plant of rapeseed 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 preflowering and fruiting stages. When one irrigation was applied at preflowring stage, it produced lower branches plant. The least number of branches was produced at control treatment.

Singh *et al*. (1994) conducted a field trial with *Biassica juncea* irrigated at 50% flowering, at 50% flowering + 50% siliqua 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 rapeseed in Canada at Saskatoon and reported that irrigation increased the number of siliquae per plant.

Sharma and Kumar (1989b) found in 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 siliqua formation stage.

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

Tomer *et al*. (1990) conducted an experiment to observe the effect of irrigation teratments viz, no irrigation, one irrigation (at pre-flowering stage) and two irrigation (one at pre-flowering and one at fruiting stage). Maximum number of siliquae was found when two irrigations were applied.One irrigation and without irrigation produced lower siliquae per plant.

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

2.1.5 Number of seeds per siliqua

Clarke and Simpson (1978) found the increasing number of seeds per siliqua 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 and rainfed conditions and observed that irrigation increased the number of seeds per siliqua 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 per siliqua in mustard with irrigation application. The increased number of seeds per siliqua was found when irrigation was applied at 30 and 60 DAS followed by irrigation at 30 DAS and without irrigation which produced lower seeds per siliqua.

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

Tomer *et al.* (1990) reported that seeds per siliqua were significantly increased with irrigation application. Maximum numbers of seeds per siliqua was found when two irrigations were applied (one at pre-flowering stage and one at fruiting stage). A siliqua contained 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 siliqua, respectively.

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

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

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

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

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

Tomer *et. al.* (1990) reported that maximum weight of 1000-seed was found when one irrigation was applied during pre-flowering stage and another one during fruiting stage of mustard. Least weight of 1000-seed was found in without irrigation treatment.

2.1.7 Grain yield

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

Singh (1983) found in an experiment with mustard (*Brassica juncea*) grown with a presowing irrigation in the Rajastan arid zone of India that irrigation at the pre-flowering stage increased the yield of mustard. But the irrigation given at siliqua 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 IW: CPE ratio of

0.4. They found yield was positively associated with number of branches per plant and siliquae per plant, number of seeds per siliqua and 1000 seed weight.

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

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

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

Katole and Sharma (1988) conducted a field experiment on clay loam soils with rapeseed to study the effect of irrigation schedule and found that yield was highest with two irrigations, one at branching and other at siliqua 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 on 20-25 day after sowing and obtained maximum seed yield at BINA farm with three levels of irrigation that at RARS Ishurdi farm with five levels of irrigation.

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

Sharma and Kumar (1989a) studied an irrigated mustard (Brassica juncea) with 60 cm irrigation at irrigation water depth and cumulative pan evaporation ratio of 0.4 or 0.6 (one and two irrigations respectively) and reported that seed yield were higher in 1984-1985 and 1985-1986 compared with respective yield under rainfed conditions.

Mondal *et al*. (2001) 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 siliqua or late siliqua development stages). The result revealed that maximum yield was obtained with one irrigation at flowering, intermediate with 2 irrigations at flowering and late siliqua stages and minimum with 3 irrigations applied at pre-flowering, early and late siliqua stages.

Hasan *et al*. (1988) conducted a field experiment in 2 locations in Bangladesh, mustard was given no irrigation (Io), 1 irrigation at 25 days after sowing (I_1), or I_1, together with later irrigation when IW: CPE (irrigation water depth and cumulative potential evaporation ratio) reached at 0.2, 0.4, 0.6 or 1.0. They observed that the highest seed yield resulted from irrigation at 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 eflécts 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 of irrigation produced the maximum seed yield in 1984-1985 and 1985-1986. Yields were obtained lower with without irrigation in those years.

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 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 (fl), irrigated at branching (lbr)+ Ifl, or lbr +Ifl + irrigation at seed development (sd), i.e. with increased level of irrigation produced greater seed yield compared to control (rainfed).

Tomer *et al.* (1990) 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 juncea* cv. Varuna) which was irrigated at vegetative, flowering andsiliqua development or seed filling stage corresponding 3, 6, 9, or 12 weeks after sowing (WAS) or at various combinations of these dates. Seed yield increased with increase in irrigation frequency. The highest mean seed yield was obtained from irrigating the crop at 3, 6 and 9 WAS.

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

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

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

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

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

Singh *et al.* (1997) reported that the stages most sensitive to water strees were the seedling stage followed by the flowering stage. Decreased in seed yield varied from

22.13 to 36.57% when irrigation was withheld at seedling and flowering stages, 17.98 to 32.43 % when withheld at seedling and seed development stages compared to irrigation applied at all these stages. However, early water stress from flowering to seed development stages decreased the yield by 4.83 to 15.46% compared with irrigation at all 3 stages.

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

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 per plant were positively correlated with irrigation in rapeseed and mustard cultivation.

2.1.9. Harvest index

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

2.2 Effect of method of weeding on crop performance of mustard

Rashid (2006) conducted an experiment in the Rabi season (November-February) of 2005-2006 to study the response of rapeseed line SAU-C-F7 in respect of yield, yield attributes and oil yield to different nitrogen levels and number of weeding. The treatment comprised of 4 levels of nitrogen and 3 level of weeding. Different N level were 0 kg N/ha (N0), 90 kg N/ha (N1), 120 kg N/ha (N2) and 150 kg N/ha (N3). The weeding treatments were no weeding (W0), one weeding at 20 DAS (W1) and two weedings at 20 and 45 DAS (W2). The experiment was laid out in a Randomized Complete Block Design (RCBD) (factorial) with three replications. Nitrogen levels and number of weeding significantly influenced the growth, yield and yield attributes of rapeseed. Plants per m^2 , plant height, branches per plant, siliquae per plant, length of siliqua, seeds per siliqua, , 1000-seed weight, seed yield, stover yield, biological yield, harvest index, oil content and oil yield were significantly influenced by nitrogen levels and weeding as individual factor. Oil content was only influenced by nitrogen application. The results revealed that nitrogen at the rate of 120 kg per ha showed the best performance regarding to yield components and yields. The maximum seed yield per ha (2343.4 kg per ha) with 120 kg N per ha was 194.28%, 71.11% and 6.87% higher than the yield obtained from 0 kg, 90 kg and 150 kg N per ha , respectively. In case of weeding factor, it was observed that two hand weeding resulted in maximum production of yield and yield attributes as well as seed and oil yields. Two hand weeding increased the seed yield by 17.66% over control. The interaction effect of nitrogen levels and number of weeding revealed that 120 kg N along with two hand weeding showed the best performance in producing the yield attributes and yields. Number of branches per plant, number of siliqua per plant, number of seeds per plant , 1000- seed weight has a significant correlation with seed yield per plant with the R values of 0.91, 0.97, 0.88 and 0.96, respectively. All of the yield attributes were highly significant. The relationship between the yields attributes and yield was highly significant.

Roy (2006) conducted an experiment at the Agronomy Field of Sher-e-Bangla Agricultural University (SAU), Dhaka in the Rabi season (November-February) of 2006 -2007 to study the influence of variety and number of weeding on the growth and yield of rapeseed. The treatment comprised of three varieties and four levels of weeding. Different varieties were improved Tori-7, BARI sarisha-12 and SAU sarisha-1. The weeding treatments were no weeding, one weeding at 20 DAS, two weedings at 20 and 30 DAS three weedings at 20, 30 and 40 DAS. The experiment was laid out in a Randomized Complete Block Design (RCBD) (factorial) with three replications. The seed yield of mustard varied with varietal difference along with different weeding intervals. The growth behaviour of the three studied varieties was different and hence weeding recommendation also varied. The variety SAU sarisha-1 showed the highest yield (1.57 t per ha) response with one weeding that followed by the same variety with two weedings (1.55 t per ha) but BARI sarisha-12 responded better with two weedings. No weeding was needed for improved Tori-7 probably due to its earlier better growth coverage.

Pandey and Mishra (2003) conducted an experiment during 1997-99 in New Delhi India, involving 5 weed control treatments viz. weedy control, hand weeding, chemical, cultural, and chemical + cultural, in a rice-Indian mustard-mungbean cropping system. Hand weeding in rice was performed at 30 days after transplanting, while in Indian mustard and mungbean at 20 DAS. In the cultural treatment, a hand-driven wooden hand plough was run between the line 35 DAS. Weed competition in the rice-Indian mustard-mung bean cropping system lowered the total grain productivity by 32%. The maximum decrease in grain productivity of rice, Indian mustard and mungbean was 35.3, 19.3 and 45.6%, respectively. The most principal weed species that competed were *Echinochloa colonum* (*E. colona*) and *E. crus-galli* in rice, *Phalaris minor* in Indian mustard and *Trianthema portulacastrum* in mungbean. The competitive effect of other weed species on grain yield was nominal as their population was sparse. In all the 3 crops, in all weed control treatments, weed population and weed dry weight were recorded significantly lower compared to the weeds control. Chemical + cultural, hand weeding and chemical treatments resulted in a marked decrease in weeds, the decreases being higher in the former two treatments. Weed control treatments caused a significant increase in grain yield of crops in both years. Chemical + cultural and hand weeding caused a significant increase in grain yield of rice, while hand weeding and chemical treatments did that in mustard and mungbean.

Wahmhoff (1990) conducted an experiment on weed control in winter rape and concluded that rape yields were affected more by climatic factors, local site conditions, crop cover and the composition of the weed population than the total weed cover.

The competition effect of some weed species on the yield of winter oilseed rape was studied by Adoezewski (1990). In 7 years trials he observed that in oil seed rape at winnagora, Anthamis arvensis as a competitive weed. He also found large infestations causing up to 50% yield reduction.

Donovan and Sharma (1994) conducted an experiment on oilseed crops and reported that factors associated with crop losses due to weeds. They found that the yield loss generally increased with increasing wild oat population. Crop quality was reduced due to weeds.

Karim *et al.* (1994) reported most prominent weeds of mustard crop as *Cyperus rotundus, Cynodon dactylon, Paspalum scrobiculatum, Altrnanthera sessilis, Panicum repens, Hygrophila polyserma, Plygonum plebjum, Eclipta alba, Digitaria sanguinalis, leucus aspera and Alternanthera philoxeroides.*

In Faozaba, India, Singh and Singh (1995) conducted trials during the winters of 1985-86 and 1986-87 on the effect of weed control on nutrition uptake by mustard and associated weeds. There were 4 weed control treatments (i.e. hand weeding once 25 days after sowing), hoeing 25 DAS+hand weeding 35 DAS, application of preem isoproturon at 0.75 kg per ha and thiolencarb at 10 kg per ha on nutrient uptake by *Brassica juncea* cv. Karti and associated weeds. All weed control treatments decreased weed DM over control.

In an experiment, Gaffer (1984) observed that height of mustard was favorably increased with the spell of weed free periods by had weeding.

Yadav *et al.* (1984) observed that siliqua yield of rapeseed were significantly increased by removing weeds at 2, 4, 6 or 8 week after sowing (WAS). Further delayed on weed removal had little effect on production of siliqua.

Roebuck and Trennery (1978) conducted an experiment on weed control of winter oilseed rape and observed that effective weed control on the autumn increased the total crop dry weight at the start of flowering by 80-90%.

Gaffer (1984) observed that the weed free condition produced the maximum seed yield and yield components of rapeseed. He also found that yield reduction was 23.0% in control as compared to weed free plots.

Ambast and Chakhaiyar (1984) observed the effect of weed and weed free duration on the growth and yield of mustard (*Brassica juncea).* They found that the maximum reduction on seed yield was due to weed infestation between 20 and 40 days of growth on mustard.

Ghosh *et al.* (1994) conducted an experiment on sandy loam at Kharagpur on weed control on mustard and reported that all weed control methods increased Indian mustard seed yield over untreated one.

From the literature reviewed above it is revealed that there is much effect of irrigation on the growth and yield of mustard and it is also revealed that 2 irrigation before siliqua maturation showed better performance then more or less number of irrigation. Weeding also has good effect on the increase of growth and yield of mustard.

Chapter III

MATERIALS AND METHODS

The experiment was undertaken during rabi season (October to February) of 2011-12 to find out the effect of irrigation and weeding on the yield components and yield of mustard (cv-sau sarisha-3) at Sher-e-Bangla Agricultural University, Sher-e-Banglanagar, Dhaka.

3.1 Experiniental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{0}22^{'}$ 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 (Appendix II).

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract (UNDP, 1988) 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 Plant Material

3.4.1 Test crop

A newly developed, high yielding variety of rapeseed, SAU Sarisha-3 developed by the Sher-e-Bangla Agricultural University, Dhaka was used in the experiment as a planting material. Plant height of the cultivar ranges from 60 to 55 cm. Its life cycle is about 60 to 65 days after emergence. Average yield of this cultivar is about 1500 kg ha^{-1}.The seed was collected from the Sher-e-Bangla Agricultural University, Dhaka. Before sowing germination test was done in the laboratory and percentage of germination was over 95%.

3.5 Methods

3.5.1 Treatments

Factor A: Four Irriation (I)

I_0 = no irrigation

I_1=one irriation at 20 DAS (Just before flowering)

I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS (During siliqua formation)

I_3= Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS (During seed maturation stage)

Factor B: 3 Weeding (W)

W_0= No weeding (Control).

W_1= One weeding at 10 DAS.

W_2= Two weeding, 1st at 10 DAS + 2nd AT 20 DAS.

3.5.2 Design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD)(factorial) with three replications. The total plot number was 12 × 3 = 36. 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 cleaned properly. The final ploughing and land preparation were done on 16 October, 2012. According to the layout of the experiment the entire experimental area was divided 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 Fertilization

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

Fertilizers	**Rate of application per ha.**
Nitrogen	300 kg
Phosphorous	180 kg
Potash	110 kg
Gypsum	180 kg
ZnSO4	5 kg
Boric Acid	10 kg
Cow dung	10 ton

The amounts of fertilizer as per recommendation 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 30 October, 2011 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, 67 plants/ m^2 was maintained by thinning excess plant at 15 DAS. The plant to plant distance was maintained as 5 cm. Weeding was done as per treatment.

3.5.7 Crop protection

The experimental crop was not infected with any disease and no fungicide was used. Hairy caterpillars attacked the young plants and accumulated on the lower surface of leaves where they usually sucked juice of green leaves. Borers and aphids also attacked the plots. They attacked at the early growing stages of seedlings. To control these pests, the infected leaves were removed from the stem and destroyed together with the insects by hand picking. Besides, aktara, pyriphos and triel- 20 ml were also applied to control these insects. The insecticide was sprayed whenever it was needed.

3.5.8 General observation of the experimental field

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

3.5.9 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 18, 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.

3.5.10 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 per ha.

3.6 Data collection

Ten (10) plants from each plot were selected at 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:

A. Weed parameters

i. Weed density per square meter

ii. Weed biomass per square meter

iii. Weed control efficiency

B. Crop growth parameters

i. Plant height (cm)

ii. No. of branches per plant

C. Yield and yield components

i. No. of siliquae per plant

ii. Length of siliqua

iii. No. of seeds per silliqua

iv. Thousand- seed weight

v. Yield (t/ha)

vi. Stover yield

vii. Biological yield

viii. Harvest index (%)

3.6.1 Weed density

The data on weed infestation as well as density were collected from each unit plot. A plant quadrate of 0.25 m^2 was placed randomly at three different spots outside an area of 10 m^2 in the middle of the plot. The infesting species of weeds within each quadrate were identified and their number was counted species wise. The average number of three samples was then multiplied by 4 to obtain the weed density per m^2.

3.6.2 Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 80°C. After drying, weight of each species was taken and expressed to g per m^2.

3.6.3 Weed control efficiency

Weed control efficiency was calculated with the following formula developed by Sawant and Jadav (1985).

$$\text{Weed control efficiency (WCE)} = \frac{\text{DWC - DWT}}{\text{DWC}} \times 100$$

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

3.6.4 Plant height

The height of the plant was determined by a 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.

3.6.5 Branches per plant

Number of branches per plant was also recorded at harvest where all the primary and secondary branches were considered in each plant.

3.6.6 Number of siliqua per plant

Number of siliquae was counted from randomly selected ten plants after harvest and averaged them to have number of siliquae per plant.

3.6.7 Siliqua length

Siliqua length was recorded from the base to the apex of each siliqua from randomly selected 10 siliqua of each treatment and then means value was calculated.

3.6.8 Number of seeds per siliqua

Total number of seed was counted from the selected 20 siliquae and averaged them to have number of seeds per siliqua.

3.6.9 1000-seed weight

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in g.

3.6.10 Yield

After threshing, cleaning and drying, total seed from the 1 m^2 area were recorded and was converted to t/ ha.

3.6.11 Stover yield

Stover obtained from each unit plot was sun-dried and weighed carefully. The dry weight of stover of central $3m^2$ area was used to record the final stover yield per plot which was finally converted to t per ha .

3.6.12 Biological yield

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

Biological yield (t per ha) = Seed yield + Stover yield.

3.6.13 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 Data analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculated and the analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Infested weed species in the experimental field

It is a general observation that conditions favorable for growing mustard are also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Five weed species belonging to four families were found to infest the experimental crop. Local name, common name, scientific name, family and morphological type of the weed species have been presented in Table 1. The density and dry weight of weeds varied considerably in different weed control treatments.

The most important weeds of the experimental plot were *Chenopodium album, Vicia sativa, Vicia hirsuta, Brassica kaber, Polygonum hydropiper and Amaranthus spinosus* respectively (Table 1).

Table 1. Weed species found in the experimental plots in mustard

SL No.	Local Name	Common name	Scientific name	Family
1	Bathua	Lambsquarter	*Chenopodium album*	Chenopodiaceae
2	Banmasur	Wild lentil	*Vicia sativa*	Fabaceae
3	Mashur chana	Common vetch	*Vicia hirsuta*	Fabaceae
4	Ban sharisha	Wild mustard	*Brassica kaber*	Brassicaceae
5	Choto bishkataly	Smart weed	*Polygonum hydropiper*	Polygonaceae
6	Kata notae	Spiny pig weed	*Amaranthus spinosus*	Amaranthaceae

4.2 Weed density

There was significant variation observed on weed density due to irrigation (Fig 1). The highest weed population (35.44) was recorded from two irrigation (I_2) and lowest weed population (34.16) was recorded from no irrigation (I_0).

Significant variation was observed on weed density throughout the growing period for different weeding treatments (Fig 2). The highest weed population (36.75) was observed in without weeding (W_0). The lowest number of weed (33.83) was observed in two weeding (W_2).

The effect of irrigation and weeding on number of total weeds was statistically significant (Table 2). The maximum total number of weeds (40.67) was found from I_2W_0 (two irrigation and no weeding) and minimum number of weeds (30.33) from three irrigation with two weeding (I_3W_2).

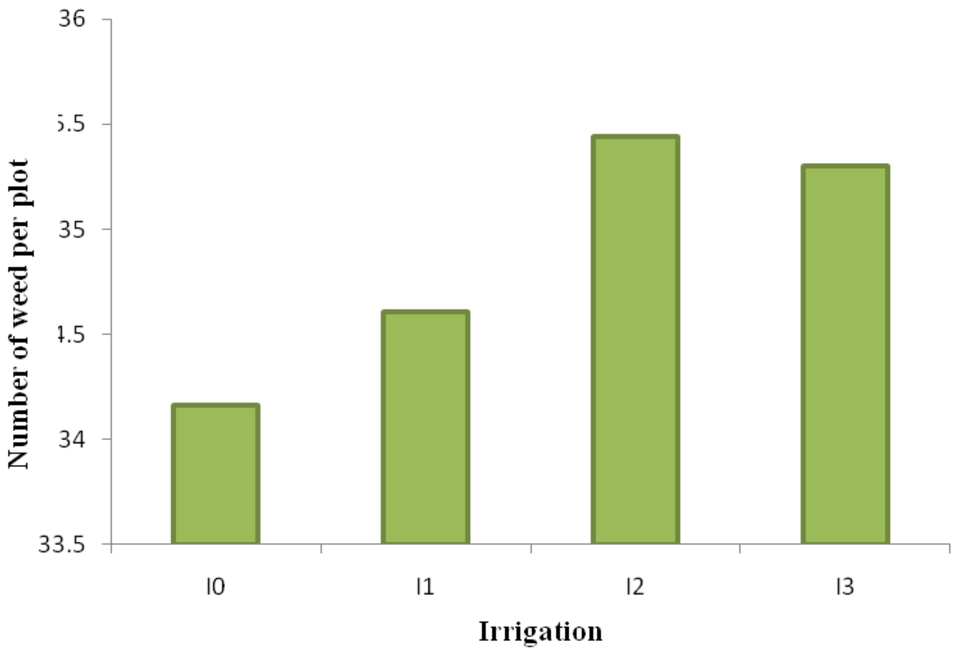

Fig. 1. Effect of irrigation on number of weed per plot of mustard

I_0 = no irrigation I_1=one irriation at 20 DAS, I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS , I_3= Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS

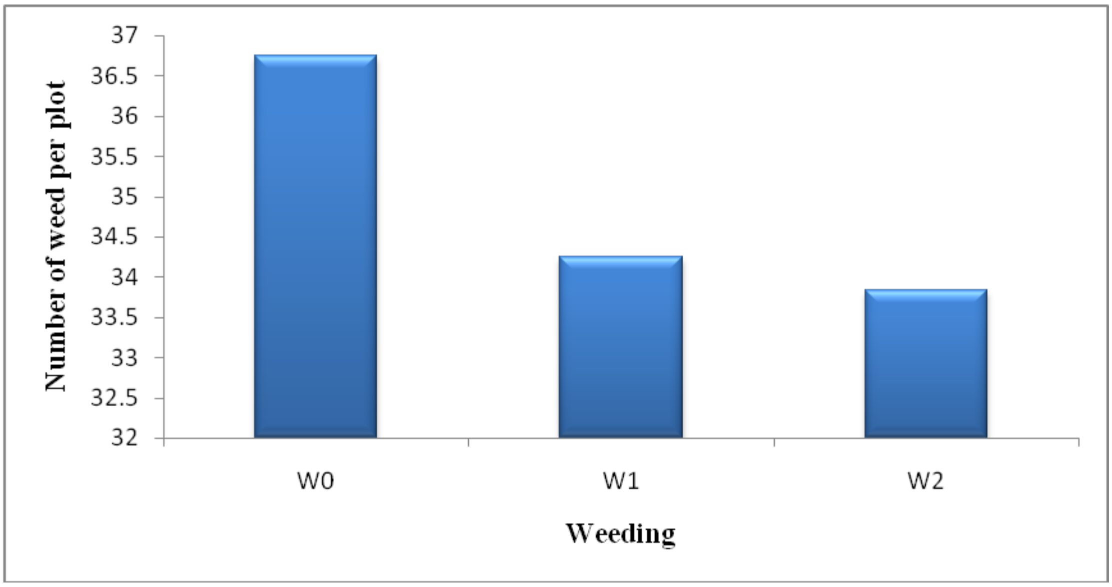

Fig. 2. Effect of weeding on number of weed per plot of mustard
W_0=No weeding (Control) W_1= One weeding at 10 DAS. W_2= Two weeding, 1st at 10 DAS + 2nd at 20 DAS

4.3 Weed biomass

Weed biomass is the materials which were dried to a constant weight. It was evident from Figure 3 that in respect of treatment irrigation weed biomass of mustard significantly varied. Figure 3 showed that I_2 significantly had highest weed biomass (11.03 g). The lowest amount of weed biomass (8.45) was found in I_0 treatment.

Different weeding showed statistically significant variation for weed dry matter. The highest weed biomass (15.65 g) was recorded from W_0 (control), whereas the lowest was observed from W_2 (8.63g) (Figure 4).

The effect of irrigation and weeding on weed biomass was statistically significant (Table 2). The maximum weed biomass (15.85 g) was found from I_0W_0 and minimum weed biomass (7.52g) from I_0W_2.

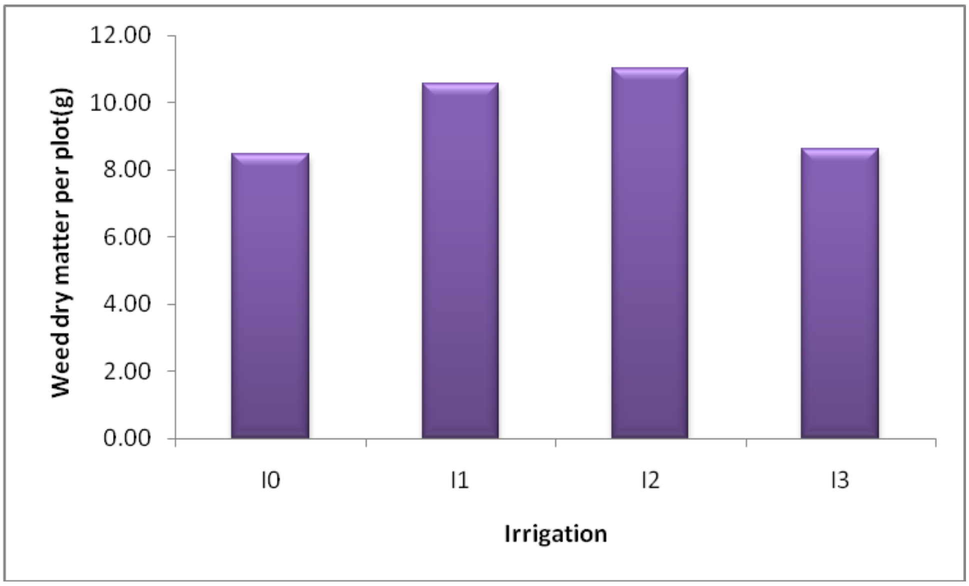

Fig. 3. Effect of irrigation on weed biomass per plot of mustard

I_0 = no irrigation I_1=one irriation at 20 DAS, I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS , I_3- Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS

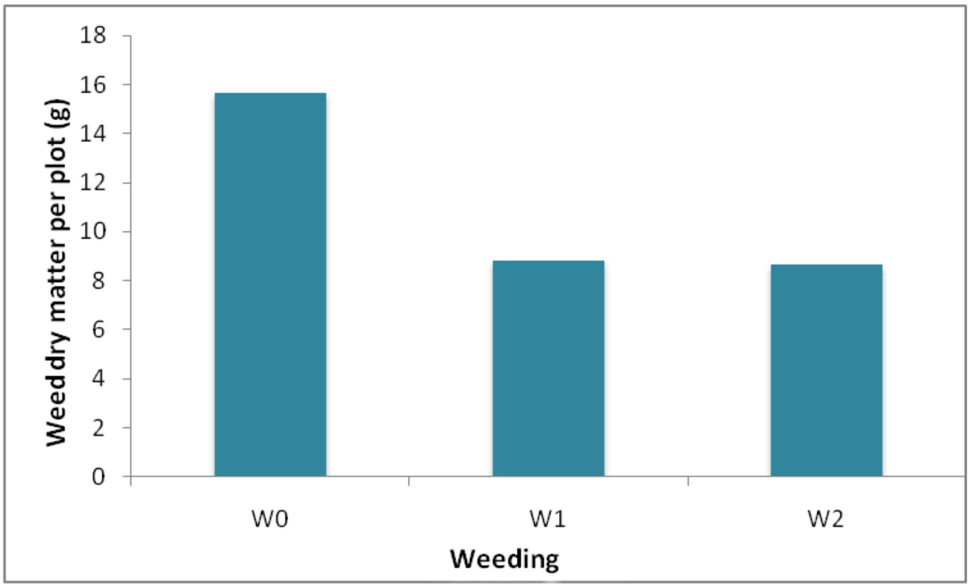

Fig. 4. Effect of weeding on weed biomass per plot of mustard

W_0= No weeding (Control). W_1= One weeding at 10 DAS. W_2= Two weeding, 1st at 10 DAS + 2nd at 20 DAS

4.4 Weed control efficiency

Weed control efficiency of mustard significantly varied due to irrigation. Figure 5 showed that I_2 significantly had highest weed control efficiency (30.41%). The lowest amount of weed control efficiency (6.49%) was found in I_0 treatment.

Different weeding showed statistically significant variation for weed control efficiency. The highest weed control efficiency (23.18%) was recorded from W_2, whereas the lowest was observed from W_0 (0.0%) (Fig.6).

The effect of irrigation and weed control methods on weed control efficiency was statistically significant (Table 2). The maximum weed control efficiency (49.65%) was found from I_0W_2 and minimum weed control efficiency (3.87%) from I_0W_1.

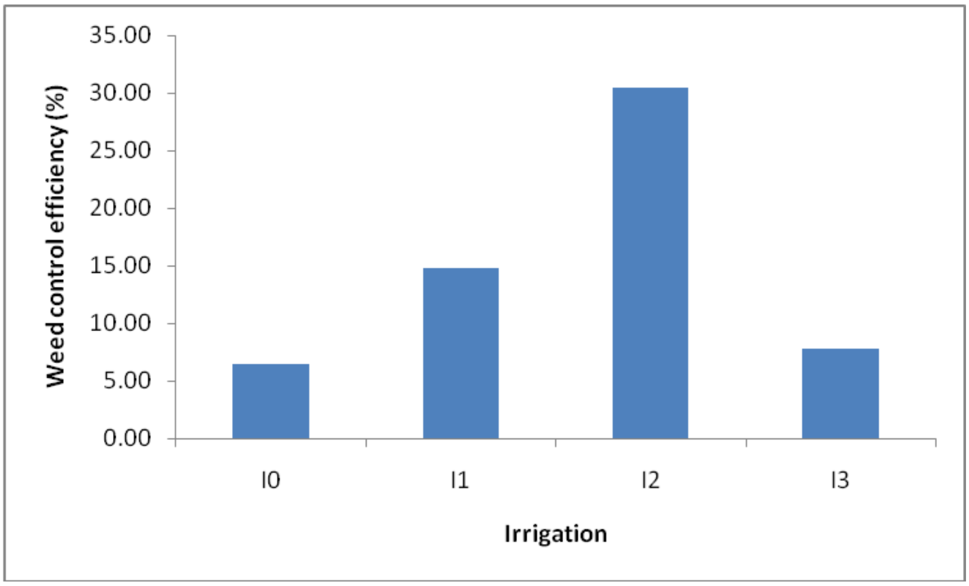

Fig. 5. Effect of irrigation on weed control efficiency of mustard

I_0 = no irrigation I_1=one irriation at 20 DAS, I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS, I_3= Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS

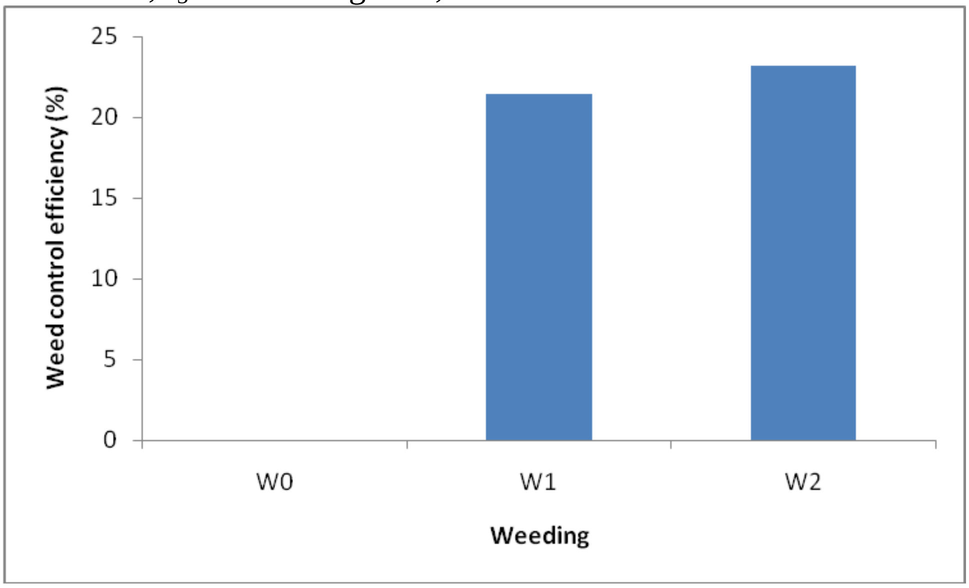

Fig. 6. Effect of weeding on weed control efficiency of mustard

W_0= No weeding (Control). W_1= One weeding at 10 DAS. W_2= Two weeding, 1st at 10 DAS + 2 nd at 20 DAS

Table. 2. Interaction effect of irrigation and weeding on number of weed per plot, dry weight of weed per plot of mustard and weed control efficiency

Treatment	Weed density per m^2	Weed biomass per m^2 (g)	Weed control efficiency (%)
I_0W_0	38.67 b	15.85 a	-
I_1W_0	34.00 f	12.38 b	-
I_2W_0	40.67 a	9.04 e	-
I_3W_0	33.67 g	9.33 d	-
I_0W_1	34.00 f	8.69 g	3.87 h
I_1W_1	34.00 f	8.91 f	28.03 c
I_2W_1	34.67 e	7.98 h	15.59 f
I_3W_1	32.67 h	8.94 f	4.10 g
I_0W_2	33.67 fg	7.52 i	49.65 a
I_1W_2	35.67 fg	10.38 c	16.15 e
I_2W_2	37.33 c	9.26 d	41.58 b
I_3W_2	30.33 i	7.63 i	19.39 d
F test	*	*	*
$S_{\bar{x}}$	3.08	1.98	1.48
CV (%)	12.33	16.91	8.9

*- significant at 5% level

4.5 Plant height

Due to different irrigations the height of mustrad plant was not significantly influenced (Table 3). Numerically, the tallest plant (101.00 cm) was recorded from I_2 (two irrigation). In contrast, the shotest plant (98.49 cm) was recorded from I_0 (no irrigation). The result corroborates with the findings of Sarker (1988) and Siag *et al.*

(1993) who observed maximum plant height in the irrigation application treatment during branching and siliqua development stages.

There was significant difference among the weeding in respect of plant height (Table 4). The tallest plant (102.2 cm) which was produced from W_2 (two weeding) was found to be similar to (100.40cm) obtained from W_1(one weeding) and the shortest plant (97.73 cm) was found in W_0 (no weeding). The results were in agreement with the findings of Khan and Tarique (2011) who found that the highest plant height was observed in completely weed free condition throughout the crop growth period with chemical weed control methods and next in two hand weeding treatment whereas lowest value was observed in no weeding treatment.

The combined use of irrigation and weeding had significant effect on plant height (Table 5). The tallest plant (107.08 cm) was found in I_2W_2 (two irrigation with two weeding) treatment combination, whereas the shortest plant (94.47 cm) was observed in I_0W_0 (no irrigation with no weeding) treatment combination which was statistically similar to 95.77cm obtained from I_0W_1 (0ne weeding with no irrigation).

4.6 Number of branches per plant

Irrigation did not significantly influence the number of branch per plant (Table 3). Numerically, the maximum number of branches per plant (7.70) was produced by I_2 and without I_0 treatment produced the lowest number of branches per plant (7.17).

Table 3. Effect of irrigation on plant height, number of branch, number of silliquae per plant, length of silliqua and number of seed per siliqua of mustard

Treatment	Plant height (cm)	Branches per plant (no.)	Siliquae per plant (no.)	Length of siliqua (cm)	Seeds per siliqua (no.)
I_0	98.49	7.17	111.9 c	4.90 b	19.37 b
I_1	100.40	7.61	122.6 b	5.17 a	19.51 b
I_2	101.00	7.70	138.8 a	5.23 a	20.06 a
I_3	99.13	7.56	124.1 b	4.91 b	19.51 b
F- test	NS	NS	*	*	*
$S_{\bar{x}}$	1.67	0.35	10.12	0.105	0.55
CV (%)	5.81	13.93	8.19	7.25	9.85

*-Significant at 5% level, NS- Non significant

I_0 = no irrigation I_1=one irriation at 20 DAS, I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS , I_3- Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS

Table 4. Effect of weeding on plant height, number of branch, number of silliqu per plant, length of silliqua and number of seed per siliqua of mustard

Treatment	Plant height (cm)		Branches per plant (no.)	Siliquae per plant (no.)		Length of siliqua (cm)	Seeds per siliqua (no.)
W_0	97.73	b	7.16	117.50	b	5.04	18.82
W_1	99.47	ab	7.47	124.10	ab	5.04	20.00
W_2	102.10	a	7.90	131.50	a	5.09	20.02
F-test	*		NS	*		NS	NS
$S_{\bar{x}}$	1.93		0.30	11.68		0.12	0.64
CV (%)	5.81		13.93	8.19		7.25	9.85

*-Significant at 5% level, NS- Non significant

W_0- No weeding (Control). W_1- One weeding at 10 DAS. W_2- Two weeding, 1st at 10 DAS + 2nd AT 20 DAS

Table 5. Interaction effect of irrigation and weeding on plant height, number of branch, number of silliquae per plant, length of silliqua and number of seeds per siliquae of mustard

Treatment	Plant height (cm)	Number of branches per plant	Number of siliquae per plant	Length of siliqua (cm)	Number of seeds per siliqua
I_0W_0	94.47 b	6.47 f	101.10 g	4.82 c	18.13 f
I_1W_0	98.47 ab	6.77 ef	106.90 g	5.11 b	18.33 f
I_2W_0	101.10 ab	6.70 ef	120.90 ef	4.89 c	17.67 g
I_3W_0	96.90 ab	7.20 de	116.50 f	5.32 a	19.63 d
I_0W_1	95.77 b	7.73 b-d	102.30 g	4.84 c	21.53 b
I_1W_1	104.70 ab	7.77 a-d	121.20 ef	5.33 a	19.77 d
I_2W_1	96.87 ab	7.97 a-c	125.80 de	4.83 c	18.43 f
I_3W_1	100.60 ab	7.90 a-c	150.40 b	5.07 b	20.33 c
I_0W_2	98.60 ab	7.40 cd	107.60 g	5.01 b	19.00 e
I_1W_2	101.90 ab	8.30 ab	139.70 c	5.07 b	20.43 c
I_2W_2	107.80 a	8.33 a	171.50 a	5.35 a	22.43 a
I_3W_2	99.93 ab	7.57 cd	128.30 d	5.03 b	19.63 d
F-test	*	*	*	*	*
$S_{\bar{x}}$	3.34	0.60	20.23	0.21	1.12
CV (%)	5.81	13.93	8.19	7.25	9.85

*-Significant at 5% level

Number of branches per plant was not significantly influenced by weeding (Table 4). The two weeding (W_2) had the highest number of branches per plant (7.90), and the lowest number of branches per plant (7.16) was obtained from no weeding (W_0).

A significant variation in the number of branches per plant was found with the interaction of irrigation and weeding (Table 5). The maximum number of branches per plant (8.33) was found in combined use of two irrigations and two times weeding treatment, which was statistically similar to 7.97, 7.90 and 7.77 obtained respectively form I_2W_1 (Two irrigation with one weeding), I_3W_1 (Three irrigation with one weeding) and I_1W_1 (One irrigation with one weeding) whereas the lowest number of branches per plant (6.47) was found in no irrigation and no weeding treatment (I_0W_0).

4.7 Number of siliquae per plant

Number of siliquae per plant is one of the most important yield contributing characters in mustard. The irrigation showed significantly variation in the number of siliqua per plant (Table 3). The maximum number of siliquae per plant (138.80) was produced by I_2 treatment and I_0 produced the minimum number of siliquae per plant (111.9), I_3 and I_1 produced respectively 124.1 and 122.6 number of siliquae per plant which was statistically similar to each other but each of them was statistically higher than 111.9 found on I_0 and was lower than 124.1. The results were partially supported by Clarke and Simpson (1978) and fully supported by Sharma ans Kumar (1989) is that irrigation increased siliquae per plant.

There was a significant difference among the weeding in the number of siliqua per plant (Table 4). The maximum number of siliqua per plant (131.50) was produced in W_2 treatment, which was statistically similar with W_1 (124.10) and the minimum number of siliquae per plant (117.5) was produced in W_0 treatment.

A significant variation was found in the treatment combinations of irrigation and weeding on number of siliqua per plant (Table 5). The maximum number of siliqua per plant (171.50) was found in I_2W_2, which was statistically higher than all other values obtained by the rest treatment combinations whereas the minimum number of siliqua per plant (101.10) was found in I_0W_0 treatment combination.

4.8 Length of siliqua

The irrigation showed variation in the length of siliqua (Table 3). I_1 and I_2 produced respectively the similar length of siliqua such as 5.17 and 5.23cm and each of which was statistically higher than the length of siliqua 4.91 and 4.90 cm produced by I_2 & $I_{0,}$ respectively.

There was a no significant difference among the weeding treatments in the length of silliqua (Table 2). Numerically, the maximum length of silliqua (5.09 cm) was produced in W_2 treatment. The minimum length of silliqua (5.04 cm) was produced in W_0 condition.

Length of silliqua indicated a significant variation among the treatment combinations of irrigation and weeding (Table 5). The maximum length of silliqua (5.35 cm) which was found in I_2W_2 treatment combination was similar to 5.33 cm and 5.32 cm obtained respectively from I_1W_1 and I_3W_0 whereas the minimum length of silliqua (4.82 cm) was found inW_0I_0 treatment.

4.9 Number seeds per silliqua

The irrigation showed variation in the number of seeds per silliqua (Table 3). The maximum number of seeds per silliqua (20.06) was produced by I_2, whereas I_0 produced the minimum number of seed per silliqua (19.37) but I_2 and I_1 was found similar to each other obtaining the number of seeds per siliiqua as 20.06 and 19.51 respectively. Seeds per siliqua was increased with the increased irrigation level due to the supply of adequate soil moisture which helped to produce the longer siliqua and have more number of seeds. This phenomena was reported by Prasad and Eshanullah (1988), Sarker and Hassan (1988), Sharma and Kumar (1989a).

No significant variation was found in number of seed per silliqua due to weeding variation (Table 4). Numerically, the maximum number of seed per silliqua (20.02) was produced in W_2 treatment. The minimum number of seed per silliqua (18.82) was produced in W_0 condition.

Number of seed per silliqua indicated a significant variation among the treatment combinations of irrigation and weeding (Table 5). The maximum number of seed per silliqua (22.43) was found in W_2I_2 treatment combination, whereas the minimum number of seed per silliqua (18.13) was found in I_0W_0 treatment, which was similar to I_1W_0 (18.33).

4.10 Thousand Seed weight (g)

Irrigation did not significantly influence the thousand seed weight (Table 6). Numerically, the highest thousand seed weight (3.20 g) was produced by I_2 and the lowest thousand seed weight (2.94 g) was produced by I_0. The result was supported by Sarker and Hassan (1988), Sharma and Kumar (1989b) and Sarker *et al.* (2000).

The weight of 1000-seed was not significantly influenced by weeding (Table 7). Numerically, the highest thousand seed weight (3.18 g) was obtained from W_2 treatment. The lowest thousand seed weight (2.98 g) was obtained from W_0 treatment.

1000-seed weight was significantly affected by the interaction effect of irrigation and weeding (Table 8). The highest thousand seed weight (3.40 g) was found in I_2W_2 treatment combination, whereas the lowest thousand seed weight (2.80 g) was found in I_0W_0 treatment. Of course, the treatment combination of I_3W_2, I_1W_2, I_3W_1, I_2W_2 and I_3W_0 produced respectively the similar 1000-seed weight as 3.23g, 3.20g, 3.20g, and 3.14g.

Table 6. Effect of irrigation on the yield and yield contributing character of mustard

Treatment	Thousand seed weight (g)	Seed Yield (t/ha)	Stover yield (t/h)	Biological yield (t/ha)	Harvest index (%)
I_0	2.94	1.34 d	1.37 b	2.71 d	48.72
I_1	3.01	1.77 c	1.67 ab	3.44 c	49.50
I_2	3.20	1.98 a	1.98 a	3.97 a	51.16
I_3	3.16	1.86 b	1.77 a	3.63 b	50.64
F test	NS	*	*	*	NS
$S_{\bar{x}}$	9.62	0.082	0.07	0.15	1.19
CV (%)	5.51	8.18	5.54	5.80	8.31

*-Significant at 5% level, NS- Non significant

I_0 = no irrigation I_1=one irrigation at 20 DAS, I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS , I_3- Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS

Table 7. Effect of weeding on the yield and yield contributing character of mustard

Treatment	Thousand seed weight	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
W_0	2.98	1.60 c	1.55 b	3.15 b	50.15
W_1	3.07	1.74 b	1.75 a	3.54 a	48.64
W_2	3.18	1.88 a	1.80 a	3.63 a	51.22
F test	NS	*	*	*	NS
$S_{\bar{x}}$	11.11	0.11	0.08	0.18	1.3851
CV (%)	5.51	8.18	5.54	5.80	8.31

*-Significant at 5% level, NS- Non significant

W_0= No weeding (Control). W_1= One weeding at 10 DAS. W_2= Two weeding, 1st at 10 DAS + 2 nd at 20 DAS.

Table 8. Interaction effect of irrigation and weeding on the yield, yield contributing characters and harvest index of mustard

Treatment	Thousand seed weight (g)	Seed yield (t/ha)	Stober yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
I_0W_0	2.80 c	1.28 i	1.24 d	2.64 g	47.24 b-d
I_1W_0	2.97 bc	1.79 f	1.61 a-d	3.40 e	52.11 a-c
I_2W_0	3.00 bc	1.75 f	1.92 a-c	3.67 cd	46.89 cd
I_3W_0	3.17 ab	1.45 h	1.42 cd	2.86 f	49.41 a-d
I_0W_1	2.97 bc	1.33 i	1.51 b-d	2.84 f	46.70 d
I_1W_1	3.03 bc	1.60 g	1.73 a-d	3.32 e	47.69 b-d
I_2W_1	3.07 bc	2.18 b	1.99 ab	4.22 a	51.19 a-d
I_3W_1	3.20 ab	1.85 e	1.91 a-c	3.77 c	48.99 a-d
I_0W_2	2.90 bc	1.40 h	1.37 d	2.65 g	52.20 ab
I_1W_2	3.20 ab	1.93 d	1.68 a-d	3.60 d	53.53 a
I_2W_2	3.40 a	2.88 a	2.04 a	4.26 a	53.68 a
I_3W_2	3.23 ab	2.02 c	1.98 ab	4.01 b	50.41 a-d
F test	*	*	*	*	*
$S_{\bar{x}}$	19.24	0.192	0.15	0.31	2.3991
CV (%)	5.51	8.18	5.54	5.80	8.31

*-Significant at 5% level, NS- Non significant

4.11 Seed yield (t/ha)

The seed yield of mustard per m^2 was converted into per hectare, and has been expressed in metric tons (Table 6). The different dose of irrigation had significant effect on the yield of seed per hectare. The highest seed yield per ha (1.98 t) obtained from the treatment I_2 was significantly different from those of the other treatments, while I_0 gave the lowest seed yield per ha of 1.34 t. Of course, the seed yield per ha (1.86 t) obtained from the treatment I_3 was statistically higher than 1.77 t per ha obtained from I_1. In fact, irrigation at seed maturity stage in the treatment of three irrigation might have caused damage in seed which resulted in the decrease of seed yield. In control condition, high mortality of seedlings resulting from shortage of soil moisture might have drastically reduced the yield. Samui *et al.* (1986) and Malavia *et al.* (1988) reported similar results in mustard in respect of seed yield. Under no irrigation treatment internal moisture deficit led to lower plant height, failed to increase in growth parameters and reduce 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 (1989b) 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 weeding (Table 7). The highest yield of seed (1.88 t/ha) was obtained from W_2 (Two weeding) while W_0 gave the lowest (1.60 t/ha) yield. The yield per hectare (1.74 t) obtained by the rest treatment (W_1) was significantly different from others.

The combined effect of irrigation and weeding was significant on yield of seed per hectare (Table 8). The highest yield of seed per hectare (2.28 ton) was obtained from I_2W_2 (two irrigation with two weeding) treatment combination. The lowest yield of seed per hectare (1.28 ton) was obtained from I_0W_0 (no irrigation and no weeding) treatment, but the rest combination treatment were significantly different from each other.

4.12 Stover yield (t/ha)

The stover yield of mustard per m^2 was converted into per hectare, and has been expressed in metric tons (Table 6). The different dose of irrigation had significant effect on the stover yield per hectare. The highest stover yield per hectare (1.98 t) was observed from $I_{2,}$ treatment and it was statistically similar to 1.77 t and 1.67 t obtained respectively from I_3 and I_1. I_0 gave the lowest stover yield per ha as 1.37t but the rest treatments were significantly different from each other. It is interesting that irrigation treatment helped to produce tallest plant, more number of branches per plant and number of siliqua plant which ultimately increased stover yield. Patel *et al.* (1991), Sarker *et al.* (1988) 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 weeding Table 7 The highest yield of stover (1.80 t) was obtained from W_1 (one weeding), which was statistically similar with W_2, while W_0 gave the lowest (1.55 t/ha) yield.

The combined effect of irrigation and weeding was significant on yield of stover per hectare (Table 8). The highest stover yield per hectare (2.04 tones) obtained from I_2W_1

was statistically similar to 1.99 t, 1.92 t, 1.91 t, 1.73 t and 1.60 t respectively obtained from I_3W_2, I_2W_2, I_2W_0, I_3W_1, I_1W_1 and I_1W_0. The lowest yield of stover per hectare (1.37 tones) was obtained from I_0W_0 treatment.

4.13 Biological yield (t/ha)

The different dose of irrigation had effect on the biological yield per hectare. The biological yield ton per hectare obtained by the 4 different irrigation treatment differed significantly from one other and the highest biological yield ton per hectare (3.97) was obtained from the treatment I_2 (1st at 20DAS + 2nd at 40 DAS) and the lowest (3.44t) was obtained I_0 (no irrigation) (Table 6).

The biological yield of mustard varied significantly due to the weeding (Table 7). The treatments W_1 and W_2 produced statistically the similar biological yield ton per hectare as 3.63 t and 3.54 t, respectively while the lowest biological yield per hectore (3.15 t) was obtain from W_0 (no weeding).

The combined effect of irrigation and weeding was significant on biological yield per hectare (Table 8). The highest biological yield per hectare (4.26 t) was obtained from I_2W_2 treatment combination. The lowest biological yield per hectare (2.65 tones) was obtained from W_0I_0 treatment. The treatment I_2W_1 produced statistically the similar biological yield ton per hectare (4.22) with the highest biological yield of 4.26 t but the biological yield ton per hectare by the rest treatment combinations more or less differed significantly from one another.

4.14 Harvest index (%)

The different irrigation had no significant effect on harvest index of mustard. Numerically, the maximum harvest index (51.16 %) was obtained from I_2 (one irrigation) and the minimum harvest index (48.72%) was obtained from I_0 treatment (Table 6).

The harvest index also did not vary significantly due to the application of different weeding (Table 7). Numerically, the highest harvest index (51.22%) was obtained from W_2 while W_1 gave the lowest (48.64 %) harvest index.

The combined effect of irrigation and weeding was significant on harvest index (Table 8). The highest harvest index (53.68 %) was obtained from I_2W_2 treatment combination. The lowest harvest index (46.70 %) was obtained from I_0W_1 treatment.

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2011 to February 2012 to investigate the effect of irrigation and weeding on the yield components and yield of mustard (cv-SAU sarisha-3). The treatment consisted of four irrigation viz. I_0 = no irrigation, I_1=one irriation at 20 DAS (just before flowering), I_2= Two irrigation, 1st at 20 DAS + 2nd at 40 DAS (during siliqua formation), I_3= Three irrigation, 1st at 20 DAS + 2nd at 40 DAS + 3rd at 60 DAS (during seed maturation stage) and three different weeding viz. W_0= No weeding (control), W_1= One weeding at 10 DAS, W_2= Two weeding, 1st at 10 DAS + 2nd at 20 DAS. The experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed significant variations among the treatments in respect of majority of the observed parameters.

Results revealed that irrigation did not affect significantly the plant characters of mustard such as branches per plant. But the yield attributes of the mustard except 1000 seed weight varied significantly due to the effect of irrigation and the highest number of siliquae per plant (138.8), the highest length of siliqua (3.23 cm) and the highest number of seeds per siliqua (20.06) were found to be obtained by the treatment irrigation I_2 while the corresponding lowest values such as 111.9, 4.90 cm and 19.37 were respectively obtained by the treatment I_0. The treatment I_2 also recorded the highest values of 1.98t, 1.98t and 3.97t respectively for the parameter of seed yield per ha, stover yield per ha and biological yield per ha. The corresponding lowest values viz 1.34t, 1.37t and 2.71t respectively were recorded by the treatment $I_{0.}$ Harvest index % did not vary significantly due to variation on irrigation.

Among the plant characters and yield attributes of mustard, only plant height and number of siliqua per plant varied significantly due to the variation of weeding and W_2 (1^{st} weeding at 10 DAS and 2^{nd} weeding at 20 DAS) obtained the highest plant height 102.10cm and produced the highest numbers of siliqua per plant (131.50). On the other hand, W_0 (no weeding) recorded the respective lowest values as 97.37cm and 117.50. Keeping consistence with the performance of yield attributes of mustard per ha, W_2 also obtained the highest seed yield per ha, highest stover yield per ha and the highest biological yield per ha which were 1.88t, 1.80t and 3.63t, respectively. Here W_0 also obtained the corresponding lowest value as 1.60t, 1.55t and 3.15t. Harvest index% variation was insignificant to weeding.

Though in the individual effect of the treatment, irrigation and weeding, some of the parameters were not found to vary significantly, but due to their interaction effect, all of the parameters of the mustard studied were found to vary significantly. In the interaction effect the parameters of both yield attributes and yield of the mustard, I_2W_2 recorded the highest values. Control treatment i.e the combination of no irrigation and no weeding (I_0W_0) obtained the lowest values in all the parameters. The highest seed yield per ha (2.88t), the highest stover yield per ha (2.04 t) and the highest biological yield per ha (4.26t) except the harvest index (where it was with the treatment I_0W_1)

were recorded from I_2W_2 and the corresponding lowest values as 1.28t, 1.24t and 2.64t were recorded from I_0 W_0.

In context to the result obtained in the experiment, it may be concluded that-

1. Growth, yield and yield contributing parameters of mustard significantly varied with irrigation and weeding.
2. The combined use of two irrigation with two weeding would be beneficial to increase the seed yield of mustard variety SAU sarisha 3 under the present agro-ecological zones of Bangladesh.

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 to substantiate further with different varieties of mustard.
3. It needs to conduct more experiments with irrigation and weeding whether it can regulate the growth, yield and seed quality of mustard SAUsarisha-3.

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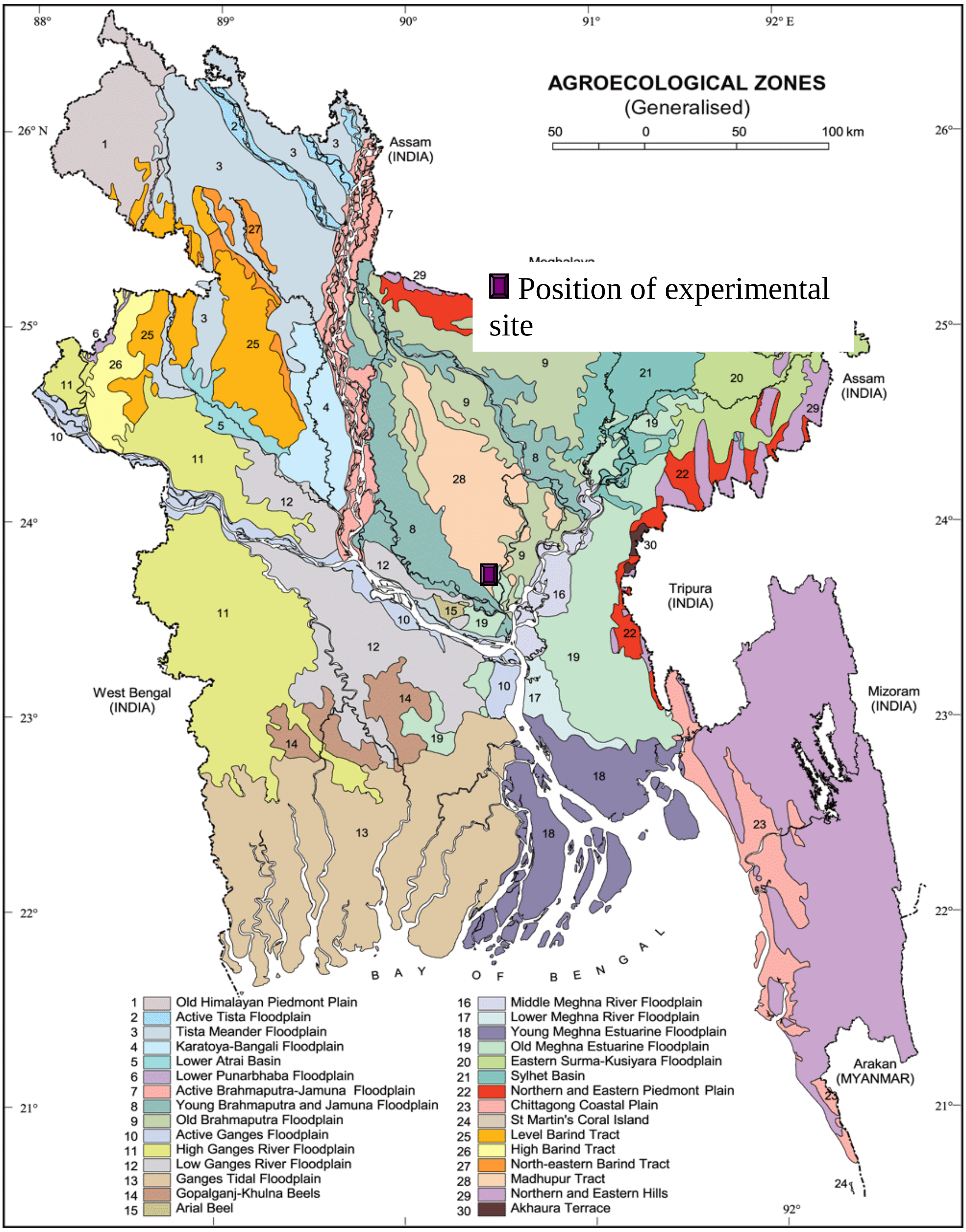
APPENDICES

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 2011-2012

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