COMPARATIVE EVALUATION OF RECOMMENDED MANAGEMENTS IN MUSTARD

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COMPARATIVE EVALUATION OF RECOMMENDED MANAGEMENTS IN MUSTARD

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TO

MY ADORED PARENTS

AND

WIFE

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CERTIFICATE

This is to certify that the thesis entitled **"COMPARATIVE EVALUATION OF RECOMMENDED MANAGEMENTS IN MUSTARD"** submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in, **Agronomy** embodies the result of a piece of bonafide research work carried out by **MITHUN RAY**, Registration Number: **06-1875** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December 30, 2013

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COMPARATIVE EVALUATION OF RECOMMENDED MANAGEMENTS IN MUSTARD

ABSTRACT

The present piece of work was conducted at the Agronomy Field of the Sher-e-Bangla Agricultural University, Dhaka during the period from (November- February) 2011-2012. The experimental area is situated under the Modhupur Tract (AEZ-28). The study was conducted to compare the performance of different recommended managements on the growth and yield of mustard var. BARI Sharisha-13. The experimental treatments included T_1 = Control (no modern managements), T_2 = Fertilizer, irrigation, weeding, fungicide, mulching, insecticide, row arrangement), T_3 = All managements except irrigation T_4 = All managements except weeding, T_5= All managements except line sowing, T_6 = All managements except mulching, T_7 = All managements except insecticide, T_8 = All managements except fungicide, T_9 = All managements except fertilizers, T_{10} = All managements except insecticide and fungicide, T_{11} = All managements except irrigation and weeding, T_{12} = All managements except irrigation, weeding and fertilizer,

T_{13} = All managements except mulching and weeding, T_{14} = All managements except weeding and fertilizer, T_{15} = All managements except insecticide, fungicide and irrigation; and T_{16} = All managements except irrigation, weeding and insecticide. Results showed that treatment T_6 gave significantly the maximum number of secondary branches (5.1), siliquae plant^{-1} (169) and chaff weight (3.1 t ha^{-1}). Treatment T_7 gave the maximum number of primary branches (4.4), siliquae plant^{-1} (162.3) at 70 DAS and stover yield (5.7 t ha^{-1}). Treatment T_{13} gave the maximum biological yield (9.56 t ha^{-1}). Seed yields of T_5 (1.56 t ha^{-1}), T_6 (1.67 t ha^{-1}), T_7 (1.50 t ha^{-1}), T_2 (1.30 t ha^{-1}), T_4 (1.5 t ha^{-1}), T_8 (1.50 t ha^{-1}) and T_{13} (1.56 t ha^{-1}) were statically similar but significantly higher than other treatments. However, the benefit-cost ratio of T_{13} (2.59) was much higher than those of T_5 (1.89), T_6 (2.31), T_7 (2.01), T_2 (1.64), T_4 (1.81) and T_8 (1.85).

LIST OF CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BARI	=	Bangladesh Agricultural Research Institute
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAS	=	Days after sowing
DAT	=	Days after transplanting
^{0} C	=	Degree Centigrade
DF	=	Degree of freedom
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram
HI	=	Harvest Index
hr	=	hour
kg	=	kilogram
LSD	=	Least significant difference
m	=	Meter
m^2	=	meter squares
me	=	Milli-equivalent
MV	=	Modern variety
mm	=	Millimeter
viz.	=	namely
N	=	Nitrogen
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
PU	=	Prilled urea
SAU	=	Sher-e- Bangla Agricultural University
t ha^{-1}	=	Tons per hectare
USG	=	Urea super granules
Zn	=	Zinc
µg	=	Microgram

Chapter 1

Introduction

INTRODUCTION

Mustard is an oil seed crop that belongs to the genus *Brassica* of the family *Brassicaceae*. It is one of the main cultivable edible oil seed crops of Bangladesh. It covers the land area of 216800 hectares in Bangladesh producing about 183500 metric tons of oilseeds (BBS, 2007). Bangladesh occupies the 5th place in respect of total oilseed production in the world and occupies the first position in respect of area and production among the oil crops (BBS, 2010). It is the most important popular oil crop which is grown in rabi season in Bangladesh. Only a few decades ago, in Bangladesh mustard oil was the exclusive cooking oil, medicinal ingredient and supplied fat in our daily diet.

However, the yield of this crop in Bangladesh is much lower as compared to other countries. The average yield of rapeseed-mustard in Bangladesh is very low (0.76 t ha^{-1}) that is less than 50% of the world average (FAO, 2004).

Bangladesh is deficit in edible oil, which cost 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 importing edible oil is a regular phenomenon of this country (BBS, 2010). Every year Bangladesh imports 2085864 metric tons of edible oil to meet up the annual requirement of the country, which costs Tk. 64430 million (BBS, 2007). 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 other reasons which hinder mustard cultivation in rabi season (BARI, 2008). Recently BARI has released some mustard varieties, which have high yield potential under the circumstance the farmers are getting lower yield of mustard with their local varieties with poor crop management practices.

The yield of mustard can be augmented by adopting modern and recommended technologies along with the use of high yielding varieties. Fertilizer is the depending source of nutrient that can be used to boost up growth and yield of rapeseed (Sinha *et al.,* 2003). High yielding varieties of mustard is very responsive to fertilizers especially nitrogen (Patel *et al.,* 2004). This element has tremendous influence on plant height, dry matter accumulation and all the yield attributes (Tripathi and Tripathi, 2003). However, excessive use of this element may produce too much of vegetative growth and thus fruit production may be impaired (Sheppard and Bates, 1980). HYVs are also responsive to nitrogenous fertilizer more under irrigated condition than under rainfed condition (Islam *et al*., 1992) encouraging the flow of assimilates from flowers to developing siliquae and ultimately the seed. But the nitrogen reserve of Bangladesh soil is very low due to warm climate accompanied by centuries of cultivation in the same piece of land (Porteh and Islam, 1984). Hoque *et al.* (1987) observed that yield increase was highly significant for two irrigations applied on rapeseed, one at the early vegetative stage and the other at the initial siliquae formation stage. The maximum plant height, siliquae and yields were also observed for using recommended phosphorus 75 kg ha^{-1} (Birbal *et al.* 2004). Row spacing had remarkable effect in producing more number of fertile siliquae plant^{-1}. Wider spacing facilitated favorable environment for producing more siliquae than closer spacing

(Siddiqui,*et al* 1999). The effect of 5 levels of irrigation and 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard were also evaluated and were found to affect the yield of mustard (Raut *et al.* 2003).

On the other hand, deficiency of fertilizer, irrigation, mulching, weeding, row arrangement, insecticide, fungicide also hampers the production of mustard.

However, considering the high cost involvement, farmers are hesitant to grow mustard that necessitates prioritizing and economizing the use of the recommended technologies associated in the cultivation of this crop. Therefore, the efficient more profitable managements need to be identified (Ibrahim *et al.*, 1989).

Keeping all the points mentioned above, the present piece of research work was under taken with the following objectives:-

i. To compare the performance of different recommended managements in respect of seed yield of mustard.

ii. To compare the performance of different recommended managements in respect of profitability of mustard production.

Chapter 2

Review of literature

REVIEW OF LITERATURE

Effect of nitrogen on growth attributes

Plant height

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30 and 60 kg N ha^{-1} under irrigated or non-irrigated condition in a field experiment. They observed that plant height increased with increasing rate of nitrogen and were higher under irrigated than non-irrigated condition.

Singh *et al.* (2002) also reported that mustard plant height increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

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

Islam and Mondal (1997) showed that application of nitrogen at the rate of 0, 100, 200, 300 kg ha^{-1}, the maximum plant height of rapeseed was found 93.6 cm at 300 kg N ha^{-1}.

Branches plant^{-1}

Singh and Prasad (2003) studied the effect of nitrogen rates (60, 120 and 180 kg ha^{-1}) and application of N application (row and even application) on the performance of Indian mustard cv. Basanti. They found that N at 120 kg ha^{-1} produced higher number of branches per plant compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the number of branches per plant.

Tripathi and Tripathi (2003) performed an experiment to investigate the effect of N levels (80, 120, 160 and 200 kg ha^{-1}) on the branches number of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and 60 days after sowing. Results showed that the number of primary branches per plant increased up to 200 kg N ha^{-1}.

Sharma and Jain (2002) conducted an experiment on mustard with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) in a cropping system and observed that 80 kg N ha^{-1} resulted with highest number of branches (24.4) per plant.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard *(B. juncea)* and found that the highest number of branches per plant was obtained with the broadcast method of N application.

Leaf area index and dry matter production

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N ha^{-1} under irrigated or non-irrigated condition. They observed that dry matter accumulation increased with increasing rate of nitrogen.

Saikia *et al.* (2002) estimated that the total dry matter of Indian mustard significantly responded with the increasing levels of nitrogen (0, 30, 90, 120 and 150 kg ha^{-1}).

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard *(B. juncea)*. They found highest total dry matter at harvest with the application of 120 kg N ha^{-1}.

Singh *et al.* (2002) also concluded that dry matter accumulation plant^{-1} in mustard was increased significantly with successive increased in nitrogen up to 120 kg ha^{-1}.

Siliquae plant^{-1}

Singh and Prasad (2003) conducted an experiment to study the effect of nitrogen rates (60, 120 and 180 kg ha^{-1}) on the performance of Indian mustard cv. Basanti. They observed that N at 120 kg ha^{-1} produced higher number of siliquae per plant (48.03). The N level higher than 120 kg ha^{-1} did not increase the number of siliquae significantly.

Sharma and Jain (2002) studied with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) along with the cropping system and found that the application of 80 kg N ha^{-1} produced the highest number of siliquae per plant of mustard.

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed to investigate the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}). He observed that adequate N fertilization is important in increasing the number of siliquae per plant and observed highest siliquae number per plant of summer oilseed rape at the rate of 160 kg N ha^{-1}.

Singh (2002) also reported that in mustard siliquae per plant increased significantly with successive increased in nitrogen up to 120 kg ha^{-1}.

Seeds siliqua^{-1}

Sharma and Jain (2002) conducted an experiment with different levels of nitrogen and observed that the application of 80 kg N ha^{-1} resulted in the highest number seeds (15.3) per siliqua in mustard.

Shukla *et al*. (2002) conducted an experiment to study the effect of nitrogen for Indian mustard *(B. juncea).* They obtained maximum number of seeds per siliqua when 120 kg ha^{-1} nitrogen was applied.

Tarafder and Mondal (1990) reported from an experiment conducted to determine the effect of nitrogen and sulphur on seed yield of mustard (var. Sonali Sharisa) and found that the combine effect of nitrogen and sulphur fertilizers increased the number of seeds per siliqua.

1000-seed weight

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed to investigate the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}). He observed that adequate N fertilization was important in increasing 1000- seed weight in summer oilseed rape and suggested that the rate of 160 kg N ha^{-1} will be adequate for the crop to meet its N requirements. 1000-seed weight differs with nitrogen levels that enhanced yield.

Singh (2002) conducted an experiment with Varuna variety of mustard with 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased 1000-seed weight. However, the significant increase in 1000 seed weight was recorded in 120 kg N ha^{-1}.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard *(B. juncea).* They obtained maximum 1000-seed weight with the application of 120 kg N ha^{-1}.

Singh and Saran (1989) set up an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased 1000-seed weight.

Seed yield

Arthamwar *et al.* (1996) conducted an experiment with mustard variety (Pusa Bold and T-59) having 3 levels of N (0, 50 and 100 kg). Result showed that highest seed yield was obtained with N at 100 kg ha^{-1} (1.20 t ha^{-1}).

BARI (1999) investigated 4 levels of nitrogen as (0, 80, 120, 140 kg ha^{-1}) on different varieties of mustard and yields were found correspondingly 493.3, 833.3, 940.0, 993.7 kg ha^{-1}.

Davaria and Mehta (1995) also reported that increasing nitrogen rate from 25 to 75 kg ha^{-1} increased seed yield from 2.07 - 2.41 t ha^{-1}.

Hossain and Gaffer (1997) conducted a trial with 5 levels of nitrogen at (0, 100, 150, 200, 250 kg ha^{-1}) on rapeseed and maximum yield was found 1.73 t ha^{-1} with 250 kg N ha^{-1}.

Kumar and Singh (2003) reported significant increase in mustard seed yield (1.6 t ha^{-1}) with nitrogen at 150 kg ha^{-1}.

Ozer (2003) studied the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}) on two cultivars of rapeseed. He observed that adequate N fertilization is important in yield formation in summer oilseed rape and suggested that the rate of 160 kg N ha^{-1} will be probably adequate for the crop to meet its N requirements.

Miah *et al*. (2004) observed that the seed yield was higher with application of urea super granules compared to application of urea.

Effect of Irrigation

1.1 Plant height

Tomar *et al.* (1992) found a relationship between irrigation levels and plant height of torio. In an experiment, plant height was increased with the increasing levels of irrigation. Plant height was greater with 2 irrigation at branching and siliqua development stage and it was highest compared to one irrigation at branching stage and without irrigation.

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 irrigation (one at flowering and one at fruiting stage).

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.

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

Dala (1963) suggested for one irrigation at the blooming stage in brown sarson (*brassica Campestris* var. *Sarson*).

Patel and Shelke (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.

1.3 Number of branches plant^{-1}

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

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

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

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

1.4 Number of siliquae plant^{-1}

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

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

Tomar *et al*. (1992) conducted an experiment to observe the effect of irrigation at 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 were found plant^{-1} when two irrigations were applied. One irrigation and without irrigation produced lower siliquae plant^{-1}.

1.5 Number of seeds siliqua^{-1}

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

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

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

1.6 Weight of 1000-seed

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

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

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.

1.7 Grain yield

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

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

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

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

1.8 Stover yield

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

1.9 Biological yield

Mitra *et al.* (2010) demonstrated that biological yield, harvest index and siliquae productions plant^{-1} were positively correlated with higher seed yield of rapeseed and mustard but number of seed per siliqua was negatively correlated.

1.10 Harvest index

Mitra, *et al.* (2010). observed in an experiment with mustard (*Brassica juncea*) cv. Varuna that two irrigation at pre-flowering and seed development stages gave higher harvest index. They also observed that irrigation at pre-flowering stage gave higher harvest index value than those of irrigation at seed development stage or without irrigation. However, information was very scarce regarding the effect of irrigation on harvest index of rapeseed.

Srivastava *et al. (*1988) observed in an experiment with mustard (*Brassica juncea*) cv. Varuna that two irrigations 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.

1.11 Effect of variety

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

Effect of weeding

Competition of mustard with weed

Chattopadhyay, *et al.* (2001). conducted an experiment on oilseed crops and reported that factors associated with crop losses due to weeds. They found that the yield loss generally increasing wild oat population. Crop quality was reduced due to weeds.

Joshi *et al.* (1991). studied the effect of weeding and weed free conditions on the growth and yield of mustard (*Brassica juncea).* They found that the maximum reduction in seed yield due to weed occurred between 20 and 40 days of growth in mustard.

Chemale and Fleck (1984) studied crop weed competition in various crop including mustard. He conducted an experiment on sandy loam soil to study the nature and magnitude of crop weed competition in intercropped chickpeas cv. Radhey/mustard cv. Varuna (4.1 row ratio). The loss of seed yield caused by crop competition with weeds until the time of crop maturity was 34% in mustard.

Weeds of mustard crop

Karim and sinha (1994) reported most prominent weeds of mustard crop as *Cyperus rotunus, Cynodon dactylon, Paspalum scrobiculatum, Alternanthera sessilis, Panicum repens, Hygrophila polyperma, Plygonum plebjum, Eclipta alba, Digitaria sanguinalis, Leucus aspera, and Alternanthera philoxeroides.*

Ghosh *et al.* (1994) conducted an experiment on weed in mustard in sandy loam soil at Kharagpur, India during 1987-89. The most problematic weeds were *Digitaria sanguinalis. Echinochloa crus-galli, Cyperus rotundus, Cynodon dactylon, Croton sperciflora and Eclipbta alba.*

Rajput *et al.* (1994) studied the weed control on mustard. They identified most problematic weeds were *Boerhavia diffusa, Cyperus rotundus, Chenopodium album, Trianthema monogana, Asphodelus tenuifolius, Melilotus indica and Convlvulus arvensis.*

Weed dry matter

In Faozabed, India, Singh and Singh (1995) conducted trials during the winters of 1985-86 and 986-87 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 (DAS), hoeing 25 DAS and hand weeding 35 DAS, application of preem.

Plant height

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

Number of branches per plant

In an experiment, Gaffer (1984) observed that primary branches plant^{-1} of mustard were favorable increased with the spell of weed free periods.

Number of siliquae per plant

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

Number of seeds per siliquae

Chemale and Fleck (1984) conducted an experiment on mustard cultivars on competition with *Euphorbia microphylla.* They observed that the number of seeds pod^{-1} decreased with increasing weed density.

Seed yield

Roebuck *et al.* (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%.

2.2 Effect of phosphorus

Plant height

Birbal *et al.* (2004) conducted an experiment on mustard in India during the 1996/97 and 1997/98 rabi season with 4 levels of phosphorus viz. 0, 25, 80 and 75 kg ha^{-1}. The maximum plant height was observed with 75kg p ha^{-1}.

Chaubey *et al.* (2001) performed an experiment during the rabi season to evaluate the response of mustard *(brassica juncea)* with 3 levels of phosphorus. They observed that plant height increased significantly with the increasing of P_2O_5 up to 60 kg ha^{-1}.

Number of branches per plant

Chaubey *et al.* (2001) preformed and experiment on mustard during the rabi season in India with 3 levels phosphorus viz. 0, 40 and 60 kg ha^{-1}. They reported that number of branches per plant increasing with the increasing level of phosphorus up to 60 kg P_2O_5 ha^{-1}.

Birbal *et al.* (2004) carried out an experiment on mustard in India during 1996/97 and 1997/99 rabi seasons with 4 levels of phosphorus viz. 0, 25, 50 and 75 kg P ha^{-1}.

Number of siliquae per plant

Sumeria *et al.* (2003) reported that P has a great influence on the yield attributes of mustard *(Brassica juncea)*. He conducted an experiment during rabi season in India with 3 levels of phosphorus viz. 20, 40, and 60 kg ha^{-1}. He observed that application of 60 kg P ha^{-1} significantly increased the number of siliquae per plant.

Singh (2002) conducted an experiment during 1998/99 and 1999/2000 to findout relationship between the phosphorus and yield attributes of Indian mustard (*Brassica juncea*) with 5 levels of phosphorus viz. 1, 15, 30, 45 and 60 kg ha^{-1}. The maximum siliquae number per plant was observed with 45 kg p ha^{-1}.

Length of siliqua

Ram *et al.* (1999) conducted an experiment in India and reported that application of phosphorus influenced the length of siliqua. The maximum leangth of siliqua of mustard was observed with 15 kg P_2O_5 ha^{-1}over the control.

Verma *et al.* (2002) studied the response of Indian mustard to 20, 45 and 60 kg P_2O_5 ha^{-1} and observed significant influence of phosphorus to increase length of siliqua only upto 45 kg P_2O_5 ha^{-1}.

Seeds per siliqua

Birbal *et al.* (2004) reported that phosphorus has a great influence on seeds of mustard *(Brassica juncea).* They conducted an experiment during rabi season in Indian with 4 levels of phosphorus viz. 0, 25, 50, and 75 kg ha^{-1}. The maximum seeds per siliqua was found with 75 kg ha^{-1}.

Davaria *et al.* (2001) revealed an experiment during the 1994/95 rabi season with 3 leels of phosphorus viz. 0, 25 and 50 kg ha^{-1}. They found that phosphorus application with 50 kg P_2O_5 ha^{-1}gave the height seeds per siliqua (12.1).

Chaubey *et al.* (2001) conducted an experiment in India with mustard (*Brassica juncea)* with different levels (0, 40 and 60 kg P_2O_5 ha^{-1}) of phosphorus. The maximum seeds per siliqua were found with 60 kg P_2O_5 ha^{-1}.

1000-seed weight

Sumeria *et al.* (2003) reported that phosphorus has a great influence on the seed weight of mustard *(Brassica juncea)*. He conducted an experiment with 3 levels of phosphorus viz. 20, 40, and 60 kg ha^{-1}. The maximum 1000-seed weight was observed with 60 kg P ha^{-1}.

Birbal *et al.* (2004) reported that seed weight of mustard greatly affected by phosphorus. Maximum 1000-seeds weight (3.54g) was found with 75 kg P ha^{-1}.

Kantwa and Meena (2002) pefomed an experiment in India during the rabi season with 3 levels of phosphorus viz. 15, 30 and 45 kg ha^{-1}.They reported that 30 kg P_2O_5 ha^{-1} significantly increased 1000-seeds weight of mustard.

Seeds yield

Davaria *et al.* (2001) reported that phosphorus has a great influence on the yield of mustard *(Brassica juncea)*. They conducted an experiment in India during 1994/95 rabi season with 3 levels of P_2O_5 viz. 0, 25 and 50 kg ha^{-1}. The maximum seed yield (1.54 t ha^{-1}) was observed with 50 kg P_2O_5 ha^{-1}.

Birbal *et al.* (2004) performed an experiment on mustard during 1996/97 and 1997/98 rabi seasons with 4 levels of phosphorus viz. 0, 25, 50, 75 kg ha^{-1}. They observed that phosphorus at 75 kg ha^{-1} gave the maximum seed yield.

Singh (2002) conducted an experiment during 1998/99 and 1999/2000 rabi seasons with 5 levels of P viz. 1, 15, 30, 45 and 60 kg ha^{-1}. He reported that phosphorus has greate influence on the yield of mustard (*Brassica juncea*) and the maximum seed yield (1.14 and 3.8 t ha^{-1} in 1999 and 2000) was recorded from application of 45 kg P ha^{-1}.

Stover yield

Patel and Shelke (1998) showed that Stover yield of Indian mustard increased significantly with application of phosphorous. They observed that 80 kg P_2O_5 ha^{-1} gave the maximum Stover yield.

Birbal *et al.* (2004) conducted an experiment in India on mustard during 1996/97 and 1997/98 winter season with 4 levels of phosphorus viz. 0, 25, 50, 75 kg ha^{-1}.The maximum stover yield was observed with 75 kg P ha^{-1}.

Davaria *et al.* (2001) conducted an experiment in India on mustard during the 994/95 rabi season with 3 levels of P_2O_5 viz. 0, 25, 50 kg ha^{-1}. The maximum stover yield (39.44 t ha^{-1}) was observed with 50 kg P_2O_5 ha^{-1}.

Oil content

Sharma and Jain (2002) conducted an experiment on mustard during 1998/99 and 1999/2000 rabi seasons with different weed management and phosphorous levels (0, 8.8, 17.6 and 26.4 kg ha^{-1}through diammonium phosphorous) to study the yield and yield quality of Indian mustard. They found application of phosphorous at 17.6 kg ha^{-1} along with weed management gave the highest oil content.

Oil yield

Poonia and Soni (2002) conducted an experiment with 3 levels of phosphorous (20, 40, and 60 kg P_2O_5 ha^{-1}) result showed that application of phosphorous at 40 kg ha^{-1}significantly increased the oil yield of Indian mustard.

Effect of population density

Plant height

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

Johnson and Hanson (2003) conducted a study to determine the interactions for commonly used spacing with canola (*Brassica napus*) performance using contemporary open-pollinated, hybrid and transgenic cultivars. They observed that population density and cultivar interaction were only significant for plant height. Shorter plants for the *Brassica rapa* cultivars was found when grown at the narrower row spacing, but *B. napus* cultivars had similar plant height at both.

Number of Branches plant^{-1}

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

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

Chauhan *et al.* (1993) found significant differences among the row spacing (20, 30 and 40 cm) in relation to production of branches plant^{-1} of rapeseed. Among 3 row spacing, 40 cm row spacing gave highest number of branches plant^{-1} while 20 cm row spacing gave minimum number of branches.

Number of siliquae plant^{-1}

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

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

Number of seeds siliquae^{-1}

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

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

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

Stover yield

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

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

Effect of potassium on growth and yield of mustard

Abd-EI-Gawad *et al*. (1990) reported on mustard that increasing levels of K application not only increased the seed yield but also increased the pod number plant^{-1} and number of seeds pod^{-1}.

Mahadkar *et al*. (1996) also reported that increasing the rate of K fertilizer increased the number of pods.

Amanullah *et al.* (2001) conducted an experiment on S and K deficient clay loam soil to determine seed yield and yield components response of *Brassica* oilseed rape versus mustard to S (15, 30, and 45 kg S ha^{-1}) and K (30, 60, and 90 kg K ha^{-1}) fertilizers plus one control (no S and K applied). Seed yield and yield components increased significantly with K and S fertilization as compared to the zero-S/zero-K control. Both genotypes responded positively for seed yield and yield components to K and S fertilization, but the magnitude of response varied with levels of S and K, as well as combined K and S applications. It is concluded that a combination of 60 kg K and 30 kg S ha^{-1} would improve seed yield and yield components of rape and mustard in the study area and contribute significantly to increased production.

Mir *et al*. (2010) conducted an experiment on mustard (*Brassica juncea* L.) to study the effect of different combinations of phosphorous and potassium applied as monocalcium superphosphate and muriate of potash respectively (each at the rate of 30, 60, 90 kg P_2O_5 and K_2O ha^{-1}) on yield and yield attributes of mustard. In addition, a uniform dose of urea at the rate of 80 kg N ha^{-1} was applied. At harvest, various yield characteristics including number of pods $plant^{-1}$ number of seed pod^{-1}, seed yield and oil yield were studied. The effect of phosphorus alone as well as in combination with potassium was significant. Treatments 60 kg P_2O_5 ha^{-1} and 60 kg P_2O_5 60 kg K_2O ha^{-1} proved optimum and the increase in seed yield was due to increase in pods $plant^{-1}$ and seeds pod^{-1}.

Effect of fungicides

Singh *et al.* (2008) evaluated four fungicides, namely iprodione (0.2%), mancozeb (0.2%), Ridomil MZ [mancozeb+metalaxy1] (0.25%) and Apron [metalaxy1] S.T (0.5%), as seed treatment against *Alternaria brassica,* causing alternaria blight of mustard, in Kausambi, Uttar Pradesh, India. Allthe 4 fungicides were significantly superior in reducing the disease intensity over the untreated control. Iprodione was found to be the most effective fungicide in controlling the disease and increasing the yield followed by mancozeb.

Alam (2007) evaluate the efficacy of some selected fungicides and plant extrats against *Alternaria brassica* and *Alternaria brassicicola* causing gray blight of mustard (var. SAU Sarisha-1, Brassica Campestris). Experiments were conducted at the Farm of Sher-a-Bangla Agriclture University, Dhaka and in the laboratory of Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal during rabi season during the month of November, 2006 to February, 2007. Four fungicides viz. Rovral 50 WP (0.2%), Dithane M-45 (0.3%), Ridomil 68 WP (0.2%), Bavostin DF (0.1%) and two plant extracts viz. Garlic clove extract, Allamanda leaf extract were employed in the experiment. Among the fungicides and plant extracts tested, Rovral 50 WP (0.2%) showed the best performance in reducing disease incidence and disease severity as well as increasing seed yield against gray blight of mustard. Seed infection by *Alternario spp.* was reduced 64.90% and seed yield was increased by 81.9% over control by the application of Rovral.

Girish *et al.* (2007) sprayed five fungicides (Copper oxychloride, Aluminium tris, Metalaxy1, Chlorothlonil and Mancozeb) to manage while rust *(Albugo brassicae)* and Alternaria leaf blight *(Alternaria brassicae)* of mustard during kharif season of 2005 under field conditions (Karnataka, India). Among those sprays, aluminium tris was effective against while rust with minimum mean disease severity of 9.8%, followed by Mancozeb (15.50%) compared to the control (33.25). Spraying of Mancoxeb was effective against *Alternaria* leaf blight compared to control. Maximum seed yield (313 kg ha^{-1}) was recorded when the crop was sprayed with Metalaxy1, followed by Aluminium tris (239 kg ha^{-1}) and Mancozeb (233 kg ha^{-1}) compared to control (174 kg ha^{-1}).

Khan *et al.* (2007) evaluated three systemic fungicides: Topsin- M (Thiophanate methyl, 70% WP), (Ridomil MZ (mancozed, 64% and Metalaxyl, 8%WP) and Bavistin (Carbendazim, 50%WP) alone and in combination with four non-systemic fungicides Captaf (Captan, 50%WP), Indofil M-45 (Mancozeb, 75%WP), Indofil Z-78 (Zineb, 755WP and Thirram, 75%WP) both *in vitro* and *in vivo* for their effectiveness to mange *Alternario brassica*. All the fungicides were evaluated for their efficacy at various concentrations, 50, 100, 150, 200 and 500 ppm, and were sprayed in the field at 0.2% a.i. All fungicides significantly reduced the severity of the disease but Ridomil MZ was most effective. Topsin-leaves, stems, pods and thus reduceing the yield and quality of the produce to a considerable extent.

Effect of Insecticides

Sharma and Khatri (1979) studied the biology of mustard aphid, *L. erysimi* (Kalt.) on mustard and observed that the means number of progeny/female during the winter crop season was 96.87 ± 27.94 and the rate of population increase was 2.95 in 15 days.

Phadke *et al.* (1982) studied the life table and growth rate of mustard aplhid, *L. erysimi* on different varieties of *Brassica* spp. And reported that highest net reproductive rate of 119.38 was found in T_9 and the lowest one of (86.12) was found in Pusabold.

Effect of sulphur

Plant height

Birbal *et al.* (2004) conducted an experiment with the effect of P (0, 25, 50 and 75 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on the yield and yield components of Indian mustard cv. Pusa Bold. They found that P at 75 kg and 60 kg S ha^{-1} gave the maximum plant height.

Raut *et al.* (2003) stated from an experiment with the effect of 5 levels of irrigation and 5 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard cv. Pusa Bold. They observed higher plant height at 20 kg S ha^{-1} resulted in higher compared to the other treatment combination.

Chaubey *et al.* (2001) conducted an experiment to evaluate the response of mustard to phosphorus (0, 40 and 60 kg P_2O_5 ha^{-1}) and sulphur (0, 15, 30, 45 and 60 kg S ha^{-1}) fertilization. Plant height increased significantly with the increasing S up to 60 kg and P_2O_5 up to 30 kg ha^{-1}respectively.

Sudhakar *et al.* (2002) investigated the effect of S (20, 40 or 60 kg ha^{-1}) on the performance of Indian mustard cv. Varuna. Applied sulphur as ammonium sulfate, which significantly improved the plant height. The increase in plant was observed up to 60 kg S ha^{-1}.

Dry matter

Bharati and Prasad (2003) reported the effect of sulphur rate on the performance of Indian mustard. The highest dry matter production and S uptake were recorded or 15 and 30 kg S ha^{-1}.

Ram *et al*. (1999) investigated the effect of phosphorus, sulphur and phosphate solubilizing bacteria (PSB, *Pseudomonas radiate*) on growth and yield of mustard (*Brassica juncea*) cv. Bio 902. They concluded that application of 60 kg S ha^{-1} increased the dry matter accumulation per plant of mustard.

Mohan and Sharma (1992) conducted a study to evaluate the effect of nitrogen and sulphur on seed yield and oil content of Indian mustard. Sulphur at the rate of 50 kg ha^{-1} significantly increased the dry matter production.

Crop Growth Rate (CGR)

Ali *et al.* (1996) investigated that increasing levels of sulphur (30 kg ha^{-1}) progressively increased the CGR values (13.19) of mustard up to 55-70 DAS but they were not significantly different and concluded that irrespective of S levels CGR became negative at 85 DAS.

Number of branches per plant

Raut *et al.* (2003) stated the effect of 5 levels of irrigation and 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard cv. Pusa Bold. They observed highest number of branches per plant sulphur at 20 kg ha^{-1} compared to the other treatment combination.

Sudhakar *et al.* (2002) studied the effect of S (20, 40 or 60 kg ha^{-1}) on the performance of Indian mustard cv. Varuna provided sulphur as ammonium sulfate was applied as basal. Sulphur significantly increased the number of primary and secondary branches per plant. The increase in primary and secondary branches per plant was observed up to 60 kg S ha^{-1}.

Chaubey *et al.* (2001) investigated the response of mustard to phosphorus (0, 40 and 60 kg P_2O_5 ha^{-1}) and sulphur (0, 15, 30, 45 and 60 kg S ha^{-1}) fertilization. The number of branches per plant increased significantly with the increasing levels of P_2O_5 and S up to 60 and 30 kg ha^{-1}, respectively.

Number of siliquae per plant

Hidyatullah *et al.* (2004) conducted an experiment to evaluate the effect of 4 levels of sulphur (0.7, 14 and 21 kg ha^{-1}) and 2 levels of NNA (0 and 50 ppm) on growth, yield and biochemical parameter of Indian mustard (*Brassica juncea*). Application of sulphur produced a significant and consistent increase in number of siliquae per plant up to 14 kg ha^{-1}.

Birbal *et al.* (2004) also investigated the effect of P (0, 25, 50 and 75 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on the yield and yield components of Indian mustard cv. Pusa Bold. They found that P at 75 kg ha^{-1} and S at 60 kg ha^{-1}produced the maximum number of siliquae per plant.

Raut *et al.* (2003) observed the effect of 5 levels of irrigation and 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard cv. Pusa Bold. They obtained the height number siliquae per plant with 20 kg S ha^{-1}compared to the other treatment combination.

Verma *et al.* (2002) carried out a study an Indian mustard, where 15 30 and 45 kg S ha^{-1} and 20, 40 and 60 kg K_2O ha^{-1} were used. They observed increased the number of siliquae per plant only up to 30 kg S ha^{-1}.

Length of siliquae

Verma *et al.* (2002) studied the response Indian mustard, where 15, 30 and 45 kg S ha^{-1} and 20, 40 and 60 kg K_2O ha^{-1}were applied and observed significant influence of sulphur to increase the length of siliquae only up to 30 kg S ha^{-1}.

Number of seeds per siliqua

Hidyatullah *et ai.* (2004) investigated the effect of 4 levels of sulphur (0, 7, 14 and 21 kg $ha^{-1}$and 2 levels of NNA (0 and 50 ppm) on growth, yield and biochemical parameters of Indian mustard (*Brassica juncea*). Number of seeds per siliqua showed significant improvement with sulphur application only up to 14 kg ha^{-1}. Birbal *et al.* (2004) also observed the effect of P (0, 25, 50 and 75 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on yield and yield components of Indian mustard cv. Pussa Bold. They found that P at 75 kg $ha^{-1}$and 60 kg S ha^{-1}produced the maximum seeds per siliqua.

Verma *et al.* (2002) carried out a tril with Indian mustard, where 15, 30 and 45 kg S ha^{-1} and 20, 40 and 60 kg K_2O ha^{-1} were used and observed that S application significantly increased the number of seeds per siliqua only up to 30 kg ha^{-1}.

Sudhakar *et al.* (2002) studied the effect of S (20, 40, or 60 kg ha^{-1}) on the performance of Indian mustard cv. Varuna, given sulpher as ammonium sulfate as basal and obtained significant increase in number of seeds per siliqua. The increase in number of seeds per siliqua was observed up to 60 kg S ha^{-1}.

Seed yield

Hidyatullah *et al.* (2004) conducted an experiment to evaluate the effect of 4 levels of sulphur (0, 7, 14 and 21 kg ha^{-1}) and 2 levels of NNA (0 and 50 ppm) on growth, yield and biochemical parameters of Indian mustard (*Brassica juncea*). Application of sulphur produced a significant and consistent increase in seed yield with the increasing levels of sulphur up to 21 kg ha^{-1}.

Birbal *et al.* (2004) also investigated the effect of P (0, 25, 50 and 75 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on yield and yield components of Indian mustard cv. Pusa Bold. They obtained maximum grain yield per hectare with the application of 75 kg P ha^{-1}in combination with 60 kg S ha^{-1}.

Raut *et al.* (2003) Stated the effect of 5 levels of irrigation and 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard cv. Pusa Bold. They observed that the highest number of siliquae per plant in higher seed yield per hectare (1787 kg ha^{-1}) S at 20 kg ha^{-1}compared to the other treatment combination.

Misra *et al.* (2003) conducted an experiment on mustard cv. Varuna with 4 levels of K (0, 20, 40 and 60 kg S $ha^{-1}$and potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) and found the increased seed yield in linear order up to 40 kg S and 60 kg K_2O ha^{-1}; and recorded the highest seed yield (2035 kg ha^{-1}) at 40 kg S $ha^{-1}$was 27.59% higher in comparison to the yield at control.

Stover yield

Birbal *et al.* (2004) conducted a study to evaluate the effect of P (0, 25, 50 and 75 kg ha^{-1}) and S (0, 20, 40 and 60 kg ha^{-1}) on yield and yield components of Indian mustard cv. Pusa Bold. They found that P at 75 kg $ha^{-1}$and 60 kg S ha^{-1}gave the maximum stover yield.

Misra (2003) conducted an experiment on mustared crop (cv. Varuna) with 4 levels of sulpher (0, 20, 40 and 60 kg S ha^{-1}) and possium (0, 30, 60 and 90 kg K_2O ha^{-1}). They found that stover yield increased in the linear order up to 40 kg S ha^{-1}.

Oil yield

Behera *et al.* (2003) conducted a field experiments to evaluate the response of cultivars (Sanjukta, Asceh and Varuna) to plant population levels (222000, 148000 and 111000 ha^{-1}) and sulfur levels (0, 10, 20 and 30 kg ha^{-1}) on yield, oil and protain contant of rainfed Indian mustard. They observed significant increase of oil yield up to 20 kg S ha^{-1}.

Praskash *et al.* (2002) conducted an experiment to evaluate the effect of sulphur rate (0, 20, 40 and 60 kg ha^{-1}) on three Indian mustard cultivars, where sulphur used as gypsum into the soil one month before sowing. Pusa Bahar and Rohini recorded the highest oil yield, when fertilized with increased in sulphur rate up to 40 kg ha^{-1}only.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during November-February, 2011-2012. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recordings and their analyses.

3.1 Site description

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka, at 23º 74′ N latitude and 90 º 35′ E longitudes with an elevation of 8.2 meter from sea level. The experimental field is a medium high land belongs to the agro-ecological zone (AEZ-28) of Madhupur Tract. The soil texture of experimental site was silty loam. The field contained low organic matter content with low N, K, S etc. The experimental site has been shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area was under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during the rabi season (October-March). The maximum and minimum air temperature varied as 25.4-29.6 and 12.7-19.0, respectively during experimental period (November- December, 2011-2012), relative humidity, total rainfall and sun shine hour were found as 68-77%, 7.7-34.4 mm and 5.5-5.7, respectively (Appendix II).

3.3 Soil

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunlight was available during the experimental period.

3.4 Planting material

A high yielding variety of mustard, BARI Sarisha-13 (*Brassica napus*) was used as test crop. It is bold and yellow colored seeded. Required seed was collected from Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

3.5 Fertilization

Urea, TSP, MP, Zn, Gypsum, Boric Acid, Cow dung were used at the rate of 300, 170, 150, 5, 180, 10 kg ha^{-1} and 12 ton ha^{-1} respectively (BARI, 2011) in all the treatment except $T_{1,}$ $T_{9,}$ $T_{12,}$ and $T_{14.}$

3.6 Experimental treatments:

The experiment consisted of the following treatments:

T_1 = Control (no modern managements)

T_2 = All managements (fertilizer, irrigation, weeding, fungicide, mulching, insecticide, row arrangement)

T_3 = All managements except irrigation

T_4 = All managements except weeding

T_5 = All managements except row arrangement

T_6 = All managements except mulching

T_7 = All managements except insecticide

T_8 = All managements except fungicide

T_9 = All managements except fertilizer

T_{10} = All managements except insecticide and fungicide

T_{11} = All managements except irrigation and weeding

T_{12} = All managements except irrigation, weeding and fertilizer

T_{13} = All managements except mulching and weeding

T_{14} = All managements except weeding and fertilizer

T_{15} = All managements except insecticide, fungicide and irrigation

T_{16} = All managements except irrigation, weeding and insecticide

3.7 Design and layout of the experiment

The experiment was laid out in a Randomized complete block design (RCBD) with three replications. Each replication was divided into sixteen plots where different management was randomly assigned in different plots. The total number of plot was 48 (16 treatments × 3 replications). The layout of the experiment has been shown in Appendix IV.

Plot Details

Plot size- 3×2 m^2

Plot to plot distance- 0.75 m

Replication (Block) to replication distance- 1.5 m

3.8 Crop production practices

3.8.1 Preparation of main land for sowing

The experimental field was first opened on 1st November, 2011 with the help of a disc plough and prepared by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a good tilth. The corners of the land were spaded. All kinds of weeds and residues of previous crop were removed from the field. The field layout was made on 9th November, 2011 according to the design immediately after final land preparation. Individual plots were cleaned and finally leveled with the help of wooden ladder. On 16th November, 2011 basal fertilizing and sowing were done following the treatment variables.

3.8.2 Fertilizer application

Basal application

Urea, TSP, MP, Zn, Gypsum, Boric Acid, Cow dung were used at the rate of 300, 170, 150, 5, 180, 10 kg ha^{-1} and 12 ton ha^{-1} respectively except in plots assigned as per treatment. Half of the urea fertilizer was applied at the final land preparation and rest half at 30 DAS.

3.8.3 Sowing

Seeds were sown @ 3 kg ha^{-1} in line except T_1 and T_5 where broadcast seed sowing was done.

3.8.4 Intercultural operations

The following intercultural operations were done for ensuring normal growth of the crop-

3.8.4.1 Thinning

Three times thinning was done at 10, 20 and 30 DAS to maintain uniform plant population in each plot.

3.8.4.2 Weeding

During plant growth period three hand weeding were done at 10, 20 and 30 DAS only in the plots as per treatment.

3.8.4.3 Irrigation and drainage

Irrigation was given four times in mustard during crop growing period. First post sowing and the rest at 10, 30 and 40 DAS only for the selected plot. First two irrigations were with the help of hose pipe and the rests were flood irrigation. The drainage system was well prepared and thus excess water drained easily.

3.8.4.4 Plant protection measures

Insecticide Actara 25 WG was applied at rate of 0.2ml/L for four times and Fungicide Dithane M-45 (0.3%) was applied for four times only for the selected treatment plot. In case of other plot insecticide fungicide was not used.

3.8.5 General observation of the experimental field

The field was observed regularly from germination to till harvesting. It was a nice view to look at the green plants at initial stage and yellow flowers at later stage. Throughout the growing period no major insect, pest and diseases was observed.

3.8.6 Sampling and harvesting

Ten plants from each plot were randomly collected for growth analysis at 15 days interval starting from 15 DAS. For final data collection, all plants of middle1m^2 area from each plot was harvested, bundled, properly tagged and then brought to the threshing floor for recording data on yield component, yield and straw yield. The crop was harvested when 90% of the plants become golden yellow color and was done on 9th February, 2012. Threshing was done manually. The seeds were cleaned and sun dried to a moisture content of 10%. Stover was also sun dried properly. Seed and Stover yields plot^{-1} were converted to t ha^{-1}.

3.9 Collection of data

A. Crop growth characters

- Plant height
- No. of Leaf
- Leaf area
- Weed dry matter
- Primary branches plant^{-1}(no.)
- Secondary branches plant^{-1}(no.)
- Above ground dry matter plant^{-1} (g)

B. Yield contributing characters

- Siliquae plant^{-1}(no.)
- Siliqua length
- Seeds siliqua^{-1}(no.)
- Chaff weight
- Stover weight
- 1000 - seed weight (g)

C. Yield

- Seed yield (t ha^{-1})
- Stover yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.10 Experimental measurements

Growth data collection on growth parameters started at 15 days after sowing, and continued till harvest at 15 days interval. Data on agronomic characters were collected from ten randomly selected plants from each plot in the field and at harvest.

3.10.1 Plant height (cm)

Plant height was measured at 40, 70 DAS and at harvest. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before flowering, and to the tip of inflorescence after flowering and averaged.

3.10.2 Leaf area

All leaves of a plant were cut with sharp blade. Their area was then measured with a LICOR automatic leaf area meter.

3.10.3 Branches plant^{-1} (no.)

Number of branches plant^{-1} was counted at harvest and expressed as per plant basis.

3.10.4 Dry matter weight plant^{-1} (g)

The samples of 10 plants plot^{-1} was uprooted from the plots excluding boarder plants and were oven dried until a constant level from which the weight of above ground dry matter was recorded and then converted to per plant basis.

3.10.5 Siliquae plant^{-1} (no.)

Ten plants are collected from each plot. After then number of siliquae were averaged for per plant basis.

3.10.6 Seeds siliqua^{-1} (no.)

Twenty siliquae were collected from total siliquae of a plant and total seeds were recorded. Final data was an average of seeds per siliqua from different plants.

3.10.7 Weight of 1000-seed (g)

One thousand cleaned dried seeds were counted randomly from each plot and weighed by using a digital electric balance at the stage when grain retained 10% moisture and the mean weight were expressed in gram.

3.10.8 Yield (t ha^{-1})

Seed yield was determined from the central 1 m^2 marked in each plot and converted to t ha^{-1} on 10% moisture basis.

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

Stove yield was determined from the central 1 m^2 of each plot. After threshing, the samples were oven dried to a constant weight and finally converted to t ha^{-1}.

3.10.9 Chaff yield (t ha^{-1})

Chaff yield was determined from the central 1 m^2 of each plot. After threshing, the samples were oven dried to a constant weight and finally converted to t ha^{-1}.

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

The biological yield was calculated with the following formula;

Biological yield= Grain yield + Stover yield

3.11 Harvest index (%)

It is the ratio of economic yield to biological yield and was calculated using following formulae (Gardner *et al.*, 1985).

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

3.12 Statistical Analysis of the Data

Collected data were analyzed following the ANOVA technique using statistical program MSTAT-C and mean differences was adjudged with LSD at 5% level of significance.

Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

In this chapter, experimental results pertaining to the effect of different management methods on the growth and yield contributing characters of mustard cv. BARI Sarisha-13 have been presented along with discussion in this chapter. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Effect of different management methods on growth attributes

4.1.1 Plant height (cm)

The plant height of mustard cv. BARI Sarisha-13 was significantly influenced with the application of different managements (Figure-1). It was observed that in case of plant height significant difference was found at 40, 70 DAS and at harvest.

At 40 DAS, the highest plant height was found with broadcast application of seed ($T_{5,}$ all managements except row arrangement) which was statistically similar with treatments $T_{7,}$ $T_{1,}$ $T_{9,}$ $T_{2,}$ $T_{8,}$ $T_{6,}$ $T_{4,}$ $T_{13,}$ $T_{12,}$ T_{15} and $T_{16.}$ The lowest plant height (46 cm) was observed with T_{10} (all managements except insecticide and fungicide) which was statistically similar with treatment $T_{3,}$ T_{14} and T_{11}.

At 70 DAS, there was significant variation among the treatments. The tallest plant height (98.16cm) was found at T_6 (all managements except mulching) followed by $T_{7,}$ $T_{8,}$ $T_{10,}$ $T_{9,}$ $T_{13,}$ $T_{2,}$ $T_{5,}$ T_{14} and $T_{11.}$ The shortest plant height was observed at T_{16} (all managements except irrigation, weeding and insecticide) and was at par with T_{11}, T_1, T_4, T_3, T_{12} and $T_{15.}$

At harvest, maximum plant height (116 cm) was found in T_3 (all managements except irrigation) which was statistically at par with $T_{8,}$ $T_{4,}$ $T_{2,}$ $T_{7,}$ $T_{10,}$ $T_{9,}$ $T_{13,}$ T_{15} and $T_{14.}$ The lowest plant height (74 cm) was found with T_{16} (all managements except irrigation, weeding and insecticide) and was at par with $T_{9,}$ $T_{13,}$ $T_{15,}$ $T_{14,}$ $T_{6,}$ $T_{5,}$ $T_{11,}$ T_{12} and $T_{1.}$

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N ha^{-1} under irrigated or non-irrigated condition in a field experiment. They observed that plant height increased with increasing rate of nitrogen and were higher under irrigated than in non-irrigated condition.

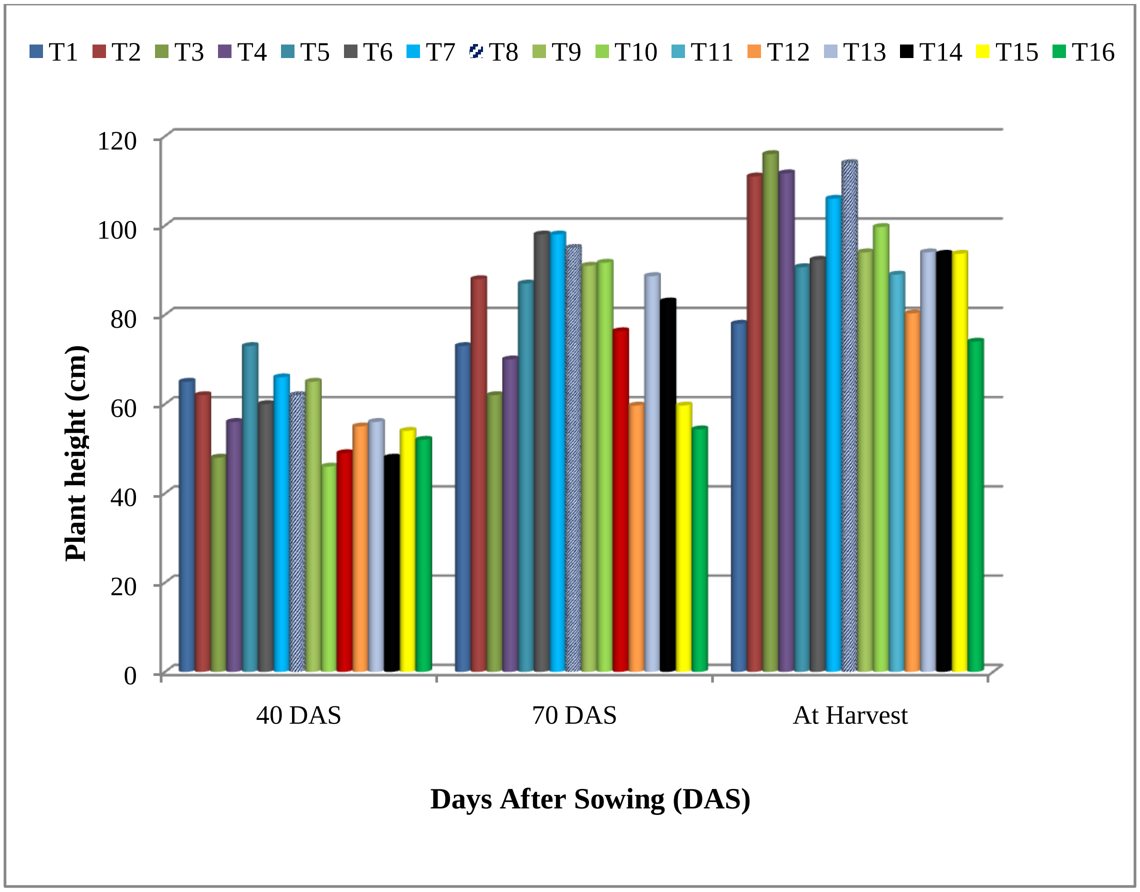

Figure 1. Plant height of mustard as influenced by different managements at different DAS ($LSD_{0.05}$ = 23.36, 22.79 and 22.22 at 40, 70 DAS and harvest, respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.1.2. Number of leaves

Number of leaves of mustard cv. BARI Sarisha-13 was significantly influenced with the application of different managements (figure-2). At 40 DAS there was significant variation observed among the treatments. The maximum number of leaves plant^{-1}(16 no.) was found at T_7 (all managements except insecticide) followed by $T_{13,}$ $T_{2,}$ $T_{6,}$ $T_{8,}$ $T_{10,}$ $T_{11,}$ $T_{5,}$ T_{16} and $T_{4.}$ The lowest number of leaves plant^{-1}(6 no.) was observed at T_{12} (all managements except irrigation, weeding and fertilizer) and was at par with T_1, T_9 and $T_{12.}$

But at 70 DAS management did not significantly influence the number of leaves plant^{-1}. However, result showed that numerically the highest number of leaves plant^{-1} (14) was produced at T_8 (all managements except fungicide) and lowest (4) was at T_{11} (all managements except irrigation and weeding).

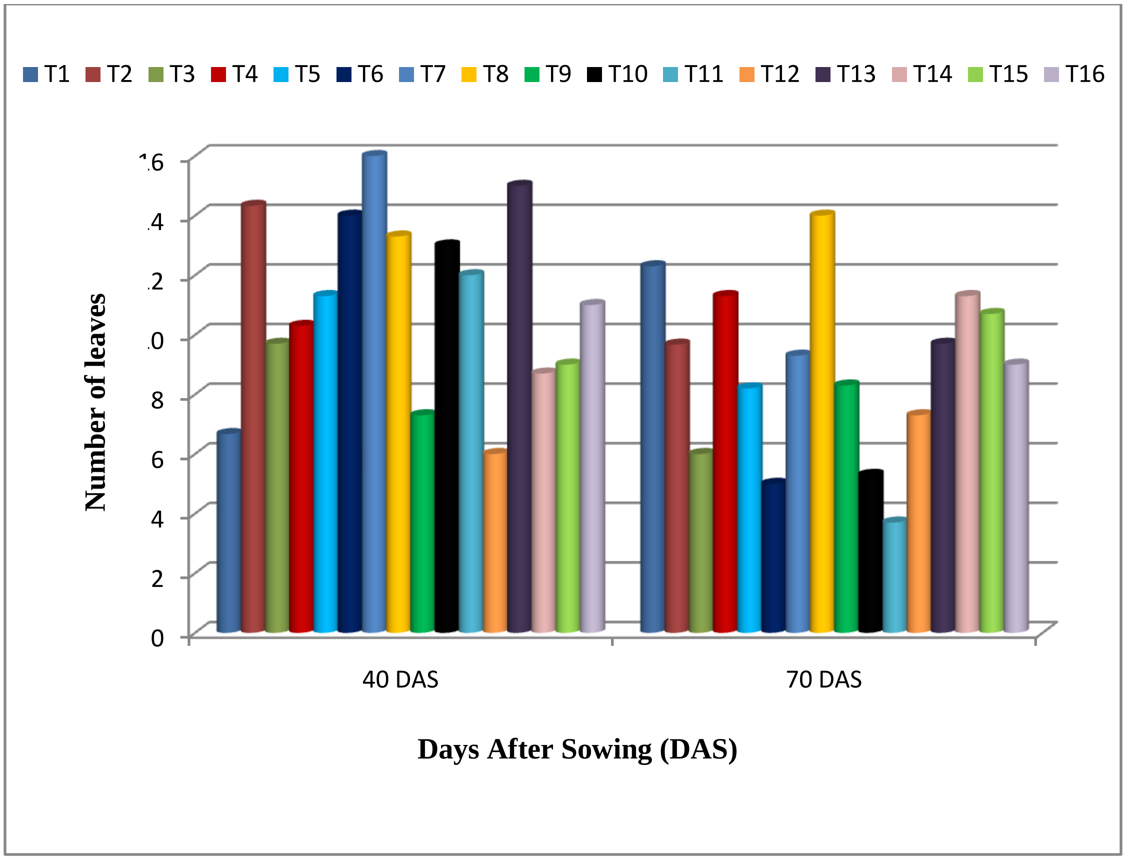

Figure 2. Number of leaves of mustard as influenced by different managements at 40 and 60 DAS (LSD $_{0.05}$ = 6.214 and 10.98 at 40 and 70 DAS respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.1.3 Leaf area plant^{-1} (cm^2)

Among all the growth characteristics leaf area is one of the key determinants for crop yield. Leaf area plant^{-1} (cm^2) of mustard varied significantly for different managements at different growth stages (Figure-3). The leaf area plant^{-1} (cm^2) as a normal phenomenon increased with the advancement of plant age and declined after attaining its maximum value with time.

At 40 DAS, the highest leaf area (203.8 cm^2) was found with T_{10} (all managements except insecticide and fungicide) which was statistically similar with treatment $T_{6,}$ $T_{5,}$ $T_{8,}$ $T_{4,}$ T_{13} and T_2. The lowest leaf area (55 cm^2) was observed with T_1 (control treatment) which was statistically similar with treatment $T_{7,}$ $T_{14,}$ $T_{3,}$ $T_{11,}$ $T_{16,}$ $T_{9,}$ T_{12} and T_{15}.

At 70 DAS, maximum leaf area (1012 cm^2) was found in T_8 (all managements except fungicide). The lowest leaf area (114.3 cm) was found with T_{11} (all managements except irrigation and weeding) and was at par with T_9 and $T_{10.}$

These finding was an accord with Miah *et al.* (2004) who reported that LAI was higher in fertilized and irrigated plots in comparison to control treatment.

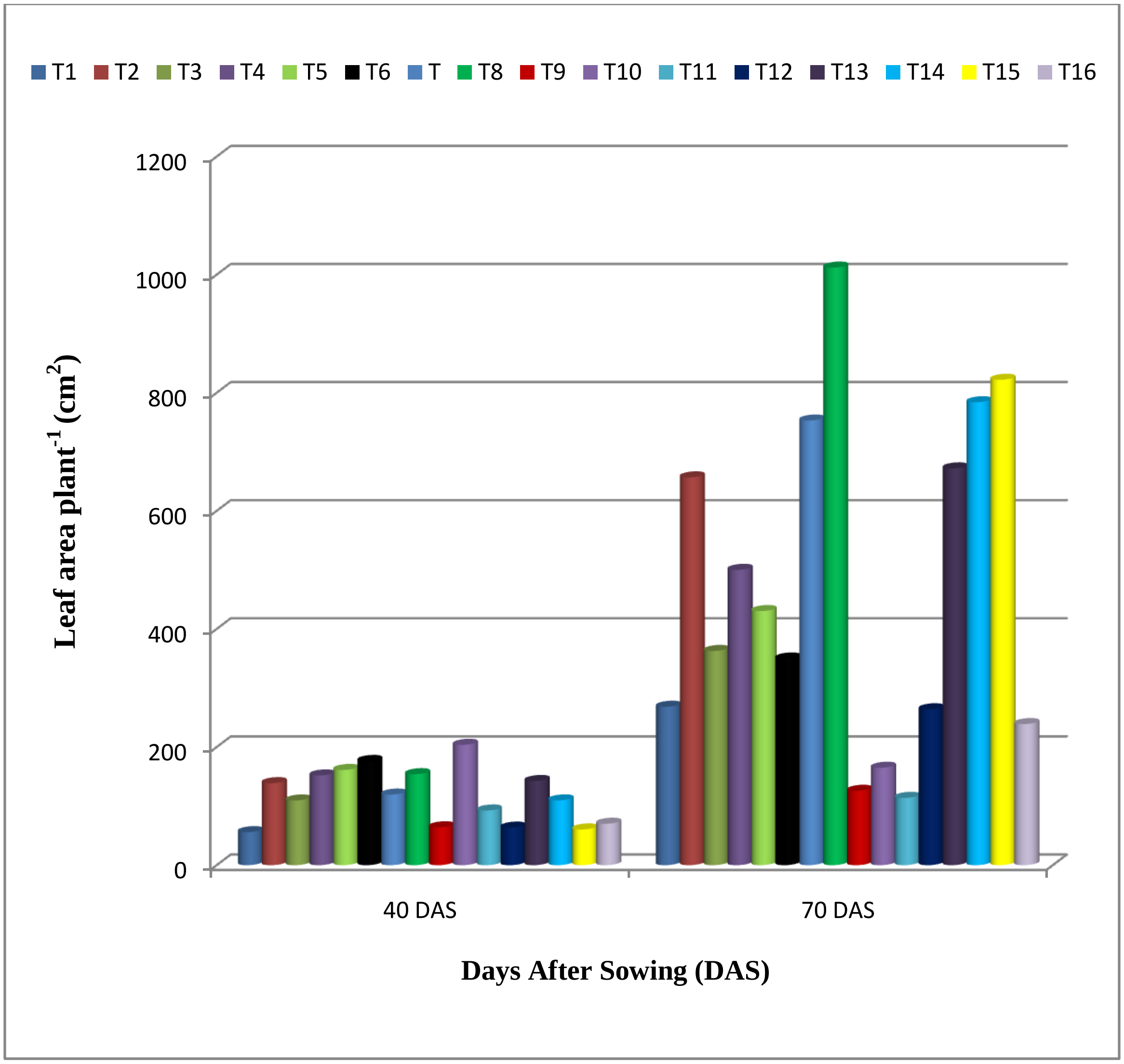

Figure 3. Leaf area plant^{-1} (cm^2) of mustard as influenced by different managements at 40 and 70 DAS (LSD $_{0.05}$ = 81.27 and 51.92 at 40 and 70 DAS respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.1.4 Above ground dry matter (g plant^{-1})

The dry matter production in plant was very slow at early growth stage (15 to 45 DAS) than sharply increased from 60 DAS to harvest. Dry matter production exerted significant difference due to managements at all growth stages (Figure-4 and Figure-5).

At 40 DAS, T_2 (all managements) produced the highest dry matter of stem plant^{-1} (5.4 g) and was statistically similar with T_{10}, T_6, T_8, T_5, T_4 and T_7. The lowest dry matter plant^{-1} was found at T_{12} (all managements except irrigation, weeding and fertilizer) that was followed by T_{11}, T_{14}, T_{13}, T_{15}, T_{16}, T_9 and T_1.

At 70 DAS, T_{13} (all managements except mulching and weeding) produced the highest dry matter of inflorescence plant^{-1} 2.2 g and was statistically similar with T_8, T_2, T_6, T_{15}, T_5, T_7, T_4, T_{16}, T_{11} and T_{10}. The lowest dry matter of inflorescence plant^{-1} (0.5g) was found at T_1 (control, no modern managements) that was followed by T_5, T_6, T_7, T_{11}, T_{14}, T_{13}, T_{15}, T_{16}, T_9, T_1 and T_{12}.

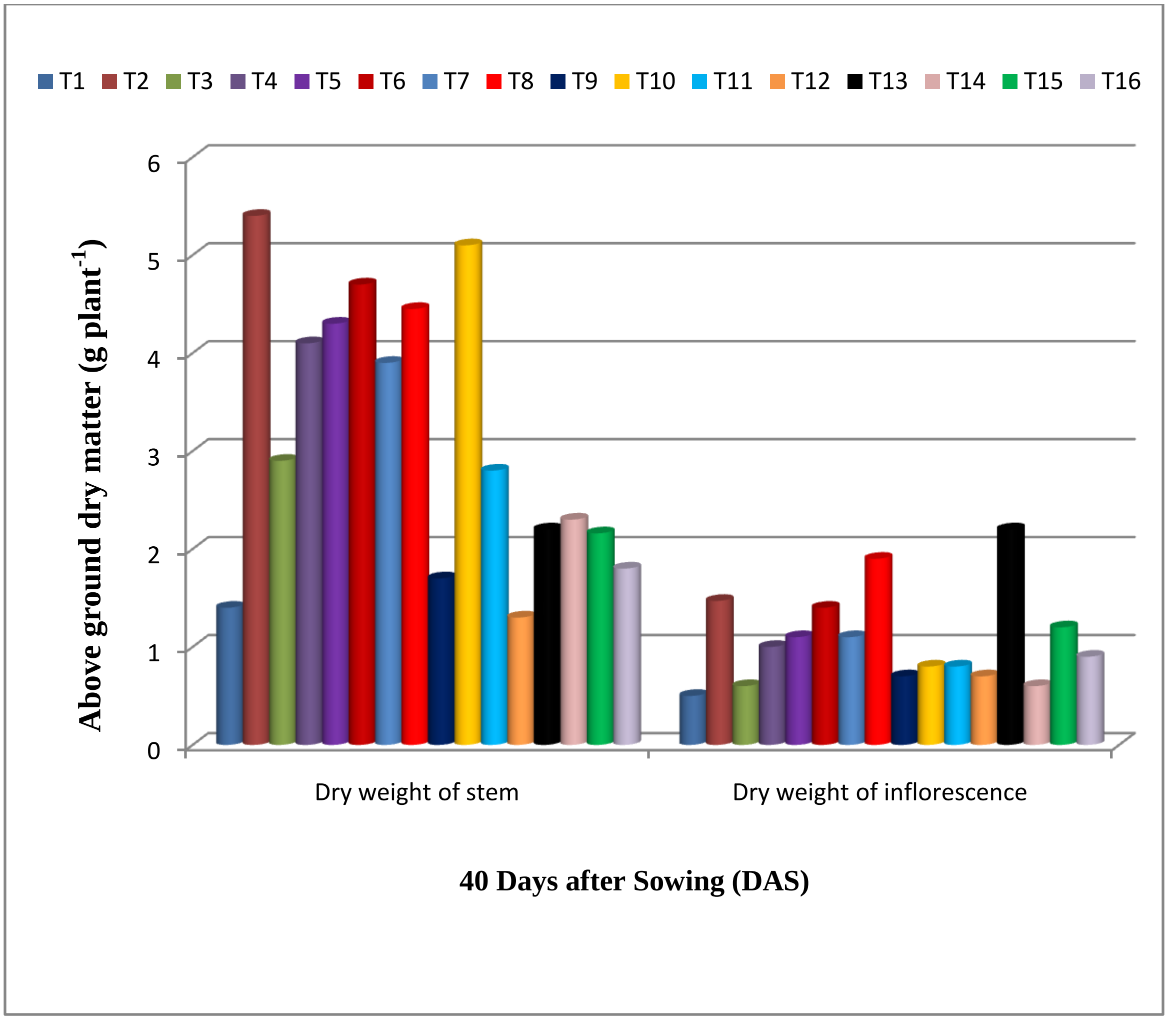

Figure 4. Dry weight of stem and inflorescence of mustard as influenced by different managements at 40 DAS (LSD $_{0.05}$ = 2.269 and 1.456 at 40 DAS)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

At 70 DAS the highest dry matter of leaves (1.7 g) was produced at T_{13} (all managements except mulching and weeding) that was followed by T_2. The lowest dry matter of leaves (0.11g) was found at T_9 (all managements except fertilizer) and was similar with $T_{5,}$ $T_{6,}$ $T_{7,}$ $T_{11,}$ $T_{14,}$ $T_{4,}$ $T_{15,}$ $T_{10,}$ $T_{9,}$ T_1 and $T_{12.}$

The highest dry matter of inflorescence (16.90 g) was produced at T_7 (all managements except insecticide) that was followed by $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{10,}$ $T_{13,}$ $T_{8,}$ T_6 and T_{14}. The lowest dry matter of inflorescence (5.30 g) was found at T_1 (control (no modern managements) and was similar with $T_{8,}$ $T_{6,}T_{14,}$ $T_{11,}$ $T_{14,}$ $T_{9,}$ $T_{16,}$ T_{15} and T_9 and highest dry matter of stem (6.30 g) was produced at T_{13} (all managements except mulching and weeding). The lowest dry matter of stem (1.60 g) was found at T_{16} (all managements except irrigation, weeding and insecticide) and was similar with $T_{5,}$ $T_{9,}$ $T_{10,}$ $T_{3,}$ $T_{11,}$ $T_{6,}$ $T_{12,}$ $T_{14,}$ T_{15} and $T_{1.}$

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.

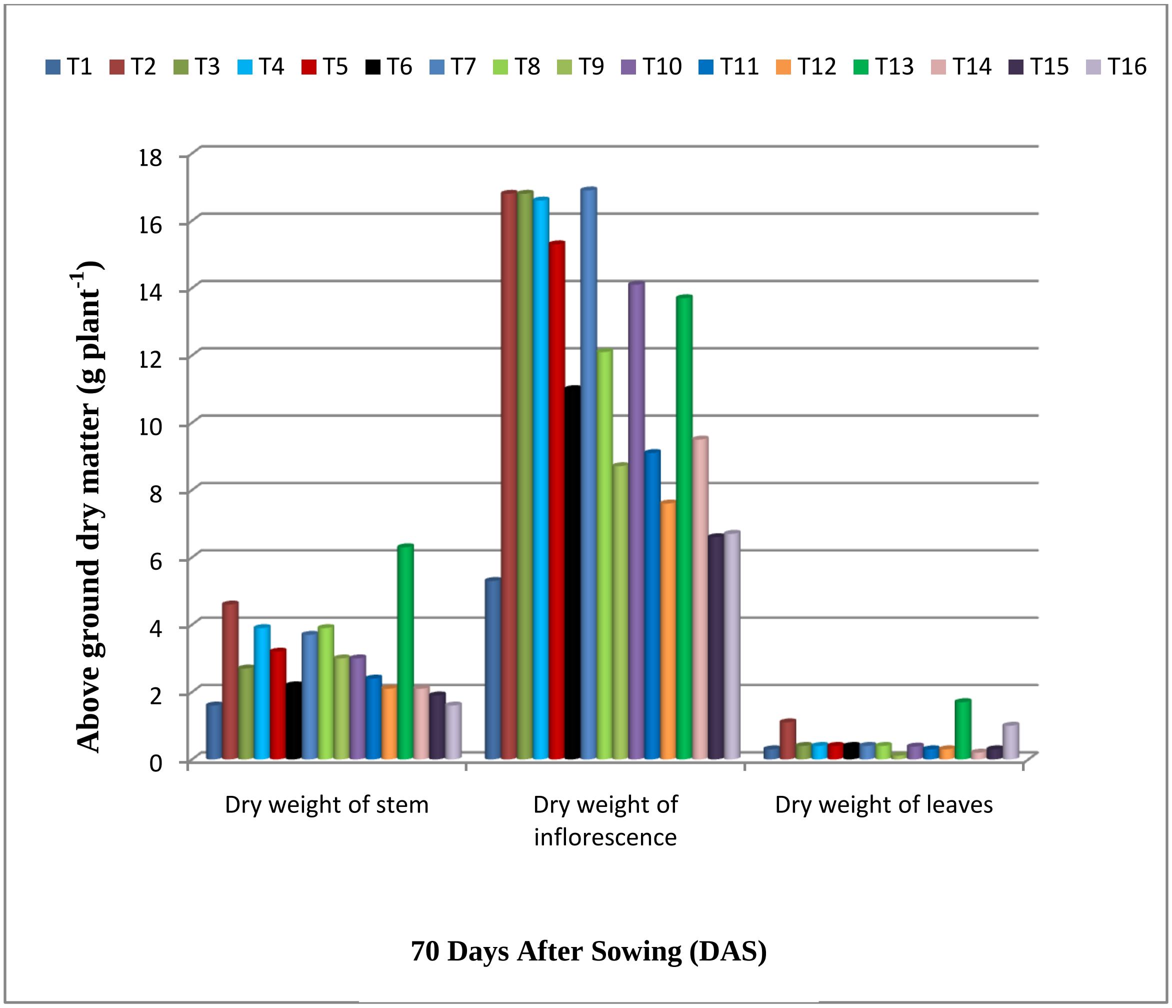

Figure 5. Dry weight of stem, inflorescence and leaves of mustard as influenced by different managements at 70 DAS ($LSD_{0.05}$ = 1.64, 8.181 and 0.674 at 70 DAS respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.1.5. Number of primary and secondary branches plant^{-1}

There was significant effect with the application of different managements on number of primary and secondary branches plant^{-1} (Figure-6). The maximum number (4.4) of primary branches was produced in T_7 (all managements except insecticide) which was statistically similar with T_2, T_5, T_{10}, T_4, T_8 and T_6. The lowest (1.2) number of primary branches was found at T_{14} (all managements except weeding and fertilizer) that was statistically similar with T_{12}, T_3, T_{16} and T_9.

In case of secondary branches there was significant effect with the application of different managements. The maximum number (5.1) of secondary branches was produced in T_6 (all managements except mulching) which was statistically similar with T_{10}, T_{13}, T_7, T_8, T_4, T_2, T_5 and T_1. The lowest (0.30) number of secondary branches was found at T_{14} (all managements except weeding and fertilizer) that was statistically similar with T_1, T_{12}, T_{16}, T_{11}, T_3, T_9 and T_{15}.

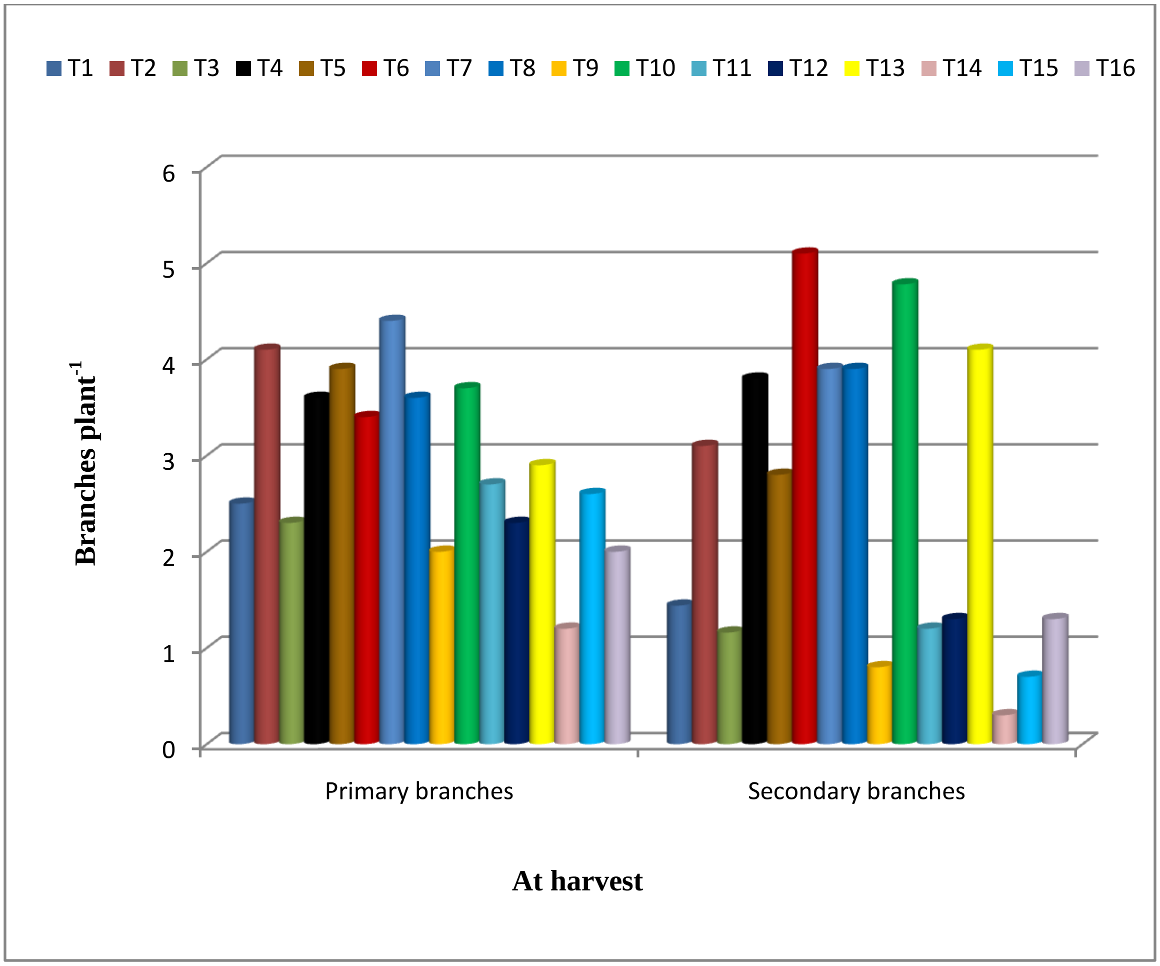

Figure 6. Number of branches of mustard as influenced by different managements at harvest (LSD $_{0.05}$ = 1.193 and 2.302 at harvest respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

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

Chaubey *et al.* (2001) preformed and experiment during the rabi season in India with 3 levels phosphorus viz. 0, 40 and 60 kg ha^{-1}. They reported that number of branches per plant increasing with the increasing level of phosphorus up to 60 kg ha^{-1}.

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

4.2 Effect of different management on yield attributes

4.2.1 Siliquae plant^{-1} (no.)

Siliquae plant^{-1} was affected significantly by different management methods (Figure-7). At 40 DAS the maximum number (26) of siliquae plant^{-1} was produced in T_{15} (all managements except insecticide, fungicide and irrigation) which was statistically similar with $T_{2,}$ $T_{7,}$ $T_{6,}$ $T_{12,}$ and T_{13}. The lowest (7.7) number of siliquae was found at T_{10} (all managements except insecticide and fungicide) that was statistically similar with T_5, $T_{9,}$ T_{11}, $T_{4,}$ T_8, T_{14}, T_3 and T_{10}.

At 70 DAS the maximum number (162.3) of siliquae plant^{-1} was produced in T_7 (all managements except insecticide) which was statistically similar with $T_{5,}$ $T_{2,}$ $T_{4,}$ $T_{8,}$ $T_{15,}$

$T_{10,}$ T_{14} and $T_{6.}$ The lowest (35.3) number of siliquae was found at T_1 (control (no modern managements) that was statistically similar with T_{14}, $T_{6,}$ T_3, $T_{11,}$ T_{12}, T_{16}, T_{13} and T_9.

At harvest the maximum number (169) of siliquae plant^{-1} was produced in T_6 (all managements except mulching) which was statistically similar with $T_{7,}$ $T_{13,}$ $T_{10,}$ $T_{8,}$ T_5 and $T_{2.}$ The lowest (45.55) number of siliquae was found at T_{12} (all managements except irrigation, weeding and fertilizer) that was statistically similar with T_{11}, $T_{16}T_1$, $T_{9,}$ T_{15}, T_{14} and T_{12}.

Singh (2002) also reported that in mustard siliquae per plant increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

Tomer *et al*. (1992) conducted an experiment to observe the effect of irrigation at 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 plant^{-1} when two irrigations were applied. One irrigation and without irrigation produced lower siliquae plant^{-1}.

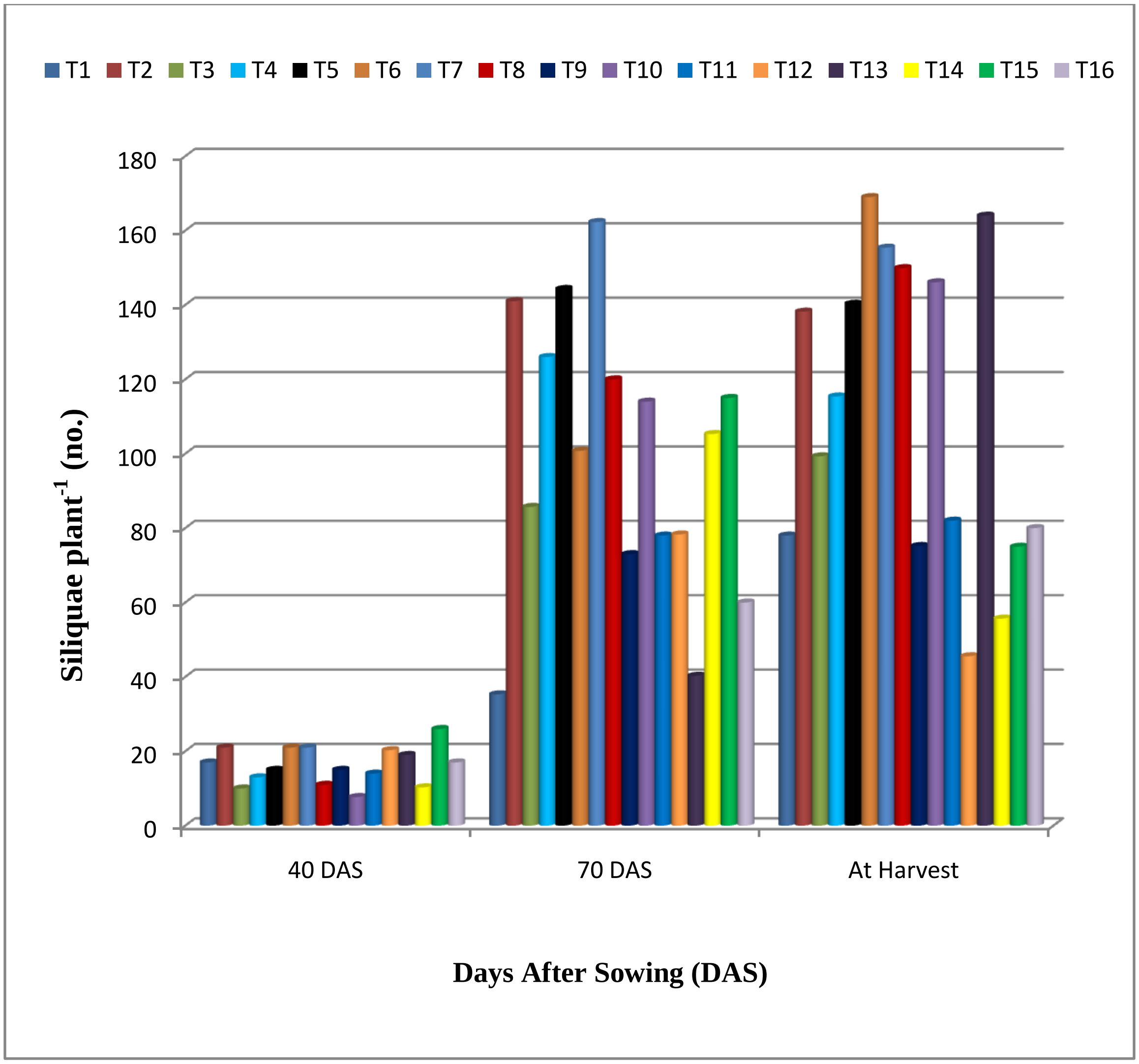

Figure 7. Number of siliquae plant^{-1} of mustard as influenced by different managements at different DAS (LSD $_{0.05}$ = 8.857, 71.61 and 48.03 at 40, 70 DAS and at harvest respectively)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.2 Siliquae length

Different managements did not significantly influence the siliquae length. However, result (Figure-8) showed that numerically the maximum (7.60 cm) siliqua length was produced at T_4 (all managements except weeding) and lowest (6.7 cm) was at T_{12} (all managements except irrigation, weeding and fertilizer).

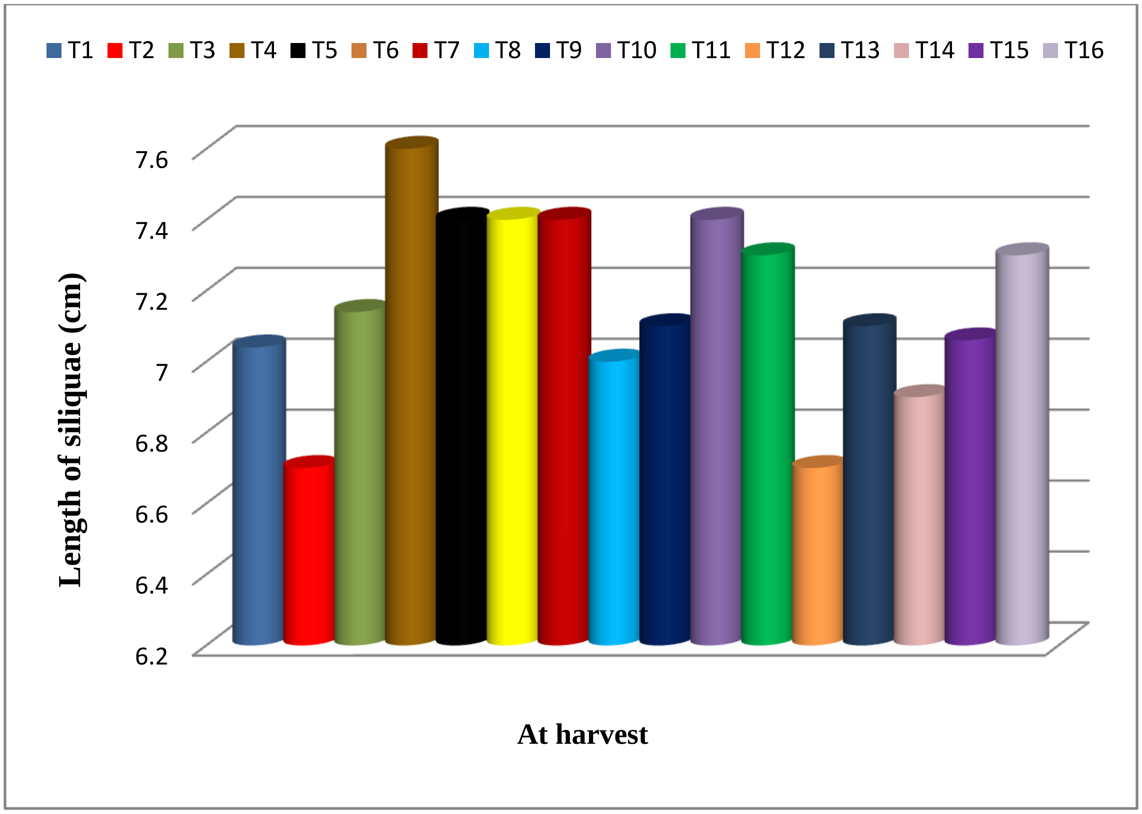

Figure 8. Length of siliqua of mustard as influenced by different managements at harvest (LSD $_{0.05}$ = 1.145 at harvest)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.3 Seeds siliqua^{-1} (no.)

Different management methods did not significantly influence the number of seeds siliqua^{-1}. However, result (Table 1 and Appendix-IX) showed that numerically the maximum (27.25) seeds siliqua^{-1} was produced at T_{10} (all managements except insecticide and fungicide) and the minimum (21.1) was at T_2 (all managements).

Rama *et al.* (1989) reported higher filled grains panicle^{-1} with 40, 80 or 120 kg N ha^{-1} applied as USG over split application of urea.

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

Chaubey *et al.* (2001) conducted an experiment in India with mustard (*Brassica juncea)* with different levels (0, 40 and 60 kg P_2O_5 ha^{-1}) of phosphorus. The maximum seeds per siliqua were found with 60 kg P_2O_5 ha^{-1}.

4.2.4 1000-seed weight (g)

Different management methods did not significant in respect of 1000-seed weight. Numerically the maximum (3.80 g) 1000-seed weight (Table 1 and Appendix-IX) was recorded in T_6 (all managements except mulching) and minimum in $T_{1.}$

The findings also in accord with the report by Yoshida (1981) and stated that the 1000-seed weight was more or less a stable genetic character and N management strategy could not increase the grain weight in this case.

Birbal *et al.* (2004) reported that seed weight of mustard was greatly affected by phosphorus. Maximum 1000-seeds weight (3.54 g) was found with 75 kg P ha^{-1}.

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

Table 1. Effect of different managements on different yield attributes of mustard

Treatment	Seeds Siliqua^{-1} (No.)	1000-seed weight (g)
T_1	22.20	3.14
T_2	21.13	3.64
T_3	23.23	3.50
T_4	21.23	3.63
T_5	25.07	3.75
T_6	23.60	3.80
T_7	24.63	3.73
T_8	25.80	3.74
T_9	24.93	3.35
T_{10}	27.25	3.48
T_{11}	24.40	3.25
T_{12}	22.23	3.20
T_{13}	24.87	3.70
T_{14}	24.13	3.30
T_{15}	25.73	3.40
T_{16}	26.10	3.36
LSD (0.05)	**8.01**	**0.90**
CV%	**19.76**	**2.72**

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

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

Seed yield is a combined output of various yield components such as siliquae plant^{-1}, seeds siliqua^{-1} and 1000 seed weight. Seed yield was affected significantly due to application of different management methods (Figure-9). The highest (1.67 t ha^{-1}) seed yield in T_6 (all managements except mulching) indicated its superiority. The maximum seed yield in T_6 (all managements except mulching) was statistically similar with $T_{2,}$ $T_{4,}$ T_5 $T_{7,}$ $T_{8,}$ and $T_{13.}$ The minimum seed yield (0.62 t ha^{-1}) was observed in T_1 (control (no modern managements)) that was followed by $T_{9,}$ $T_{16,}$ $T_{14,}$ T_{11} and $T_{12.}$

Kumar and Singh (2003) reported significant increase in seed yield (1.6 t ha^{-1}) with nitrogen at 150 kg ha^{-1}.

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

Davaria *et al.* (2001) reported that phosphorus has a great influence on the yield of mustard *(Brassica juncea)*. They conducted an experiment in India during 1994/95 rabi season with 3 levels of P_2O_5 viz. 0, 25, and 50 kg ha^{-1}. The maximum seed yield (1.54 t ha^{-1}) was observed with 50 kg P_2O_5 ha^{-1}.

Raut *et al.* (2003) stated the effect of 5 levels of irrigation and 4 levels of S (0, 20, 40 and 60 kg ha^{-1}) on the growth and yield attributes of Indian mustard cv. Pusa Bold. They observed highest number of siliquae per plant in higher seed yield per hectare (1787 kg ha^{-1}) S at 20 kg ha^{-1} compared to the other treatment combinations.

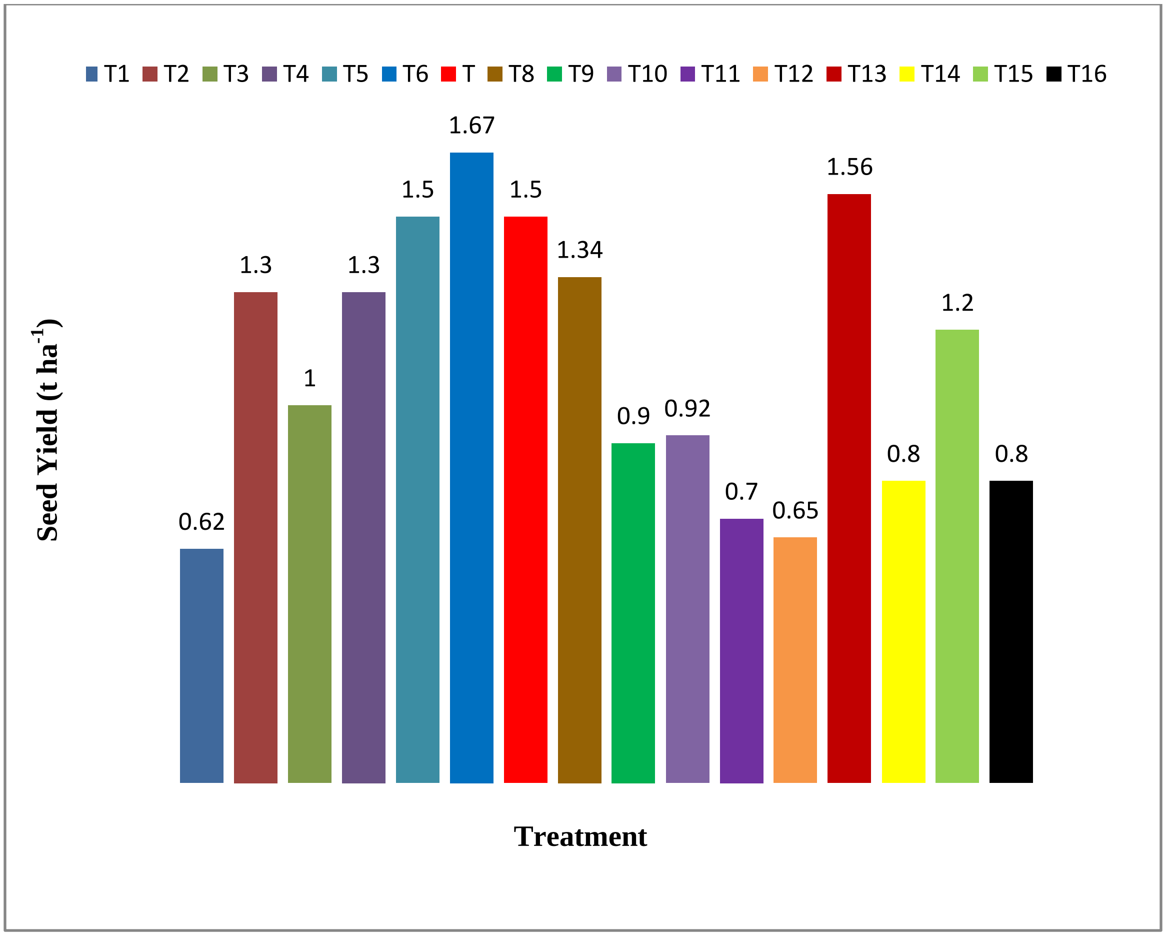

Figure 9. Yield of mustard as influenced by different managements at harvest (LSD $_{0.05}$= 371)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

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

Stover yield (t ha^{-1}) of mustard cv. BARI Sarisha-13 was significantly influenced with the application of different managements (Figure-10). The highest stover yield (5.7 t ha^{-1}) was found at T_7 (all managements except insecticide) and was at par with T_8. The lowest (1.29 t ha^{-1}) stover yield was found at T_{12} (all managements except irrigation, weeding and fertilizer) that was statistically similar with $T_{14.}$

These findings were in agreement with that of Singh and Prasad and (2003) and Singh (2002) observed higher stover yield of mustard with successive increase of the nitrogen level.

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

Patel and Shelke (1998) showed that stover yield of Indian mustard increased significantly with the application of phosphorous. They observed that 80 kg P_2O_5 ha^{-1} gave the maximum stover yield.

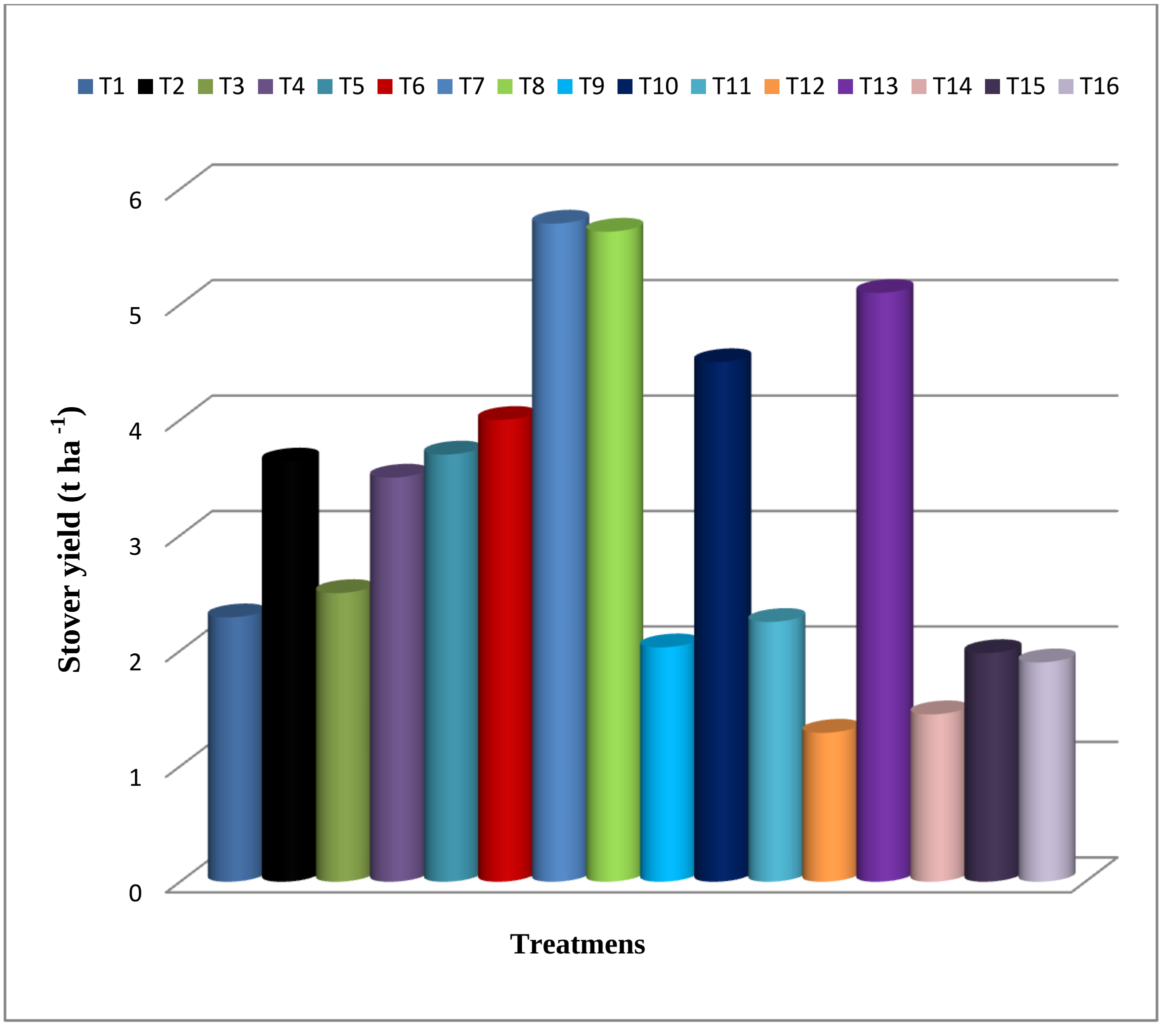

Figure 10. Stover weight of mustard as influenced by different managements at harvest (LSD $_{0.05}$= 12.79)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.7 Chaff weight

Chaff weight (t ha $^{-1}$) of mustard was significantly influenced with the application of different managements (Figure-11). They highest chaff weight (3.1 t ha^{-1}) was found at T_6 (all managements except mulching) and was at par with T_{13}. The lowest (0.72 t ha^{-1}) chaff weight was found at T_{12} (all managements except irrigation, weeding and fertilizer).

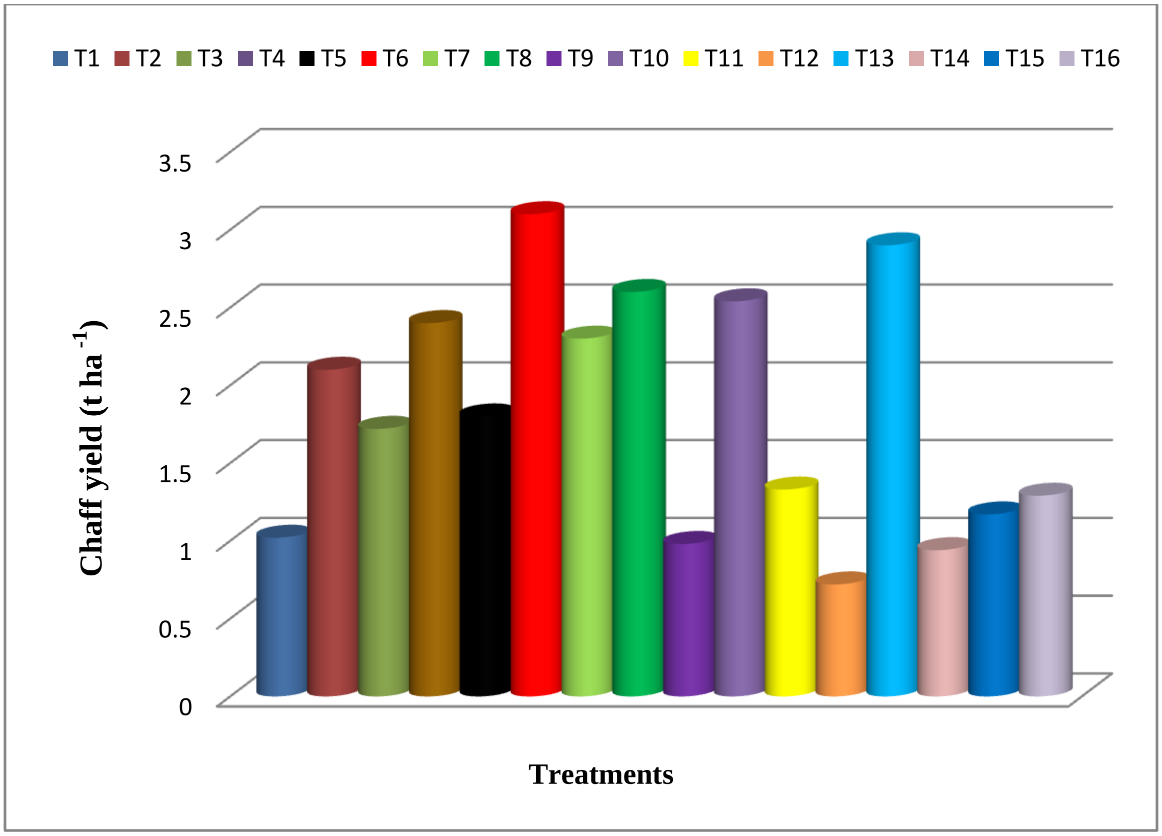

Figure 11. Chaff weight of mustard as influenced by different managements at harvest (LSD $_{0.05}$= 7.19)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.8 Biological yield (t ha $^{-1}$)

It was evident from the results that biological yield was significantly affected by the different managements on mustard cv. BARI Sarisha-13 (Figure-12). The maximum biological yield (9.56 t ha^{-1}) was found from T_{13} (all managements except mulching and weeding) that was statistically similar withT_8. On the other hand, the lowest biological yield (2.66 t ha^{-1}) was obtained from T_{12} (all managements except irrigation, weeding and fertilizer) that was followed by T_{14}.

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

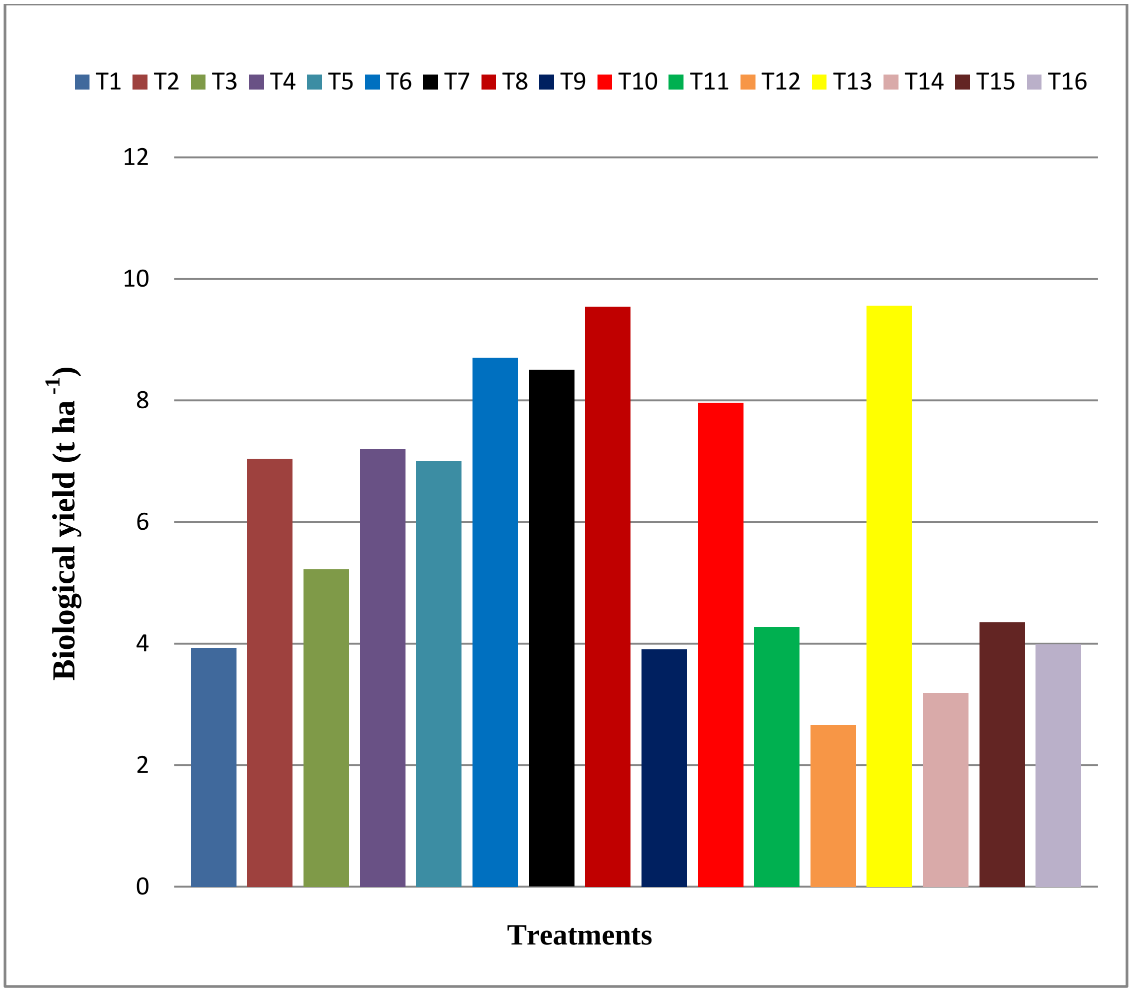

Figure 12. Biological yield of mustard as influenced by different managements at harvest (LSD $_{0.05}$= 9.19)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.9 Harvest index (%)

Harvest index is the ratio of economic yield and biological yield. Harvest index was significantly affected due to different managements on mustard cv. BARI Sarisha-13 (Figure-13). The maximum harvest index (27.59 %) was found from T_{15} (all managements except insecticide, fungicide and irrigation) that was statistically similar with T_{14}. The lowest harvest index (11.56 %) was found at T_{10} (all managements except insecticide and fungicide) that was statistically similar with T_8.

Srivastava *et al.* (1988) observed in an experiment with mustard (*Brassica juncea*) cv. Varuna that two irrigations 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 done at seed development stage or without irrigation. However, information was very scarce regarding the effect of irrigation on harvest index of rapeseed.

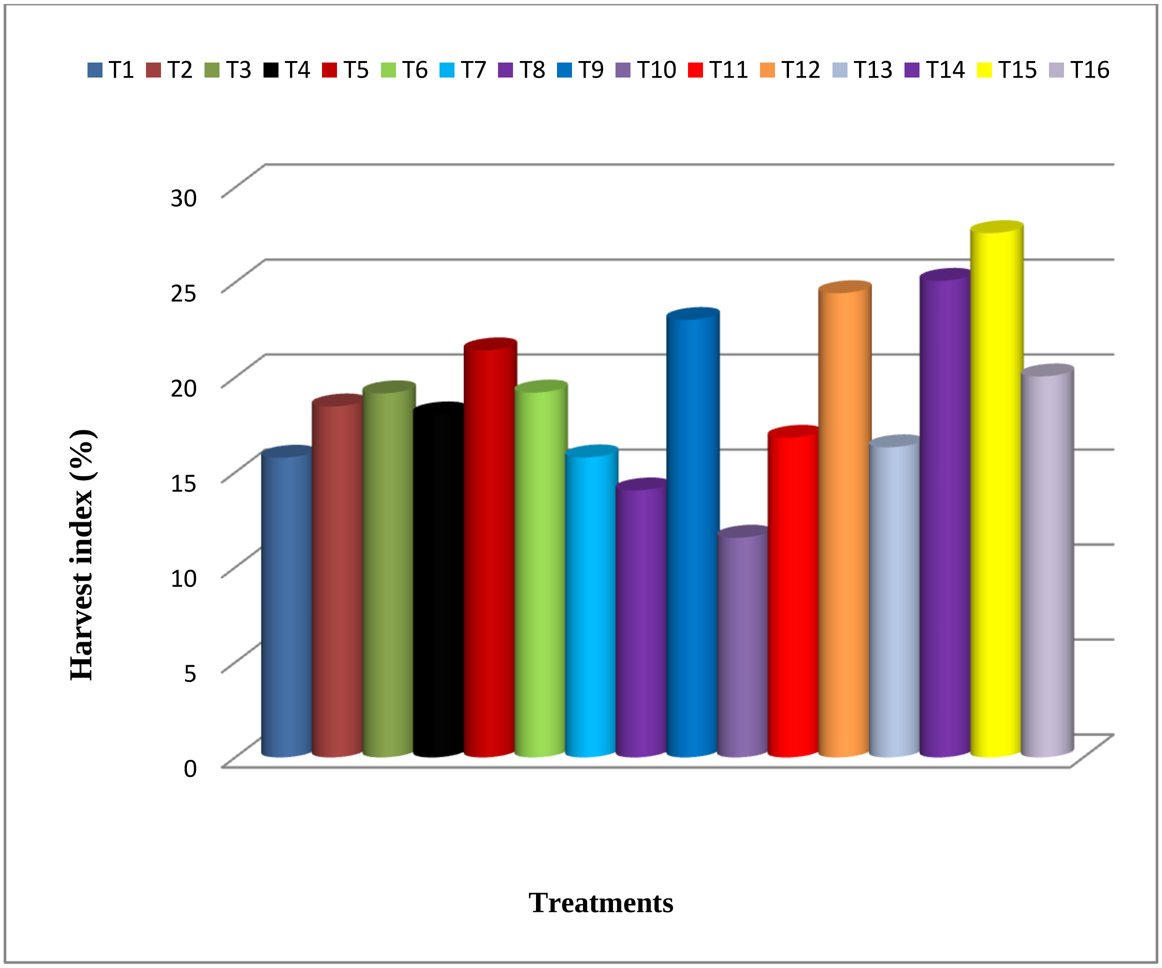

Figure 13. Harvest index of mustard as influenced by different managements at harvest

(LSD $_{0.05}$= 13.19)

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

4.2.10 Cost Analysis

Table 2. Cost, benefit and benefit cost ratio of mustard as influenced by different managements

Treatments	Cost (Tk. ha^{-1})	Benefit (Tk. ha^{-1})	Benefit Cost Ratio
T_1	39210	45475	1.20
T_2	56080	92350	1.64
T_3	53930	70550	1.30
T_4	49870	90250	1.81
T_5	54930	103750	1.89
T_6	51020	117950	2.31
T_7	54660	110100	2.01
T_8	54660	100975	1.85
T_9	28380	61525	2.17
T_{10}	53240	72800	1.37
T_{11}	47720	50950	1.06
T_{12}	20020	44025	2.20
T_{13}	43810	113600	2.59
T_{14}	22170	53975	2.43
T_{15}	51090	79875	1.56
T_{16}	46300	55975	1.20

T_1= Control (no modern managements), T_2= All managements, T_3= All managements except irrigation, T_4= All managements except weeding, T_5= All managements except row arrangement, T_6= All managements except mulching, T_7= All managements except insecticide, T_8= All managements except fungicide, T_9= All managements except fertilizer, T_{10}= All managements except insecticide and fungicide, T_{11}= All managements except irrigation and weeding, T_{12}= All managements except irrigation, weeding and fertilizer, T_{13}= All managements except mulching and weeding, T_{14}= All managements except weeding and fertilizer, T_{15}= All managements except insecticide, fungicide and irrigation, T_{16}= All managements except irrigation, weeding and insecticide.

Here cost of labour 230 Tk day^{-1}, ploughing 2000 Tk ha^{-1}, Urea 18 Tk kg^{-1}, TSP 28 Tk kg^{-1}, Zn 8 Tk kg^{-1}, Boric acid 250 Tk kg^{-1}, Cow dung 1000 Tk ton^{-1}, Irrigation 2000 Tk ha^{-1}, Insecticide 500 Tk ha^{-1}, Fungicide 500 Tk ha^{-1}, Mustard 60 Tk kg^{-1}, Straw 2500 Tk ton^{-1}.

Chapter 5

Summary and Conclusion

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SUMMARY AND CONCLUSION

The present piece of work was conducted at the Agronomy Field of the Sher-e-Bangla Agricultural University, Dhaka during the period from November-February, 2011-2012 situated under the Modhupur Tract (AEZ-28). The research work was done to investigate the influence of different management method on the growth and yield of mustard. The experimental treatments included T_1 = control (no modern managements), T_2 = All managements (fertilizer, irrigation, weeding, fungicide, mulching, insecticide, row arrangement), T_3 = all managements except irrigation, T_4 = all managements except weeding, T_5 = all managements except row arrangement, T_6 = all managements except mulching, T_7 = all managements except insecticide, T_8 = all managements except fungicide, T_9 = all managements except fertilizer, T_{10} = all managements except insecticide and fungicide, T_{11}= all managements except irrigation and weeding, T_{12} = all managements except irrigation, weeding and fertilizer, T_{13} = all managements except mulching and weeding, T_{14} = all managements except weeding and fertilizer, T_{15} = all managements except insecticide, fungicide and irrigation, T_{16} = all managements except irrigation, weeding and insecticide.

The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were 16 treatments and 3 replications. Total number of unit plot was 48. The size of unit plot was 3m × 2 m. The distance maintained between 2 unit plots was 0.75 m and that between replications was 1.5 m.

Intercultural operations such as thinning, mulching, weeding, irrigation, drainage and pest management were done as per treatment. Ten plants plot^{-1} excluding the border ones were selected at random and uprooted prior to harvest for recording data on crop parameter under study for each sampling dates. The crop was harvested when 90% of the plants become golden yellow color and was done on 9th February, 2012. The threshing was done manually. The seeds were cleaned and sun dried to moisture content at 10 %. Stover was also sun dried properly. The data on crop growth characters like plant height (at 40, 70 DAS and at harvest), branches plant^{-1} (at harvest), and above ground dry matter (at 40, 70 DAS) were recorded. On the other hand yield components like siliquae plant^{-1} (no.), seeds siliqua^{-1} (no.), 1000-seed weight (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were recorded after harvest. Data were analyzed by following the ANOVA techniques using statistical program MSTAT-C and mean differences were adjudged with LSD at 5% level of significance.

Different managements significantly influenced all growth characters but the number of leaves plant^{-1}, Siliqua length, number of seeds siliqua^{-1}, 1000-seed weight did not significantly influence.

Different managements produced the tallest plant height (73 cm) at T_5 (all managements except row arrangement), 98.16 cm at T_6 (all managements except mulching), and 116 cm at T_3 (All managements except irrigation), respectively at 40, 70 DAS and at harvest. The maximum number of leaves plant^{-1} (16) was found at T_7 (all managements except insecticide) at 40 DAS.

At 40 and 70 DAS, the highest leaf area (203.8 cm^2) at T_{10} (all managements except insecticide and fungicide) and (1012 cm^2) was found in T_8 (all managements except fungicide). At 40 DAS, T_2 (all managements) produced the highest (5.4 g) dry matter $plant^{-1}$ and T_{13} (all managements except mulching and weeding) produced the highest (2.2 g) dry matter of inflorescence $plant^{-1}$. At 70 DAS the highest dry matter of inflorescence (16.90 g) at T_7 (all managements except insecticide) and dry matter of leaf (1.7 g) was produced at T_{13} (all managements except mulching and weeding). The maximum number (4.4) of primary branches T_7 (all managements except insecticide) and secondary branches (5.1) were produced in T_6 (all managements except mulching)

At 40, 70 DAS and at harvest the maximum number of siliquae $plant^{-1}$ (26) at T_{15} (all managements except insecticide, fungicide and irrigation), (162.3) in T_7 (all managements except insecticide) and (169) of siliquae $plant^{-1}$ were produced in T_6 (all managements except mulching) respectively. The maximum seed yield (1.67 t ha^{-1}) in T_6 (all managements except mulching), stover yield (5.7 t ha^{-1}) at T_7 (all managements except insecticide), chaff weight (3.1 t ha^{-1}) at T_6 (all managements except mulching), biological yield (9.56 t ha^{-1}) at T_{13} (all managements except mulching and weeding) and harvest index (27.59 %) were found from T_{15} (all managements except insecticide, fungicide and irrigation).

Results showed that different method of managements had significant effect on all the yield parameters except number of seeds $siliqua^{-1}$, siliqua length, and 1000 grain weight.

Treatment T_6 (all managements except mulching) gave the maximum number of secondary branches (5.1), siliquae $plant^{-1}$ (169) at harvest, chaff weight (3.1 t ha^{-1}), seed yield (1.67t ha^{-1}). When mustard was grown the branch and leaf covered the left area between the adjacent plants. So there was no enough space for evaporating much moisture that hampered growth and yield. So the maximum yield was obtained from this treatment.

Treatment T_7 (all managements except insecticide) gave the maximum number of primary branches (4.4), siliquae plant^{-1} (162.3) at 70 DAS, stover yield (5.7 t ha^{-1}). Although insecticide was used, but there were no much attack by the insect. So the maximum yield was obtains from this treatment.

Treatment T_{13} (all managements except mulching and weeding) gave the maximum biological yield (9.56 t ha^{-1}). Mustard plant covered all the space and the more the space the more the branches were grown. So there was no chance for growing weed.

Treatment T_5 (all managements except row arrangement) gave seed yield (1.56 t ha^{-1}) was statistically similar with T_6. When broadcast seed application was done root formation become better than line sowing. In line sowing intercultural operation became easier than broadcast seed application.

From the above discussion, the following conclusions may be drawn:

- ❖ Treatment T_2 = All managements (fertilizer, irrigation, weeding, fungicide, mulching, insecticide, row arrangement), T_6 (all managements except mulching), T_7 (all managements except insecticide), T_4 (all managements except weeding), T_5 (all managements except row arrangement), T_8 (all managements except fungicide) T_{13} (all managements except mulching and weeding) should be recommended because mulching, insecticide, fungicide, row arrangement, weeding did not reduce more yield compare to its application cost.
- ❖ If a farmer wants to reduce the cost of production they can abandon mulching, insecticide, fungicide, row arrangement, weeding in case of mustard cultivation.

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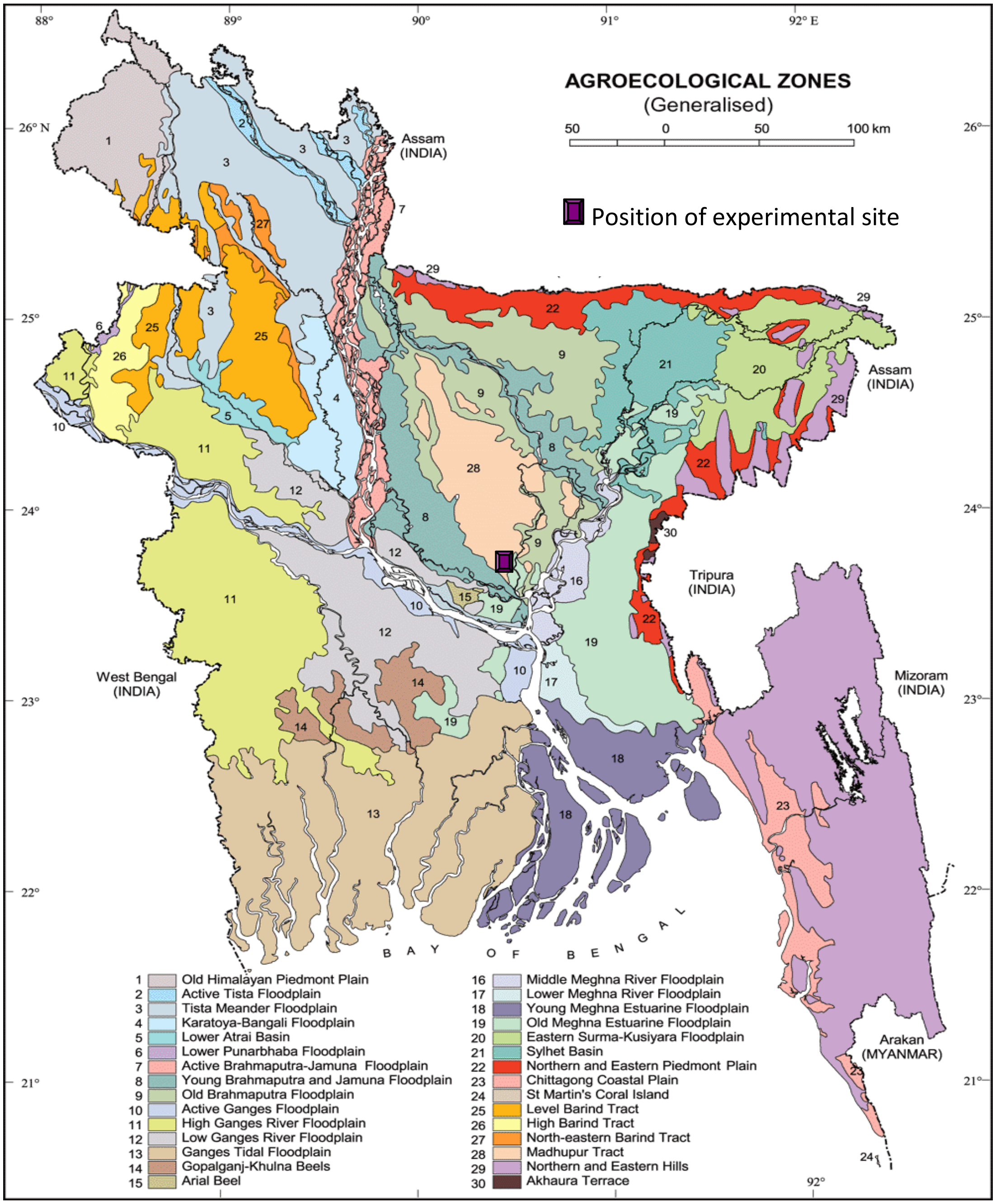
Appendices

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average air temperature, relative humidity, total rainfall and sun shine hours of the experimental site during November'11- February'12

Year	Month	Air Temperature (^{0}C)			Relative Humidity (%)	Total Rainfall (mm)	Sun Shine (hr)
		Max.	Min.	Mean			
2011	Nov.	29.6	19.0	24.3	77.0	34.4	5.7
	Dec.	26.4	14.1	20.25	69.0	12.8	5.5
2012	Jan.	25.4	12.7	19.05	68.0	7.7	5.6
	Feb.	28.1	15.5	21.8	68.0	28.9	5.5

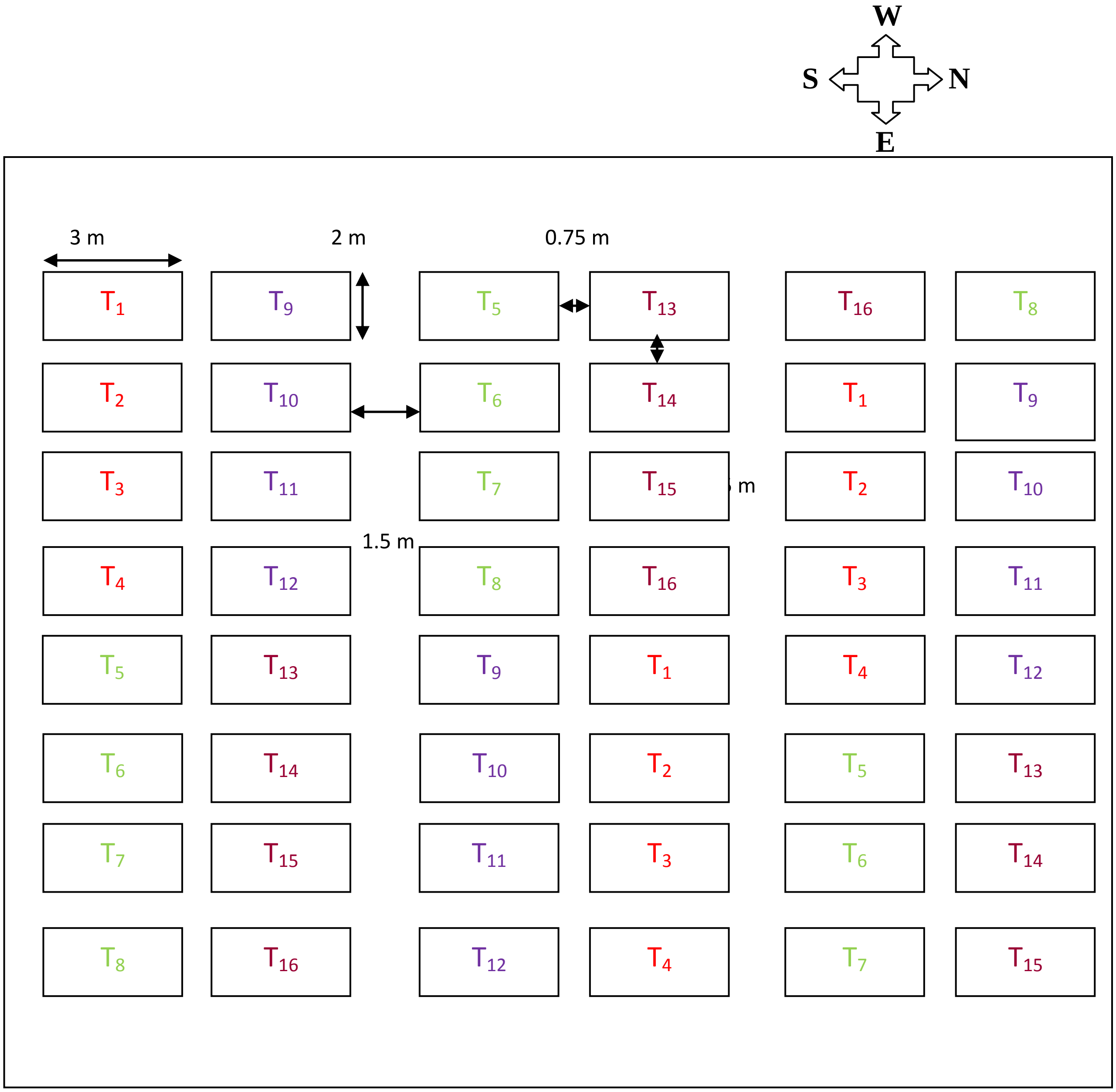
Source: Bangladesh Meteorological Department (Climate division), Agargaon Dhaka-1207

Appendix III. Physiochemical characteristics of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	25.68
% Silt	53.85
% Clay	20.47
Textural class	silty loam
pH	7.1
Organic carbon (%)	0.31
Organic matter (%)	0.54
Total N (%)	0.027
Available P (µg/ g soil)	23.64
Exchangeable K (me/ 100 g soil)	0.60
Available S (µg/ g soil)	28.43
Available B (µg/ g soil)	0.05
Available Zn (µg/ g soil)	2.31

Source: Jabin (2010)

Appendix IV. Layout of the experimental field



Replication I **Replication II** **Replication III**

Appendix V. Means square values for Siliquae plant^{-1} of mustard at different days after sowing (DAS)

Sources of variation	Degrees of freedom	Means square values at different days after sowing (DAS)		
		40	70	At harvest
Replication	3	6.438	6429.521	11661.237
Treatment	16	75.221*	2921.187*	5135.367*
Error	48	15.505	1692.921	761.609
CV (%)		31.20	38.49	25.01

*Significant at 5% level

^{ns} Non-Significant

Appendix VI. Means square values for primary and secondary branches plant^{-1} (No.) of mustard

Sources of variation	Degrees of freedom	Means square values for primary and secondary branches	
		Primary branches	Secondary branches
Replication	3	2.846	3.206
Treatment	16	2.445*	6.955*
Error	48	0.467	3.235
CV (%)		23.24	51.74

*Significant at 5% level

^{ns} Non-Significant

Appendix VII. Means square values for leaf area of mustard at different days after sowing (DAS)

Sources of variation	Degrees of freedom	Means square values for leaf area at	
		40 DAS	**70 DAS**
Replication	2	88.945	124.396
Treatment	15	6165.027*	24.132*
Error	30	2180.820	39.574
CV (%)		40.57	71.05

*Significant at 5% level

ns Non-Significant

Appendix VIII. Means square values for above ground dry matter (g) of mustard at different days after sowing (DAS)

Sources of variation	Degrees of freedom	Means square values at different days after sowing (DAS)				
		Stem (40DAS)	**Inflorescence (40DAS)**	**Leaf (70DAS)**	**Stem (70DAS)**	**Inflorescence (70DAS)**
Replication	2	2.612	0.151	0.196	3.067	5.585
Treatment	15	5.866*	0.603*	0.467*	4.576*	50.864*
Error	30	1.706	0.561	0.152	0.889	22.063
CV (%)		41.47	76.02	66.22	31.23	40.31

*Significant at 5% level

ns Non-Significant

Appendix IX. Means square values for Siliquae plant^{-1} (No.), Seeds Siliqua^{-1} (No.), 1000-seed weight (g) and seed yield (t ha^{-1}) of mustard

Sources of variation	Degrees of freedom	Means square values			
		Siliquae plant^{-1} (No.)	Seeds siliqua^{-1} (No.)	1000-seed weight (g)	Seed yield (t ha^{-1})
Replication	2	11661.237	6.554	0.003	0.038
Treatment	15	5135.367*	16.923^{ns}	0.141^{ns}	0.287*
Error	30	761.609	21.205	0.009	0.029
CV (%)		25.01	19.76	2.72	14.83%

*Significant at 5% level

^{ns} Non-Significant

Appendix X. Means square values for stover yield (t ha^{-1}), biological yield (t ha^{1}) and harvest index (%) of mustard

Sources of variation	Degrees of freedom	Means square values			
		Stover yield (t ha^{-1})	Biological yield (t ha^{1})	Harvest index (%)	Chaff Wt. (t ha^{-1})
Replication	2	0.091	0.073	11.788	0.010
Treatment	15	6.424*	17.254*	58.959*	1.646*
Error	30	0.044	0.097	3.137	0.026
CV (%)		6.62	5.09	8.79	8.84%

*Significant at 5% level