STUDY ON THE PERFORMANCE OF WEED MANAGEMENT TECHNIQUES AFFECTING GROWTH AND YIELD OF MUSTARD

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CERTIFICATE

This is to certify that the thesis entitled " ***STUDY ON THE PERFORMANCE OF WEED MANAGEMENT TECHNIQUES AFFECTING GROWTH AND YIELD OF MUSTARD****" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***SHIULI PAUL,*** *Registration. No.* ***12-04858*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:
Dhaka, Bangladesh

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The author

STUDY ON THE PERFORMANCE OF WEED MANAGEMENT TECHNIQUES AFFECTING GROWTH AND YIELD OF MUSTARD

ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during October, 2017 to March, 2018 to study on the performance of different weed management techniques affecting growth and yield of mustard varieties. The experiment comprised of two factors *viz*., (i) three mustard varieties *viz*., V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17 and (ii) Five Weed managements *viz*., W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS. Results revealed that mustard varieties, weed managements techniques and their interaction significantly affected weed population m^{-2}, dry weight of weed m^{-2}, weed control efficiency and branches $plant^{-1}$ (no.), crop growth rate , relative growth rate, siliquae $plant^{-1}$ (no.), seeds $siliqua^{-1}$, 1000 seed weight(g), seed yield (t ha^{-1}), stover yield(t ha^{-1}), biological yield(t ha^{-1}) and harvest index (%) of mustard. Among the mustard varieties 'BARI Sharisha-17' performed superior than other varieties and it produced (1.61 t ha^{-1}) seed which was 96.34% higher than BARI Sharisha-14 (0.82 t ha^{-1}). In the case of weed managements two hand weeding at 10 and 20 DAS (W_2) resulted better than other treatments and the estimated seed yield (1.61 t ha^{-1}) was recorded which was 69.47 % higher than no weeding treatment (0.82 t ha^{-1}). Similar trend was observed in interaction of variety and weed managements. BARI Sharisha-17 (V_3) along with two hand weeding at 10 and 20 DAS (W_2) produced maximum seed yield (1.89 t ha^{-1}) which was 329.55% higher than BARI Sharisha-14 (V_1) along with no weeding treatment. So it might be concluded that BARI Sharisha-17 along with two hand weeding at 10 and 20 DAS could be a better mustard cultivation package in cultivating mustard at SAU campus.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
µg	=	Micro gram
^{0}C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
g	=	Gram (g)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
Hr	=	Hour
kg	=	Kilogram
LSD	=	Least Significant Difference
mm	=	Millimeter
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non significant
ppm	=	Parts per million
q	=	Quintal
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER 1

INTRODUCTION

Mustard *Brassica sp*. under the family Cruciferae is a potential oil producing crop in winter (*Rabi*) season due to its wider adaptability and suitability to exploit residual moisture (Mukherjee, 2010). Oil seed crops are very important for human food and have gained third position among the crops next to cereals and legumes (Downey 1990). The oil is utilized for human consumption in cooking and frying purposes. The whole seed is used as condiment in the preparation of pickles and for flavoring curries and vegetables. The mustard oil is also used in preparing vegetable ghee, hair oil, medicines, soaps, lubricating oil and in tanning industries. The oil content in mustard seeds varies from 37-49 % (Bhowmik *et al.,* 2014). The oil cake is left after extraction is utilized as cattle feed and manure. The demand for consuming oil is exponentially increasing for the ever growing population but the supply is not up to the mark. For bridging the gap between demand and supply, productivity needs to be enhanced. This target could be achieved through area expansion and or increase in productivity of rapeseed-mustard. Scope for area expansion is limited because every year about 1% cultivable land is decreased so production would be increased only though increases in productivity per unit land. The per hectare productivity of the crop is quite low in the Bangladesh (1262 kg ha^{-1}) against the world average of about 1970 kg ha^{-1} in world (DRMR, 2015). The low productivity of mustard in the country might be the resultant of a number of factors *viz*. agronomic, edaphic, genetic and others. Among the agronomic factors, proper weed management may be a very serious issue (Singh, 1992).

Weed competition in mustard is more serious during early stage; because crop growth during winter (*rabi*) season remains slow during the first 4-6 weeks after sowing (Chauhan *et al.,* 2005). However, during later stage it grows vigorously and has suppressing effect on weeds but in late sowing mustard affected during flowering and siliqua formation stage due to high temperature as it is a thermo sensitive crop. As this crop is grown in poor soil with poor management practices, weed infestation is one of the major causes of low productivity. The critical period of crop weed competition in rapeseed-mustard is 15-40 days and weeds cause alarming decline in crop production

ranging from 15-60% to a total failure yield (Shekhawat *et al*., 2012, Singh *et al.*, 2010, Banga and Yadav, 2001, Singh *et al*., 2001 and Bhan, 1992,) depending on weed flora, its intensity, stage, nature and duration of the crop weed competition. If left uncontrolled, the weeds in many fields are capable of reducing yields by more than 80 % (Singh *et al.*, 2012).

The most noxious weed species which attack mustard and oilseed rape crops include *Sinapis arvensis*, *Avena fatua*, *Setaria viridis*, *Cyperus rotundus*, *Cynodon dactylon*, *Parthenium hysterophorus, Amaranthus viridis, Digera arvensis, Euphorbia hirta, Cleome viscosq, Portulaca oleracea, Trichoalesma indicum, Melilotus indica*et. (Ghadiri *et al*., 2008, Yadav *et al*., 1999 and Madhabilatha *et al.*, 1997). These weed species act as earlier competitors to the crop during establishment period, and may decrease subsequent crop growth (Ghadiri and Naderi, 2008 and Bagherani and Shimi, 2001). Weeds compete with crops for light, moisture, space and plant nutrients and other environmental requirements and consequently interfere with the normal growth of crops (Upadhyay *et al*., 2012, Bijanzadeh and Ghadiri, 2006 and Abdollahi and Ghadiri, 2004).

Weeds being injurious, harmful or poisonous are a constant source of trouble for the successful growth and development of crops. Weeds pose severe problem for crop husbandry, reducing the soil fertility and moisture, act as alternate host for insect and pest and develop a potential threat to the succeeding crops. Besides lowering production, weeds also decrease oil quality and quantity (Bagherani and Shimi 2001). Several methods have been used for weed control in rapeseed, like hand weeding, cultivation in row cropping and use of chemicals. Hand weeding is still the conventional weed control practice in rapeseed. While the studies of Chauhan *et al.* (2005) and Yadav (2004) revealed that hand weeding twice increased seed and oil yields, siliquae plant^{-1} and 1000-seed weight. Bowerman (1990) also reported that significant yield increase could be achieved mainly where the level of weed control is high. The taller plant, greater number of branches per plant, number of seeds per siliqua, number of siliquae per plant,1000-seed weight, and crop yield were recorded for the weed-free control condition, followed by hand weeding at 30 and 45 days after sowing (DAS) (Sharma and Jain, 2002). Most workers informed about a single

weeding from 20 to 40 DAS through which yield loss of mustard can be minimized (Yadav *et al*., 1999).

Herbicides are defined as a chemical substance that is used to eliminate unwanted plants. The mechanism of action (MOA) is the way the herbicide controls susceptible plants. More specifically, it describes the biological processes that are disrupted by the herbicide. These biochemical pathways control the growth and development of plants; when herbicides are applied, these processes cannot be carried out and plant injury and death will occur. Trifluralin is recommended for weed control in rapeseed fields. This herbicide can control some broad leaved and grass weeds (Miri and Rahimi, 2009). Recently, several post emergence herbicides including pronamide, haloxyfoppmethyl, propaquizafop, and isoxaben have been applied to control weed. Pendemethylin one of the pre emergence herbicide is used to control weed. Pronamideare applied as a post emergence herbicide for control of annual grass and broadleaved weeds in oilseed rape (El-Bastawesy *et al*., 2000). Haloxyfoppmethyl and propaquizafop control emerged weedy grasses or volunteer grains when applied in the three leaved to early tillering stages (Harker *et al*., 1995). Isoxaben applied as a post emergence herbicide to control annual broadleaved weeds in oilseed rape (Schneegurt *et al*., 1994).

Most farmers of Bangladesh do not adopt weed control in mustard field due to its short life span, although weeding is essential for achieving a higher yield of mustard. Therefore, the present investigation was conducted with the following objectives:

i. To find out the performance of variety on the growth and yield of mustard
ii. To evaluate the weed management techniques in mustard and
iii. To find out the best combination among the mustard variety and weed management techniques for potential production of mustard

CHAPTER 2

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abroad regarding the performance of different weed management techniques for better growth and yield of mustard varieties to gather knowledge helpful in conducting the present research work and subsequently writing up the result and discussion.

2.1 Infested weed species in the experimental field

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the predominant weeds observed in the experimental area were *Chenopodium album* (Bathua), *Thithonia diversifolia* L. (wild sunflower), *Anagallis arvensis* (Krishan neel), *Melilotus alba* (Senji), *Cyperus rotundus* (motha) and *Cynodon dactylon* (Doob) during both the years of experimentation.

Field investigation was carried out by Bamboriya *et al*. (2017) during *rabi* season of 2014-15 at Udaipur to evaluate the effect of different weed management practices on yield and nutrient uptake of mustard. The experiment comprises of 10 treatments, which consisted of weedy check, one hand weeding at 20 DAS, two hand weeding at 20 and 40 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS, quizalofop-p-ethyl 0.050 kg ha^{-1} at 30 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, isoproturon 1.25 kg ha^{-1} at 30 DAS and weed free

check. The experiment was laid out in a randomized block design and replicated four times. They reported that Mustard was heavily infested with mixed flora of monocot and dicot weeds chiefly consisted of *Phalaris minor, Cyperus rotundus and Cynodon dactylon;Chenopodium album, Chenopodium murale, Rumex acetosella, Convolvulus arvensis, Parthenium hysterophorus, Anagallis arven-sis and Cichorium intybus,* respectively.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that the pre-dominant weeds were noted in the experimental field *Phalaris minor* (21.35%), *Cynodon dactylon* (7.78%), *Chenopodium album* (17.58%), *Anagallis arvensis* (27.43%), *Melilotus alba*, *Vicia hirsuta, Lathyrus asphaca and Rumex sp*.(19.22%) of broad leaved and *Cyperus rotundus* (10.61%) of sedges group.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, *Brassica napus* and *Brassica campestris*. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. They reported that the tallest plant was obtained from weeding condition along with the species *Brassica campestris* whereas the shortest plant was found in interaction with or without weeding along with *Brassica napus*. The taller plant was obtained from weeded plots than that at non weeded plots throughout the growing period.

Experiment was carried out by Khan *et al.* (2008) to study the efficacy of some pre and post emergence herbicides on yield and yield components of canola at Malakandher Research Farm, NWFP Agricultural University, Peshawar during rabi season 2000-2001. The experiment was laid out in Randomized Complete Block (RCB) design with four replications. There were 10 treatments in each replication *viz.*, pre emergence: Treflan 4 EC 1.20 kg ha^{-1}, Dual Gold 960 EC 1.44 kg ha^{-1}, Stomp 330 EC 0.99 kg ha^{-1}, Sencor WP70 0.35 kg ha^{-1} and post emergence: Ronstar 12 L 0.36 kg ha^{-1}, Fusilade 13EC 0.26 kg ha^{-1}, Topik 15 Wp 0.03 kg ha^{-1}, Puma super 75 EW 0.75 kg ha^{-1}, Agil 100 EC 0.15 kg ha^{-1} and Weedy check. The result revealed that the weed species infesting the experimental field were *Avena fatua, Sorghum helapense, Phalaris minor, Convolvulus arvensis, Cyperus rotundus, Fumaria indica, Vicia sativa, Medicago denticulata, Rumex crispus* and *Anagallis arvensis* etc.

2.2 Weeds m^{-2}

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that all weed control treatments significantly influenced weed density over the weedy check. Preemergence application of Oxadiargyl 90 g ha^{-1} resulted more effective in reducing the density of broad-leaved weed as well.

Experiment was carried out by Khan *et al.* (2008) to study the efficacy of some pre and post emergence herbicides on yield and yield components of canola at Malakandher Research Farm, NWFP Agricultural University, Peshawar during rabi season 2000-2001. The experiment was laid out in Randomized Complete Block (RCB) design with four replications. There were 10 treatments in each replication *viz.*, pre emergence: Treflan 4 EC 1.20 kg ha^{-1}, Dual Gold 960 EC 1.44 kg ha^{-1}, Stomp 330 EC 0.99 kg ha^{-1}, Sencor WP70 0.35 kg ha^{-1} and post emergence: Ronstar 12 L 0.36 kg ha^{-1}, Fusilade 13EC 0.26 kg ha^{-1}, Topik 15 Wp 0.03 kg ha^{-1}, Puma super 75 EW 0.75

kg ha^{-1}, Agil 100 EC 0.15 kg ha^{-1} and Weedy check. The result revealed that the maximum weeds m^{-2} (18.83) was recorded in the weedy check and minimum in Treflan 4EC (3.20 m^{-2}) treated plots. The density in the best treatment was however statistically at par with Fusilade 13EC (4.77 m^{-2}).

2.3 Dry matter weight of weed m^{-2}

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that all the weed management treatments resulted into significant reduction in weeds dry weight (g m^{-2}) at harvest compared to unweeded check during both the years of experiment. The least weeds dry weight of 30.00 and 42.00 g m^{-2} were recorded under pre emergence application of pendimethalin 30 EC+Imazethapyr 2 EC (T5) during 2013-14 and 2014-15, respectively. But it severely hampered germination of mustard crop closely followed by two hand weeding at 25-30 and 40-45 DAS while highest weeds dry weight of 209.62 g m^{-2} was recorded under weedy check.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.*, pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that due to species-wise suppression of weeds, all weed control treatments appreciably

reduced weed dry matter accumulation as compared to weedy check. Oxadiargyl 90 g ha^{-1} reduced the dry matter accumulation appreciably as compared to other weed control treatments, however, other treatment e.g. pendimethalin 1000 g ha^{-1} also reduced the weed dry matter and was at par with trifluralin 750 g ha^{-1}. Quizalofop 60 g and clodinafop 60 g ha^{-1} each applied as post-emergence could not control the full spectrum of weeds as both of these have been reported to control the P. minor more effectively as compared to BLWs. They reported that the maximum dry matter of weeds m^{-2} (175.15 g) was observed from control treatment (no weeding) and the minimum dry matter of weed (32.88 g) was observed from oxadiargyl 90 g ha^{-1} (pre-emergence) treatment.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. Brassica napus and Brassica campestris, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. They reported that the least weed dry weight (23.79 g m^{-2}) obtained from the weeding condition along with species *Brassica campestris* whereas the highest weed dry weight (57.80 g m^{-2}) was found in no weeding along with *Brassica napus*.

2.4 Weed control efficiency

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one

hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the highest WCE (83.18 %) were recorded under two hand weeding treatment (T_{10}) where as the lowest WCE (41.68 %) was recorded under Oxadiargyl 6EC @ 0.09 kg ha^{-1} (T_4) treatment.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that as far as the weed control efficiency (W.C.E. %) was concerned, it was also affected due to various weed control treatments. The higher W.C.E. was recorded in oxadiargyl 90 g ha^{-1}, fb pendimethalin 1000 g ha^{-1}, trifluralin 750 g $ha^{-1}$and oxyfluorfen 150 g ha^{-1} and lowest with quizalofop 60 g ha^{-1} and clodinafop 60 g ha^{-1}, respectively. Quizalofop and clodinafop both of these herbicides used to control only narrow leaved weeds and in the experimental field density of narrow leaf weeds was comparatively less as compared to broad leaved weeds, so this was a main reason to showed the minimum W.C.E. over rest of the herbicide treatments.

2.5 Plant height

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45

DAS were evaluated in Randomized Block Design with three replications. They revealed that the plant height of mustard improved slightly due to application of weed management treatments over weedy check. The mean maximum plant height of 165.4 cm was recorded under 2 HW, which was statistically at par with other treatments and significantly superior over treatment T_5 during both the years. The mean increases in plant height due to treatment T_3 were 8.4 and 54.7 cm, respectively over weedy check (T_1) and treatment T_5.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.*, pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that significantly taller plants were recorded under oxadiargyl 90 g ha^{-1} (164.50 cm), fb pendimethlin 1000 g ha^{-1} (157.40 cm), trifluralin 750 g ha^{-1} (155.35 cm) and oxyfluorfen 150 g ha^{-1} (147.62 cm) due to effective control of weeds and favorable growth of the crop in these treatments and minimum plant height was recorded with control (no weed management) (106.73 cm) quizalofop 60 g ha^{-1} (126.72 cm) and clodinafop 60 g ha^{-1} (129.43).

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1= 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding).The found that BINA Sarisha-6 possessed the maximum plant height (110.39 cm) while BARI Sarisha-14 had the minimum plant height (92.17 cm). Among the treatments two weeding plots had the highest plant height (101.94 cm) while no weeding had the minimum plant height (96.92 cm).

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, *Brassica napus* and *Brassica campestris.* The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. They reported that the tallest plant (137.53 cm) was obtained from weeding along with *Brassica campestris* and the shortest one (85.03 cm) was obtained from no weeding along with *Brassica napus.*

2.6 Dry matter weight of crop

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, *Brassica napus* and *Brassica campestris.* The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. They reported that total dry matter (TDM) is the sum of dry weight of roots, stem, leaves, branches, and fruits (siliqua). Initial low accumulation of TDM increased rapidly till 85 DAS followed by a slower increase. Results showed that the higher TDM (484.42 g m^{-2}) obtained from the weeding condition along with species *Brassica campestris* whereas the smaller TDM (375.45 g m^{-2}) was found in no weeding along with *Brassica napus*. A single weeding had significant effect on TDM accumulation. Irrespective of the species higher TDM was obtained from weeding condition than that of no weeding condition.

2.7 Branches plant^{-1}

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007

and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). The found that BINA Sarisha-5 produced highest branches plant^{-1}(5.54) followed by BARI Sarisha-14 (4.22) and BINA Sarisha-6 (3.83). Comparison of the treatment means reflected that maximum branches plant^{-1}(5.39) was recorded where two weeding were conducted, while minimum number (3.39) was counted in the no weeding.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, *Brassica napus* and *Brassica campestris*. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. They reported that the number of branches plant^{-1} increased gradually with time. The interaction effect of weeding and species was found significant but the trend was irregular. However, the highest number of branches (11.07) was obtained at weeding treatment plants with *Brassica napus* and the lowest number (6.40) from no weeding along with *Brassica campestris*. Weeding gave the higher number of branches as compared to no weeding treatment.

2.8 Siliquae plant^{-1}

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC

(ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the siliquae $plant^{-1}$ was influenced significantly due to weed management practices during both the years. The maximum siliquae $plant^{-1}$ (156.80) was observed in two hand weeding and the minimum one (117.80) from T_5 (Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}) treatment

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that the highest siliquae $plant^{-1}$ (247.72) was recorded from weed free plot followed by Oxadiargyl 90 g ha^{-1} (PE) (240.53), Pendimethalin 1000 g ha^{-1} (PE) (230.56), Trifluralin 750 g ha^{-1} (PPI) (224.18) and the minimum one (115.54) was recorded from control (no weed management plot).

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). The found that BINA Sarisha-5 had the highest number of siliquae $plant^{-1}$ (65.67) followed by BARI Sarisha-14 (50.78) and BINA Sarisha-6 (46.22). The highest number of siliquae $plant^{-1}$(65.61) was recorded in two weeding plots while the lowest number was noted in no weeding (44.44).

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, *Brassica napus* and *Brassica campestris*. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest siliquae plant^{-1} (82.53) obtained from the weeding condition along with species *Brassica campestris* whereas the lowest siliquae plant^{-1} (62.42) was found in no weeding along with *Brassica napus*.

2.9 Seeds siliqua^{-1}

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the maximum seeds siliqua^{-1} (13.07) was observed in two hand weeding and the minimum one (9.32) from T_5 (Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}) treatment which was statistically similar with T_1 (weedy check) treatment.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-

plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that the highest seeds $siliqua^{-1}$ (11.81) was recorded from weed free plot followed by Oxadiargyl 90 g ha^{-1} (PE) (11.43), Pendimethalin 1000 g ha^{-1} (PE) (11.21), Trifluralin 750 g ha^{-1} (PPI) (10.95) and the minimum one (7.61) was recorded from control (no weed management plot.

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). The found that BINA Sarisha-5 produced highest $seedsiliqua^{-1}$ (26.61) followed by BARI Sarisha-14 (19.22) and BINA Sarisha-6 (18.39). The highest number of seed $siliqua^{-1}$(22.36) obtained from two weeding treatment, while the lowest number of seeds/siliqua (20.44) was found in no weeding.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. Brassica napus and Brassica campestris, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest seeds $siliqua^{-1}$ (21.04) obtained from the weeding condition along with species *Brassica campestris* whereas the lowest seeds $siliqua^{-1}$ (18.31) was found in no weeding along with *Brassica campestris*.

2.10 1000 seed weight

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the maximum 1000 seed weight (4.33 g) was observed in T_{10} (two hand weeding) treatment and the minimum one (3.97 g) from T_1 (Weedy check) treatment.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that the highest 1000 seed weight (4.95 g) was recorded from weed free plot followed by Oxadiargyl 90 g ha^{-1} (PE) (4.85 g), Pendimethalin 1000 g ha^{-1} (PE) (4.78 g), Trifluralin 750 g ha^{-1} (PPI) (4.74 g) and the minimum one (4.28 g) was recorded from control (no weed management plot).

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for

weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). The found that the highest 1000-seed weight was produced by BINA Sarisha-5 (3.14) and the lowest was in BINA Sharisha-6 (2.84) in both the growing seasons. Among the weeding treatments the maximum 1000-seed weight (3.14) was obtained from two weeding plots while the lowest 1000-seed weight (2.80) was obtained from no weeding.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. Brassica napus and Brassica campestris, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest 1000 seed weight (2.98 g) obtained from the weeding condition along with species *Brassica napus* whereas the lowest 1000 seed weight (2.52 g) was found in no weeding along with *Brassica campestris*.

Experiment was carried out by Khan *et al.* (2008) to study the efficacy of some pre and post emergence herbicides on yield and yield components of canola at Malakandher Research Farm, NWFP Agricultural University, Peshawar during rabi season 2000-2001. The experiment was laid out in Randomized Complete Block (RCB) design with four replications. There were 10 treatments in each replication *viz.*, pre emergence: Treflan 4 EC 1.20 kg ha^{-1}, Dual Gold 960 EC 1.44 kg ha^{-1}, Stomp 330 EC 0.99 kg ha^{-1}, Sencor WP70 0.35 kg ha^{-1} and post emergence: Ronstar 12 L 0.36 kg ha^{-1}, Fusilade 13EC 0.26 kg ha^{-1}, Topik 15 Wp 0.03 kg ha^{-1}, Puma super 75 EW 0.75 kg ha^{-1}, Agil 100 EC 0.15 kg ha^{-1} and Weedy check. The result revealed that statistical analysis of the data revealed that herbicides had significant effect on 1000 seed weight. The highest (3.68 g) 1000 seed weight was obtained from Treflan 4EC and Fusilade 13EC (3.40 g) plots. It was further observed that the lowest 1000 seed weight (2.72 g) was obtained from Sencor WP70 treated plots, which was statistically equal (2.78 g) to the weedy check plots.

2.11 Seed yield

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the highest seed yield (16.96 q ha^{-1}) was observed in T_{10} (two hand weeding) treatment and the minimum one (9.67 q ha^{1}) from T_5 (Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}) treatment which was statistically similar with T_1 (weedy check) treatment.

Field investigation was carried out by Bamboriya *et al*. (2017) during *rabi* season of 2014-15 at Udaipur to evaluate the effect of different weed management practices on yield and nutrient uptake of mustard. The experiment comprises of 10 treatments, which consisted of weedy check, one hand weeding at 20 DAS, two hand weeding at 20 and 40 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS, quizalofop-p-ethyl 0.050 kg ha^{-1} at 30 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, isoproturon 1.25 kg ha^{-1} at 30 DAS and weed free check. The experiment was laid out in a randomized block design and replicated four times. They reported that the maximum seed yield (1955.25 kg ha^{-1}) was recorded from two hand weeding treatment while the minimum seed yield (1166.75 kg ha^{-1}) was recorded from Weedy check treatment.

The experiment was conducted by Yadav *et al*. (2017) during Rabi season 2011-12 at Agronomy Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, Uttar. Ten treatments *Viz.,* pendimethalin 1000 g ha^{-1} (pre-emergence), oxadiargyl 90 g ha^{-1} (pre-emergence), trifluralin 750 g ha^{-1}(pre-

plant incorporation), oxyfluorfen 150 g ha^{-1} (pre-emergence), quizalofop 60 g ha^{-1}, (post-emergence) clodinafop 60 g ha^{-1}, (post-emergence) isoproturon 1000 g ha^{-1} (pre-emergence), isoproturon 1000 g ha^{-1} (post-emergence)), weedy check and weed free check in a randomized block design (RBD) with three replications. They reported that influenced the seed yield in the same manner Oxadiargyl 90 g ha^{-1}, pendimethalin 1000 g ha^{-1}, trifluralin 750 g ha^{-1} and oxyfluorfen 150 gha^{-1} being at par recorded significantly higher seed yield over rest of the treatments.

The experiment was carried out by Akhter *et al.* (2016) at the experimental field of Rajshahi University Campus, Bangladesh) during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). They found that among the varieties BINA Sarisha-5 gave highest seed yield (840 t ha^{-1}) and BINA Sarisha-6 produced lowest yield (609.00 t ha^{-1}). That maximum seed yield (898.50 t ha^{-1}) was produced by two weeding plots. While minimum seed yield (515 t ha^{-1}) was obtained in no weeding.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. *Brassica napus* and *Brassica campestris*, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest seed yield (1.52 t ha^{-1}) obtained from the weeding condition along with species *Brassica campestris* whereas the lowest seed yield (1.06 t ha^{-1}) was found in no weeding along with *Brassica napus.*

Experiment was carried out by Khan *et al.* (2008) to study the efficacy of some pre and post emergence herbicides on yield and yield components of canola at

Malakandher Research Farm, NWFP Agricultural University, Peshawar during rabi season 2000-2001. The experiment was laid out in Randomized Complete Block (RCB) design with four replications. There were 10 treatments in each replication *viz.*, pre emergence: Treflan 4 EC 1.20 kg ha^{-1}, Dual Gold 960 EC 1.44 kg ha^{-1}, Stomp 330 EC 0.99 kg ha^{-1}, Sencor WP70 0.35 kg ha^{-1} and post emergence: Ronstar 12 L 0.36 kg ha^{-1}, Fusilade 13EC 0.26 kg ha^{-1}, Topik 15 Wp 0.03 kg ha^{-1}, Puma super 75 EW 0.75 kg ha^{-1}, Agil 100 EC 0.15 kg ha^{-1} and Weedy check. The result revealed that maximum seed yield of 1568 kg ha^{-1} was produced by Treflan 4EC treated plots. However, it was statistically at par with the Fusilade 13EC (1458 kg ha^{-1}). The Fusilade 13EC was in turn statistically similar with Ronstar 12L (1346 kg ha^{-1}), Topik 15WP (1365 kg ha^{-1}), Puma Super 75EW (1376 kg ha^{-1}) and Agil 100EC (1341 kg ha^{-1}). Minimum seed yield of 1077 and 1155 kg ha^{-1} was obtained in Sencor WP70 treated and weedy check plots, respectively. Seed yield significantly increased with the application of Treflan 4EC and Fusilade 13EC herbicides.

2.12 Stover yield

A field experiments was conducted by Gupta *et al*. (2018) during two consecutive rabi seasons of 2013-14 and 2014-15 to study the effect of weed management practices on yield, weed dynamics and economics of mustard and to find out the most effective and economic weed management practice for mustard under semi arid conditions of Rajasthan. The present experiment consist of 10 treatments *viz.* T_1: weedy check,T_2: Pendimethalian 30 EC @ 0.75 kg ha^{-1}, T_3: pendimethalian 38.7 CS @ 0.75 kg ha^{-1}, T_4: Oxadiargyl 6EC @ 0.09 kg ha^{-1}, T_5: Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}, T_6: Oxyflurofen 23.5 EC @ 0.15 kg ha^{-1}, T_7: Quizalofop-p-ethyl 5EC @ 0.06 kg ha^{-1}, T_8: Clodinafop-p- ethyl 15WP @ 0.06 kg ha^{-1}, T_9: one hand weeding (HW) at 25-30 DAS and T_{10}: Two hand weeding at 25-30 and 40-45 DAS were evaluated in Randomized Block Design with three replications. They revealed that the highest stover yield (53.08 q ha^{-1}) was observed in T_{10} (two hand weeding) treatment and the minimum one (31.25 q ha^{1}) from T_5 (Pendimethlian 30 EC+ Imazethapyr 2 EC (ready mix) @ 0.75 k ha^{-1}) treatment which was statistically similar with T_1 (weedy check) treatment.

Field investigation was carried out by Bamboriya *et al*. (2017) during *rabi* season of 2014-15 at Udaipur to evaluate the effect of different weed management practices on

yield and nutrient uptake of mustard. The experiment comprises of 10 treatments, which consisted of weedy check, one hand weeding at 20 DAS, two hand weeding at 20 and 40 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS, quizalofop-p-ethyl 0.050 kg ha^{-1} at 30 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, isoproturon 1.25 kg ha^{-1} at 30 DAS and weed free check. The experiment was laid out in a randomized block design and replicated four times. They reported that the maximum stover yield (5568.25 kg ha^{-1}) was recorded from two hand weeding treatment while the minimum stover yield (3943.00 kg ha^{-1}) was recorded from Weedy check treatment.

2.13 Biological yield

Field investigation was carried out by Bamboriya *et al*. (2017) during *rabi* season of 2014-15 at Udaipur to evaluate the effect of different weed management practices on yield and nutrient uptake of mustard. The experiment comprises of 10 treatments, which consisted of weedy check, one hand weeding at 20 DAS, two hand weeding at 20 and 40 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS, quizalofop-p-ethyl 0.050 kg ha^{-1} at 30 DAS, fenoxaprop-p-ethyl 0.075 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, fluazifop-p-butyl 0.055 kg ha^{-1} at 10 DAS + one hoeing at 40 DAS, isoproturon 1.25 kg ha^{-1} at 30 DAS and weed free check. The experiment was laid out in a randomized block design and replicated four times. They reported that the maximum biological yield (7523.50 kg ha^{-1}) was recorded from two hand weeding treatment while the minimum biological yield (5109.75 kg ha^{-1}) was recorded from Weedy check treatment.

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. Brassica napus and Brassica campestris, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest biological yield

(4.84 t ha^{-1}) obtained from the weeding condition along with species *Brassica campestris* whereas the lowest biological yield (3.75 t ha^{-1}) was found in no weeding along with *Brassica napus.*

2.14 Harvest index

An experiment was conducted by Awal and Fardous (2014) at the Crop Botany Field Laboratory, Bangladesh Agricultural University, Mymensingh, from November 2010 to February 2011 to assess the effect of a single weeding on crop growth and yield of two mustard species, Brassica napus and Brassica campestris. The experiment comprised 4 treatments from the combination of two weeding regimes viz. weeding and without weeding conditions with two species of mustard viz. Brassica napus and Brassica campestris, represented by the cultivars BINA Sarisha-5 and BINA Sarisha-6, respectively. The experiment was laid out following a Randomized Complete Block Design with three replications. Results showed that the highest harvest index (33.88 %) obtained from the weeding condition along with species *Brassica napus* whereas the lowest harvest index (27.81 %) was found in no weeding along with *Brassica campestris*.

CHAPTER 3

MATERIALS AND METHODS

Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2017 to March, 2018.

3.1.2 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone - Modhupur Tract (AEZ-28). The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix I.

3.1.3 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The mean maximum and minimum air temperature range were (30.18-31.46^{0}c) and (14.85-15.27^{0}c) respectively. The mean relative humidity ranges from 67.82-74.41%, rainfall varies from 4.2-6.3 mm day^{-1}, wind speed (1-3 km hr^{-1}), sunshine hour (4.15-7.48) and evaporation rate range from (2.04-2.07 mm day^{-1}) were recorded from the SAU meteorological yard, Dhaka. However the prevailing weather conditions during the study period (October, 2017 to March, 2018) have been presented in Appendix II.

3.2 Plant materials

BARI Sharisha-14 (*Brassica campestris*) was released by Oil Seed Research Centre in 1997 crossing ‘Tori 7’ with ‘Sonali sorisha’ by hybridization technique and released

as BARI Sharisha-14 variety in 2006 by National Seed Board. The average height is 75-85 cm, leaf light green, produced 80-100 siliquae plant^{-1}, 22-26 seeds siliqua^{-1}, yellow color seed, 1000 seed weight 3.5-3.8 g, life cycle 75-80 days and average yield is 1.40 - 1.60 t ha^{-1}. It can produce 25-30% more mustard than 'Tori 7'.

BARI Sharisha-15 (*Brassica campestris*): The germplasm was collected from Bogura in 2002, after some trial it was released as BARI Sharisha-15 variety by National Seed Board in 2006. The average height is 90-100 cm, produced 70-80 siliquae plant^{-1}, 20-22 seeds siliqua^{-1}, yellow color seed, 1000 seed weight 3.25-3.50 g, life cycle 80-85 days and average yield is 1.55 - 1.65 t ha^{-1}. It can produce 30-35% more mustard than 'Tori 7'.

BARI Sharisha-17 (*Brassica napus*) has been developed crossing between 'BARI Sharisha-15' and 'Sonali Sorisha'. After some field trial in Oil Seed Research Centre and regional research centre, it was released in 2013 as BARI Sharisha-17 variety by National Seed Board. BARI Sharisha-17 is short duration mustard variety, life cycle 82-86 days, average height is 95-97 cm, produced 60-65 siliquae plant^{-1}, 28-30 seeds siliqua^{-1}, yellow color seed, 1000 seed weight 3.00-3.40 g and average yield is 1.70 - 1.80 t ha^{-1}. It can produce 5-10% more mustard than 'BARI Sharisha-14'.

3.3 Treatments under investigation

There were two factors in the experiment namely variety and weed management mentioned below:

A. Factor-1 (Variety: 3)

i. V_1 = BARI Sharisha-14

ii. V_2 = BARI Sharisha-15

iii. V_3 = BARI Sharisha-17

B. Factor-2 (Weed management levels: 5)

i. W_0= No weeding (control),
ii. W_1= One hand weeding at 10 DAS,
iii. W_2= Two hand weeding at 10 and 20 DAS,
iv. W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and
v. W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

3.4 Description of herbicides

A short description of the herbicides used in the experiment is given in Table 1.

Table 1. Short description of the herbicides used in the experiment

Trade name	Common name	Mode of action	Selectivity	Dose	Time of application
Panida 33 EC	Pendemethylin	Systemic	Selective	2000 ml ha^{-1}	Pre-emergence
Whipsuper 9 EC	Fenoxaprop-p-ethyl	Systemic	Selective	750 ml ha^{-1}	Post-emergence

3.5 Experimental design and layout

The experiment was laid out in a split plot design with 3 replications. There were 15 treatment combinations and 45 unit plots. The unit plot size was 5 m^2 (2.5 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively.

3.6 Land preparation

The experimental land was opened with a power tiller on 20th October, 2017. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 30th October, 2017 and was ready for sowing seeds.

3.7 Fertilizer application

The fertilizers were applied as basal dose @ Urea 205 kg ha^{-1}, TSP 150 kg ha^{-1}, MoP 85 kg ha^{-1}, Gypsum 120 kg ha^{-1}, Zink Sulphate 4 kg ha^{-1}, Boric acid 10 kg ha^{-1} and Cow dung 10 ton ha^{-1} at final land preparation, respectively in all plots except urea.

Half of the urea was applied during final land preparation and another half was applied during flowering stage. During final land preparation all fertilizers were applied by broadcasting and mixed thoroughly with soil and the 2nd doses of urea was side dressed.

3.8 Sowing of seeds

Seeds were sown at the rate of 7 kg ha^{-1} in the furrow on 1st November, 2017 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was 30 cm.

3.9 Intercultural operations

3.9.1 Thinning

Thinning was done to maintain 10 cm plant to plant distance after 10 days of germination.

3.9.2 Weed control

Weed control was done as per experimental treatments.

3.9.3 Irrigation and drainage

Pre-sowing irrigation in row was given to ensure the maximum germination percentage. The second and third irrigation was done at 24 and 53 DAS.

3.9.4 Pest management

To control aphid Malathion 57 EC @ 2 ml L^{-1} was applied 2 times at 10 DAS interval.

3.10 Harvesting and sampling

The crop was harvested as per plot at 90 DAS when about 95% of the siliquae were ripen. Samples were collected from different places of each plot leaving undisturbed plant in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor.

3.11 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.12 Drying, cleaning and weighing

The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed. The dried seeds and stover were cleaned and weighed.

3.13 Recording of data

The data were recorded on the following parameters

i. Weed parameters

a. Weed population (no. m^{-2})

b. Dry weight of weed m^{-2} (g)

c. Weed control efficiency

ii. Plant characters

a. Plant height (cm)
b. Dry matter weight $plant^{-1}$ (g)
c. Crop growth rate (CGR) (g m^{-2} day^{-1})

d. Relative growth rate (RGR) (g g^{-1} day^{-1})

e. Branches $plant^{-1}$ (no.)

f. Siliquae $plant^{-1}$ (no.)

g. Seeds $siliqua^{-1}$ (no.)

h. 1000 seed weight (g)

i. Seed yield (t ha^{-1})

j. Stover yield (t ha^{-1})

k. Biological yield (t ha^{-1})

l. Harvest index (%)

3.14 Procedure of recording data

3.14.1 Weed parameters

i. Weed population

The data on weed infestation as well as density were collected from each treated plot at 25 days interval up to harvest. A plant quadrate of 1.0 m^2 was placed at three different spots of 5 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted at different dates.

ii. Dry matter of weed m^{-2}

The weeds inside each quadrate for density count were uprooted and cleaned. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 70^0 C. After drying, weight of weed was taken and expressed to g m^{-2}.

iii. Weed control efficiency

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

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

3.14.2 Plant characters

i. Plant height (cm)

Ten plants were collected randomly from each plot. The height of the plants were measured from the ground level to the tip of the plant at 25, 50, 75 days after sowing (DAS) and harvest.

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

Ten plants were collected randomly from each plot at 25, 50, 75 days after sowing (DAS) and harvest. The sample plants were oven dried for 72 hours at 70°C and then dry weight plant^{-1} was determined.

xiii. Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula developed by Radford (1967):

$$CGR=\frac{1}{GA}\times\frac{W2-W1}{T2-T1}\ g\ m^{-2}\ d^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

xiv. Relative growth rate (**RGR**)

Relative growth rate (RGR) is the growth rate relative to the size of the population.

Relative growth rate was calculated using the following formula developed by Radford (1967):

RGR= $\frac{\ln W2 - \ln W1}{T2 - T1}$ g^{-1} $g^{-1}d^{-1}$

Where,

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

ln = Natural logarithm

iii. Branch plant^{-1} (no.)

Ten plants were collected randomly from each plot. Number of branch per plant was counted from each plant sample and then averaged at 50, 75 days after sowing (DAS) and harvest.

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

Number of siliquae plants^{-1} was counted from the 10 plant sample and then the average siliqua number was calculated.

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

Number of seeds siliqua^{-1} was counted from 20 siliquae of plants and then the average seed number was calculated.

vi. 1000 seed weight (g)

1000-seeds were counted which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were recorded.

vii. Seed yield (t ha^{-1})

Seed yield was recorded by weighing the harvested seed plot^{-1} (1 m^2) and was calculated in t ha^{-1}.

viii. Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell of harvested area was sun dried and the weight was recorded and then converted to t ha^{-1}.

ix. Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield was the biological yield. Biological yield (t ha^{-1}) = Seed yield (t ha^{-1}) + Stover yield (t ha^{-1}).

x. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

$$HI=\frac{Grain\ yield}{Biological\ yield}\times 100$$

Here, Biological yield (t ha^{-1}) = Seed yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.15 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from a study to investigate the performance of different weed management techniques affecting growth and yield of mustard varieties. The results of the weed parameters and crop characters as influenced by different weed management techniques have been presented and discussed in this chapter.

4.1 Infested weed species in the experimental field

It is a general observation that conditions favorable for growing mustard are also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Eleven weed species belonging to seven families were found to infest the experimental crop. Local name, common name, scientific name and family of the weed species have been presented in Table 2.

The most important weeds of the experimental plot were *Eleusine indica, Cynodon dactylon, Dactyloctenium aegyptium, Echinochola colonum, Cyperus rotundus, Brassica kaber, Heliotropium indicum, Amaranthus spinosus, Alternanthera philoxeroides, Chenopodium album and Solanum nigrum,* respectively. Among the Eleven weed species four were grasses, one was sedge, two were amaranth and other three families' weeds were found. The Similar type of weed flora in mustard crop was reported by (Yadav *et al.*, 2017; Bisen and Singh; 2008 and Yadav; 2004).

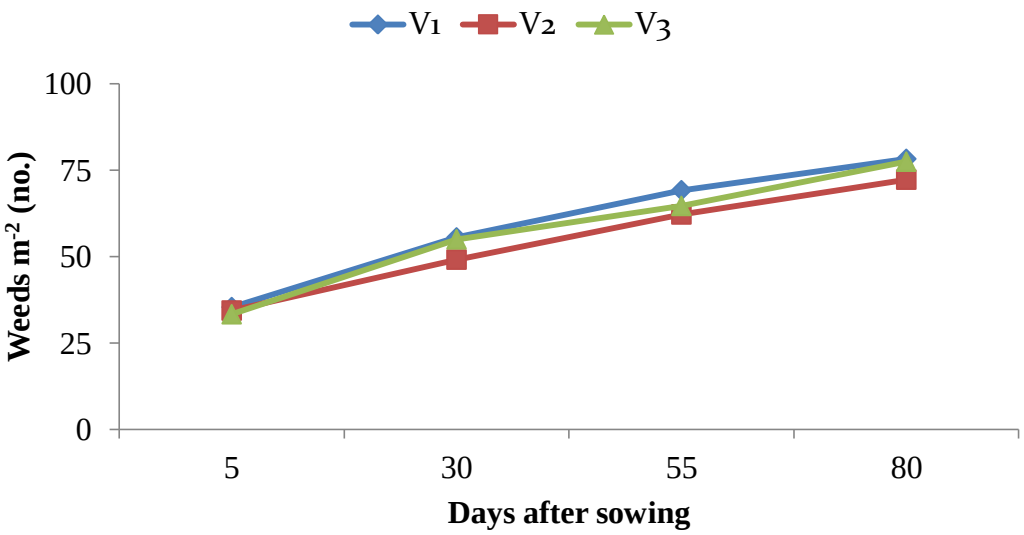
Table 2. Common weed species which were found in the experiment field

Sl. No.	Bangali Name	Common Name	Scientific Name	Family
1	Chapra	Goose grass	*Eleusine indica*	Poaceae
2	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae
3	Kakpaya	Crow foot weed	*Dactyloctenium aegyptium*	Poaceae
4	Choto shama	Jungle rice	*Echinochola colonum*	Poaceae
5	Mutha	Purple nutsedge	*Cyperus rotundus*	Cyperaceae
6	Ban shorisha	Wild mustard	*Brassica kaber*	Brassicaceae
7	Hati shur	Wild clary	*Heliotropium indicum*	Boraginaceae
8	Kanta notae	Spiny pig-weed	*Amaranthus spinosus*	Amaranthaceae
9	Malanch	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae
10	Bothua	Lambs quarter	*Chenopodium album*	Chenopodiaceae
11	Ban begun	Black night shade	*Solanum nigrum*	Solanaceae

4.2 Weeds m^{-2} (no.)

4.2.1 Effect of Variety

There was no significant variation observed on weeds m^{-2} over time for varietal variation (Figure 1). Numerically highest weeds m^{-2} (35.33, 55.47, 69.13 and 78.20 at 5, 30, 55 and 80 DAS, respectively) was recorded from BARI Sharisha-14 (V_1) and lowest weeds m^{-2} (49.07, 62.13 and 72.20 at 30, 55 and 80 DAS, respectively) recorded from BARI Sharisha-15 (V_2). At 5 DAS, numerically lowest weeds m^{-2} (33.27) was observed from BARI Sharisha-17 (V_3).

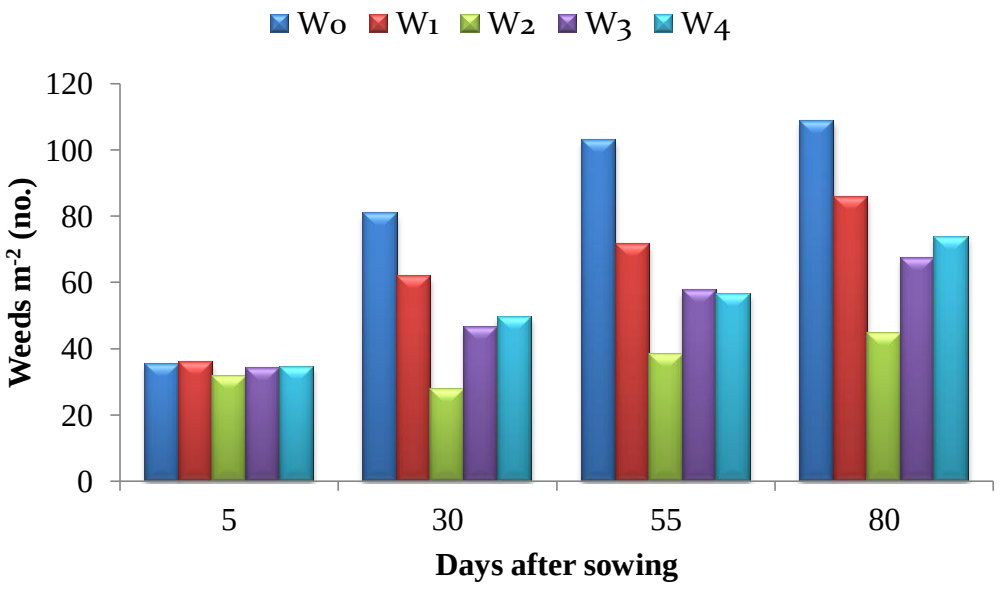


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 1. Effect of variety on the weeds m^{-2} in mustard field at different days after sowing ($LSD_{0.05}$= NS, NS, NS and NS at 5, 30, 55 and 80 DAS, respectively)

4.2.2 Effect of weed management

Significant variation was observed on weeds m^{-2} throughout the growing period for different weed management (Figure 2). At 5 DAS, the highest weeds m^{-2}(35.78) was observed in one hand weeding at 10 DAS (W_1), which was statistically similar with W_0, W_3 and W_4 and the lowest weeds m^{-2} (31.67) was observed in two hand weeding at 10 DAS and 20 DAS (W_2), which was statistically similar with W_3. At 30, 55 and 80 DAS, the highest weeds m^{-2} (80.78, 102.70 and 108.70, respectively) were observed in no weeding (W_0) and the lowest weeds m^{-2} (27.67, 38.33 and 44.56, respectively) were observed in two hand weeding at 10 DAS and 20 DAS (W_2), which was statistically differed with other treatments. The variability in weed population in different treatments can be attributed to the fact that hand weeding are more effective for weed control than the others. These findings are in close conformity with those of (Gupta *et al.*, 2018; Yadav *et al.*, 2017; Awal and Fardous, 2014; Patel *et al.*, 2013; Kumar *et al.*, 2012; Bijanzadeh *et al.*, 2010 and Khan *et al.*, 2008).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 2. Effect of different weed managements on the weeds m^{-2} in mustard field at different days after sowing ($LSD_{0.05}$= 2.87, 4.99, 6.84 and 5.59 at 5, 30, 55 and 80 DAS, respectively)

4.2.3 Interaction effect of variety and weed management

For variety and weed management combination, significant variation was observed for weed density throughout the growing period shown in Table 3. At 5, 30, 55 and 80 DAS, the highest weeds m^{-2} (40.67, 90.33, 113.70 and 121.70, respectively) was observed in BARI Sharisha-14 (V_1) in combination with no weeding (W_0), which was statistically similar with V_2W_4 and V_1W_1 at 5 DAS. At 5 and 55 DAS the lowest weeds m^{-2} (31.00 and 35.00, respectively) was observed in BARI Sharisha-14 (V_1) in combination with two hand weeding at 10 DAS and 20 DAS (W_2), which was statistically differed from treatment combinations V_1W_0, V_1W_1 and V_2W_4 at 5 DAS and with V_2W_2 and V_3W_2 at 55 DAS. At 30 DAS the lowest weeds m^{-2} (23.00) was observed in BARI Sharisha-17 (V_3) in combination with two hand weeding at 10 DAS and 20 DAS (W_2) which was statistically similar with treatment combination V_1W_2 and V_2W_2. At 80 DAS the lowest weeds m^{-2} (37.00) was observed in BARI Sharisha-15 (V_2) in combination two hand weeding at 10 DAS and 20 DAS (W_2), which was statistically similar with treatment combinationV_1W_2.

Table 3. Interaction effect of variety and different weed managements on the weeds m^{-2} in mustard field at different days after sowing

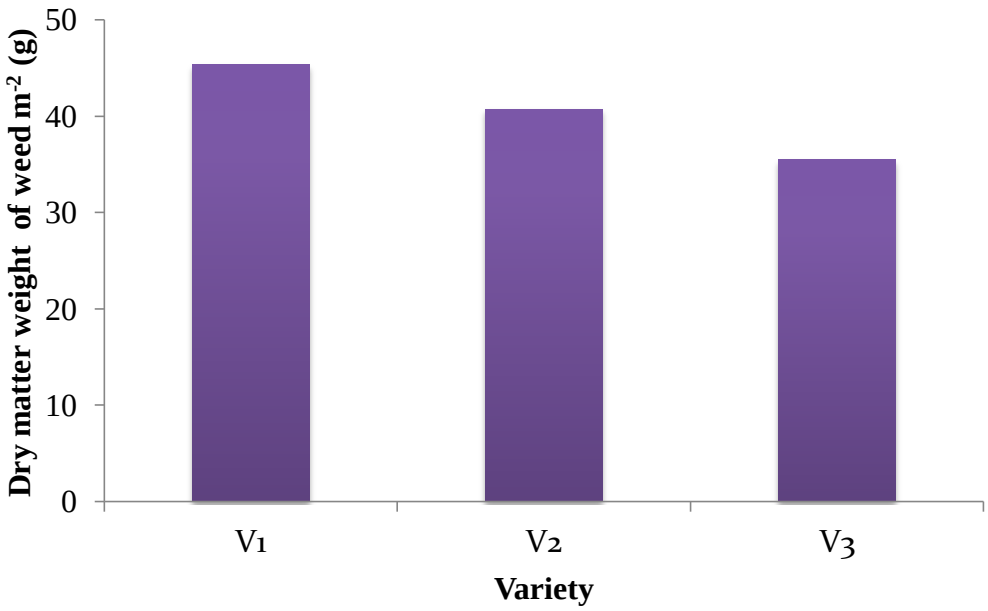
Treatment combinations	Weeds m^{-2} (no.) at days after sowing			
	5	30	55	80
V_1W_0	40.67 a	90.33 a	113.7 a	121.7 a
V_1W_1	36.33 a-c	60.33 c	82.33 c	92.33 cd
V_1W_2	31.00 d	30.33 f	35.00 g	44.00 jk
V_1W_3	34.67 b-d	48.33 de	56.00 e	63.00 i
V_1W_4	34.00 b-d	48.00 de	58.67 de	70.00 g-i
V_2W_0	32.67 cd	74.33 b	94.33 b	101.3 bc
V_2W_1	35.33 b-d	50.33 de	62.33 de	83.33 de
V_2W_2	32.00 cd	29.67 f	37.33 g	37.00 k
V_2W_3	34.00 b-d	45.67 e	59.67 de	65.33 hi
V_2W_4	37.67 ab	45.33 e	57.00 e	74.00 e-h
V_3W_0	33.00 b-d	77.67 b	100.0 b	103.0 b
V_3W_1	35.67 b-d	74.33 b	69.67 d	81.33 ef
V_3W_2	32.00 cd	23.00 f	42.67 fg	52.67 j
V_3W_3	33.67 b-d	44.67 e	57.00 e	73.00 f-h
V_3W_4	32.00 cd	55.00 cd	53.67 ef	77.00 e-g
LSD $_{(0.05)}$	**4.97**	**8.64**	**11.84**	**9.68**
CV (%)	**8.59**	**9.65**	**10.77**	**7.56**

V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

4.3 Dry matter weight of weed m^{-2} (g)

4.3.1 Effect of Variety

Significant variation was observed on dry matter weight of weed m^{-2} for varietal variation (Figure 3). The maximum dry matter weight of weed m^{-2}(45.38 g) was recorded from BARI Sharisha-14 (V_1) and lowest one (35.47 g) was recorded from BARI Sharisha-17 (V_3). The result of our study was not similar with the finding of Awal and Fardous (2014) who reported that the species effect on weed growth was found insignificant which very common phenomenon in weed ecology is.

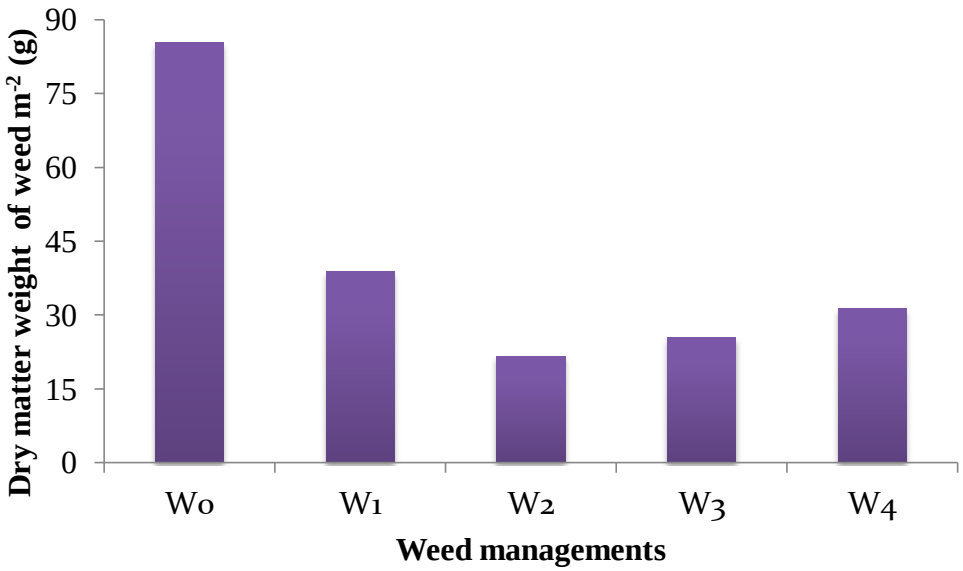


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 3. Effect of variety on the dry matter weight of weed m^{-2} in mustard field at different days after sowing ($LSD_{0.05}$=3.46)

4.3.2 Effect of weed management

Significant variation was observed on dry matter weight of weed $m^{-2}$for different weed managements shown in figure 4. The highest dry matter weight of weed m^{-2} (85.33 g) was recorded from no weeding treatment (W_0) and hence the lowest dry matter weight of weed m^{-2} (21.67 g) was recorded from two hand weeding at 10 DAS and 20 DAS (W_2) which was statistically similar with W_3. This might be due to effective weed control achieved under efficient method of weed management (two hand weeding) in terms of lower weed population per unit area and less availability of underground (nutrient and moisture) and above ground resources (light) to weeds due to more competitive and smothering effect of crop, resulting lower weed dry matter m^{-2}. The findings are supported by the results of (Gupta *et al.*, 2018; Bamboriya *et al*., 2017; Jangir *et al.*, 2017; Yadav*et al.*, 2017; Adhikari and Ghosh, 2014; Awal and Fardous, 2014; Kour *et al.*, 2014; Patel *et al.*, 2013; Meena and Shah, 2011; Mitra, 2011; Singh, 2009; Sarkar *et al.*, 2005; Tekale *et al*., 2005 and Banga *et al.*, 2004) stated that one hand weeding in mustard field at 25 DAS gave the lowest weed count, weed dry weight and weed growth rate.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 4. Effect of different weed managements on the dry matter weight of weed m^{-2} in mustard field at different days after sowing ($LSD_{0.05}$=4.70)

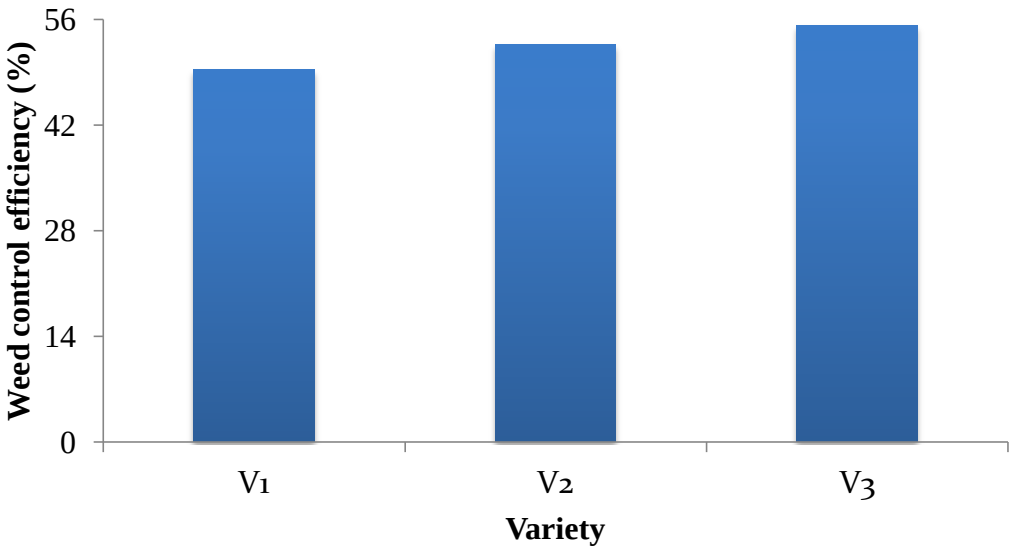
4.3.3 Interaction effect of variety and weed management

Significant variation was observed for dry matter weight of weed m^{-2} under different variety and weed management combinations (Table 3). The highest dry matter weight of weed m^{-2} (90.00 g) was observed from BARI Sharisha-14 and no weeding combination (V_1W_0), which was statistically similar with V_2W_0 and the lowest dry matter weight of weed m^{-2} (18.67 g) was recorded from BARI Sharisha-14 and two hand weeding at 10 DAS and 20 DAS combination (V_3W_2) which was statistically similar with V_2W_2, V_1W_2, V_2W_3 and V_3W_3.

4.4 Weed control efficiency (%)

4.4.1 Effect of Variety

Significant variation was not observed for weed control efficiency due to varietal variation shown in Figure 5. Numerically the highest and lowest weed control efficiency (55.11% and 49.33%) was found from BARI Sharisha-17 (V_3) and BARI Sharisha-14 (V_1), respectively.

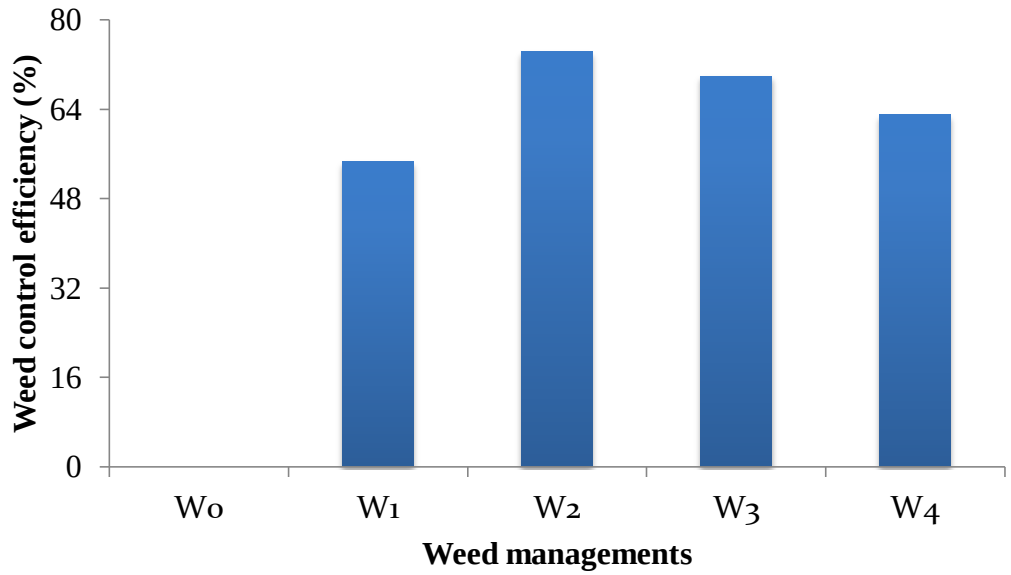


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 5. Effect of variety on the weed control efficiency in mustard field at different days after sowing ($LSD_{0.05}$=NS)

4.4.2 Effect of weed management

For different weed management treatments, significant variation was observed for weed control efficiency (Figure 6). Two hand weeding at 10 DAS and 20 DAS (W_2) scored the highest weed control efficiency (74.34%) which was statistically differed from others. The lowest weed control efficiency (0.00%) was observed under no weeding treatment (W_0). This might be due to effective weed control achieved under efficient method of weed management (two hand weeding) in terms of lower weed population per unit area and less availability of underground (nutrient and moisture) and above ground resources (light) to weeds due to more competitive and smothering effect of crop, resulting lower weed biomass and weed control efficiency . Similar findings were also reported by (Gupta *et al.*, 2018; Jangir *et al.*, 2017; Adhikari and Ghosh 2014; Kour *et al.*, 2014; Patel *et al.*, 2013; Kumar *et al.*, 2012; Sarkar *et al.*, 2005 and Banga *et al.*, 2004).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 6. Effect of different weed management on the weed control efficiency in mustard field at different days after sowing ($LSD_{0.05}$=4.11)

4.4.3 Interaction effect of variety and weed management

Significant variation was observed for weed control efficiency under different variety and weed management combinations (Table 4). The highest weed control efficiency (76.46%) was recorded form combinations of BARI Sharisha-17 (V_3) and two hand weeding at 10 DAS and 20 DAS (W_2), which was statistically similar with V_2W_2, V_3W_3 and V_1W_2. The lowest weed control efficiency (0.00%) was observed under all the varieties (BARI Sharisha-14, BARI Sharisha-15 and BARI Sharisha-17) and no weeding treatment combinations (V_1W_0, V_2W_0 and V_3W_0).

Table 4. Interaction effect of variety and different weed managements on the dry matter of weed m^{-2} and weed control efficiency in mustard field

Treatment combinations	Dry matter of weed m^{-2} (g)	Weed control efficiency (%)
V_1W_0	90.00 a	0.00 g
V_1W_1	45.73 c	49.27 f
V_1W_2	25.67 f-h	70.68 ab
V_1W_3	28.83 ef	67.86 bc
V_1W_4	36.67 de	58.82 de
V_2W_0	86.67 ab	0.00 g
V_2W_1	41.00 cd	52.13 ef
V_2W_2	20.67 gh	75.89 a
V_2W_3	25.00 f-h	70.82 ab
V_2W_4	30.33 ef	64.55 b-d
V_3W_0	79.33 b	0.00 g
V_3W_1	29.67 ef	62.28 cd
V_3W_2	18.67 h	76.46 a
V_3W_3	22.67 f-h	71.12 ab
V_3W_4	27.00 fg	65.70 b-d
$LSD_{(0.05)}$	**8.15**	**7.11**
CV (%)	**11.93**	**8.06**

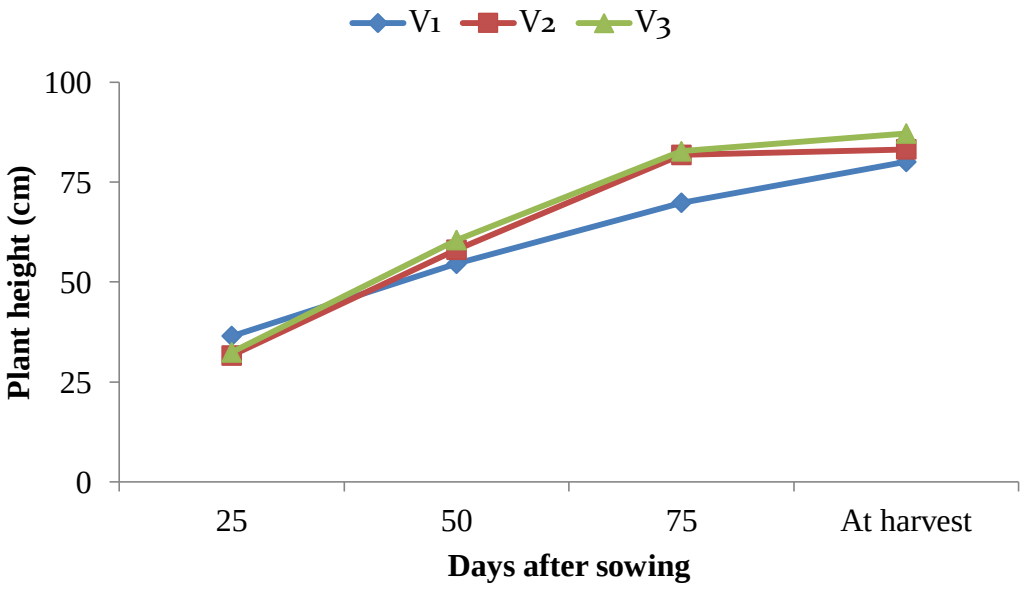
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

4.5 Plant height (cm)

4.5.1 Effect of Variety

Plant height of mustard varied significantly for varietal variation throughout the growing period except at harvest (Figure 7). At 25 DAS, BARI Sarisha-14 (V_1) attained the tallest plant (36.47 cm) and BARI Sarisha-15 (V_2) attained the shortest plant (31.58 cm) which was statistically similar with BARI Sarisha-17 (V_3). At 50 and 75 DAS BARI Sarisha-17 (V_3) attained the tallest plant (60.47 cm and 82.67 cm, respectively) which was statistically similar with BARI Sarisha-15 (V_2) and BARI Sarisha-14 (V_1) attained the shortest plant (54.53 cm and 69.80 cm, respectively). The

result could be due to genetic variability of mustard variety. The results are in agreement with the result of (Awal and Fardous 2014; Islam, 2006 and Mondal *et al*., 2003) who found that plant height differed significantly among the varieties of *Brassica napus*.



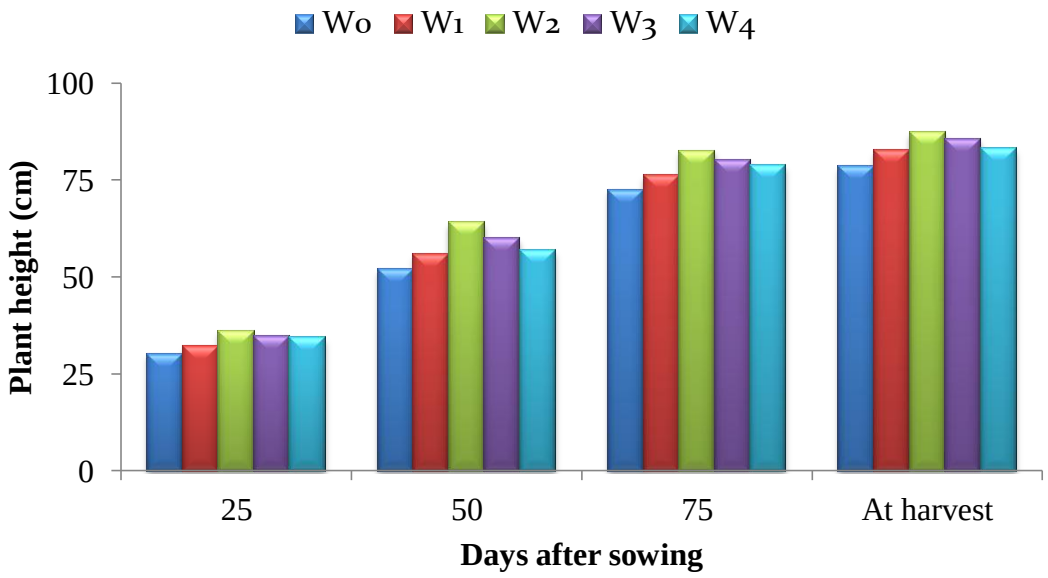
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 7. Effect of variety on the plant height of mustard at different days after sowing ($LSD_{0.05}$=2.92, 2.57, 8.09 and NS at 25, 50, 75 DAS and At Harvest, respectively)

4.5.2 Effect of weed management

There was significant variation observed for plant height due to different weed management (Figure 8). Two hand weeding at 10 DAS and 20 DAS (W_2) attained the tallest plant (36.18 cm, 63.98 cm, 82.52 cm and 87.32 cm at 25, 50, 75 DAS and harvest, respectively) which was statistically similar with W_3 and W_4 at 25 DAS; with W_3 at 50 DAS; with W_1, W_3 and W_4 at 75 DAS and harvest and no weeding treatment (W_0) attained shortest plant (30.15 cm, 51.83 cm, 72.57 cm and 78.52 cm at 25, 50, 75 DAS and harvest, respectively). It might be due to the fact that both the herbicide and hand weeding suppresses the weed growth efficiently at the crucial stage of crop growth which checks the weed growth and resulted in better plant growth. Yadav *et al.* (2017) and Anonymous (2012) also concluded that better growth and development of the crop under competition free environment with effective control of weeds due to

different weed control treatments showed influence on the attaining higher plant height. The results are in agreement with those reported by (Jangir *et al.*, 2017; Chauhan *et al.*, 2005; Singh, 2006; Kumar *et al.*, 2012; Awal and Fardous, 2014 and Sharma and Jain, 2002) who exposed that plant height was found to be taller in weeding condition in mustard crop.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 8. Effect of different weed management on the plant height of mustard at different days after sowing ($LSD_{0.05}$=3.66, 6.43, 7.10 and 7.41 at 25, 50, 75 DAS and At Harvest, respectively)

4.5.3 Interaction effect of variety and weed control treatments

Plant height was significantly affected by the interaction of variety and weed management shown in Table 5. At 25 DAS, the tallest plant (38.61 cm) was recorded from the combination of BARI Sharisha-14(V_1) and two hand weeding at 10 DAS and 20 DAS (W_2) which was statistically similar with V_1W_3, V_1W_4, V_1W_1, V_1W_0, V_2W_2, V_2W_3, V_2W_4, V_3W_2, V_3W_3 and V_3W_4 and the shortest plant (27.69 cm) was recorded from BARI Sharisha-15 (V_2) and no weeding (W_0) which was statistically similar with V_2W_1, V_3W_0, V_3W_1, V_3W_4, V_2W_4, V_2W_3 and V_1W_0. Combination of BARI Sharisha-17 (V_3) and two hand weeding at 10 DAS and 20 DAS (W_2) attained the tallest plant (65.83 cm, 88.60 cm and 90.33 cm) at 50, 75 DAS and harvest,

respectively which were statistically similar with all the treatment combinations except V_1W_0, V_1W_1, V_1W_4, V_2W_0 and V_3W_0 at 50 DAS; V_1W_0, V_1W_1, V_1W_2, V_1W_3, V_1W_4 and V_3W_0 at 75 DAS and finally V_1W_0 and V_1W_1 at harvest. On the other hand, combination of BARI Sharisha-14 (V_1) and no weeding(W_0) attained the shortest plant (47.76 cm, 65.38 cm and 72.47 cm) at 50, 70 DAS and harvest, respectively which were statistically similar with V_1W_1, V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_3W_0 and V_2W_4 at 50 DAS; with V_1W_1, V_1W_4, V_1W_3, V_1W_2, V_3W_0 and V_2W_0 at 75 DAS and V_1W_1, V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_3, V_2W_4 and V_3W_0 at harvest.

Table 5. Interaction effect of variety and different weed managements on the plant height of mustard at different days after sowing

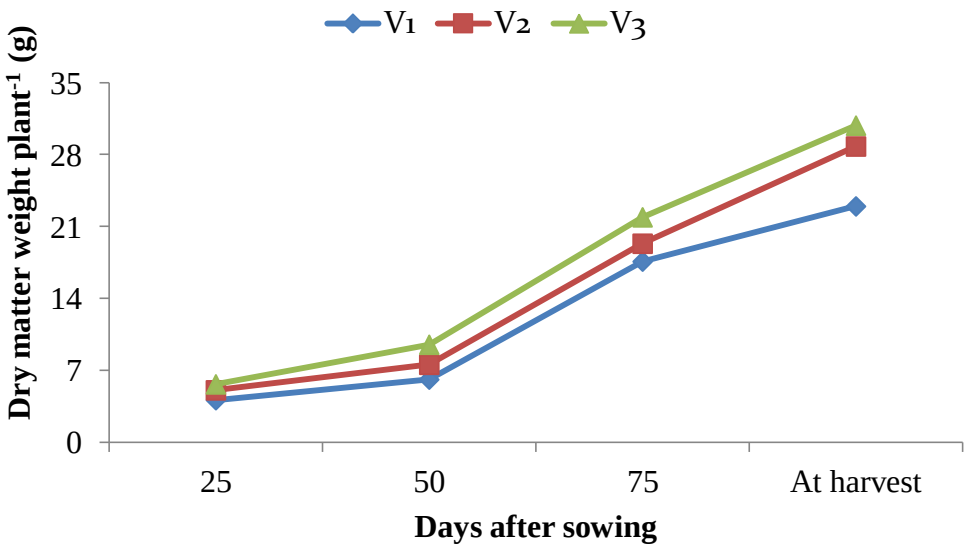
Treatment combinations	Plant height (cm) at days after sowing			
	25	50	75	At harvest
V_1W_0	33.48 a-d	47.76 c	65.38 e	72.47 c
V_1W_1	35.56 a-c	52.56 bc	68.83 de	76.87 bc
V_1W_2	38.61 a	62.79 ab	73.67 b-e	85.40 ab
V_1W_3	37.17 ab	55.32 a-c	71.20 cde	84.07 a-c
V_1W_4	37.53 ab	54.23 bc	69.93 de	81.26 a-c
V_2W_0	27.69 d	53.90 bc	76.73 a-e	79.80 a-c
V_2W_1	29.46 cd	54.94 a-c	79.47 a-d	83.07 a-c
V_2W_2	35.48 a-c	63.33 ab	85.28 ab	86.23 ab
V_2W_3	32.60 a-d	61.95 ab	84.33 ab	84.37 a-c
V_2W_4	32.68 a-d	56.08 a-c	83.00 a-c	82.37 a-c
V_3W_0	29.27 cd	53.82 bc	75.60 b-e	83.30 a-c
V_3W_1	31.43 b-d	59.86 ab	80.60 a-d	87.80 ab
V_3W_2	34.47 a-c	65.83 a	88.60 a	90.33 a
V_3W_3	34.07 a-c	62.49 ab	85.07 ab	88.42 ab
V_3W_4	32.57 a-d	60.36 ab	83.51 ab	85.75 ab
LSD $_{(0.05)}$	**6.34**	**11.13**	**12.29**	**12.83**
CV (%)	**11.24**	**11.45**	**9.34**	**9.12**

V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

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

4.6.1 Effect of Variety

Dry matter is the material which was dried to a constant weight. Dry matter (DM) production determines the production potential of a crop. A sublime DM production is the first emergent for high yield. It was pronounced from Figure 9 that irrespective of treatments DM of all the varieties significantly varied at all sampling dates. Figure 9 showed that BARI Sharisha-17 (V3) scored the highest dry matter weight plant^{-1}throughout the growing period (5.65 g, 9.50 g, 21.90 g and 30.82 g at 25, 50, 75 DAS and harvest, respectively) which was statistically similar with V_2 at harvest. The lowest dry matter weight plant^{-1}(4.11 g, 6.11 g, 17.59 g and 22.96 g at 25, 50, 75 DAS and harvest, respectively) was scored by BARI Sharisha-14 (V_1) which was statistically similar with V_2 at 75 DAS. Similar results were found by (Awal and Fardous, 2014; Islam, 2006 and Mondal *et al*., 2003) who found that *Brassica campestris* produced the larger total dry matter weight as compared to *Brassica napus.*

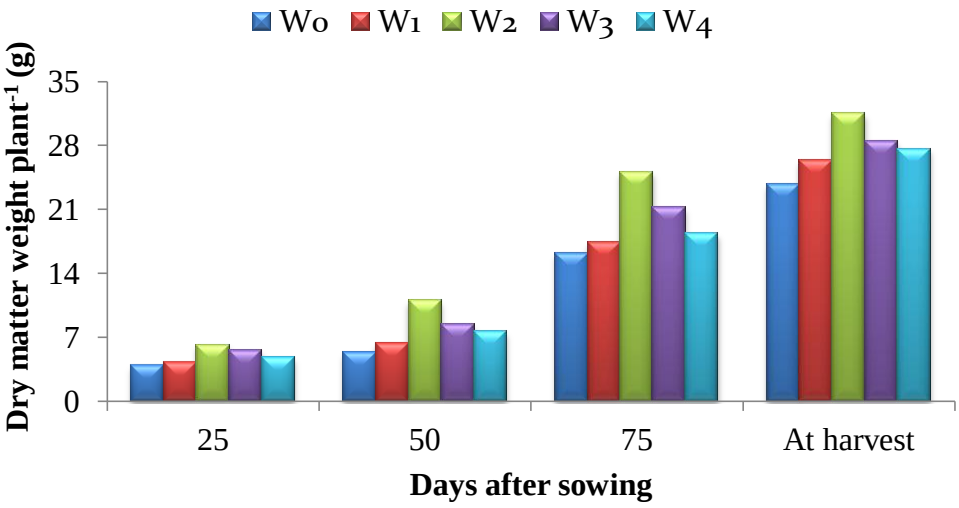


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 9. Effect of variety on the dry matter weight plant^{-1} of mustard at different days after sowing ($LSD_{0.05}$=0.51, 1.23, 2.50 and 2.67 at 25, 50, 75 DAS and at harvest, respectively)

4.6.2 Effect of weed management

Dry matter production was gradually increased up to 50 DAS but the magnitude of increment was rapid after 50 DAS. Dry matter weight plant^{-1} was significantly affected by different weed managements (Figure 10). From the early stages distinct differences were noticed among the weed managements in respect of dry matter production. The lowest dry matter weight plant^{-1} (3.95 g, 5.34 g, 16.12 g and 23.73 g at 25, 50, 75 DAS and harvest, respectively) throughout the growing period was observed in no weeding treatment (W_0) which was statistically similar with W_1 at all growth stages except 50 DAS. On the other hand the highest dry matter weight plant^{-1} (6.18 g, 10.98 g, 25.06 g and 31.46 g at 25, 50, 75 DAS and harvest, respectively) were observed in W_2 treatment which was statistically differed with other weed management treatments at all growth stages. Total dry matter (TDM) is the sum of dry weight of roots, stem, leaves, branches, and fruits (siliqua). Under weed free condition the crop plant got facility to uptake more nutrients due to the suppression of weed growth that might have been the driving force behind higher dry matter and nutrient uptake in mustard under these weed control treatments especially two hand weeding. Such higher uptake might be attributed to higher seed yield production under better weed management treatments. Jangir *et al.* (2017) also reported that both the herbicide and hand weeding treatments suppressed the weed growth efficiently which is supplemented at the crucial stage of crop growth which checks the weed growth and resulted in better plant growth and increased the dry matter content of plant. The results were in agreement with those reported by (Bamboriya *et al*., 2017; Awal and Fardous, 2014; Mukherjee, 2014; Chander *et al*., 2013; Kumar *et al.,* 2012; Hamzei *et al.,* 2007; Singh, 2006 and Chauhan *et al.,* 2005) who reported that dry matter weight of plant was larger in weed free condition as compared to un-weedy situation.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 10. Effect of different weed management on the dry matter weight plant^{-1} of mustard at different days after sowing ($LSD_{0.05}$= 0.61, 0.75, 2.24 and 2.81at 25, 50, 75 DAS and at harvest, respectively)

4.6.3 Interaction effect of variety and weed control treatments

The interaction of variety and weed managements had significant effect on dry matter weight plant^{-1} throughout the growing period (Table 6). All the weed management treatments gave higher dry matter production over time where no weeding counted the lowest value. The treatment combination V_3W_2 consistently produced the highest dry matter weight plant^{-1}over time (6.83 g, 14.44 g, 28.79 g and 34.60 g, respectively) which showed similarity with V_2W_2, V_3W_3 and V_2W_3 at 25 DAS and with V_2W_2, V_3W_3, V_2W_3, V_2W_4 and V_3W_4 at harvest and on the contrarily treatment combination V_1W_0 produced consistently lowest dry matter weight plant^{-1} over time (3.52 g, 3.97 g, 13.41 g and 20.53 g, respectively) which was statistically similar with V_1W_1, V_2W_0, V_1W_4 and V_1W_3 at 25 DAS; with V_1W_1 at 50 DAS; with V_1W_1, V_1W_4 and V_2W_0 at 75 DAS and finally with V_1W_1, V_1W_4, V_2W_0, V_1W_3.

Table 6. Interaction effect of variety and different weed managements on the dry matter weight plant^{-1} of mustard at different days after sowing

Treatment combinations	Dry matter weight plant^{-1} (g) at days after sowing			
	25	50	75	At harvest
V_1W_0	3.52 f	3.97 h	13.41 h	20.53 f
V_1W_1	3.56 f	4.87 gh	15.40 gh	21.76 f
V_1W_2	5.16 b-d	7.29 de	23.04 bc	26.73 c-e
V_1W_3	4.24 c-f	7.28 de	19.43 c-f	23.36 d-f
V_1W_4	4.08 ef	7.13 de	16.66 f-h	22.41 ef
V_2W_0	3.47 f	5.82 fg	16.75 f-h	22.49 ef
V_2W_1	4.21 d-f	6.28 ef	17.31 e-g	28.04 cd
V_2W_2	6.54 a	11.20 b	23.35 b	33.03 ab
V_2W_3	5.94 ab	7.62 cd	21.75 b-d	30.58 a-c
V_2W_4	5.18 b-d	6.84 d-f	17.50 e-g	29.83 a-c
V_3W_0	4.85 c-e	6.23 ef	18.19 d-g	28.17 b-d
V_3W_1	4.94 b-e	7.84 cd	19.40 c-f	29.22 bc
V_3W_2	6.83 a	14.44 a	28.79 a	34.60 a
V_3W_3	6.37 a	10.20 b	22.36 bc	31.50 a-c
V_3W_4	5.26 bc	8.81 c	20.76 b-e	30.60 a-c
LSD $_{(0.05)}$	1.05	1.30	3.87	4.87
CV (%)	12.61	10	11.72	10.5

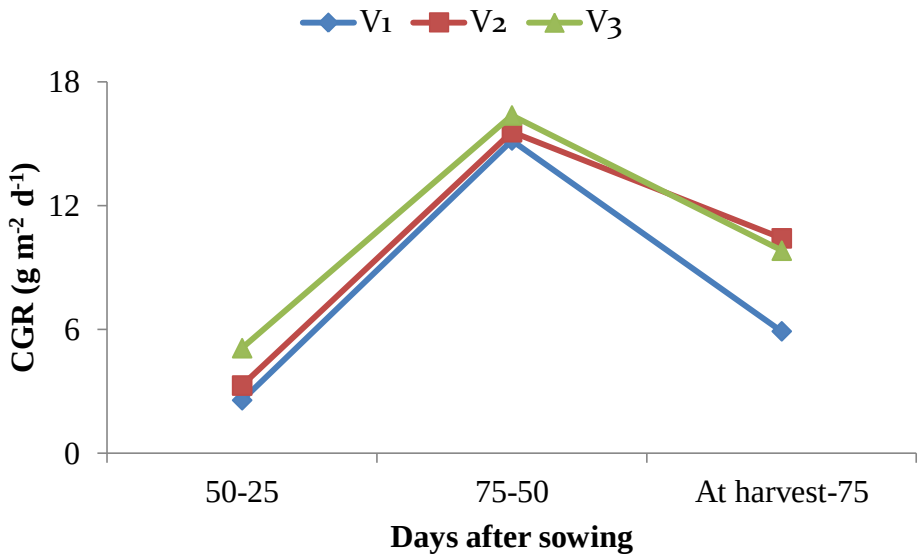
V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

4.7 Crop growth rate (CGR) (g m^{-2} d^{-1})

4.7.1 Effect of Variety

Crop growth rate is a magnitude of the increase in size, mass or number of crops over a period of time. In our investigation it differed significantly due to varietal variation in all growth stages except 75-50 DAS shown in Figure 11. At 50-25, V_3 scored the highest CGR (5.09 g m^{-2} day^{-1}) which was statistically differed from others and mustard variety V_1 scored the lowest CGR (2.57 g m^{-2} day^{-1}) which was also statistically differed from others. At harvest-75 DAS, V_2 scored the highest CGR

(10.41 g m^{-2} day^{-1}) which was statistically similar with V_3 and mustard variety V_1 scored the lowest CGR (5.91 g m^{-2} day^{-1}) which was statistically differed from others.

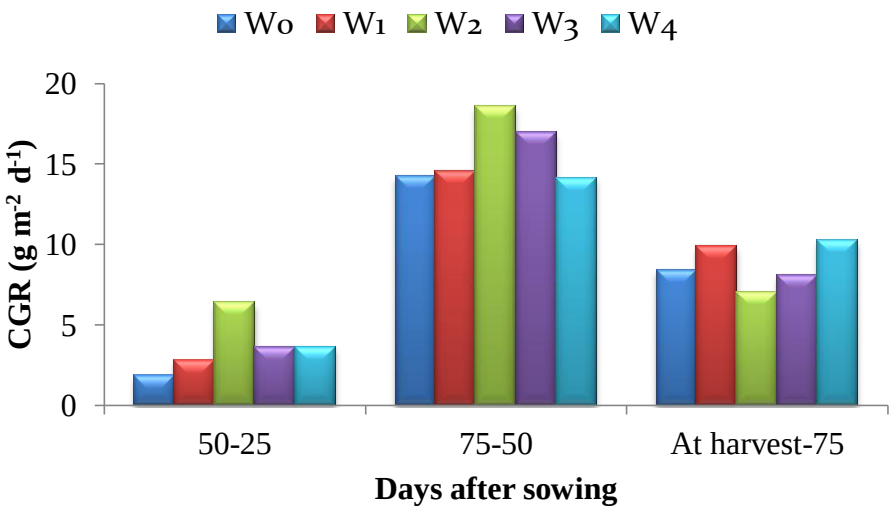


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 11. Effect of variety on the crop growth rate (CGR) of mustard at different days after sowing ($LSD_{0.05}$=0.38, NS and 0.89 at 50-25, 75-50 and 75 DAS-at harvest, respectively)

4.7.2 Effect of weed management

The crop growth rate of mustard was significantly influenced by different weed management over time (Figure 12). At 50-25 and 75-50 DAS, the treatment W_2 gave distinctly the highest CGR (6.34 g m^{-2} day^{-1} and 18.59 g m^{-2} day^{-1}, respectively) and treatment W_0 gave the lowest CGR (1.84 g m^{-2} day^{-1} and 14.23 g m^{-2} day^{-1}, respectively) which was statistically similar with W_1 and W_4 at 75-50 DAS. At harvest-75 DAS, treatment W_4 gave the highest CGR (10.24 g $m^{-2}day^{-1}$) which was statistically similar with W_1 and treatment W_2 gave the lowest CGR (7.03 g m^{-2} day^{-1}) which was statistically differed from others.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 12. Effect of different weed management on the crop growth rate (CGR) of mustard at different days after sowing ($LSD_{0.05}$=0.37, 1.48 and 0.96 at 50-25, 75-50 and 75 DAS-at harvest, respectively)

4.7.3 Interaction effect of variety and weed management

The interaction of variety and weed management significantly influenced the CGR throughout the growing period (Table 7). During the experimentation period, in most of the treatment combinations, the magnitude of CGR increment was rapid from 50-25 DAS to 75-50 DAS and then a gradual reduction was observed. At 50-25 DAS the highest CGR (10.05 g m^{-2} day^{-1}) was attained by treatment combination V_3W_2 and the lowest one (0.59 g m^{-2} day^{-1}) was attained by treatment combination V_1W_0. At 75-50 DAS the highest CGR (20.79g m^{-2} day^{-1}) was attained by treatment combination V_1W_2 which was statistically similar with V_2W_3 and V_3W_2 and the lowest one (12.46 g m^{-2} day^{-1}) was attained by treatment combination V_1W_0 which was statistically similar with V_1W_1, V_1W_4, V_2W_0, V_2W_1 and V_2W_4. At harvest-75 DAS the highest CGR (13.57 g m^{-2} day^{-1}) was attained by treatment combination V_2W_4 which was statistically differed from others and the lowest one (4.06 g m^{-2} day^{-1}) was attained by treatment combination V_1W_2 which was statistically similar with V_2W_4.

Table 7. Interaction effect of variety and different weed managements on the CGR of mustard at different days after sowing

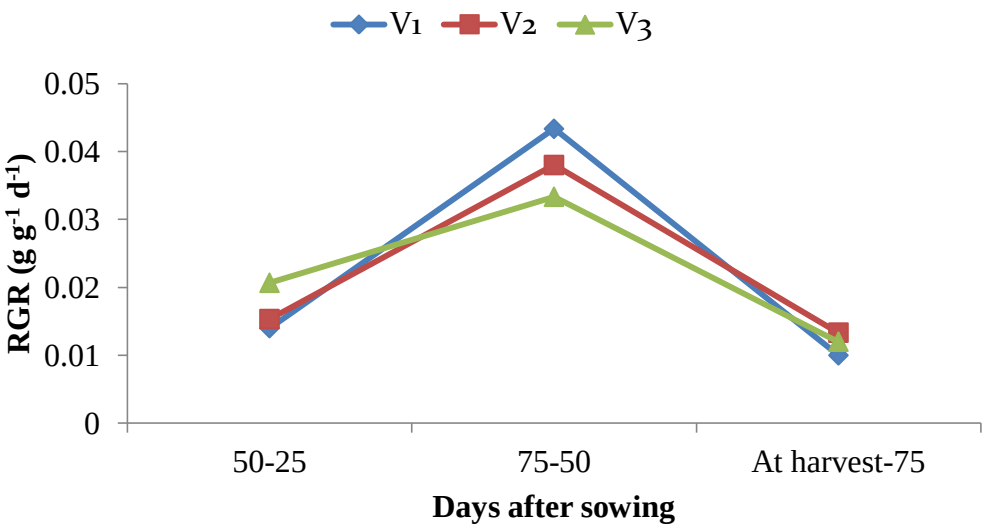
Treatment combinations	CGR (g m^{-2} d^{-1}) at days after sowing		
	50-25	75-50	At harvest-75
V_1W_0	0.59 i	12.46 c	7.84 d
V_1W_1	1.73 h	13.90 bc	7.00 d
V_1W_2	2.82 fg	20.79 a	4.06 e
V_1W_3	3.69 de	16.03 b	4.32 e
V_1W_4	4.03 d	12.57 c	6.33 d
V_2W_0	3.10 ef	14.44 bc	6.31 d
V_2W_1	2.73 fg	14.56 bc	11.8 b
V_2W_2	6.16 b	16.04 b	10.65 bc
V_2W_3	2.21 gh	18.66 a	9.71 c
V_2W_4	2.21 gh	14.06 bc	13.57 a
V_3W_0	1.82 h	15.79 b	10.99 bc
V_3W_1	3.83 d	15.26 b	10.81 bc
V_3W_2	10.05 a	18.93 a	6.39 d
V_3W_3	5.06 c	16.05 b	10.06 c
V_3W_4	4.69 c	15.78 b	10.82 bc
$LSD_{(0.05)}$	**0.64**	**2.56**	**1.67**
CV (%)	**10.31**	**9.67**	**11.38**

V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

4.8 Relative growth rate (RGR) (g $g^{-1}d^{-1}$)

4.8.1 Effect of Variety

The results of our study showed that, RGR did not significantly differed due to varietal variation in all growth stages shown in Figure 13. At harvest-75 DAS numerically V_2 scored the highest RGR (0.013 g g^{-1} day^{-1}) the lowest one (0.010 g g^{-1} day^{-1}) was attained by V_1.

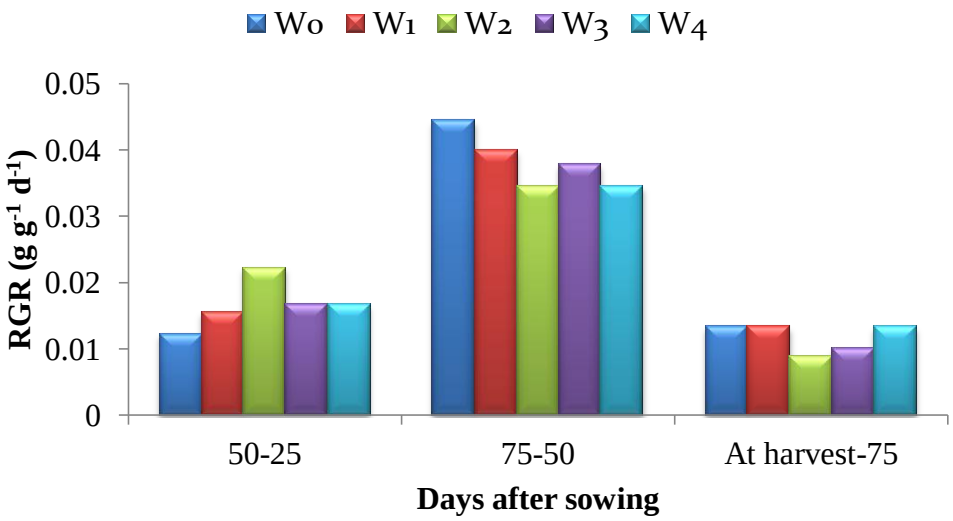


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 13. Effect of variety on the relative growth rate (RGR) of mustard at different days after sowing ($LSD_{0.05}$= NS, NS and NS at 50-25, 75-50, 75 DAS-At Harvest, respectively)

4.8.2 Effect of weed management

The relative growth rate of mustard was significantly influenced by different weed management over time except harvest-75 DAS (Figure 14). At 50-25 DAS the treatment W_2 attained the highest RGR (0.022 g g^{-1} day^{-1}) which was statistically similar with rest of the weed management treatments except no weeding (W_0) and treatment W_0 attained the lowest RGR (0.012 g g^{-1} day^{-1}) which was statistically similar with rest of the weed management treatments except two hand weeding at 10 and 20 DAS. At 75-50 DAS, treatment W_0 gave the highest RGR (0.044g g^{-1} day^{-1}) which was statistically similar with W_1 and W_3 and both the treatments W_2 and W_4 attained the lowest RGR (0.034g g^{-1} day^{-1}) which were statistically differed W_0.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 14. Effect of different weed management on the relative growth rate (RGR) of mustard at different days after sowing ($LSD_{0.05}$= 0.01, 0.01 and NS at 50-25, 75-50 and 75 DAS-at harvest, respectively)

4.8.3 Interaction effect of variety and weed management

The interaction of variety and weed management significantly influenced the RGR throughout the growing period except at harvest-75 DAS (Table 8). At 50-25 DAS the highest RGR (0.033 g g^{-1} day^{-1}) was attained by treatment combination V_3W_2 which was statistically at par with V_1W_3, V_1W_4, V_2W_0, V_2W_1, V_2W_2, V_3W_1, V_3W_3 and V_3W_4 and the lowest one (0.007g g^{-1} day^{-1}) was attained by treatment combination V_1W_0 which was statistically at par with all the treatment combinations except V_3W_2. At 75-50 DAS the highest RGR (0.050g g^{-1} day^{-1}) was attained by treatment combination V_1W_0 which was statistically similar with rest of the treatment combinations except V_2W_2, V_3W_2 and V_3W_3 and the lowest one (0.027g g^{-1} day^{-1}) was attained by treatment combination V_3W_2 which was statistically similar with rest of the treatment combinations except V_1W_0, V_1W_1 and V_1W_2.

Table 8. Interaction effect of variety and different weed managements on the RGR of mustard at different days after sowing

Treatment combinations	RGR (g g^{-1} d^{-1}) at days after sowing		
	50-25	75-50	At harvest-75
V_1W_0	0.007 b	0.050 a	0.013
V_1W_1	0.010 b	0.047 ab	0.010
V_1W_2	0.013 b	0.047 ab	0.007
V_1W_3	0.020 ab	0.040 a-c	0.010
V_1W_4	0.020 ab	0.033 a-c	0.010
V_2W_0	0.020 ab	0.040 a-c	0.010
V_2W_1	0.017 ab	0.040 a-c	0.017
V_2W_2	0.020 ab	0.030 bc	0.010
V_2W_3	0.010 b	0.043 a-c	0.010
V_2W_4	0.010 b	0.037 a-c	0.020
V_3W_0	0.010 b	0.043 a-c	0.017
V_3W_1	0.020 ab	0.033 a-c	0.013
V_3W_2	0.033 a	0.027 c	0.010
V_3W_3	0.020 ab	0.030 bc	0.010
V_3W_4	0.020 ab	0.033 a-c	0.010
$LSD_{(0.05)}$	**0.02**	**0.02**	**NS**
CV (%)	**17.32**	**13.65**	**31**

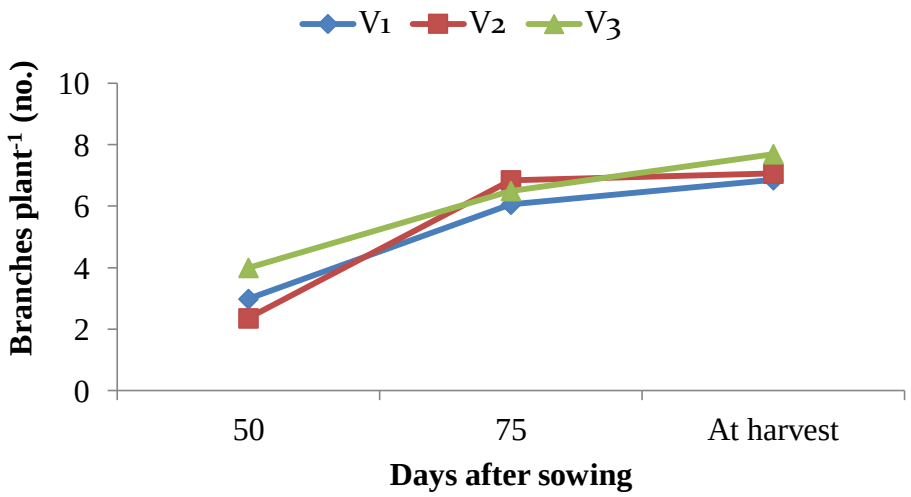
V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

4.9 Branches $plant^{-1}$ (no.)

4.9.1 Effect of Variety

Varietal variation had significant effect on branches $plant^{-1}$ over time (Figure 15). The results revealed that, V_3 produced maximum branches $plant^{-1}$ (4.00 and 7.69 at 50 DAS and harvest, respectively) which was statistically differed from other treatments. At 75 DAS, maximum branches $plant^{-1}$(6.84) was produced by V_2 which was statistically similar with V_3. On the other hand at 50 DAS, the minimum branches $plant^{-1}$ (2.36) was produced by V_2. V_1 produced the minimum the branches $plant^{-1}$ (6.05 and 6.85at 75 DAS and harvest, respectively) which were statistically similar

with V_2 at harvest. The results were in consistent with (Awal and Fardous, 2014 and Khaton, 2004) who reported that number of branches plant^{-1} differed significantly among the different genotypes of *Brassica campestris* cvs. Agrani and Safal, *Brassica napus* cvs. MM49-3-98 and MM 06-02rb, and *Brassica juncea* cvs. MM 04-04, RAI 5 etc.



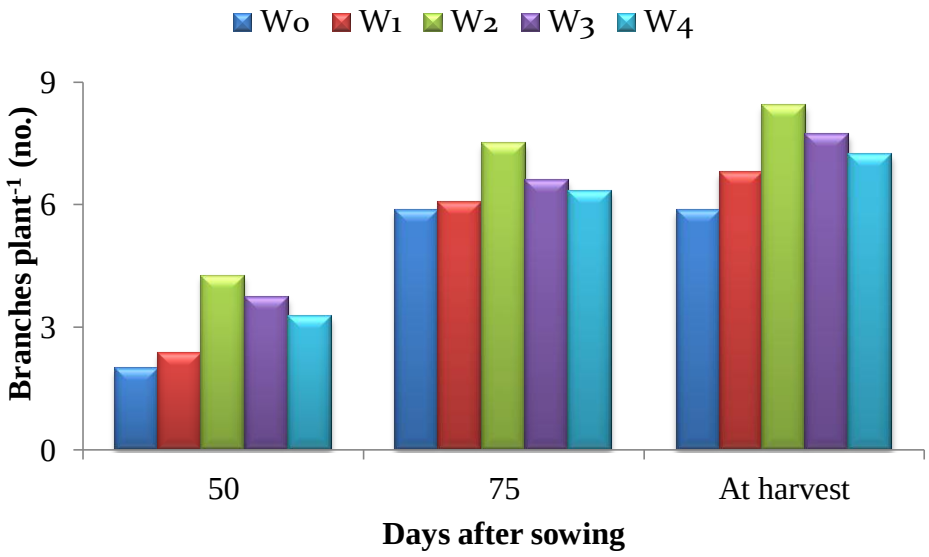
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 15. Effect of different weed management on the branches plant^{-1} of mustard at different days after sowing ($LSD_{0.05}$= 0.53, 0.3 and 0.51at 50, 75 DAS and at harvest, respectively)

4.9.2 Effect of weed management

Different weed managements had significant effect on branches plant^{-1} over time (Figure 16). The results revealed that, W_2 produced maximum branches plant^{-1} (4.25, 7.50 and 8.43 at 50, 75 DAS and harvest, respectively) which was statistically similar with W_3 at harvest and the minimum ones (1.97, 5.86 and 5.86 at 50, 75 DAS and harvest, respectively) were produced by W_0 which was statistically similar with W_1, W_3 and W_4 at 75 DAS. Under weed free condition the plant growth was vigorous and plant produced more branches because there was no crop weed competition for natural resources (light, water, essential plant nutrients etc.). On the other hand plant grown under no weeding plot competed with weed. As we know weeds are naturally stronger and competitive than crop plant by their habit, so the crop plant could not compete with weed for natural resources consequently accumulated lower dry matter plant^{-1}. Singh and Sinsinwar (2002) who observed that, hand weeding twice gave the

greatest number of branches per plant in mustard. Weeding gave the higher number of branches as compared to no weeding treatment. Similar results were reported by (Jangir*et al.*, 2017; Awal and Fardous, 2014; Kumar *et al.*, 2012; Singh, 2006 and Chauhan *et al.*, 2005) in mustard crop.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 16. Effect of different weed management on the branches $plant^{-1}$ of mustard at different days after sowing ($LSD_{0.05}$= 0.33, 0.77 and 0.80at 50, 75 DAS and at harvest, respectively)

4.9.3 Interaction effect of variety and weed management

Interaction effect of variety and different weed managements had significant effect on branches $plant^{-1}$ over time (Table 9). The results revealed that, treatment combination V_3W_2 produced maximum branches $plant^{-1}$ (4.99, 8.73 and 9.82 at 50, 75 DAS and harvest, respectively) which was statistically varied with other treatment combinations. At 50 DAS the minimum branches $plant^{-1}$ (1.08) was produced by V_2W_0 which was statistically similar with V_2W_1 and V_1W_0. At 75 DAS the minimum branches $plant^{-1}$ (5.53) was produced by V_3W_0 which was statistically differed from V_3W_2 and V_2W_2. Again the minimum branches $plant^{-1}$(5.43 at harvest) was produced by V_1W_0 which was statistically similar with V_2W_0, V_1W_1 and V_3W_0.

Table 9. Interaction effect of variety and different weed managements on the branches plant^{-1} of mustard at different days after sowing

Treatment combinations	Branches plant^{-1} (no.) at days after sowing		
	50	75	At harvest
V_1W_0	1.53 g	5.67 d	5.43 e
V_1W_1	2.40 f	5.93 cd	6.59 c-e
V_1W_2	4.09 bc	6.47 b-d	7.67 bc
V_1W_3	3.97 bc	6.13 b-d	7.48 bc
V_1W_4	2.93 ef	6.07 b-d	7.07 bc
V_2W_0	1.08 g	6.37 b-d	5.64 de
V_2W_1	1.33 g	6.60 b-d	6.87 b-d
V_2W_2	3.67 cd	7.30 b	7.80 bc
V_2W_3	2.90 ef	7.13 bc	7.67 bc
V_2W_4	2.80 ef	6.81 b-d	7.33 bc
V_3W_0	3.30 de	5.53 d	6.50 c-e
V_3W_1	3.36 de	5.60 d	6.87 b-d
V_3W_2	4.99 a	8.73 a	9.82 a
V_3W_3	4.30 b	6.47 b-d	8.00 b
V_3W_4	4.03 bc	6.13 b-d	7.27 bc
LSD $_{(0.05)}$	**0.56**	**1.34**	**1.39**
CV (%)	**10.74**	**12.28**	**11.47**

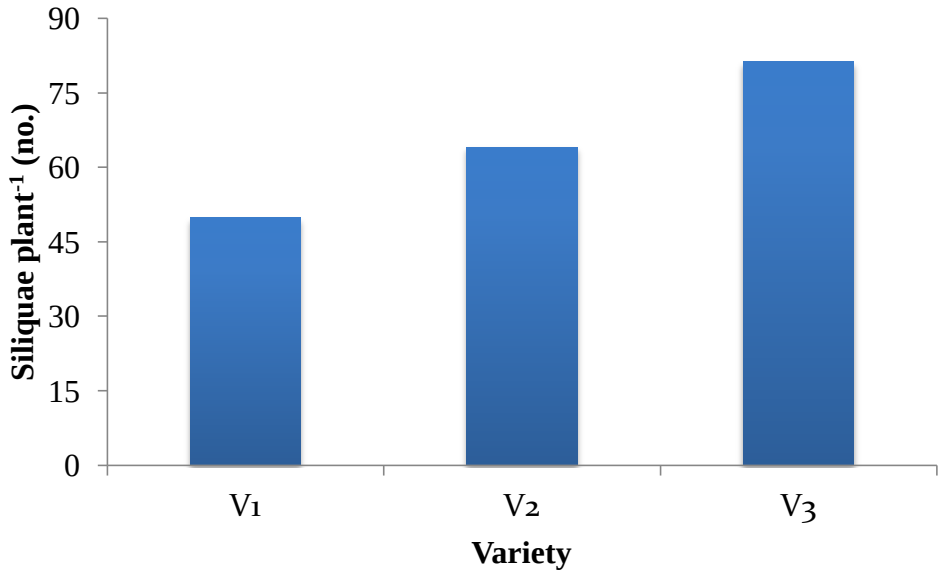
V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

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

4.10.1 Effect of Variety

Significant variation was observed in siliquae plant^{-1} of mustard due to the effect of variety shown in Figure 17. The distinctly highest siliquae plant^{-1} (81.22) was found in BARI Sharisha-17 (V_3) followed by V_2 (64.05) and the lowest one (49.85) was from BARI Sharisha-14 (V_1). BARI Sharisha-17 produced 62.93% and 26.81% more siliquae plant^{-1} than BARI Sharisha-14 and BARI Sharisha-15, respectively. The results obtained from the present study were in consistent with the results of (Awal and Fardous, 2014 and Khaton, 2004) who reported that siliquae plant^{-1} differed

significantly among the varieties of mustard like *Brassica campestris* cvs. Agrani and Safal, *Brassica napus* cvs. MM 49-3-98 and MM 06-02rb, and *Brassica juncea* cvs. MM 04-04 and RAI 5 etc. (Islam, 2006; Mondal *et al*., 2003; Omprakash, 2002; Singh *et al*., 1991 and Prakash *et al*., 1987) also found the similar results.

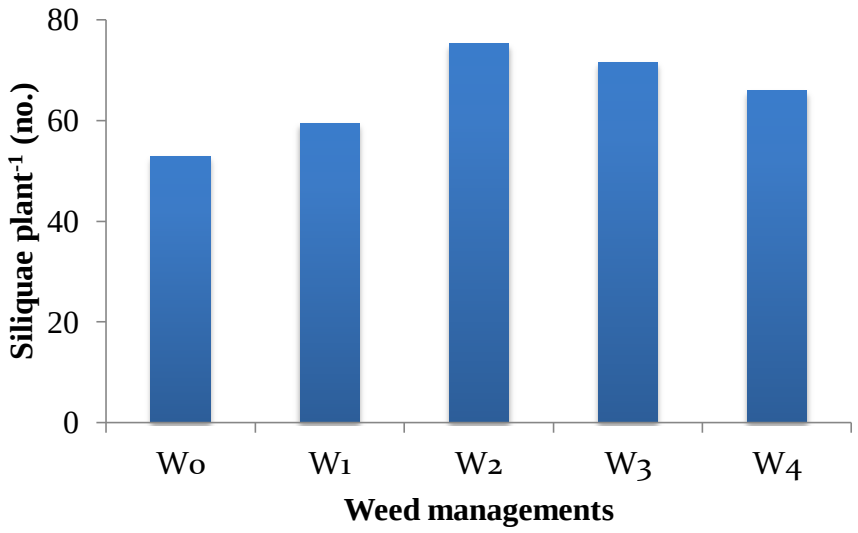


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 17. Effect of variety on the siliquae plant^{-1} of mustard ($LSD_{0.05}$=4.33)

4.10.2 Effect of weed management

Significant variation was found in siliquae plant^{-1} due to the effect of weed control (Figure 18). The highest siliquae plant^{-1} (75.27) was obtained from the effect of W_2 which was statistically identical with the effect of W_3 and the lowest siliquae plant^{-1} (52.92) was obtained from no weeding treated plot (W_0). Two hand weeding at 10 DAS and 20 DAS (W_2) gave 42.23% more siliquae plant^{-1} than no weeding (W_0). The increases in siliquae plant^{-1} under hand weeding might be due to better suppression of weeds which might have maintained greater availability of nutrients and moisture content due to less removal by weeds. This might have increased nutrient and water uptake by cropsleading to increase rate of photosynthesis and ultimately better supply of photosynthates to various sinks resulting increased the siliquae plant^{-1}. Similar findings have also been reported (Gupta *et al.*, 2018; Awal and Fardous, 2014; Tekale *et al*., 2005; Omprakash, 2002; Singh and Singh, 2001 and Bowerman, 1990) who observed that the weeding gave the greater number of siliqua plant^{-1} in mustard.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 18. Effect of different weed management on the plant^{-1} of mustard ($LSD_{0.05}$=6.38)

4.10.3 Interaction effect of variety and weed control treatments

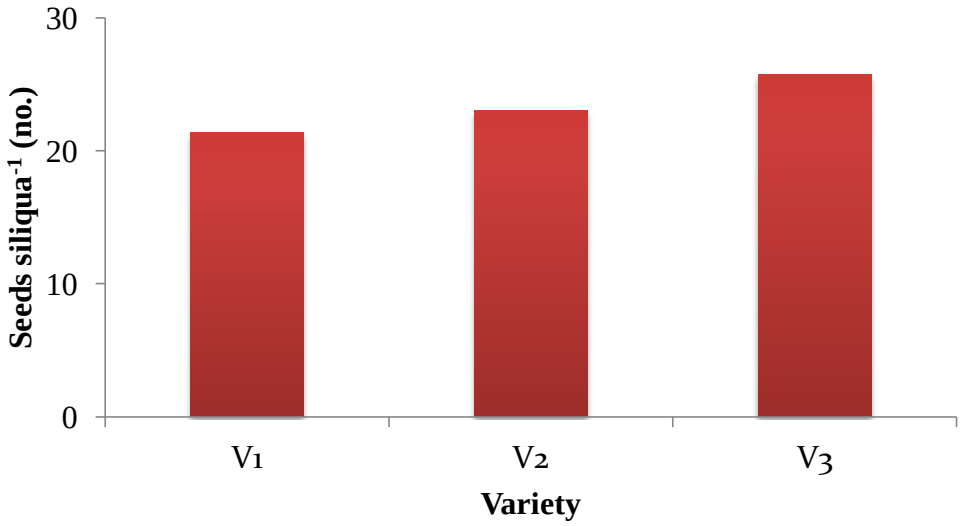
Significant variation was obtained in siliquae plant^{-1}due to the interaction effect of variety and weed management (Table 9). The highest siliquae plant^{-1}(90.60) was obtained from the interaction effect of V_3W_2which was statistically at par with V_3W_3 and V_3W_4 and the lowest siliquae plant^{-1} (38.40) was obtained from the interaction effect of V_1W_0 which was statistically at par withV_1W_1. These results were in agreement with the findings of

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

4.11.1 Effect of Variety

Significant difference was noticed in seeds siliqua^{-1} of mustard due to varietal difference shown in Figure 19. The highest seeds siliqua^{-1}(25.71) was observed in BARI Sharisha-17 (V_3) followed by V_2 (23.05) and the lowest one (21.39) was from BARI Sharisha-14 (V_1). BARI Sharisha-17 produced 20.20% and 11.54% more seeds siliqua^{-1}than BARI Sharisha-14 and BARI Sharisha-15, respectively. This could be attributed to decrease crop-weed competition at the critical stages for longer growth

period which facilitated better growth and development resulting in better expressions of yield-attributing characters *viz.* seeds siliqua^{-1}.

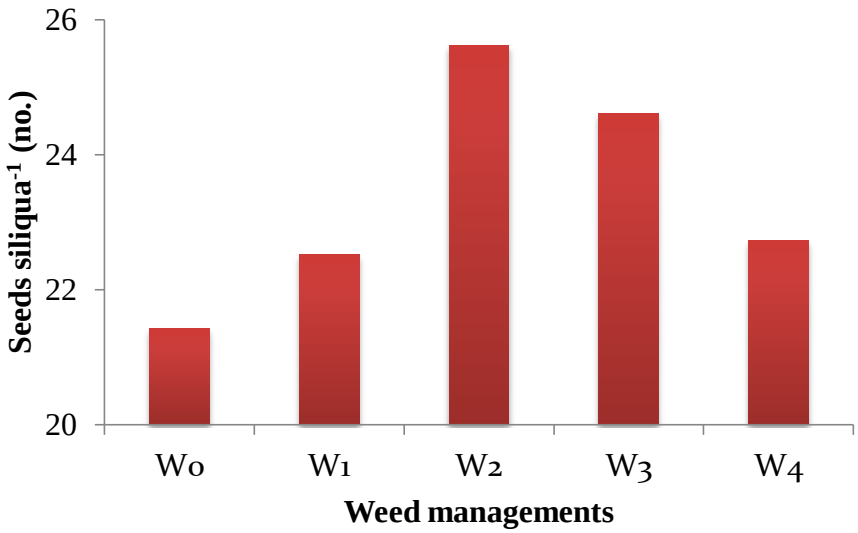


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 19. Effect of variety on the seeds siliqua^{-1} of mustard ($LSD_{0.05}$=3.11)

4.11.2 Effect of weed management

Significant variation was observed in seeds siliqua^{-1} due to different weed managements (Figure 20). The highest seeds siliqua^{-1}(25.62) was obtained from the effect of W_2 which was statistically identical with the effect of W_3 and the lowest seeds siliqua^{-1}(21.42) was obtained from no weeding treated plot (W_0) which was statistically identical with the effect of W_1 and W_4. Two hand weeding at 10 DAS and 20 DAS (W_2) gave 19.61% more seeds siliqua^{-1} than no weeding (W_0).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 20. Effect of different weed management on the seeds siliqua^{-1} of mustard ($LSD_{0.05}$=2.02)

4.11.3 Interaction effect of variety and weed control treatments

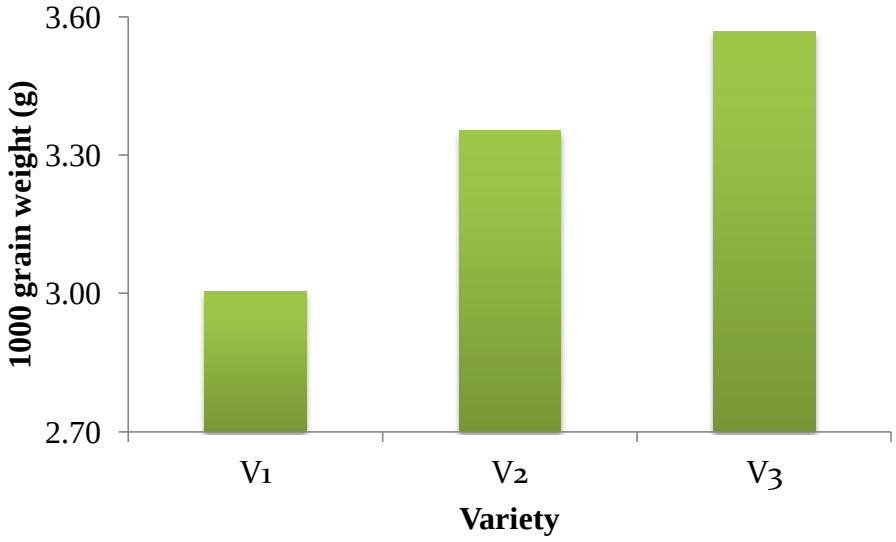
Significant variation was observed in seeds siliqua^{-1} due to the interaction effect of variety and weed management (Table 9). The maximum seeds siliqua^{-1}(27.67) was recorded from the interaction effect of V_3W_2 which was statistically at par with V_3W_3, V_3W_4, V_2W_2, V_2W_3 and V_3W_1 and the lowest seeds siliqua^{-1} (20.00) was recorded from the interaction effect of V_1W_0 which was statistically at par withV_2W_0, V_1W_4, V_2W_4, V_2W_1, V_1W_3, V_1W_1 and V_1W_2. These results were in agreement with the findings of

4.12 1000 seed weight (g)

4.12.1 Effect of Variety

1000 seed weight showed significant variation among the different varieties (Figure 21). Result exposed that, BARI Sharisha-17 (V_3) produced highest 1000 seed weight (3.57 g). The second highest 1000 seed weight (3.35 g) was produced by BARI Sharisha-15 (V_2). The lowest 1000 seed weight (3.01 g) was produced by BARI Sharisha-14 (V_1). The results obtained from the present study were in consistent with

the results of (Awal and Fardous, 2014; Islam, 2006; Khaton, 2004; Mondal *et al*., 2003; Omprakash, 2002; Singh *et al*., 1991 and Prakash *et al*., 1987) who reported that yield components differed significantly among the varieties of mustard.



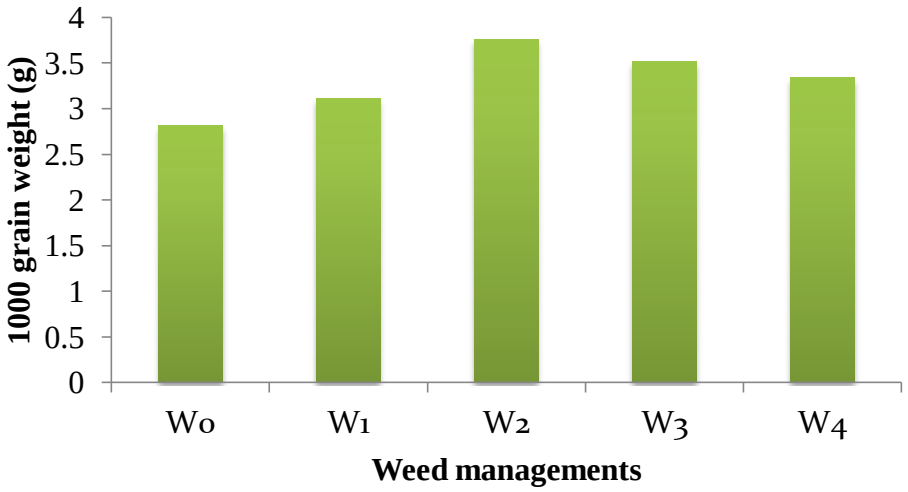
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 21. Effect of variety on the 1000 seed weight of mustard ($LSD_{0.05}$=0.43)

4.12.2 Effect of weed management

Effect of weed management showed significant variation in 1000 seed weight. Results of the investigation showed that, two hand weeding at 10 DAS and 20 DAS (W_2) gave the highest 1000 seed weight (3.76 g) which was statistically similar with W_3 (Figure 22). The lowest 1000 seed weight (2.82 g) was found from no weeding (W_0). In our investigation two hand weeding at 10 and 20 DAS performed better to control weed population and the plot was weed free which facilitated better uptake of nutrient, light and moisture trigger the plant growth and development, increased the photosynthesis rate and more partitioning of photosynthates from source to sink, thus produced the seed with higher weight. On the other hand under no weeding condition in the earlier growth period weed population severely affected crop plant and plant could not compete with weed for those natural resources consequently drastically reduced the growth and development as well as crop yield. These results were in conformity with those reported by (Gupta *et al.,* 2018; Awal and Fardous, 2014; Khan *et al.,* 2008; Amin *et al.,* 2003; Singh *et al.,* 2000; Yadav *et al.,* 1995 and Raghavan and Hariharan

1991) who stated that seed weight increases in weed management condition compare to that of no weeding condition.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 22. Effect of different weed management on the 1000 seed weight of mustard ($LSD_{0.05}$=0.38)

4.12.3 Interaction effect of variety and weed management

Interaction effect of variety and weed management showed significant variation in 1000 seed weight shown in Table 10. The highest seed weight (4.33 g) was found from the interaction effect of V_3W_2 which was statistically similar with V_3W_3. The lowest 1000 seed weight (2.60 g) was found with the interaction effect of V_1W_0 which was statistically similar with V_2W_0, V_1W_1, V_1W_3, V_1W_4, V_3W_0 and V_3W_1. This result supports the findings of

Table 10. Interaction effect of variety and different weed managements on the yield contributing characters of mustard

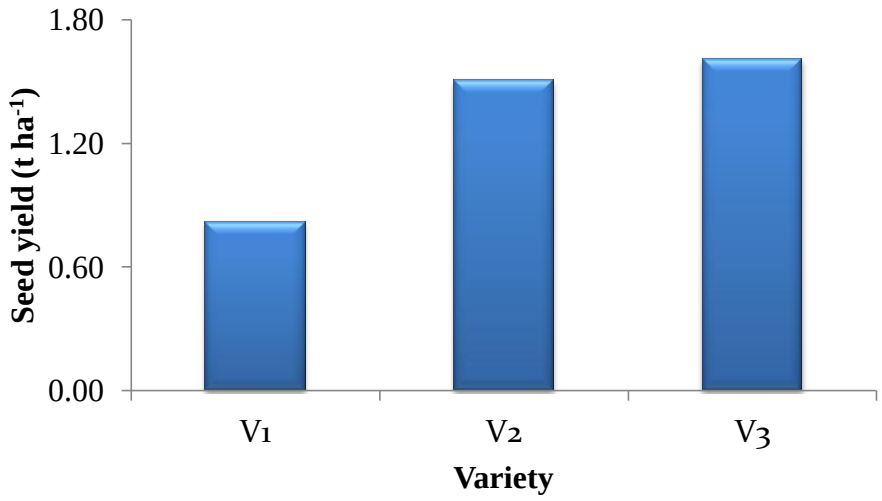
Treatment combinations	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	1000 seed weight (g)
V_1W_0	38.40 i	20.00 f	2.60 e
V_1W_1	45.97 hi	20.60 ef	2.93 de
V_1W_2	57.22 fg	23.40 c-f	3.32 b-d
V_1W_3	55.20 gh	22.14 d-f	3.13 c-e
V_1W_4	52.47 gh	20.83 ef	3.05 c-e
V_2W_0	52.83 gh	20.30 f	2.83 de
V_2W_1	54.40 gh	22.23 d-f	3.35 b-d
V_2W_2	78.00 b-d	25.80 a-c	3.64 bc
V_2W_3	72.48 c-e	24.73 a-d	3.47 b-d
V_2W_4	62.55 e-g	22.17 d-f	3.48 b-d
V_3W_0	67.53 d-f	23.97 b-e	3.01 c-e
V_3W_1	78.07 b-d	24.73 a-d	3.06 c-e
V_3W_2	90.60 a	27.67 a	4.33 a
V_3W_3	86.97 ab	26.97 ab	3.96 ab
V_3W_4	82.93 a-c	25.20 a-d	3.48 b-d
LSD $_{(0.05)}$	**11.05**	**3.50**	**0.65**
CV (%)	**10.08**	**8.88**	**11.71**

V_1= BARI Sharisha- 14, V_2= BARI Sharisha- 15 and V_3= BARI Sharisha- 17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl 9EC @ 750 ml ha^{-1} at 21 DAS

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

4.13.1 Effect of Variety

Seed yield varied significantly for different varieties shown in Figure 23. The highest seed yield (1.61 t ha^{-1}) was produced by BARI Sharisha-17 (V_3) which was statistically similar with BARI Sharisha-15 (V_2) producing 1.51 t ha^{-1}. The lowest seed yield (0.82 t ha^{-1}) was produced by BARI Sharisha-14 (V_1). BARI Sharisha-17 produced 96.34% more seed than BARI Sharisha-14. (Awal and Fardous, 2014 and Khaton, 2004) also observed a wide variation of seed yield among the species like *Brassica napus and Brassica campestris*.



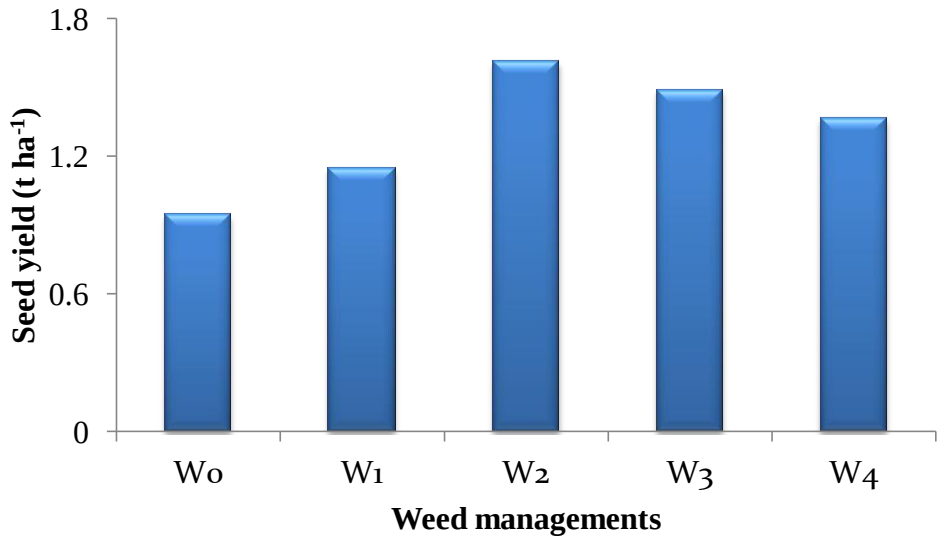
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 23. Effect of variety on the seed yield of mustard ($LSD_{0.05}$=0.21)

4.13.2 Effect of weed management

Significant variation was observed for seed yield due to different weed managements (Figure 24). The highest seed yield (1.61 t ha^{-1}) was produced when the plot done with two hand weeding at 10 DAS and 20 DAS (W_2) which was statistically similar with W_3 producing 1.49 t ha^{-1} and the lowest seed yield (0.95 t ha^{-1}) was produced from no weeding treatment (W_0). Two hand weeding at 10 DAS and 20 DAS (W_2) produced 69.47% more seed than no weeding treatment. The remarkable increase in seed yield might be due to effective control of weeds, lower dry weight of weeds and higher weed control efficiency as well as lower weed index which cumulatively facilitated the crop to utilize more nutrients and water for better growth and development in terms of various growth attributing characters and yield attributing characters. On the other hand the lowest value of yield attributes and yield maybe due to severe competition by weeds for resources, which made the crop plant incompetent to take up more moisture and nutrients, consequently growth was adversely affected. Poor growth of nutrients in weedy check might have produced less photosynthates and partitioned less assimilates to numerous metabolic sink and ultimately poor development of yield components and seed yield. Reduced crop-weed competition under thus saved a substantial amount of nutrients for crop that led to profuse growth enabling the crop to utilize more soil moisture and nutrients from deeper soil layers, ultimately increased the photosynthesis rate which leaded to more partitioning of

photosynthates from source to sink and produced more seed (Bijarnia *et al*., 2017; Singh *et al.,* 2015 and Kour *et al*., 2014) reported that twice hand weeding at 20 and 40 DAS treatment controlled all types of weeds very effectively and minimized the weed competition. As a result, it produced more seed yield (1955 kg ha^{-1}) compare to that of no weeding treatment (1167 kg ha^{-1}). Yadav *et al.* (2017) reported that improvement in yield contributing characters and thereby seed yield under weed control treatments may be attributed to low weed pressure. Weedy check had lowest seed yield due to higher weed density and dry matter accumulation. Weed in untreated check reduced seed yield of mustard by 49.24%. These findings were in close agreement with those reported by (Gupta *et al.,* 2018; Bamboriya *et al*., 2017; Jangir *et al.,* 2017; Kumar and Kaur, 2015; Adhikary and Ghosh, 2014; Awal and Fardous, 2014; Mukherjee, 2014; Kumar *et al.*, 2012; Bijanzadeh *et al.*, 2010; Miri and Rahimi, 2009; Singh *et al.,* 2009; Khan *et al.,* 2008; Rathi *et al.,* 2007; Sarkar *et al.*, 2005 and Sharma *et al.,* 2005) who observed that the mustard seed yield was found highest in weed free condition compare to that of no weeding condition.



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 24. Effect of different weed management on the seed yield of mustard ($LSD_{0.05}$=0.14)

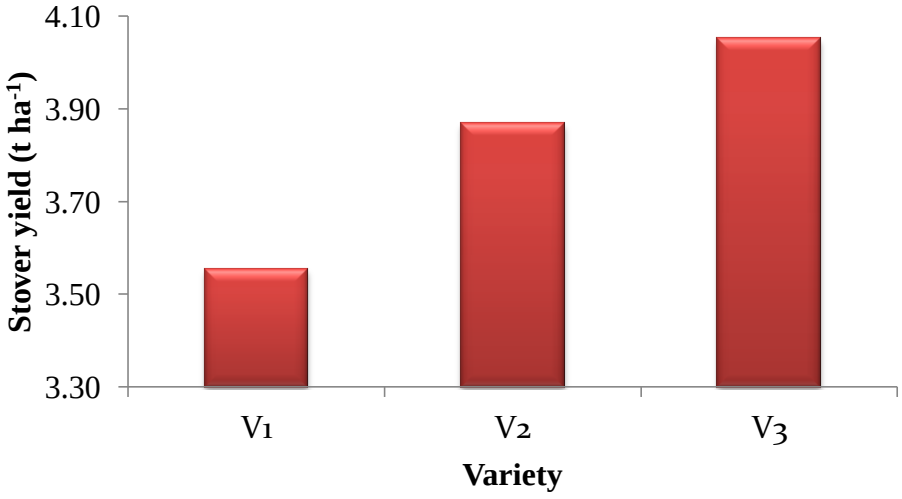
4.13.3 Interaction effect of variety and weed control treatments

The seed yield varied significantly due to different varietal and weed management treatment combinations (Table 10). The highest seed yield (1.89 t ha^{-1}) was produced by BARI Sharisha-17 (V_3) along with two hand weeding (W_2) which was statistically similar with V_3W_3 producing 1.86 t ha^{-1}. The lowest seed yield (0.44 t ha^{-1}) was produced by BARI Sharisha-14 (V_1) along with no weeding (W_0). This result is in agreement with

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

4.14.1 Effect of Variety

Stover yield varied significantly for different varieties shown in Figure 25. The highest stover yield (4.05 t ha^{-1}) was produced by BARI Sharisha-17 (V_3) which was statistically similar with BARI Sharisha-15 (V_2) producing 3.87 t ha^{-1}. The lowest stover yield (3.55 t ha^{-1}) was produced by BARI Sharisha-14 (V_1).



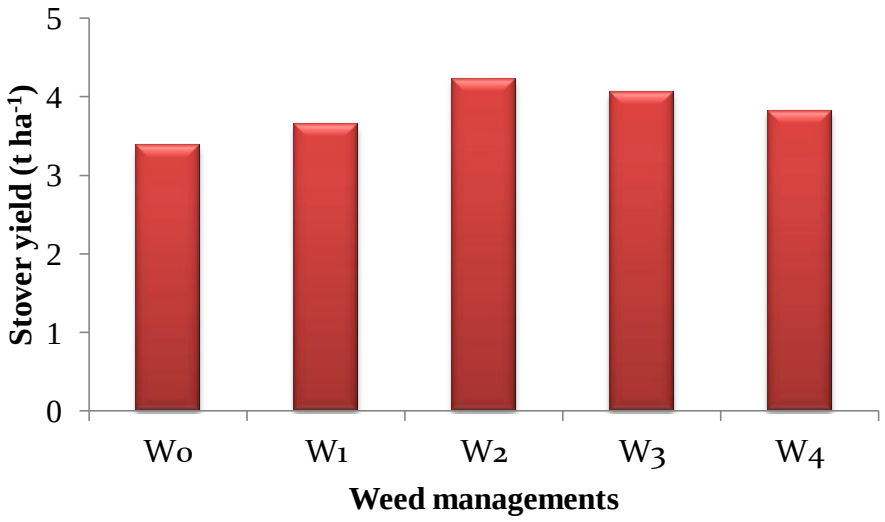
V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 25. Effect of variety on the stover yield of mustard ($LSD_{0.05}$=0.25)

4.14.2 Effect of weed management

Significant variation was observed for stover yield due to different weed managements (Figure 26). The highest stover yield (4.22 t ha^{-1}) was produced when the plot done with two hand weeding at 10 DAS and 20 DAS (W_2) which was

statistically similar with W_3 and W_4 and the lowest stover yield (3.38 t ha^{-1}) was produced from no weeding treatment (W_0) which was statistically similar with W_1. The remarkable increase in stover yield might be due to effective control of weeds, lower dry weight of weeds and higher weed control efficiency as well as lower weed index which cumulatively facilitated the crop to utilize more nutrients and water for better growth and development which facilitated more biomass production and finally stover yield of mustard. These findings were in close agreement with those reported by (Jangir *et al.*, 2017; Adhikary and Ghosh, 2014; Kumar *et al.*, 2012; Rathi *et al.*, 2007 and Sarkar *et al.*, 2005).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 26. Effect of different weed management on the stover yield of mustard ($LSD_{0.05}$=0.41)

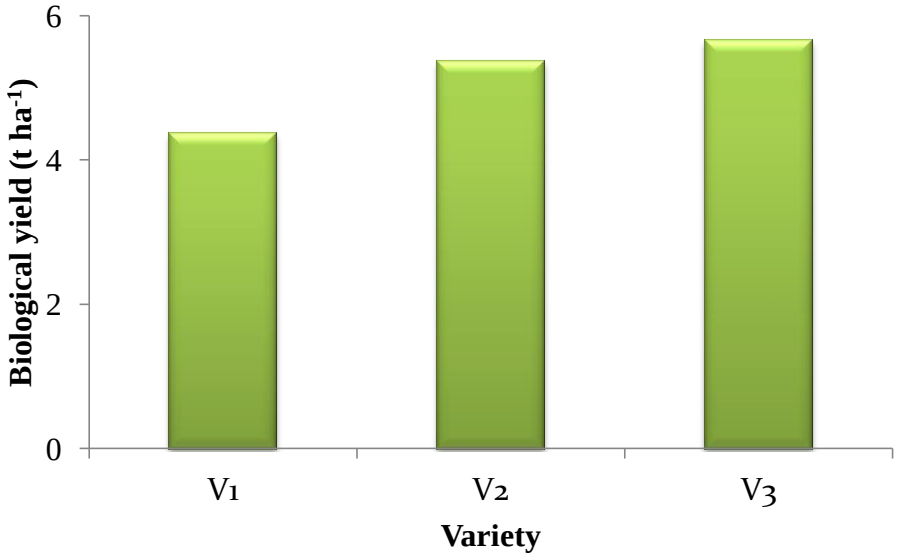
4.14.3 Interaction effect of variety and weed control treatments

The stover yield varied significantly due to different varietal and weed management treatment combinations (Table 10). The highest stover yield (4.45 t ha^{-1}) was produced by BARI Sharisha-17 (V_3) along with two hand weeding (W_2) which was statistically similar with V_3W_3, V_2W_2, V_2W_3, V_2W_4, V_3W_1, V_3W_4 and V_1W_2. The lowest stover yield (3.26 t ha^{-1}) was produced by BARI Sharisha-14 (V_1) along with no weeding (W_0) which was statistically similar with V_1W_1, V_2W_0, V_1W_4, V_1W_3, V_2W_1, V_3W_0, V_2W_4 and V_3W_1.

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

4.15.1 Effect of Variety

Significant difference was found in biological yield of mustard in respect of varietal difference shown in Figure 27. It was observed that BARI Sharisha-17 (V_3) produced significantly highest biological yield (5.66 t ha^{-1}) followed by BARI Sharisha-15(V_2) (5.38 t ha^{-1}) and the lowest biological yield (4.37 t ha^{-1}) was recorded from BARI Sharisha-14 (V_1).

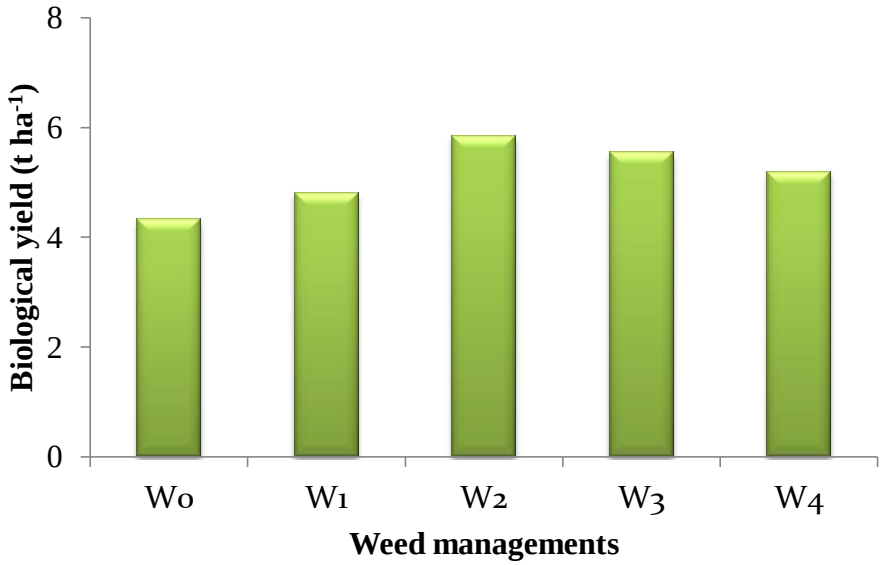


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 27. Effect of variety on the biological yield of mustard ($LSD_{0.05}$=0.44)

4.15.2 Effect of weed control treatments

The biological yield varied significantly due to different weed management shown in figure 28. Treatment W_2 gave the highest biological yield (5.84 t ha^{-1}) followed by W_3 (5.54 t ha^{-1}). No weeding (W_0) treatment gave the lowest biological yield (4.32 t ha^{-1}).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 28. Effect of different weed management on the biological yield of mustard ($LSD_{0.05}$=0.47)

4.15.3 Interaction effect of variety and weed management

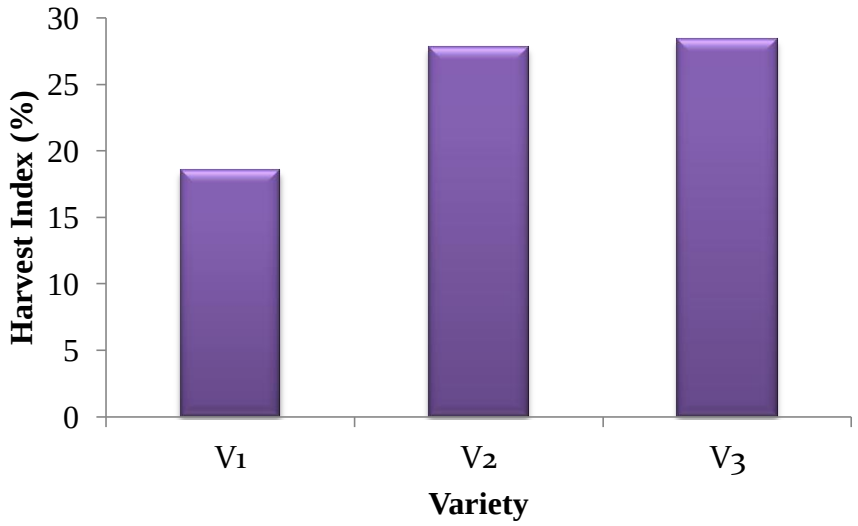
Biological yield was significantly affected by the interaction of variety and weed management (Table 10). The highest biological yield (6.34 t ha^{-1}) was obtained from the combination of BARI Sharisha-17 (V_3) along with two hand weeding (W_2) which was statistically similar with V_3W_3, V_2W_2, V_2W_3 and V_3W_4. The lowest biological yield (3.70 t ha^{-1}) was found from the combination of BARI Sharisha-14 (V_1) with no weeding which was statistically similar with V_1W_1, V_1W_4 and V_2W_0.

4.16 Harvest index (%)

4.16.1 Effect of Variety

Variety showed significant variation in harvest index (Figure 29). BARI Sharisha-17 (V_3) showed the highest harvest index (28.37%) followed by BARI Sharisha-15 (V_2) which attained 27.74 % harvest index whereas lowest harvest index (18.50%) was found in BARI Sharisha-14 (V_1). Similar result was found by (Awal and Fardous, 2014 and Singh *et al.*, 1991) in mustard which supported our results. Moderately high

genotypic variation for harvest index in mustard was reported by them for the mustard cultivars like CAR2, CAR6, BC2 and RH30 of *Brassica carinata* species.

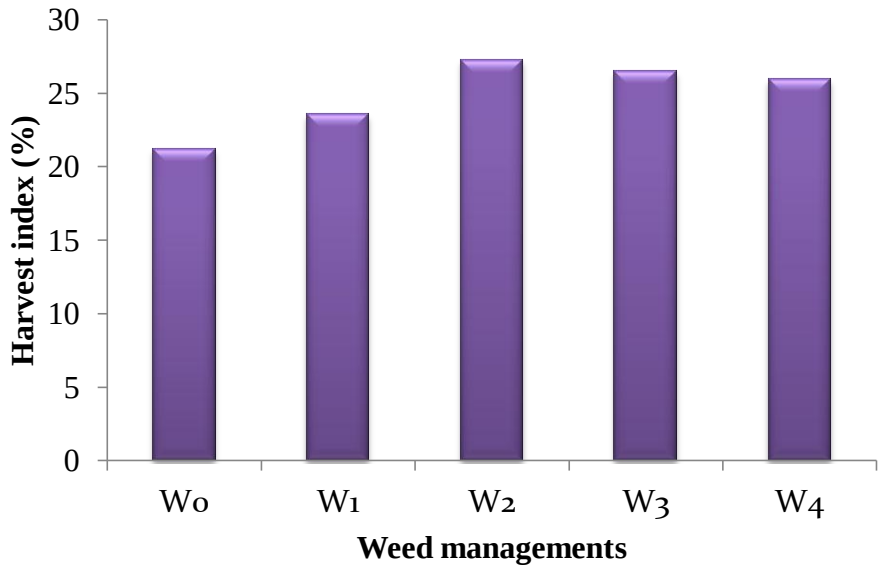


V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17

Figure 29. Effect of variety on the harvest index of mustard ($LSD_{0.05}$=2.54)

4.16.2 Effect of weed management

Significant variation was observed in harvest index due to the effect of weeding (Figure 30). The highest harvest index (27.25%) was found due to the effect of W_2 which was statistically similar with W_3 and W_4. No weeding (W_0) scored the lowest harvest index (21.20%). Similar result was found by (Jangir *et al.*, 2017; Awal and Fardous, 2014; Mishra and Kurchania, 2001 and Singh *et al.*, 2000) who reported that harvest index was higher in weed free condition than un-weeded control. While, contradictory result was recorded in this regard by Arya (2004).



W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

Figure 30. Effect of different weed management on the harvest index of mustard ($LSD_{0.05}$=2.13)

4.16.3 Interaction effect of variety and weed management

Interaction effect of variety and weeding showed significant variation in harvest index (Table 11). The highest harvest index (29.98%) was observed from the interaction effect of V_3W_3 which was at par withV_3W_2, V_3W_4, V_2W_1, V_2W_2, V_2W_3, V_2W_4 and V_3W_0. The lowest harvest index (12.14%) was obtained from the interaction of V_1W_0.

Table 11. Interaction effect of variety and different weed managements on the yield characters of mustard

Treatment combinations	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1W_0	0.44 h	3.26 g	3.70 g	12.14 e
V_1W_1	0.71 g	3.32 fg	4.03 fg	17.73 d
V_1W_2	1.06 ef	4.00 a-f	5.06 c-e	21.02 b-d
V_1W_3	0.98 f	3.65 c-g	4.64 d-f	21.37 b-d
V_1W_4	0.90 fg	3.54 c-g	4.44 e-g	20.22 cd
V_2W_0	0.99 f	3.47 d-g	4.46 e-g	22.18 bc
V_2W_1	1.47 cd	3.66 b-g	5.13 c-e	28.63 a
V_2W_2	1.89 a	4.22 a-c	6.11 ab	30.90 a
V_2W_3	1.62 c	4.15 a-d	5.77 a-c	28.02 a
V_2W_4	1.57 c	3.84 a-g	5.41 b-d	28.97 a
V_3W_0	1.41 cd	3.40 e-g	4.81 d-f	29.29 a
V_3W_1	1.27 de	3.96 a-g	5.23 c-e	24.18 b
V_3W_2	1.89 a	4.45 a	6.34 a	29.82 a
V_3W_3	1.86 ab	4.37 ab	6.23 a	29.98 a
V_3W_4	1.63 bc	4.08 a-e	5.71 a-c	28.57 a
LSD $_{(0.05)}$	**0.24**	**0.71**	**0.82**	**3.69**
CV (%)	**10.86**	**11.01**	**9.41**	**8.82**

V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17; W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS

CHAPTER 5

SUMMARY AND CONCLUSION

The present piece of work was done at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2017 to March, 2018 to study on the performance of weed management techniques affecting growth and yield of mustard.

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 5 m^2 and total numbers of plots were 45. The experiment comprised with two factors *viz.* (i) three mustard varieties *viz*., V_1= BARI Sharisha-14, V_2= BARI Sharisha-15 and V_3= BARI Sharisha-17 and (ii) Five Weed managements *viz*., W_0= No weeding (control), W_1= One hand weeding at 10 DAS, W_2= Two hand weeding at 10 and 20 DAS, W_3= Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS and W_4= Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS. There were 15 treatment combinations. Mustard varieties were assigned to the main plot and the weed managements were assigned to sub plot. Data on different growth, yield contributing characters and yield were recorded from the experimental field and analyzed statistically.

The data on weed parameters were collected from 5 DAS to 80 DAS. Weed parameters such as total weed population (no. m^{-2}), dry weight of weed m^{-2} (g) and weed control efficiency (%) were examined. The data on growth parameters *viz.*, plant height, dry matter weight $plant^{-1}$, Crop growth rate (CGR), Relative growth rate (RGR) and branches $plant^{-1}$ were recorded during the period from 25 DAS to at harvest. Yield contributing characters and yield parameters *viz*., siliquae $plant^{-1}$, seeds $siliqua^{-1}$, 1000 seed weight, seed yield, straw yield, biological yield and harvest index of seeds were recorded.

Eleven weed species belonging to seven families were found to infest the experimental crop. The weeds of the experimental plots were weeds *Eleusine indica, Cynodon dactylon, Dactyloctenium aegyptium, Echinochola colonum, Cyperus rotundus, Brassica kaber, Heliotropium indicum, Amaranthus spinosus, Alternanthera philoxeroides, Chenopodium album and Solanum nigrum,* respectively.

Weed population, dry matter of weed m^{-2} and weed control efficiency were significantly influenced by the weed control treatments.

Results of the present investigation revealed that mustard variety BARI Sharisha-17 performed superior than other in respect of plant growth, yield and yield contributing character of mustard. The maximum plant height (82.67 cm at 75 DAS), dry matter weight $plant^{-1}$ (30.82 g), branches $plant^{-1}$ (7.69), siliquae $plant^{-1}$(81.22), seeds $siliqua^{-1}$ (25.71), 1000 seed weight (3.57 g), seed yield (1.61 t ha^{-1}), stover yield (4.05 t ha^{-1}), biological yield (5.66 t ha^{-1}) and harvest index (28.37 %) were recorded from BARI Sharisha-17 while maximum CGR (10.41 g m^{-2} d^{-1}) was recorded from BARI Sharisha-15. The minimum plant height (69.80 cm at 75 DAS), dry matter weight $plant^{-1}$(22.96 g), branches $plant^{-1}$ (6.85), CGR (5.91 g m^{-2} d^{-1}), siliquae $plant^{-1}$ (49.85), seeds $siliqua^{-1}$ (21.39), 1000 seed weight (3.01 g), seed yield (0.82 t ha^{-1}), stover yield (3.55 t ha^{-1}), biological yield (4.37 t ha^{-1}) and harvest index (18.50 %) were recorded from BARI Sharisha-14.

Different weed management techniques significantly influenced maximum plant growth, yield and yield contributing characters of mustard. Result revealed that the maximum plant height (87.32 cm at harvest), dry matter weight $plant^{-1}$ (31.46 g), branches $plant^{-1}$ (8.43), siliquae $plant^{-1}$(75.27), seeds $siliqua^{-1}$ (25.62), 1000 seed weight (3.76 g), seed yield (1.61 t ha^{-1}), stover yield (4.22 t ha^{-1}), biological yield (5.84 t ha^{-1}) and harvest index (27.25 %) were recorded from two hand weeding at 10 and 20 DAS (W_2), while maximum CGR (10.24 g m^{-2} d^{-1}) was recorded from herbicide Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS (W_4). The minimum plant height (78.52 cm at harvest), dry matter weight $plant^{-1}$ (23.73 g), branches $plant^{-1}$ (5.86), siliquae $plant^{-1}$ (52.92), seeds $siliqua^{-1}$ (21.42), 1000 seed weight (2.82 g), seed yield (0.95 t ha^{-1}), stover yield (3.38 t ha^{-1}), biological yield (4.32 t ha^{-1}) and harvest index (21.20 %) were recorded from no weeding (W_0) while the minimum CGR (7.03 g m^{-2} d^{-1}) was recorded from two hand weeding at 10 and 20 DAS (W_2).

Interaction of mustard varieties and different weed management techniques significantly influenced maximum plant growth, yield and yield contributing characters of mustard. Result revealed that the maximum plant height (90.33 cm at harvest), dry matter weight $plant^{-1}$ (34.60 g), branches $plant^{-1}$ (9.82), siliquae $plant^{-1}$

(90.60), seeds siliqua^{-1} (27.67), 1000 seed weight (4.33 g), seed yield (1.89 t ha^{-1}), stover yield (4.45 t ha^{-1}), biological yield (6.34 t ha^{-1}) and harvest index (29.82 %) were recorded from BARI Sharisha-17 in combination with two hand weeding at 10 and 20 DAS (W_2), while maximum CGR (13.57 g m^{-2} d^{-1}) was recorded from BARI Sharisha-15 along with herbicide Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS (W_4). The minimum plant height (72.47 cm at harvest), dry matter weight plant^{-1} (20.53 g), branches plant^{-1} (5.43), siliquae plant^{-1} (38.40), seeds siliqua^{-1} (20.00), 1000 seed weight (2.60 g), seed yield (0.44 t ha^{-1}), stover yield (3.26 t ha^{-1}), biological yield (3.70 t ha^{-1}) and harvest index (12.14 %) were recorded from BARI Sharisha-14 along with no weeding (W_0) while the minimum CGR (4.06 g m^{-2} d^{-1}) was recorded from BARI Sharisha-14 in combination with two hand weeding at 10 and 20 DAS (W_2). It was observed that BARI Sharisha-17 coupled with two hand weeding at 10 and 20 DAS (V_3W_2) emerged as most efficient treatment for greater yield (1.89 t ha^{-1}) of mustard.

It may be concluded that among mustard varieties BARI Sharisha-17 performed better along with two hand weeding at 10 and 20 DAS for better growth with maximum yield attributes of yield harvest (1.89 t ha^{-1}) of mustard in different mustard growing area in Bangladesh.

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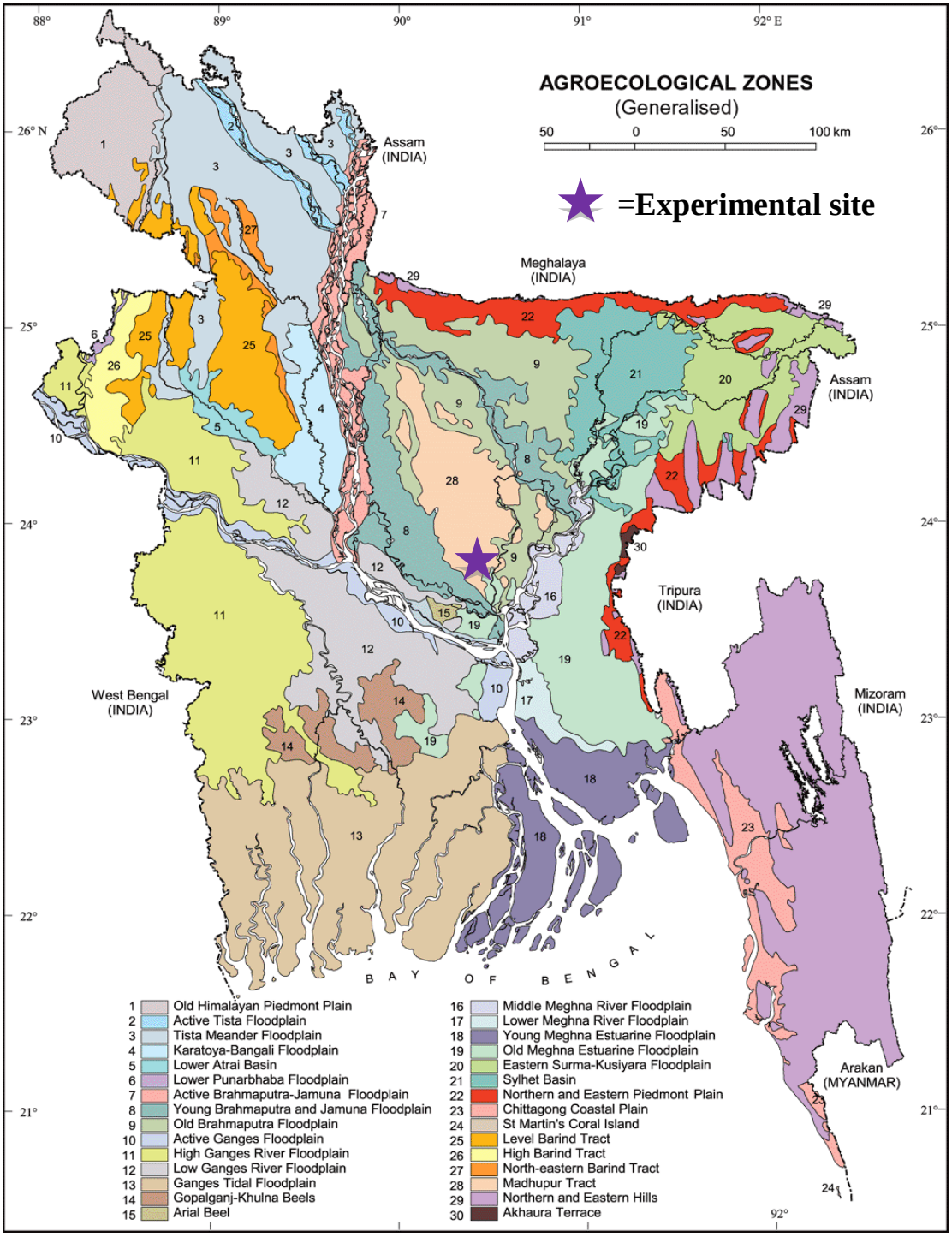
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total weeding (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from October, 2017 to March, 2018

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2017	October	30.18	14.85	67.82	137
	November	28.89	11.88	56.58	51
	December	25.13	8.98	69.85	1.21
2018	January	23.97	9.28	71.09	Trace
	February	25.12	13.89	76.99	Trace
	March	29.21	14.09	75.89	1.01

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data on number of weeds m^{-2} in mustard field as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of number of weeds m^{-2} at different days after sowing (DAS)			
		5	30	55	80
Replication	2	10.16	20.42	9.09	356.60
Variety (A)	2	16.02^{NS}	189.16^{NS}	189.09^{NS}	159.20^{NS}
Error	4	30.62	71.49	104.22	119.60
Weed management (B)	4	23.69*	3480.64*	5174.14*	5025.92*
Variety (A) X Weed management (B)	8	18.19*	148.88*	122.73*	157.51*
Error	24	8.69	26.30	49.40	32.96

*Significant at 1% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on number of weeds m^{-2} in mustard field as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of	
		Dry matter of weed m^{-2}	Weed control efficiency
Replication	2	9.42	15.60
Variety (A)	2	369.01*	126.50^{NS}
Error	4	11.62	70.18
Weed management (B)	4	6022.43*	8217.24*
Variety (A) X Weed management (B)	8	16.31*	23.64*
Error	24	23.36	17.80

*Significant at 1% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on plant height of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of plant height at different days after sowing (DAS)			
		25	50	75	At harvest
Replication	2	14.33	39.37	155.29	2.42
Variety (A)	2	103.49*	133.70*	773.94*	190.22^{NS}
Error	4	8.27	6.40	63.64	95.63
Weed management (B)	4	49.69*	187.13*	131.02*	100.89*
Variety (A) X Weed management (B)	8	1.72*	7.60*	3.63*	11.65*
Error	24	14.16	43.62	53.21	57.93

*Significant at 1% level of significance

^{NS} Non significant

Appendix VII. Analysis of variance of the data on dry matter weight plant^{-1} of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of data on dry matter weight plant^{-1} at different days after sowing (DAS)			
		25	50	75	At harvest
Replication	2	0.25	1.24	4.63	37.75
Variety (A)	2	9.05*	43.54*	70.54*	249.86*
Error	4	0.26	1.48	6.10	6.93
Weed management (B)	4	7.56*	42.03*	115.02*	72.36*
Variety (A) X Weed management (B)	8	0.43*	4.23*	3.02*	4.66*
Error	24	0.39	0.60	5.28	8.35

*Significant at 1% level of significance

^{NS} Non significant

Appendix VIII. Analysis of variance of the data on CGR of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of data on CGR at different days after sowing (DAS)		
		50-25	75-50	At harvest-75
Replication	2	0.21	8.83	0.01
Variety (A)	2	25.31*	5.71^{NS}	89.53*
Error	4	0.14	1.79	0.78
Weed management (B)	4	25.49*	35.28*	15.90*
Variety (A) X Weed management (B)	8	8.27*	8.96*	12.82*
Error	24	0.14	2.30	0.98

*Significant at 1% level of significance

^{NS} Non significant

Appendix IX. Analysis of variance of the data on RGR of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of data on RGR at different days after sowing (DAS)		
		50-25	75-50	At harvest-75
Replication	2	0.00	0.00	0.00
Variety (A)	2	0.00^{NS}	0.00^{NS}	0.00^{NS}
Error	4	0.00	0.00	0.00
Weed management (B)	4	0.00*	0.00*	0.00^{NS}
Variety (A) X Weed management (B)	8	0.00*	0.00*	0.00^{NS}
Error	24	0.00	0.00	0.00

*Significant at 1% level of significance

^{NS} Non significant

Appendix X. Analysis of variance of the data on branches plant^{-1} of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of data on branches plant^{-1} at different days after sowing (DAS)		
		50	75	At harvest
Replication	2	0.56	0.79	0.12
Variety (A)	2	10.27*	2.34*	2.87*
Error	4	0.27	0.14	0.25
Weed management (B)	4	7.97*	3.72*	8.45*
Variety (A) X Weed management (B)	8	0.32*	1.07*	0.70*
Error	24	0.11	0.63	0.68

*Significant at 1% level of significance

^{NS} Non significant

Appendix XI. Analysis of variance of the data on yield contributing characters of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of		
		Siliquae plant^{-1}	Seeds siliqua^{-1}	1000 grain weight
Replication	2	213.34	30.99	0.23
Variety (A)	2	3701.46*	71.00*	1.21*
Error	4	18.20	9.41	0.18
Weed management (B)	4	732.90*	25.96*	1.20*
Variety (A) X Weed management (B)	8	25.05*	0.72*	0.14*
Error	24	42.97	4.31	0.15

*Significant at 1% level of significance

^{NS} Non significant

Appendix XII. Analysis of variance of the data on yield characters of mustard as influenced by combined effect of different varieties and weed management

Source of variation	df	Mean square of			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.06	0.01	0.14	4.68
Variety (A)	2	2.78*	0.95*	6.89*	458.10*
Error	4	0.04	0.06	0.19	6.27
Weed management (B)	4	0.64*	1.00*	3.23*	55.29*
Variety (A) X Weed management (B)	8	0.05*	0.04*	0.04*	19.26*
Error	24	0.02	0.18	0.23	4.81

*Significant at 1% level of significance

^{NS} Non significant

Plate 1. Experimental plot with control treatment (no weed management)

Plate 2. Experimental plot with one hand weeding at 10 DAS

Plate 3. Experimental plot with two hand weeding at 10 and 20 DAS

Plate 4. Experimental plot with Panida 33EC (Pendemethylin) @ 2000 ml ha^{-1} at 5 DAS

Plate 5. Experimental plot with Whipsuper (Fenoxaprop-p-ethyl) 9EC @ 750 ml ha^{-1} at 21 DAS