# WEED MANAGEMENT THROUGH ALLELOPATHIC INTERACTION OF MUSTARD VARIETIES

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**WEED MANAGEMENT THROUGH ALLELOPATHIC INTERACTION OF MUSTARD VARIETIES**

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## *CERTIFICATE*

*This is to certify that thesis entitled, "**WEED MANAGEMENT THROUGH ALLELOPATHIC INTERACTION OF MUSTARD VARIETIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. ABDULLAH AL MASUD,** Registration no.**14-05897** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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**DEDICATED TO**

**MY**

**BELOVED PARENTS**

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***The Author***

# WEED MANAGEMENT THROUGH ALLELOPATHIC INTERACTION OF MUSTARD VARIETIES

## ABSTRACT

A series of experiments were carried out in the laboratory and agronomic field of the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, from October-2019 to February 2020 in Rabi season to investigate the effect of weed management through allelopathic interaction of mustard varieties. The experimental design in laboratory bioassay was a completely randomized design (CRD) with three replications. The field experiment consisted of two factors. Factor-A: Mustard varieties (5) *viz,* RAI-5, BARI Sarisha-7, BARI Sarisha-8, BARI Sarisha-15, BARI Sarisha-18 (canola), and factor-B: Weed management (3) *viz*, no weeding, 1 hand weeding at 15 DAS, and 2 Hand weeding at 15 and 30 DAS. The field experiment was laid out in a split-plot design having 3 replications. Data on different parameters in laboratory and field conditions were collected for assessing the results. In the laboratory, RAI-5, BARI Sarisha-7, BARI Sarisha-8, and BARI Sarisha-18 significantly reduced the germination, root and shoot growth of model plants (*Lactuca sativa* and *Raphanus sativus*) and weed (*Echinochloa colona*). There was a dominance of *Cynodon dactylon, Cyperus rotundus and E. colona* weed species in the mustard field. However, weed densities were minimal in the Rai-5 and BARI Sarisha-18(Canola) raised plots. The allelopathic potentiality of these varieties may be important reason for suppressing weeds in the field which support the lab experiments. BARI Sarisha-18 (canola) variety recorded the maximum seed yield (1.81 t $ha^{-1}$), comparable to others mustard varieties. Weed management had shown a non-significant effect on the seed yield of mustard. Although the combination of BARI Sarisha-18(canola) with two weeding gave the highest seed yield (1.85 t $ha^{-1}$), the most economically viable combination was BARI Sarisha-18(Canola) with no weeding which gave the highest gross return (115140 Tk.), net return (74852 Tk.), and benefit-cost ratio (2.86). This suggests that the allelopathic trait of mustard is independent of local adaptation and yield potential under weed-free conditions and would be most useful to help farmers maximize yield and control weeds.

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| | |
|---|---|
| AEZ | Agro-Ecological Zone |
| BARI | Bangladesh Agricultural Research Institute |
| BAU | Bangladesh Agricultural University |
| BBS | Bangladesh Bureau of Statistics |
| CV% | Percentage of coefficient of variance |
| cv. | Cultivar |
| DAE | Department of Agricultural Extension |
| DAT | Days after transplanting |
| $^{0}C$ | Degree Celsius |
| et al | And others |
| FAO | Food and Agriculture Organization |
| g | gram(s) |
| $ha^{-1}$ | Per hectare |
| HI | Harvest Index |
| i.e. | That is |
| kg | Kilogram |
| Max | Maximum |
| mg | Milligram |
| Min | Minimum |
| MoP | Muriate of Potash |
| N | Nitrogen |
| No. | Number |
| NS | Not significant |
| % | Percent |
| SAU | Sher-e-Bangla Agricultural University |
| SRDI | Soil Resources and Development Institute |
| t | Ton |
| TSP | Triple Super Phosphate |
| Wt. | Weight |

# CHAPTER I

# INTRODUCTION

Mustard (*Brassica spp*. L.) is a worldwide cultivated thermo and photosensitive oilseed crop. Asia produces 41.50 % of mustard seed which occupies the first position in terms of percentage share of production followed by the USA (FAOSTAT, 2018). Edible oils play vital roles in human nutrition by providing calories and aiding in the digestion of several fat-soluble vitamins, for example, Vitamin A (Albahrani and Ronda, 2016). The per capita recommended dietary allowance of oil is 6 gm day$^{-1}$ for a diet with 2700 Kcal (Miah and Mondal, 2017).Oilseeds were cultivated in less than 2.20 % of total arable land under the rice-based cultivation system in Bangladesh, where three fourth of total cultivable land was engaged in rice production in 2015-16 (BBS, 2019)is the major oilseeds in Bangladesh which exhibits an increase in production from 1994 to 2018 except few fluctuations in the case of total production and area under cultivation (FAOSTAT, 2018). Mustard occupied more than 69.94 % of the total cultivated area of oilseeds followed by sesame, groundnut, and soybean (BBS, 2019). With the increase in population, the demand for edible oil and oilseeds is on an increasing trend (Alam, 2020). Bangladesh has to import a noticeable amount of edible oil and oilseeds to meet up the existing accelerating demand. The value of imported oilseed and edible oil has increased dramatically from USD 544 million in 2002-03 to USD2371 million in 2018-19 which were 4.99 and 4.23 % of the total value of imports respectively (Bangladesh Bank, 2020). The yield of mustard has increased from 0.75tha$^{-1}$ in 2001 to 1.15 tha$^{-1}$ in 2019 (MoA, 2007; BBS, 2019). Bangladesh was not in an advantageous position in the case of mustard production (Miah and Rashid, 2015) which was due to, lack of high-yielding varieties and poor management as practiced at farmer's fields.

Seed yield and other yield contributing characters significantly varied among the varieties of rapeseed and Mustard (BARI, 2001). Rahman *et al.* (2019) reported that there was a significant yield difference among the varieties of rapes and mustard with the same species. *Brassica* (genus of mustard) has three species that produce edible oil, they are *B. napus, B. campestris* and *B. juncea*. Of these, *B. napus* and *B. campestris* are of the greatest importance in the world’s oil seed trade. In this subcontinent, *B. juncea* is also an important oil seed crop. Until recently, Mustard varieties such as Tori-7, Sampad (both *B. campestris*), and Doulat (*B. juncea*) were mainly grown in this country. Recently several varieties of high-yielding potential characteristics have been developed by BARI.

*Brassica* species is a wild plant, which naturally grows on the plains and hilly areas. In North America and Europe, *Brassica* species are important oil seed crops and have the potential for use as green manure crops (Grodzinsky, 1992). Members of Brassicaceae have frequently been cited as an allelopathic crop (Bell and Muller, 1973). Some *Brassica* species have harmful effects on crops including reduced seed germination and the emergence of subsequent small-grain crops when grown in rotation (Bialy *et al.*, 1990; Muehlchn *et al.*, 1990). In a natural grassland community, allyl-isothiocyanates (ITC) isolated from black mustard (*Brassica nigra* (L.) residues inhibited the establishment of grass species. Benzyl-ITC, a break-down product of white mustard (Subbiah and Krishnaswamy, 2013; Tollsten*et al.*, 1988) was phytotoxic to velvetleaf, sicklepod (*Senna obtusifolia* L. formerly *Cassia obtusifolia* L.) and sorghum [*Sorghum bicolor* (L.) Moench]. Other breakdown products of glucosinolate like ionic thiocyanate (SCN-) inhibited the root or shoot growth of many crop species (Brown *et al.*, 1991). Volatile compounds like isoprenoid and benzenoid released from *Brassica* tissue degradation may suppress weed growth (Tollsten *et al.*, 1988). It was also found in many studies that allelochemicals, which inhibited the growth of some species at certain concentrations, might stimulate the growth of the same or different species at lower concentrations (Narwal, 1994). The stimulatory (negative) allelopathic effects of any plant on the other plant can be used to develop ecofriendly, cheap, and effective 'Green Growth Promoter's' (Oudhia *et al.*, 1988). Boydston and Hang (1995) reported that the concentration of allelopathic mustard oils varies with species and variety of mustard.

Allelopathy is defined as the direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escape into the environment (Brown *et al.*, 1991). Many of the phytotoxic substances, suspected of causing germination and growth inhibition have been identified from plant tissues and soils. These substances are termed allelochemicals (Saeedipour, 2010) or, more commonly, allelochemicals. Allelochemicals usually are called secondary plant products or waste products of the main metabolic pathways in plants.

The readily visible effects of allelochemicals on the growth and development of plants include inhibited or retarded germination rate; seeds darkened and swollen; reduced root or radicle and shoot or coleoptile extension; swelling or necrosis of root tips; curling of the root axis; discoloration, lack of root hairs; increased number of seminal roots; reduced dry weight accumulation; and lowered reproductive capacity. These gross morphological effects may be secondary manifestations of primary events, caused by a variety of more specific effects acting at the cellular or molecular level in the receiver plants (Li *et al*., 2015). To have any effect on the target plant the allelochemicals have to be released from the donor plant. These may be released through leaching, root exudation, volatilization, and decomposition of plant residues.

Weeds are one of the major constraints for the poor yield of the mustard crop as they compete with the crop plants for moisture, nutrients, light, and space. There are different views about the intensity of weed losses, but it is fact that weeds cause great losses to crops, depending upon the degree of weed infestation, duration of weed competition, and soil and climatic conditions (Mansoor *et al.*, 2004). Approximately, 20-30% yield reduction is caused by weeds in the mustard crop (Singh *et al.*, 2010). Karim (1987) estimated that weeds caused a yield loss of 28% of total food crops, 33% in cereals, 14% in pulses, 27% in oil seeds, and 33% in rice crops. There is no specific way to control weeds of all types because different kinds of social, economical, and environmental factors influence the choice of control method to be used. Quarshi *et al.* (2002) reported that weed could be controlled by manual, cultural, and chemical methods.

Weed management is the process of limiting weed infestation and minimizing competition with crops. When weeds are limitedthey have minimal effect on crop growth and yield. Control weed through weed management is another important strategy for higher yield realization. This necessitates that a systematic study on weed dynamics in such crops is essential for strategic weed-management planning. Further, a weed-control method to be accepted by the farmers must be agronomically feasible, economically viable, and should be under the farmer’s manageable capacity.

Keeping all points in mind mentioned above, the proposed research work was undertaken to achieve the following objectives-

**Objectives:**

- Screen out the allelopathic potential mustard varieties of Bangladesh
- Determine the effect of weed management on the growth and yield of mustard
- Observe the combined effect of variety and weed management on weed growth and yield performance of mustard

# CHAPTER II

# REVIEW OF LITERATURE

Mustard is an important oil crop of Bangladesh thatcontributes to a large extent tothe national economy. But the research works done on this crop concerning varietal potentiality and weed management are inadequate. Its growth and yield are determined by various factors of which varietal potentiality and weed management are most important. Very little work has been done involving the screening out the potentiality of mustard varieties and weed management on it. Some of the work applicable to the present study has been reviewed below:

## 2.1Inhibition of weed

Ackroyd and Ngouajio (2011) observed that oilseed *Raphanus sativus* var. *oleiferus*, Indian mustard (*Brassica juncea*), and white mustard (*Sinapis alba*) were used as green manures, germination percentage and radicle elongation of muskmelon (*Cucumis melo*) were reduced.

*Brassica* spp. cover crops and weed control is well-reviewed by Boydston and Al-khatib (2008). They focus on plant allelopathyas the tool of weed control, and also on the hydrolysis produced by glucosinolates as the allelochemicals responsible. One of the secondary plan metabolites is glucosinolates which arefound in *Brassica* spp., and myrosinase enzyme can hydrolysis the glucosinolates into toxic products like isothiocyanates, whichcan control weed seeds.

Haramoto and Gallandt (2005) found that some allelopathic cover crops including rapeseed and yellow mustard inhibit both weeds and subsequent crops.

Turk *et al.* (2005) reported that germination and seedling growth suppression of alfalfa (*Medicago sativa* L.), lentil (*Lens culinaris* Medikus), wild oat (*Avena fatua* L.) and *R. raphanistrum* subspp. *sativus* have been reported by the application of root and whole plant extracts of black mustard (*Brassica nigra* L.)

Turk and Tawaha (2003) indicated that the black mustard (*Brassica nigra* L.) contains water-soluble substances that inhibited the germination and seedling growth of wild oat (*Avena fatua* L.). Aqueous extracts of *B. nigra* leaf, stem, flower, and root plant part weremade to determine their effects on germination and dry weights of hypocotyl and radicle length of 8 days old A. *fatua* L. seedlings over a range of extract concentrations. Increasing the aqueous extract concentrations of separated *B. nigra* L., plant parts significantly inhibited *A. fatua* L. germination, seedling length, and weight. Radicle length was more sensitive to extract source than seed germination or hypocotyl length. Soil incorporation of fresh B. nigra roots only or both roots and shoots reduced *A. fatua* emergence, plant height, and dry weight per plant.

Al-Khatib and Boydston (1999) observed that *Brassica spp*. (*B. hirta*, *B. juncea*, B. nigra, *B. napus*) suppress weeds through (a) vigorous early-season growth, smothers the weeds before they are established, (b) release of allelochemicals into the soil from the shoots of living plants, plant residues, or plants incorporated into the soil by tillage, and (c) leaching/secretion of glucosinolates into the growing media; their hydrolysis to isothiocyanates inhibits weed seed germination and growth.

Wild types of *Brassica spp.* possess high allelopathic potential due to the presence of a higher concentration of potent glucosinolates. Al-Khatib and Boydston (1999) in their review have reported that methyl, phenyl, ethyl, and allyl isothiocyanate considerably inhibited the germination and growth of barnyard grass, redroot pigweed, cucumber, and pea than benzyl, butyl, propyl, and b-phenylethyl isothiocyanate. Besides, allelopathy may also result from additive or synergistic activity of many allelochemicals rather than from a single one. Green manuring of *Brassica* spp. suppresses the weeds but could also injure succeeding crops. Studies with potato, peppermint, cucumber, and peas following rapeseed and white mustard showed that rapeseed injured only pea and peppermint and white mustard was harmless to these crops

Oleszek *et al*. (1996) in their review concluded that some *Crucifereae* spp. possess potential to inhibit germination and growth of weeds and thus this spp. could be successfully used in weed control. The degradation products of glucosinolates seem to be responsible forthe allelopathic potential of *Brassica spp*. The field studies were conducted todetermine the smothering effect of three *Brassica spp*. viz., *B. juncea*, *B. napus* and *B. carinata* accession on the weed spp. The crops were sown ina completely randomized design with three replications in plots of 6 x 4 m. The crops were raised with the recommended cultural practices anda uniform plant stand was maintained; however, no herbicide or cultural practices were applied for weed control. The weed population and dry weight were recorded at crop harvest.

The genus *Brassica* is reported to have allelopathic properties that can affect the germination, establishment and growth of other species in the agro ecosystems. Wild mustard has a complex reaction tothe crop environment and controls weeds and pests. The complex of glucosinolates and their derivatives corrunon to the genus *Brassica* are being explored as possible active agents for the control of both weeds and pests.

Bell and Muller (1973) observed that decayed material of mustard plants was extremely allelopathic and being water-soluble, reduced the weed seeds germination.

**2.2Major weed flora in mustard crop**

Bhawana *et al*. (2019) observed the dominant weeds in the mustard field in three species belonging to Poaceae family followed by Chenopodiaceae, Compositae, Asteraceae, Convolvulaceae, Fabaceae, Polygonaceae and Cyperaceae. Among the grassy weeds, *Cynodon dactylon* (L.) Pers. was the predominant weed followed by *Polypogonmon speliensis* and *Phalaris minor*. *Cyperus rotundus* L. was the only sedge present in the experimental field. Among the broadleaved weeds, *Chenopodium album* L. was the dominant one followed by *Anagallis arvensis* L., *Parthenium hysterophorus* L., *Convolvulus arvensis, Melilotus album, Vicia hirsute* and *Rumex* sp.

Suryavanshi *et al*. (2018) found that the dominant weeds associated with gobhimustard were mainly comprised of dicot weeds like *Medicago sativa, Sonchus arvensis, Cichorium intybus* and *Physalis minima* only.

Gupta *et al.* (2018) studied the predominant weeds were *Chenopodium album* (Bathua), *Thithoria diversifolia* L. (wild sunflower), *Anagallis arvensis* (Krishanneel), *Melilotus alba* (Senji), *Cyperus rotundus*(mutha), and *Cynodon dactylon* (Durba) during crop seasons in a mustard field.

Bamboriya *et al*. (2017) detected mustard was heavily infested with mixed flora of monocot and dicot weeds chiefly consisting of*P.minor, C. rotundus* and *C. dactylon; C. album, C. murale, R. acetosella, Convolvulus arvensis, P. hysterophorus*, *Anagallis arvensis* and *Cichorium intybus* respectively.

Kumar *et al.* (2015) observed that the dominant broadleaf weeds were: *Amaranthus spinosus* L., *Gallinsoga parviflora* Cav., *Coronopus didymus* L., and monocots weeds were: *Digitaria sangunalis* L., *Poa annua* L., *Avena fatua L.* Other weeds were

*Polygonum alatum* L., *Malva parviflora* L., *Chenopodium botrys* L., *Setaria galuca* L., *Panicum dicotomiflorum* L., and *Medicago denticulate* Willd.

Kour *et al.* (2014) ranked the most dominant weed species based on their summed dominance ratioand followed the order: *Medicago sativa* > *Anagallis arvensis* >*Cyperus rotundus*>*Trachyspermum* spp. >*Cynodon dactylon*. *Medicago sativa* was the top-ranking dominant weed, followed by *Anagallis arvensis*. Other weeds were *Polygonum alatum* L., *Malva parviflora* L., *Chenopodium botrys* L., *Setaria galuca* L., *Panicum dicotomiflorum* L., and *Medicago denticulate* Willd.

### 2.3 Mustard varieties weed suppression

Norsworthy and Meehan (2005) evaluated the ability of ITCs to differentially suppress Texaspanicum (*Panicum texanum* Buckl.), large crabgrass (*Digitaria sanguinalis* L.), and sicklepod, and found that weed species greatly differed in their susceptibility to varying ITCs. Yellow mustard was more effective at suppressing shepherd’s purse (*Capsella bursa-pastoris* L.), kochia (*Kochia scoparia* L.), and green foxtail (*Setaria viridis*L.*)* compared to rapeseed (*Brassica napus* L.)

Narwal *et al.* (2004) conducted a field experiment and stated that some accessions of *B. juncea* and *B. nigra* caused a significant reduction of 75–82% at 75 days after germination and 75–98% at harvest (120 days) in the density of weeds, namely *Rumex retroflexus*, *Melilotus alba*, *Chenopodium album*, *Cirsium arvense*, *Avena ludoviciana*, and *Phalaris minor*, respectively.

Brassica residues are most suitable for weed control in transplanted vegetable crops, orchards, and woody cultivated plants. Oleszek*et al.* (1996) listed six glucosinolates viz., sinigrin, sinalbin, gluconapin, glucobrassicin, gluconastrutiin, and 4-hydroxyglucobrassicin found in *Cruciferae spp*. to be useful in weed control strategies. Among *Brassica spp. B. campestris* reduced the weed density in the same field in the following year, therefore, it is used as a weed controlling crop by the Tarahumara Indians in North Mexico.

Joshi (1991) reported that *Brassica spp*. suppresses the weeds through their vigorous growth and release of allelochemicals. *B. nigra* and *B. juncea* were found the most potent because they produced maximum volatiles particularly allyl isothiocyanate, a potent allelochemical.

## 2.4 Effect of mustard varieties on the weed biomass production and crop growth

Farooq *et al.* (2013) reported that although allelopathy is often considered as a negative interference of plant species through chemical interactions there is another dimension to this chemical warfare: certain allelochemicals may promote plant growth and development when released below specific thresholds. Several phenolics and alkaloids have been found to promote the physiological processes of plants and resultantly stimulate growth when released or applied at low concentrations. Some *Brassica* species contain phytochemicals thatpromote the growth of crops. Brassinosteroids are a brilliant example of the stimulatory behavior of *Brassica* species.

Rice *et al.* (2007) showed that seed meal of Indian mustard significantly reduced the biomass of redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album* L.).

Grove *et al.* (1979) reported that brassinolide is a conventional plant hormone thatacts as growth promoter and yield enhancer in fruit and grain crops, despite the fact it inculcates the resistant factors to cold weather and drought resistance in the plants. Extensive varieties of plants are accompanied by brassinosteroids compounds. It is Vital for the better growth of all plants; sometimes plants become dwarfs if they cannot comprise the ability to synthesize their brassinolide. The plant will grow better in the presence of brassinolide and if its availability is more forthe plants then the growth rate will be higher. Brassinolide provides the opportunity forthe plants to grow faster because it increases the rate of photosynthesis and its absence influence the growth and development of the plant.

Seeds treated with brassinolide gave more vigorous growth and healthy seedling. This fact was revealed by Jones *et al.* (1996) who concluded that brassinosteroids accelerated plant growth when applied to cress seeds. A small concentration of brassinolide was applied to the cress seeds and it was recorded that it improved the germination but a higher concentration of brassinolide inhibited the root germination of cress seeds.

Boydston and Hang (1995) showed that the addition of rapeseed residues in sandy soils reduced the biomass of hairy nightshade (*Solanum sarrachoides* Sendtn) and long sandbur [*Cenchrus longispinus* (Hack.) Fern.] by up to 90 and 83%, respectively.

Narwal (1994) reported that the allelochemicals, which inhibited the growth of some species at certain concentrations, might stimulate the growth of the same or different species at a lower concentration. The stimulatory (negative) allelopathic effects of any plant on the other plant can be used to develop eco-friendly, cheap, and effective "Green Growth Promoters".

Sarmah *et al*. (1992) observed that several accessions of rapeseed, Indian Mustard, and Ethiopian Mustard (*B. carinata* A. Braun) suppressed the growth and biomass accumulation of different winter weeds. The suppressive effect followed an order of rapeseed > Indian Mustard> Ethiopian Mustard. Interestingly, the suppressive effects of these species were higher against broad-leaved weeds than narrow-leaved weeds, which might be due to the selective action of responsible allelochemicals.

### 2.5 Effect of mustard varieties

#### 2.5.1 Plant Height

Das *et al.* (2019) reported that the height of a plant is determined by the genetical character and under a given set of environment different variety will acquire their height according to their genetical makeup.

Tyeb *et al.* (2013) reported that the variation in plant height is due to the effect of varietal differences. The variation of plant height is probably due to the genetic make-up of the cultivars.

Rashid *et al.* (2010) conducted a field experiment to find out the effect of the different levels of fertilizers on the growth parameters of Mustard varieties of BARI sharisa-9 ($V_1$), BARI sharisa-12 ($V_2$) and BARI sharisa-15 ($V_3$), and to find out the optimum and economically viable fertilizer dose and reported that variety BARI sharisa-15 is of the tall plant type and that others are of intermediate and short stature in plant height. The significant difference in plant height might be associated with the variety characteristics or genetic makeup of the plant.

Sana *et al.* (2003) reported that the final plant height reflected the growth behavior of a crop.

### 2.5.2 Number of branches

Helal *et al.* (2016) corraborated that a higher number of branches plant$^{-1}$is the result of the genetic makeup of the crop and environmental conditions which play a remarkable role towards the final seed yield of the crop.

Mamun *et al.* (2014) carried out a study on the performance of rapeseed and mustard varieties grown under different planting densitiesandobserved that BARI Sarisha-13 produced the highest number of branches plant$^{-1}$ (6.14) which was 33.77% higher (4.59) than BARI Sarisha-15.

Sana *et al.* (2003) reported thata higher number of branchesplant$^{-1}$ is the result of the genetic makeup of the crop and environmental conditions which play a remarkable role towards the final seed yield of the crop.

### 2.5.3 Dry matter weight

Helal *et al.* (2016) indicated that dry matter production patterns at different days after sowing showed that different varieties varied their dry matter production pattern. These variations were noticed from one stage to another stage and none of the variety/lines followed the same pattern at different days of sampling. It indicated that each variety/line responded independently from one stage to another stage to the environment in respect of the growth of the plant, branching, and leaf number and ultimately differed in dry matter production.

Rashid *et al.* (2010) noticed significant variation in dry matter (DM) accumulation for different Mustard varieties on all days after sowing. This might be due to the different varieties which produced a different type of siliqua, and thus, the DM varied significantly.

### 2.5.4 Siliqua plant$^{-1}$

Alam *et al.* (2014) conducted that the varieties of mustard used in the experiment exerted significant influence on yield and yield attributes and among different varieties, the maximum number of siliquaeplant$^{-1}$ (108 and 90) was recorded in BJDH-05 which differed significantly from other varieties. This has contributed to higher yield. The lowest number of siliqua plants$^{-1}$ (52.0 and 56.3) were found in BARI Sarisha-14.

Mamun *et al.* (2014) found that the number of siliqua plant$^{-1}$ of mustard was significantly affected by different varieties.

Singh *et al.*, (2001) experimented Jodhpur and observed that number of siliqua plant$^{-1}$ recorded higher in cultivar Pusa Bold (257) compared to cultivar TS9 (198).

Hossain *et al.* (1996) reported that the varieties of rapeseed differed significantly in respect of siliqua length. The longer siliqua was found in hybrid BGN-900 (7.75 cm) that was similar to Hyole-101, Sampad, Dhali, and Hyola-51.

Yadav *et al.* (1978) suggested that for ensuring high yields in *B. juncea,* the plant type should have more siliquaplant$^{-1}$ (100-125).

**2.5.5 Seed siliqua$^{-1}$**

Rahman *et al*. (2019) revealed that the maximum number of seeds per siliqua (23.12) was produced in $V_2$ (BARI Sarisha 15) treatment and the minimum number of seed per siliqua (18.82) was produced in $V_1$ (BARI Sarisha 14) treatment.

**2.5.6 1000 seeds weight**

Helal *et al.* (2016) observed significant variations in terms of the number of seedssiliqua$^{-1}$ among all the varieties due to the reason of difference in the genetic makeup of the variety, which is primarily influenced by heredity.

Mamun *et al.* (2014) carried out a study on the performance of rapeseed and Mustard varieties grown under different planting densitiesandobserved that BARI Sarisha-13 had the highest 1000- seed weight (4.00 g) whereas the lowest (2.82 g) - in SAU Sarisha-3.

Mondal and Wahab (2001) described that weight of 1000 seeds varied from variety to variety and species to species.

**2.5.7 Seed yield**

Biswas *et al.* (2019) revealed that mustard varieties significantly affect seed yield and among different varieties, higher seed yield (2.24 t ha$^{-1}$) was observed in the improved Tori-7 variety which was followed by BARI Sarisha-16 (1.96 t ha$^{-1}$)) and BARI Sarisha-13 (1.57 t ha$^{-1}$). The lowest seed yield (1.34 t ha$^{-1}$) was obtained from $V_3$ (BARI Sarisha-15) which was statistically similar to SAU Sarisha-3 (1.53 t ha$^{-1}$).

Das *et al*. (2019) revealed that seed yield significantly differs among varieties and the maximum seed yield was recorded in Kesari Gold (1746 and 2153 kg $ha^{-1}$ respectively in 1st and 2nd year) followed by Kesari 5111.

Helal *et al.* (2016) conducted that the production of higher yield by different varieties might be due to the contribution of cumulative favorable effects of the crop characteristics viz., the number of branchesplant$^{-1}$, *siliqua* plant$^{-1}$and seeds siliqua$^{-1}$.

Junjariya (2014) corraborated that the seed yield of Indian Mustard was influenced significantly bydifferent cultivars. Bio-902 remained at par with RGN-13 and significantly superior as compared to RGN-48 and PBR-357. Bio-902 cultivar produced 8.72 and 23.03 percent higher yield, respectively, over RGN- 48 and PBR-357. However, RGN-13 and RGN-48 were remained at par with each other and significantly superior over PBR-357.

Islam and Mahfuza (2011) experimented with the research field of Agronomy Division, BARI, Joydebpur, Gazipur during the *Rabi* season of 2010-2011. BARI Sarisha-11 produced the highest seed yield (1472 kg $ha^{-1}$) while BARI Sarisha-14 was the lowest (1252 kg $ha^{-1}$). The highest mean seed yield was recorded at the maturity stage (1480 kg $ha^{-1}$) and decreased towards the green siliqua stage.

Zaman *et al.* (1991) reported that the seed yield of Mustards wasvaried with different varieties.

### 2.5.8 Stover yield

Sultana *et al.* (2009) studied that stover yield for different varieties of rapeseed under study differed significantly. Kollania produced a higher stover yield (2159.0 kg $ha^{-1}$) which was statistically at par with SAU Sarisha-1 (2156.0 kg $ha^{-1}$) and higher than Improved Tori -7 (1681.0 kg $ha^{-1}$).

### 2.5.9 Biological yield

Tobe *et al.* (2013) also reported variation in biological yield among different cultivars of *B. napus* and showed that cv. Hyola410 produced the highest seed yield (4759 kg $ha^{-1}$) as compared to cvs. RDF003 (4280 kg $ha^{-1}$) and Sarigol (3628 kg $ha^{-1}$).

Rana and Pachauri (2001) quoted that cv. Bio 902 recorded a higher biological yield (7250 kg $ha^{-1}$) as compared to cv. TERI (OE) M 21 (6850 kg $ha^{-1}$).

### 2.5.10 Harvest index

Thakur *et al.* (2021 indicated that the harvest index was significantly influenced by different varieties andthe maximum harvest index (36.95) was observed in $T_2$[45S35]. However, treatment $T_1$ [BULLET] was found to be statistically at par with $T_2$ [45S35]. As discussed earlier, the different hybrids have different yield potentials, which is the reason for yield variation among different varieties.

Lal *et al.* (2020) revealed that the maximum harvest index under RGN-73 (20.8%) was higher but statistical at par with RGN-229 (20.5%), while both varieties were significantly superior toRH-30 (18.9%) and Pusa bold (18.3%). This might be due to genotype characteristics and the high yielding potential of the variety.

Uddin *et al.* (2011) reported that the harvest index differed significantly among the varieties due to its genetic variability.

Shah *et al.* (1991) reported that variety had a great influence on the harvest index.

### 2.6 Effect of weed Management

Mukherjee (2014) performed a field experiment to investigate the different weed management techniques in mustard in which he found that the weeds accumulate the dry weight (13.2 $gm^{-2}$) after the twohand weeding at 25 and 50 DAS over control (62.2 $gm^{-2}$).

Chauhan *et al.* (2005) field experiment conducted in Madhya Pradesh, India during the years of 1998 and 1999 and found in mustard *Brassica juncea* (L.) that 2 hand-weedings (25 and 40 DAS) in mustard drastically lessened the density of weed, biomass weed and enhanced the yield of crop seed.

Cheema *et al.* (2002) implemented an experiment to check the effectiveness of many weed management approaches in *Brassica napus* at Faisalabad, Pakistan. They recorded that two-hand clearings at 20 and 40 DAS significantly reduce the weed dry weight 77%, weed density 67 % over the whole, and maximum seed yield of 942 kg $ha^{-1}$.

Angiras *et al.* (1990) experimented to know the weed management in *Brassica napus* in Himachal Pradesh, India. In this experiment, they study the weed-free and weeded circumstances and found that weed dry weight in weed-free condition (110 g/m) over weedy conditions (260.5 $gm^{-2}$) in a whole crop season.

Chakhaiyar and Ambasht (1990) conducted that a field experiment at Uttar Pradesh, India to see the influence of various weedy and weed-free duration in the mustard crop. From the investigations of the experiment, they found the weed dry weight 110.5 $gm^{-2}$ in weedy conditions and 8.5 to 88.4 $gm^{-2}$ after 20and 100 days emergence of the crop respectively.

**2.7 Weed management practices on growth, yield contributing characters, and yield of mustard**

Kumar *et al*. (2019) reported that among weed management practices, the highest seed & Biological yield (2493 kg $ha^{-1}$& 9628 kg $ha^{-1}$) were obtained with two HW treatments which were significant rest over the treatment of mustard crop.

Gupta *et al*. (2018) revealed that the two hand weeding at 25-30 and 40-45 days after sowing recorded maximum mean plant height (165.4 cm), siliqua $plant^{-1}$ (153.7 cm), seeds $siliqua^{-1}$ (13), test weight (4.33 g), mustard seed and stover yield (16.16 and 50.51 q ha-1) during both the years of study which was statistically at par with 1 hand weeding (16.08 and 50.39 q $ha^{-1}$) and pre-emergence application of pendimethalin 38.7CS (15.86 and 48.49 q $ha^{-1}$).

Bijarnia *et al.* (2017) reported that among the weed management sources, the application of 1.0 kg $ha^{-1}$pendimethalin reduced the dry matter of different weeds and enhance the growth, yield attributes, and also produced the maximum seed and straw yield. Kumar *et al*. (2017) revealed that the two hand weeding also remains superior seed yield (2493 kg $ha^{-1}$) and straw yield (7135 kg $ha^{-1}$). Application of pendimethalin also exhibited a higher seed yield (2162 kg $ha^{-1}$) with a minimum weed competition index (13.30 %).

Kalita and Mundra (2015) recorded maximum seed yield (2240 kg $ha^{-1}$) under one hand weeding, however, it was statistically at par with pre-emergence application of oxadiargyl 0.09 kg ha-1 (2234 kg $ha^{-1}$). Similarly, stover and biological yields (5589 and 7830 kg $ha^{-1}$, respectively) were also recoded maximum under one hand weeding treatment which was very closely followed by oxadiargyl 0.09 kg $ha^{-1}$. However, the maximum harvest index (29.03 percent) was registered under oxadiargyl 0.09 kg $ha^{-1}$

which was found statistically at par with one hand weeding 25 DAS and pendimethalin 0.75 kg $ha^{-1}$ treatments in this regard. The percent enhancement in seed yield underhand weeding and oxadiargyl 0.09 kg $ha^{-1}$ was 70.73 and 70.27, respectively compared to the weedy check.

Awal and Fardous (2014) results indicated that both species gave higher yield due to the operation of a single weeding as compared to without weeding. The highest seed yield of 1.48 t $ha^{-1}$ was obtained from the crop treated with one hand weeding whereas the lowest yield 1.08 t $ha^{-1}$ was observed in the un-weeded control treatment. In the context of species, the higher seed yield 1.31 t $ha^{-1}$ was found in *B. campestris s*and that of lower seed yield 1.25 t $ha^{-1}$ was found from *B. napus*.

Mukherjee (2014) performed a field experiment to investigate the different weed management techniques in mustard in which he found that the weeds accumulate the dry weight (13.2 $gm^{-2}$) after the two hand weeding at 25 and 50 DAS over control (62.2 $gm^{-2}$). Moreover, he recorded the seed yield (2.27 $tha^{-1}$) after the two hand weeding at 25 and 50 DAS than control (0.87 $tha^{-1}$). Straw yield recorded after the two hand weeding at 25 and 50 DAS is (3.84 $tha^{-1}$) over control (2.79 $tha^{-1}$).

Patel *et al*. (2013) revealed that the higher values of plant growth characters *viz*., dry matter production per plant (51.00 g) and yield attributing characters viz., number of siliquae per plant (280.37), number of seeds per siliqua (14.70), and test weight (4.25 g) were recorded under weed-free treatment. Pendimethalin 0.5 kg $ha^{-1}$ Pre -emergence +1 Hand weeding at 25 DAS, oxadiargyl 75 $gha^{-1}$ Pre -emergence +1 Hand weeding at 25 DAS, and pendimethalin 0.5 kg $ha^{-1}$ Pre -emergence were found equally effective in respect to these characters which were significantly higher than rest of the treatments. Among the treatments, weed-free treatment recorded significantly higher seed yield (1738 $kgha^{-1}$), stover yield (4937 kg $ha^{-1}$), and harvest index (26.03%) of mustard than the rest of the treatments.

Kumar *et al.* (2012) performed a study at Himachal Pradesh, India to study the integrated weed management approaches in mustard in which they recorded the seed yield (1577kg $ha^{-1}$) and plant height (174.8 cm) in two hand clearings at 30 and 60 DAS than the un-weeded plots (830 kg $ha^{-1}$) and (139.3 cm). They also recorded the dry weight of weeds (18.8 $gm^{-2}$) at harvest after two manual weeding at 30 and 60 DAS and nitrogen (7.83 kg $ha^{-1}$) and sulphur (2.13 kg $ha^{-1}$) uptake by weeds.

Shaheenuzzaman *et al.* (2010) planned a study to evaluate the different approaches to weed controlling in mustard inBangladesh. In this experiment, they compare the weed-free and no weeding treatments and found the plant height (124.7 cm) in weed-free conditions while in weeded conditions (110 cm), respectively.

Yadav *et al*. (2004) reported that in mustard the weedy conditions throughout the growing season decrease the seed yield by about 37.5%.

Singh *et al*. (2001) planned a study to identify the weed management processes in *Brassica* species in India. They compare the different duration of weed and find out that the maximum seed yield of 1692 kg $ha^{-1}$in two hand weedings at 25 and 45 DAS over weed-free condition 1825 $kgha^{-1}$.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the effect of varietal potentiality and weed management of mustard. Materials used and methodologies followed in the present investigation have been described in this chapter.

## 3.1 Experimental period

The experiment was conducted during the period from October-2019 to February 2020 in the Rabi season.

## 3.2 Description of the experimental site

### 3.2.1 Geographical location

The experiment was conducted both in the Central laboratory and Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meters above sea level (Anon., 2004).

### 3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988 b). For a better understanding ofthe experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

### 3.2.3 Soil

The soil texture was silty clay with pH 6.1. The morphological, physical, and chemical characteristics of the experimental soil have been presented in Appendix-II.

### 3.2.4 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April, and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity, and rainfall during the experiment period was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

## 3.3 Experiment type

Both field and lab experiment were conducted for this research.

### 3.3.1 Lab experiment

#### 3.3.1.1 Bioassay

A bioassay is an analytical method to determine the concentration or potency of a substance by its effect on living cells or tissues. Bioassays are quantitative biological assays used to estimate the potency of agents by observing their effects on living tissue/cell culture systems. In this experiment, a bioassay was done to screen out the allelopathic potentiality of the 15 mustard varieties (Doner crop) and how they impact weed or weed biology, whichis measured by standardized values of treated test crop over control treatment. Measuring values such as germination %, germination speed rate, Relative germination %, germination index, Relative root elongation, shoot, and root inhibition % were measuredfor screening out the potentiality of mustard varieties.

#### 3.3.1.2 Characteristics of receiver crop

The characteristics of the receiver plant are:

i) Must absorb allelochemicals exuded from the donor plants and show reaction as either inhibition or stimulation

ii) Available in many places, inexpensive, do not require complex treated procedures before use, easily grow in the laboratory, green house, and field conditions

iii) Have an agronomical impact

For this experiment, *Lactuca sativa*, *Raphanus sativus*, and *Echinochloa colona* were used as receiver crops.

### 3.3.1.3 Description of the mustard varieties which were used in this experiment

| Variety | Releasing year | Crop duration (Day) | Yield (tha$^{-1}$) | Oil content (%) |
|---|---|---|---|---|
| 1. Rai-5 | 1976 | 110-120 | 1.0-1.2 | 39-40 |
| 2. Tori-7 | 1976 | 75-80 | 1.6-2.0 | 38-41 |
| 3. Kallyani (TS-72) | 1979 | 80-85 | 1.2-1.4 | 40-42 |
| 4. Sonali (SS-75) | 1979 | 90-100 | 1.8-2.0 | 44-45 |
| 5. BARI Sarisha-6 | 1994 | 90-100 | 2.1-2.5 | 44-45 |
| 6. BARI Sarisha-7 | 1994 | 90-100 | 2.0-2.5 | 42-45 |
| 7. BARI Sarisha-8 | 1994 | 90-100 | 2.1-2.4 | 43-45 |
| 8. BARI Sarisha-9 | 2000 | 80-85 | 1.2-1.4 | 43-44 |
| 9. BARI Sarisha-12 | 2001 | 80-85 | 1.2-1.4 | 43-44 |
| 10. BARI Sarisha-13 | 2004 | 90-95 | 2.2-2.8 | 42-43 |
| 11. BARI Sarisha-14 | 2006 | 75-80 | 1.4-1.6 | 40-45 |
| 12. BARI Sarisha-15 | 2006 | 80-85 | 1.4-1.7 | 48-52 |
| 13. BARI Sarisha-16 | 2009 | 105-110 | 2.2-2.3 | 40-42 |
| 14.BARI Sarisha-17 | 2013 | 80-85 | 1.7-1.8 | 43-45 |
| 15. BARI Sarisha-18 | 2017 | 80-85 | 2.0-2.5 | 40-46 |

**Source:** http://www.bari.gov.bd(BARI-2020)

### 3.3.1.4 Procedure of the experiment

For breaking the dormancy of mustard seeds were kept in drier at 45-48 °C for 7 days. Then the seeds were soaked in distilled water. After 24 h soaking the seeds were sown on a sheet of moist filter paper at 25 °C in dark. After 48 h the seeds were transferred to a growth chamber with a 12 h photoperiod. After another 48 h, the uniform germinated mustard seedlings were transferred (10 mustard seedlings per petri- dish) to 55 mm Petri-dish each containing a sheet of filter paper moistenedwith 2.5 mL 1mM phosphate (pH 7.0) and grown for further a 48 h. Then 10 seeds of *E. colona*, *L. sativa*, and *R. sativus* seeds were sown on the filter paper in each petri-dish, allowed to grow with the mustard seedlings under the conditions as described above. Each treatment was replicated three times and followed complete Block Design (CRD). After 48 h the germination %, germination speed rate, relative germination % were calculated and the length of the shoot and root of *L. sativa*, *R. sativus*, and *E. colona* were measured with a ruler. Control seedlings were incubated without mustard seedlings in the same way. Various data recording procedure was given below

**3.3.1.5 Procedure of data recording**

**i) Germination percentage %**

Germination percentage is an estimate of the viability of a population of seeds. The equation to calculate germination percentage. (Abdel-Haleem, 2015).

$$\text{Germination \%} = \frac{\text{Seeds germinated in petri dish}}{\text{total seeds in petri dish}} \times 100$$

**ii) Relative seed germination (%)**

Relative seed germination (%) measured by Tam &Tiquia (1994).

$$\text{Relative seed germination (\%)} = \frac{\text{Number of seeds germinated in the extract}}{\text{Number of seeds germinated in the control}} \times 100$$

**iv) Coefficient of the rate of germination of receiver plant (CRG)**

Coefficient of the rate of germination of the receiver plant was measured by following formula (Al- Muradis,1998).

$$\text{CRG} = \frac{(\text{N1} + \text{N2} + \text{N3} + \ldots\ldots\ldots. + \text{Nn})}{(\text{N1T1}) + (\text{N2T2}) + \ldots. + (\text{NnTt})} \times 100$$

Where $N_1$ = Number of germinated seed on $T_1$ time, $N_2$ = Number of germinated seed on $T_2$ time, and $N_n$ = Number of germinated seed on $T_n$ time

**iv) Speed of germination of the receiver plant**

Speed of germination expresses the rate of germination in terms of the total number of seeds that germinate in a time interval (Gairola*et al.*, 2011).

Speed of germination = $N_1/D_1 + N_2/D_2 + N_3/D_3 + \ldots\ldots\ldots\ldots + N_n/D_n$

Where, N = Numbers of germinated seeds, and D = Number of days

**v) Relative elongation ratio of shoot**

The relative elongation ratio of the shoot (RER) was measured by using the following formula (Rho and Kil, 1986).

$$\text{Relative elongation ratio of shoot} = \frac{\text{Mean shoot length of tested plant}}{\text{Mean shoot lengthy in control}} \times 100$$

**vi) Relative elongation ratio of root**

The relative elongation ratio of root(RER) was measured by using the following formula (Rho and Kil, 1986).

$$\text{Relative elongation ratio of root} = \frac{\text{Mean root length of tested plant}}{\text{Mean root length in control}} \times 100$$

**vii) Germination index**

Germination index is an estimate of the time (in days) it takes a certain germination percentage to occur (Tam and Tiquia, 1994).

$$\text{Germination index} = \frac{(\%\text{ Seed germination})\text{ x }(\%\text{ Root elongation})}{100\%}$$

**viii) Germination inhibition (%)**

Factors that influence internal chemical or metabolic conditions of the seed which prevent it from germination are known as germination inhibition (Lin *et al.*, 2004)

$$\text{Germination inhibition }(\%) = 1 - \frac{\text{Germinated seed with mustard}}{\text{germinated seed in control}} \times 100$$

**ix) Soot growth inhibition (%)**

Shoot growth inhibition of the receiver plant was measured by the following formula (Islam *et al.*, 2018)

$$\text{Shoot length inhibition}(\%) =$$

$$1 - \frac{\text{Shoot length of test crop with mustard seedling present in petri dish}}{\text{Shoot length of test crop in control}} \times 100$$

**ix) Root growth inhibition (%)**

Root growth inhibition of the receiver plant was measured by the following formula (*Islam et al.,* 2018)

$$\text{Root length inhibition}(\%) = 1 - \frac{\text{Root length of test crop with mustard seedling present in petri dish}}{\text{Root length of test crop in control}} \times 100$$

### 3.3.2 Field experiment

After screening out the potential allelopathic varieties from a lab experiment, a field experiment was conducted

#### 3.3.2.1 Treatments under investigation

There were two factors in the experiment namely mustard varietyand weed management as mentioned below:

| **Factor-A: Mustard variety (5):** | **Factor-B: Weed management (3)** |
|---|---|
| $V_1$: RAI-5 | $W_0$: No weeding |
| $V_2$: BARI Sarisha-7 | $W_1$: 1 weeding at 15 days |
| $V_3$: BARI Sarisha-8 | $W_2$: 2 weeding at 15 and 30 days |
| $V_4$: BARI Sarisha-15 | |
| $V_5$: BARI Sarisha-18 (Canola) | |

#### 3.3.2.2 Treatment combinations

Treatment combinations were $\mathbf{V_1W_0}$, $\mathbf{V_1W_1}$, $\mathbf{V_1W_2}$, $\mathbf{V_2W_0}$, $\mathbf{V_2W_1}$, $\mathbf{V_2W_2}$, $\mathbf{V_3W_0}$, $\mathbf{V_3W_1}$, $\mathbf{V_3W_2}$, $\mathbf{V_4W_0}$, $\mathbf{V_4W_1}$, $\mathbf{V_4W_2}$, $\mathbf{V_5W_0}$, $\mathbf{V_5W_1}$ and $\mathbf{V_5W_2}$

#### 3.3.2.3 Experimental design and layout

The experiment was laid out in a split-plot design having 3 replications. In the main plot, there was avariety of treatments and in the subplot, there was weed management treatment. There are 15 treatment combinations and 45 unit plots. The unit plot size was 5.4 $m^2$ (2.7 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. The layout of the experimental field was shown in Appendix -IV.

#### 3.3.2.4 Land preparation

The experimental land was opened with a power tiller on the date 20th October 2019. Ploughing and cross ploughing wasdone with a power tiller followed by laddering. Land preparation was completed on the date 23rd October 2019 and was ready for sowing seeds.

#### 3.3.2.5 Fertilizer requirement

| Fertilizers | Quantity/requirement (kg $ha^{-1}$) |
|---|---|
| Cowdung | 8000 |
| Urea | 250 |
| TSP | 170 |
| MOP | 85 |
| Gypsum | 150 |
| Zinc sulphate | 5 |
| Boric Acid | 10 |

Source: (BARIkrishiprojuktiHatboi-2019 recommendation)

#### 3.3.2.6 Fertilizer application

Cowdung, urea, triple superphosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and boric acid were used as sources of nitrogen, phosphorus, potassium, zinc, boron, and others nutrient respectively. The total amount of TSP, MoP, gypsum, zinc sulphate, boric acid, cowdung, and one and a half amount of urea was applied at final land preparation. The rest amount of the urea was applied during flower initiation of mustard (BARIkrishiprojuktiHatboi-2019 recommendation).

#### 3.3.2.7 Sowing of seeds

Seeds were sown at the rate of 10 kg $ha^{-1}$ in the furrow on date 23rd October 2019 and the furrows were covered with the soils soon after seeding. Seeds were being treated with Bavistin before sowing the seeds to control the seed-borne disease. The seeds were sown continuously in 30 cm apart rows at about 2-3 cm depth in the afternoon and covered with soil.

#### 3.3.2.8 Intercultural operations

**i) Weeding**

Weeding was done according to the pre- requisite of the treatment.

**ii) Thinning**

Thinning was done in all the unit plots with care to maintain a constant plant population on each row. Finally, plants were kept at a 5 cm distance in rows.

**iii) Irrigation**

Irrigation was given in the respective plots to ensure puddle soil. First irrigation was given at 15 days after sowing (DAS) and the second irrigation was given at 40-45 (DAS). A little irrigation was given at 55-60 (DAS).

**iv) Application of pesticides**

In the experimental field, mustard crops were attacked by aphids (*Lipaphis erysimi*. K). Malathion 57 EC at the rate of 2 mllitre$^{-1}$ of water was applied for controlling aphids attack in the field. The application of spraying pesticide was done in the afternoon while the pollinating bees were away from the experimental field.

**3.3.2.9 Harvesting and processing**

Different varieties required different time requirements for maturity. From the experimental field crop varieties of mustard were harvested at maturity when 80% of the siliqua turned into straw yellowish in color. Harvesting was done in the morning to avoid shattering. Boarder lines plants were excluded. Crops were harvested from the pre-demarcated area of 1 m$^2$ at the center of each plot at ground level with the help of a sickle for grain and stover yield. Before harvesting, ten plants were sampled randomly from each plot, were bundled separately, taggedand brought to a clean cemented threshing floor from which different yield parameters were recorded. The crop was sun-dried properly by spreading them over the floor and seeds were separated from the siliqua by beating the bundles with the help of bamboo sticks. The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield was recorded. The biological yield was calculated as the sum of the seed yield and stover yield.

### 3.3.2.10 Data collection

The data were recorded on the following parameters.

**Weed data**

i. Weed flora in the mustard field
ii. Relative weed density (%)
iii. Weed density ($m^{-2}$)
iv. Weed dry matter weight ($m^{-2}$)
v. Weed control efficiency
vi. Weed control index
vii. Simpson's diversity index (SDI)

**Mustard varieties**

**a) Growth parameters**

viii. Plant height (cm)
ix. No. of primary branches plant$^{-1}$ (no.)
x. No. of secondary branches plant$^{-1}$ (no.)
xi. No. of leaves plant$^{-1}$
xii. Above-ground dry matter weight plant$^{-1}$ (g)

**b) Yield contributing characters**

xiii. Siliqua plant$^{-1}$ (no.)
xiv. Siliqua length plant$^{-1}$ (no.)
xv. Seeds siliqua$^{-1}$ (no.)
xvi. 1000-seed weight (g)

**c) Yield characters**

xvii. Seed yield (t ha$^{-1}$)
xviii. Stover yield (t ha$^{-1}$)
xix. Biological yield (t ha$^{-1}$) and
xx. Harvest index (%)

### 3.3.2.11 Procedure of recording data

**i) Weed flora in the experimental field**

Weed species were found in the experimental field were recorded according to their's common name, scientific name, and family.

**ii) Relative weed density in weedy check plot**

Relative weed density in the weedy check plot was estimated at 30 and 60 DAT. The relative weed density was worked out as per the formula given by Mishra (1968).

$$\text{Relative weed density (\%)} = \frac{\text{Number of individuals of same species}}{\text{Number of individuals of all species}} \times 100$$

**iii) Weed density ($m^{-2}$)**

From the pre-demarcated area of 1 $m^2$ of each plot, the total weeds were uprooted and were counted at 15 and 30 DAS in the experimental field of mustard.

**iv) Weed dry matter weight ($m^{-2}$)**

After counting the fresh weeds, weeds were then oven-dried at 80 $^0$C until a constant weight was obtained. The sample was then transferred into desiccators and allowed to cool down to room temperature and then the final weight of the sample was taken at 15 and 30 DAS of mustard respectively.

**v) Weed control efficiency (WCE)**

Weed control efficiency was measured by using the following formula given by Mani *et al.*, (1973).

$$\text{WCE} = \frac{\text{Weed population in control} - \text{weed population in treated plot}}{\text{Weed population in control}} \times 100$$

**vi) Weed control index (WCI)**

Weed control efficiency was measured by using the following formula given by Mishra and Tosh, (1979).

$$\text{WCI} = \frac{\text{Weed dry weight in control} - \text{weed dry weight in treated plot}}{\text{Weed dry weight in control}} \times 100$$

**vii. Simpson's diversity index (SDI)**

Weed diversity and frequency were summarized using Simpson's Diversity Index (Simpson, 1949). SDI is used to quantify biodiversity in ecological studies.
It takes into account the number of species present, as well as the abundance of each species:

$SDI = 1 - \sum n \frac{(n-1)}{N(N-1)}$

Where n is the total number of plants of a particular species and N is the total number of all weed species.

SDI values (%) for the eleven wheat varieties used in the field experiment were correlated with the inhibition index from the laboratory bioassay.

**viii) Plant height (cm)**

The height of the selected plant was measured from the ground level to the tip of the plant at 15, 30, 45 DAS, and harvest, respectively. Mean plant height of mustard plant were calculated and expressed in cm.

**ix) No. of primary branches plant$^{-1}$ (no.)**

The primary branch plant$^{-1}$ was counted from ten randomly sampled plants. It was done by counting the total number of primary branches of all sampled plants then the average data were recorded. Data were recorded at 45 DAS and harvest, respectively

**x) No. of secondary branches plant$^{-1}$ (no.)**

The secondary branch plant$^{-1}$ was counted from ten randomly sampled plants. It was done by counting the total number of secondary branches of all sampled plants then the average data were recorded. Data were recorded at 45 DAS and harvest, respectively**.**

**xi) No. of leaves plant$^{-1}$ (no.)**

The leaves of plant$^{-1}$werecounted from ten randomly sampled plants. It was done by counting the total number of leaves of all sampled plants then the average data were recorded. Data were recorded at 15, 30 & 45 DAS.

**xii) Above ground dry matter weight plant$^{-1}$(g)**

Ten plants were collected randomly from each plot at 15, 30, 45 DAS and harvest respectively. The sample plants were oven-dried for 72 hours at 70°C and then dry matter content plant$^{-1}$ was determined. Mean dry matter plant$^{-1}$ of the mustard plant was calculated and expressed in gram (g) for recording data.

**xiii) No. siliqua plant$^{-1}$ (no.)**

Siliqua plant$^{-1}$ was counted from the 10 selected plant samples and then the average siliqua number was calculated.

**xvi) Length of siliqua plant$^{-1}$ (cm)**

Length of 10 siliqua was collected randomly from the sampled plants and the mean length was recorded.

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

Seeds siliqua$^{-1}$ was counted from splitting ten siliquawhich were sampled from sample plants and then the mean value was determined.

**xvi) 1000-seed weight (g)**

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

**xvii) Seed yield (t ha$^{-1}$)**

The mean seed weight was taken by threshing the plants of each sample area and then converted to t ha$^{-1}$on a dry weight basis.

**xviii) Stover yield (t ha**$^{-1}$)

The stover weights of mustards were calculated after threshing and separation of the grains from the plant of the sample area and then expressed in t ha$^{-1}$ on a dry weight basis.

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

The summation of seed yield and above-ground stover yield was the biological yield. Biological yield =Grain yield + Stover yield.

**xx). Harvest index (%)**

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

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

Here, Biological yield = Grain yield + stover yield

**3.3.2.12 Economic analysis of mustard cultivation**

In this research from the beginning to end of the experiment, individuals cost data of all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production.

**i. Input cost**

Input costs were divided into two parts. These were as follows:

**A. Non-material cost**

Non-material cost is all the labor cost. Human labor was obtained from adult male laborers. In a day, 8 hours working of a laborer was considered as a man's day. The mechanical labor came from the tractor. A period of eight working hours of a tractor was taken to be tractor day.

Individual labor wages 400 Tkday$^{-1}$.

**B. Material cost**

Its included seeds rate ha$^{-1}$, fertilizers, pesticide application, irrigation application cost.

**ii. Overhead cost**

Overhead cost is the land cost. The value of the land varies from place to place. In this research, the value of land was taken Tk. 200000 $ha^{-1}$. The interest on this cost was calculated for 6 months @ Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank.

**iii. Miscellaneous cost (common cost)**

It was 5% of the total input cost

**iv. Gross Return from mustard**

Gross return from mustard (Tk. $ha^{-1}$) = Value of seed (Tk. $ha^{-1}$) + Value of Stover (Tk. $ha^{-1}$)

**v. Net return (NR)**

Net return was calculated by using the following formula:

NR (Tk. $ha^{-1}$) = Gross return (Tk. $ha^{-1}$) – Total cost of production (Tk. $ha^{-1}$).

**vi. Benefit-cost ratio of mustard (BCR)**

Benefit-cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:

$$\text{BCR} = \frac{\text{Gross return (Tk/ ha)}}{\text{Cost of production (Tk/ha)}}$$

**3.3.2.13 Data analysis technique**

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of the computer package MSTAT c. The mean differences among the treatments were adjusted by Duncan's Multiple Range Test (DMRT) at a 5% level of significance (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

This section envelops the presentation and discussion of the results obtained from the study to investigate the effect of varietal potentiality and weed management of mustard. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

**4.1 Lab experiment:** To screen out the allelopathic potentiality of the 15 mustard varieties (Doner crop) and how they impact weed seed germination and growth.

The results found from the first experiment regarding the effects of different mustard varieties allelopathic effect on the germination percentage (%), relative seed germination (%), coefficient of the rate of germination of receiver plant, speed of germination of the receiver plant, relative elongation ratio of the shoot, relative elongation ratio of the root, germination index, germination inhibition, shoot growth inhibition, root growth inhibition of the *Lactuca sativa*, *Raphanus sativus*, and *Echinochloa colona* have been presented.

### 4.1.1 Germination percentage (%)

Experiment results revealed that the *L. sativa*, *R. sativus and E. colona* recorded the maximum germination percentage (100.00, 100.00, and 85.71 %) with the co-growth of BARI Sarisha-15 variety which was statistically similar with the *L. sativa* recorded germination percentage (100%) with the co-growth of BARI Sarisha-12 variety, *L. sativa and R. sativus* recorded germination percentage (100%) with the co growth of Tori-7 variety, *R. sativus* recorded germination percentage (100 %)with the co-growth of BARI Sarisha-16, BARI Sarisha-14, BARI Sarisha-6, Sonali (SS-75) varieties.Whereas *L. sativa* and *E. colona* recorded the minimum germination percentage (42.86 % and 14.29%)with the co-growth of BARI Sarisha-18 (Canola) variety which is statistically similar with *R. sativus* recorded the germination percentage (42.86 %) with the co-growth of Rai-5 variety. The differences ingermination percentage among mustard varieties were due to the effect of allelochemicals which reduced germination of *L. sativa*, *R. sativus* and *E. colona* (Table-1). The result obtained from the present study was similar tothe findings of Al-Khatib and Boydston (1999) and reported that *Brassica spp*. (*B. hirta*, *B. juncea*, *B. nigra* and *B. napus*) suppress weeds through (a) vigorous early-season growth, smothers the weeds before they are established, (b) release of allelochemicals into the soil from the shoots of living plants, plant residues, or plants incorporated into the soil by tillage, and (c) leaching/secretion of glucosinolates into the growing media; their hydrolysis to isothiocyanates inhibits weed seed germination and growth.

**Table 1. Effect of mustard varieties on the germination percentage (%) of *L. sativa, R. sativus and E. colona***

| Treatments (Mustard varieties) | Germination percentage (%) | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 57.14±1.37 d | 57.14 ±1.4 d | 28.57 ±0.98 e |
| BARI Sarisha-8 | 71.43 ±1.78 c | 71.43 ±1.78 c | 42.86 ±1.53 d |
| BARI Sarisha-13 | 85.71 ±2.14 b | 85.71 ±2.14 b | 57.14 ±2.04 c |
| BARI Sarisha-18 | 42.86±1.07 e | 57.14 ±1.43 d | 14.29 ±0.51 f |
| Tori-7 | 100.00 ±0 a | 100.00 ±0 a | 57.14 ±2.04 c |
| Sonali (SS-75) | 85.71 ±2.14 b | 100.00 ±0 a | 57.14 ±2.04 c |
| Kallyani (TS-72) | 71.43 ±1.78 c | 85.71 ±2.14 b | 71.43 ±2.55 b |
| BARI Sarisha-6 | 71.43 ±1.78 c | 100.00 ± 0 a | 71.43 ±2.55 b |
| BARI Sarisha-9 | 71.43 ±1.78 c | 85.71 ±2.14 b | 71.43 ±2.55 b |
| BARI Sarisha-12 | 100.00 ± 0 a | 85.71 ±2.14 b | 71.43±2.55 b |
| BARI Sarisha-14 | 85.71 ±2.14 b | 100.00 ± 0 a | 57.14 ±2.04 c |
| BARI Sarisha-15 | 100.00± 0 a | 100.00 ± 0 a | 85.71 ±3.06 a |
| BARI Sarisha-17 | 85.71 ±2.14 b | 85.71 ±2.14 b | 57.14 ±2.01 c |
| Rai-5 | 28.57 ±0.68 f | 42.86 ±1.07 e | 0.00 ±0 g |
| BARI Sarisha-16 | 85.71 ±2.14 b | 100.00 ± 0 a | 57.14 ±2.04 c |
| **SE** | 0.63 | 0.47 | 0.36 |
| **CV (%)** | 1.02 | 0.69 | 0.84 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.2 Relative seed germination (%)

Experiment result had shown that *L. sativa, R. sativus and E. colona* recorded the maximum relative seed germination percentage (100.00, 100.00, and 100 %) with the co-growth of BARI Sarisha-15 variety, which was statistically similar with *L. sativa* recorded relative seed germination percentage (100 %) with the co-growth of BARI Sarisha-12 and Tori-7 varieties, *R. sativus* recorded relative seed germination percentage (100 %) with the co-growth of BARI Sarisha-17, BARI Sarisha-16, BARI Sarisha-14, BARI Sarisha-6, Sonali (SS-75), Kallyani (TS-72), Tori-7 varieties. Whereas *L. sativa* recorded the minimum relative seed germination percentage (42.86 %) with the co-growth of BARI Sarisha-18 (Canola) variety which is statistically similar with *R. sativus and E. colona* recorded relative seed germination percentage (42.86 and 00 %) with the co-growth of Rai-5 variety (Table-2). Thedifferences of relative seed germination among Sarisha varieties were due to the effect of allelochemicals which reduced or hamper germination of *L. sativa*, *R. sativus* and *E. colona*.The result obtained from the present study was similar tothe findings of Al-Khatib and Boydston (1999) and reported that *Brassica spp*. (*B. hirta*, *B. juncea*, *B. nigra*, *B. napus*) suppress weeds through (a) vigorous early-season growth, smothers the weeds before they are established, (b) release of allelochemicals into the soil from the shoots of living plants, plant residues, or plants incorporated into the soil by tillage, and (c) leaching/secretion of glucosinolates into the growing media; their hydrolysis to isothiocyanates inhibits weed seed germination and growth.

**Table 2. Effect of mustard varieties on the relative germination (%) of *L. sativa*, *R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Relative germination (%) | | |
|---|---|---|---|
| | *L. sativa* | *R. sativus* | *E. colona* |
| BARI Sarisha-7 | 57.14 ±1.06 d | 57.14 ±0.63 d | 33.33 ±0.34 e |
| BARI Sarisha-8 | 71.43 ±1.42 c | 71.43 ±0.89 c | 50.00 ±0.56 d |
| BARI Sarisha-13 | 85.71 ±1.71 b | 85.71 ±1.07 b | 66.67 ±0.74 c |
| BARI Sarisha-18 | 42.86 ±0.85 e | 57.14 ±0.71 d | 16.67 ±0.19 f |
| Tori-7 | 100.00 ±0 a | 100.00 ±0 a | 66.67 ±0.75 c |
| Sonali (SS-75) | 85.71 ±1.71 b | 100.00 ±0a | 66.67 ±0.75 c |
| Kallyani (TS-72) | 71.43 ±1.43 c | 100.00 ±0 a | 83.33 ±0.94 b |
| BARI Sarisha-6 | 71.43 ±1.434 c | 100.00 ±0 a | 83.33 ±0.94 b |
| BARI Sarisha-9 | 71.43 ±1.43 c | 85.71 ±1.07 b | 83.33 ±0.94 b |
| BARI Sarisha-12 | 100.00 ±0 a | 85.71 ±1.07 b | 83.33 ±0.94 b |
| BARI Sarisha-14 | 85.71 ±1.71 b | 100.00 ±0 a | 66.67 ±0.75 c |
| BARI Sarisha-15 | 100.00±0 a | 100.00 ±0 a | 100.00 ±0 a |
| BARI Sarisha-17 | 85.71 ±1.71 b | 100.00 ±0a | 66.67 ±0.75 c |
| Rai-5 | 28.57 ±0.57 f | 42.86 ±0.53 e | 0.00 ±0 g |
| BARI Sarisha-16 | 85.71 ±1.71 b | 100.00 ±0 a | 66.67 ±0.75 c |
| **SE** | 0.94 | 1.53 | 0.76 |
| **CV (%)** | 1.52 | 2.19 | 1.50 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.3 Coefficient of the rate of germination of receiver plant

The experiment result had shown that *L. sativa* recorded the maximum coefficient of the rate of germination (1.92 %) with the co-growth of Kallyani (TS-72) varietywhich was statistically similar with the co-growth of BARI Sarisha-12 and BARI Sarisha-15 varieties where the coefficient of the rate of germination is maximum (1.91 %), *R. sativus* recorded the coefficient of the rate of germination (1.97 %) with the co-growth of BARI Sarisha-15 variety which was statistically similar with the co-growth of BARI Sarisha-13(1.96 %) and *E. colona* recorded coefficient of the rate of germination (1.85 %) with the co-growth of BARI Sarisha-16. Whereas *L. sativa*, *R. sativus and E. colona* recorded the minimum coefficient of the rate of germination (1.67, 1.79, and 0.00 %) with the co-growth of Rai-5 variety (Table-3). The result obtained from the present study was similar tothe findings of Boydston and Al-khatib (2008) and Haramoto and Gallandt (2004). They focus on plant allelopathyas the tool of weed control, and also on the hydrolysis produced by glucosinolates as the allelochemicals responsible. One of the secondary plan metabolites is glucosinolates which are found in *Brassica* spp., and myrosinase enzyme can hydrolysis the glucosinolates into toxic products like isothiocyanates, which have the ability to control weed seeds.

**Table 3. Effect of mustard varieties on the coefficient of the rate of germination (%) of *L. sativa, R. sativus and E. colona***

| Treatments (Mustard varieties) | Coefficient of the rate of germination (%) | | |
|---|---|---|---|
| | *L. sativa* | *R. sativus* | *E. colona* |
| BARI Sarisha-7 | 1.76 ± 0.12 f | 1.88 ±0.08 e | 1.56 ±0.19 f |
| BARI Sarisha-8 | 1.84 ±0.13 c | 1.92 ±0.09 b | 1.78 ±0.28 c |
| BARI Sarisha-13 | 1.79 ±0.13 e | 1.96 ±0.09 a | 1.72 ±0.31 d |
| BARI Sarisha-18 | 1.79 ±0.12 e | 1.88 ±0.09 e | 1.67 ±0.15 e |
| Tori-7 | 1.84 ±0.12 c | 1.90 ±0.09 cd | 1.72 ±0.41 d |
| Sonali (SS-75) | 1.87 ±0.12 b | 1.92 ±0.09 b | 1.79 ±0.36 b |
| Kallyani (TS-72) | 1.92 ±0.12 a | 1.85 ±0.1 g | 1.81 ±0.35 b |
| BARI Sarisha-6 | 1.81 ±0.12 d | 1.92 ±0.09 b | 1.67 ±0.27 e |
| BARI Sarisha-9 | 1.81 ±0.11 d | 1.79 ±0.09 h | 1.67 ±0.27 e |
| BARI Sarisha-12 | 1.91 ±0.12 a | 1.89 ±0.1 de | 1.81 ±0.49 b |
| BARI Sarisha-14 | 1.81 ±0.12 d | 1.91 ±0.08 c | 1.49 ±0.34 g |
| BARI Sarisha-15 | 1.91 ±0.13 a | 1.97 ±0.09 a | 1.79 ±0.49 b |
| BARI Sarisha-17 | 1.79 ±0.12 e | 1.85 ±0.09 g | 1.72 ±0.31 d |
| Rai-5 | 1.67 ±0.11 g | 1.79 ±0 h | 0.00 ±0.08 h |
| BARI Sarisha-16 | 1.88 ±0.12 b | 1.92 ±0.1 b | 1.85 ±0.39 a |
| **SE** | 0.008 | 0.007 | 0.008 |
| **CV (%)** | 0.53 | 0.43 | 0.60 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.4 Speed of germination of the receiver plant

The experiment result had shown that *L. sativa*, *R. sativus and E. colona*recorded the maximum speed of germination (9.33, 10.33, and 6.00) with the co-growth of BARI Sarisha-15 variety which was statistically similar with the co-growth of BARI Sarisha-12 variety. Whereas *L. sativa, R. sativus* and *E. colona* recorded the minimum speed of germination (1.67, 3.00, and 0.00) with the co-growth of Rai-5 variety (Table-4). The variation of the result might be due to the varietal potentiality and also the production and impact of allelochemical on the receiver plant. The result of the present study was similar tothe findings of Warton *et al.* (2001) who reported that *Brassica* species produce glucosinolateswhichare accumulated in intact plants but released when the plant is injured. The β-thioglucosidasestrivi-ally is known as“myrosinase” encounter glucosinolates. β-thioglucosidases are responsible for the breakdown of glucose-sulfur bond and permit a reorganization for thegeneration of biocidal catabolites particularly known as isothiocyanates. The glucosinolates released into the rhizosphere have biocidal effects on plants thus reducing germination, growth, and development.

**Table 4. Effect of mustard varieties on the speed of germination of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Speed of germination | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 3.83 ±0.11 j | 4.83 ±0.14i | 1.17 ±0.03 h |
| BARI Sarisha-8 | 5.67 ±0.16 h | 6.67 ±0.19 g | 3.00 ±0.09 f |
| BARI Sarisha-13 | 6.00 ±0.18 g | 8.50 ±0.25 d | 3.33 ±0.1 e |
| BARI Sarisha-18 | 3.00 ±0.09 k | 4.83 ±0.14i | 0.83 ±0.02i |
| Tori-7 | 7.830 ±0.23 b | 8.83 ±0.26 c | 3.33 ±0.1 e |
| Sonali (SS-75) | 7.00 ±0.21 b | 9.33 ±0.28 b | 3.33 ±0.1 e |
| Kallyani (TS-72) | 6.67 ±0.2 e | 7.83 ±0.23 e | 5.17 ±0.15 b |
| BARI Sarisha-6 | 5.17 ±0.15i | 9.33 ±0.28 b | 3.67 ±0.11 d |
| BARI Sarisha-9 | 5.17 ±0.15i | 6.00 ±0.18 h | 3.67 ±0.11 d |
| BARI Sarisha-12 | 9.33 ±0.28 a | 7.50 ±0.22 f | 5.17 ±0.15 b |
| BARI Sarisha-14 | 6.50 ±0.19 f | 8.83 ±0.26 c | 1.83 ±0.05 g |
| BARI Sarisha-15 | 9.33 ±0.28 a | 10.33 ±0.31 a | 6.00 ±0.18 a |
| BARI Sarisha-17 | 6.00 ±0.18 g | 7.83 ±0.23 e | 3.33 ±0.1 e |
| Rai-5 | 1.67 ±0.05 l | 3.00 ±0.09 j | 0.00 ±0 j |
| BARI Sarisha-16 | 7.50 ±0.27 c | 9.33 ±0.28 b | 4.33±0.13 c |
| **SE** | 0.05 | 0.07 | 0.05 |
| **CV (%)** | 1.05 | 1.24 | 1.80 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.5 Relative elongation ratio of shoot

Experiment result had shown that *L. sativa* and *R. sativus* recorded the maximum relative elongation ratio of the shoot (97.04 and 95.19) with the co-growth of BARI Sarisha-15 variety which was statistically similar with the co-growth of BARI Sarisha-14 variety, *R. sativus* recorded relative elongation ratio of the shoot (93.34), *E. colona*recorded therelative elongation ratio of the shoot (97.67) with the co-growth of BARI Sarisha-12 variety. Whereas *L. sativa, R. sativus* and *E. colona* recorded the minimum relative elongation ratio of the shoot (37.74, 51.73, and 34.66) with the co-growth of Rai-5 variety which was statistically similar with the co-growth of BARI Sarisha-18 (Canola) variety where *L. sativa* and *E. colona* recorded relative elongation ratio of the shoot (39.35 and 34.56) (Table-5). The variation of the result might be due to the varietal potentiality and also the production and impact of allelochemical on the receiver plant.

**Table 5. Effect of mustard varieties on the relative shoot elongation ratio of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Relative shoot elongation ratio | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 40.16 ±1.74 k | 80.27 ±3.27ef | 42.23 ±1.74 h |
| BARI Sarisha-8 | 50.67 ±2.2 j | 79.07 ±3.43 f | 47.19 ±1.96 g |
| BARI Sarisha-13 | 54.99 ±2.21i | 82.93 ±3.61 d | 79.61 ±3.46 e |
| BARI Sarisha-18 | 39.35 ±1.71 kl | 59.74 ±2.59 h | 34.56 ±1.51i |
| Tori-7 | 87.87 ±3.82 c | 87.07 ±3.78bc | 91.26 ±3.96 b |
| Sonali (SS-75) | 90.03 ±3.91 b | 82.67 ±3.59 de | 98.06 ±4.26 a |
| Kallyani (TS-72) | 88.95 ±3.86bc | 89.19 ±3.87 b | 87.96 ±3.82 c |
| BARI Sarisha-6 | 76.01 ±3.3 e | 73.21±3.18 g | 87.96 ±3.82 c |
| BARI Sarisha-9 | 62.80 ±2.73 h | 74.67 ±3.24 g | 80.19 ±3.48 e |
| BARI Sarisha-12 | 78.17 ±3.39 d | 79.59 ±3.46 f | 97.67 ±4.24 a |
| BARI Sarisha-14 | 68.20 ±2.96 g | 93.34 ±4.05 a | 93.20 ±4.05 b |
| BARI Sarisha-15 | 97.04 ±4.21 a | 95.19 ±4.13 a | 75.73 ±3.29 f |
| BARI Sarisha-17 | 70.89 ±3.08 f | 84.79 ±3.68 cd | 84.47 ±3.67 d |
| Rai-5 | 37.74 ±1.64 l | 51.73 ±2.24i | 34.66 ±1.42i |
| BARI Sarisha-16 | 63.34 ±2.62 h | 73.47 ±3.19 g | 88.93 ±3.86 c |
| **SE** | 1.05 | 1.22 | 0.97 |
| **CV (%)** | 1.92 | 1.90 | 1.58 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.6 Relative elongation ratio of root

Experiment result had shown that the *L. sativa* recorded the maximum relative elongation ratio of root (94.26) with the co-growth of Tori-7 variety *which is statistically similar with R. sativus* recorded relative elongation ratio of root (99.03) with the co-growth of Kallyani (TS-72) variety, *E. colona* recorded the relative elongation ratio of root (84.96) with the co-growth of BARI Sarisha-17variety. Whereas *L. sativa*, *R. sativus*, and *E. colona* recorded the minimum relative elongation ratio of root (30.33, 30.69, and 35.71) with the co-growth of Rai-5 variety which was statistically similar with the co-growth of BARI Sarisha-18 (Canola) variety where *L. sativa* recorded relative elongation ratio of the root of (32.14), *E. colona* recorded relative elongation ratio of root (36.09) with the co-growth of BARI Sarisha-18 (Canola) variety (Table-6). The variation of the result might be due to the varietal potentiality and also production and impact of allelochemical on receiver plant

**Table 6. Effect of mustard varieties on the relative root elongation ratio of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Relative root elongation ratio | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 36.89 ±1.09 j | 41.79 ±1.35i | 37.12 ±1.13 j |
| BARI Sarisha-8 | 50.205 ±1.67i | 43.24±1.34 hi | 43.80 ±1.45i |
| BARI Sarisha-13 | 50.82 ±1.69i | 58.97 ±1.96 f | 57.33 ±1.91 g |
| BARI Sarisha-18 | 36.07 ±1.2 j | 32.14 ±1.07 j | 36.09 ±1.2 j |
| Tori-7 | 94.26 ±3.14 a | 81.79 ±2.72 c | 73.31 ±2.44 d |
| Sonali (SS-75) | 84.43 ±2.81 b | 91.03 ±3.03 b | 79.89 ±2.66 b |
| Kallyani (TS-72) | 68.24 ±2.27 e | 99.03 ±3.31 a | 74.81 ±2.49 cd |
| BARI Sarisha-6 | 65.98 ±2.19 f | 45.79 ±1.52 g | 69.55 ±2.31 f |
| BARI Sarisha-9 | 57.99 ±1.93 g | 47.25 ±1.57 g | 48.87 ±1.62 h |
| BARI Sarisha-12 | 53.28 ±1.77 h | 43.93 ±1.46 h | 75.19 ±2.5 c |
| BARI Sarisha-14 | 71.72 ±2.39 c | 79.94 ±2.66 d | 79.81 ±2.66 b |
| BARI Sarisha-15 | 70.90 ±2.36 cd | 68.48 ±2.28 e | 71.43 ±2.38 e |
| BARI Sarisha-17 | 69.67 ±2.32 de | 57.52 ±1.91 f | 84.96 ±2.83 a |
| Rai-5 | 30.33 ±1.01 k | 30.69 ±1.02 j | 35.71 ±1.19 j |
| BARI Sarisha-16 | 71.72 ±2.39 c | 69.45 ±2.31 e | 56.96 ±1.89 g |
| **SE** | 0.89 | 0.78 | 0.87 |
| **CV (%)** | 1.80 | 1.63 | 1.73 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.7 Germination index

The germination indexwhich is a measure of the percentage and speed of germination, indicates a slight difference between each variety in response to temperature and light regime. Higher values for this measure indicate a greater rate of germination. Different Sarisha varieties significantly affect the germination index of *L. sativa*, *R. sativus*, and *E. colona* (Table 7). Experiment results had shown that *L. sativa*recorded the maximum germination index (94.26)with the co-growth of Tori-7 variety which is statistically similar with *R. sativus* recorded thegermination index (91.03)with the co-growth of Sonali (SS-75) variety, *E. colona* recorded germination index (61.23) with the co-growth of BARI Sarisha-15 variety. Whereas *L. sativa*, *R. sativus*, and *E. colona*recorded the minimum relative elongation ratio of root (8.67, 13.15, and 0.00 l) with the co-growth of Rai-5 variety.

**Table 7. Effect of mustard varieties on the germination index of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Germination index | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 21.10 ±0.52 k | 23.88 ±0.41 k | 10.62 ±0.29 j |
| BARI Sarisha-8 | 35.86 ±0.68 j | 30.89 ±0.74 j | 18.77 ±0.61i |
| BARI Sarisha-13 | 43.56 ±1.21 h | 50.55 ±1.17 f | 32.76 ±0.81 h |
| BARI Sarisha-18 | 15.46 ±0.32 l | 18.37 ±0.49 l | 5.16 ±0.15 k |
| Tori-7 | 94.26 ±1.94 a | 81.79 ±1.74 c | 41.89 ±1.39 f |
| Sonali (SS-75) | 72.37 ±1.85 b | 91.03 ±1.91 a | 45.65 ±1.42 e |
| Kallyani (TS-72) | 48.74 ±1.68 f | 84.88 ±1.78 b | 53.44 ±1.76 b |
| BARI Sarisha-6 | 47.13 ±0.77 g | 45.79 ±1.65 g | 49.68 ±1.51 c |
| BARI Sarisha-9 | 41.42 ±0.81i | 40.50 ±0.99 h | 34.91 ±1.24 g |
| BARI Sarisha-12 | 53.28 ±1.04 e | 37.65 ±1.53i | 53.71 ±1.55 b |
| BARI Sarisha-14 | 61.48 ±1.63 c | 79.94 ±1.91 d | 45.61 ±1.08 e |
| BARI Sarisha-15 | 70.90 ±1.63 b | 68.48 ±1.71 e | 61.23 ±2.31 a |
| BARI Sarisha-17 | 59.72 ±1.17 d | 49.30 ±2.02 f | 48.55 ±1.12 d |
| Rai-5 | 8.67 ±0.21 m | 13.15 ±0.36 m | 0.00 ±0 l |
| BARI Sarisha-16 | 61.49 ±1.42 c | 69.45 ±1.35 e | 32.56 ±0.95 h |
| **SE** | 0.77 | 0.66 | 0.46 |
| **CV (%)** | 1.92 | 1.54 | 1.59 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.8 Germination inhibition (%)

Experiment results had shown that *L. sativa*, *R. sativus*, and *E. colona* recorded the maximum germination inhibition percentage (71.43, 57.14, and 100.00 %) with the co-growth of Rai-5 variety. Whereas *L.sativa*, *R. sativus*, and *E. colona* recorded the minimum germination inhibition percentage (00, 00, and 00 %) with the co-growth of BARI Sarisha-15 variety which was statistically similar with the co-growth of BARI Sarisha-14 variety where *R. sativus* recorded germination inhibition percentage (00 %), *L. sativa* recorded germination inhibition percentage (00 %) with the co-growth of Tori-7,Sonali (SS-75), Kallyani (TS-72),BARI Sarisha-6 varieties and *R. sativus* recorded germination inhibition percentage (00 %)with the co-growth of BARI Sarisha-17 variety (Table-8).Turk and Tawaha (2003) reported that black mustard (*Brassica nigra* L.) contains water-soluble substances that inhibited the germination and seedling growth of wild oat (*Avena fatua* L.).Oleszek *et al*. (1996) also reported that *Brassica spp* have allelopathic properties that can affect germination, establishment, and growth of other species in the agroecosystems.

**Table 8. Effect of mustard varieties on the germination inhibition percentage of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Germination inhibition percentage | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 42.86 ±3.34 c | 42.86 ±3.56 b | 66.67 ±4.97 c |
| BARI Sarisha-8 | 28.57 ±2.04 d | 28.57 ±2.04 c | 50.00 ±3.57 d |
| BARI Sarisha-13 | 14.29 ±1.02 e | 14.29 ±1.02 d | 33.33 ±2.38 e |
| BARI Sarisha-18 | 57.14 ±4.08 b | 42.86 ±3.06 b | 83.33 ±5.95 b |
| Tori-7 | 0.00 ±0 f | 0.00 ±0 e | 33.33 ±2.38 e |
| Sonali (SS-75) | 14.29 ±1.02 e | 0.00 ±0 e | 33.33 ±2.38 e |
| Kallyani (TS-72) | 28.57 ±2.04 d | 0.00 ±0 e | 16.67 ±1.19 f |
| BARI Sarisha-6 | 28.57 ±2.04 d | 0.00 ±0 e | 16.67 ±1.1 f |
| BARI Sarisha-9 | 28.57 ±2.04 d | 14.29 ±1.02 d | 16.67 ±1.19 f |
| BARI Sarisha-12 | 0.00 ±0 f | 14.29 ±1.02 d | 16.67 ±1.19 f |
| BARI Sarisha-14 | 14.29 ±1.02 e | 0.00 ±0 e | 33.33 ±2.38 e |
| BARI Sarisha-15 | 0.00 ±0 f | 0.00 ±0 e | 0.00 ±0 g |
| BARI Sarisha-17 | 14.29 ±1.02 e | 0.00 ±0 e | 33.33 ±2.38 e |
| Rai-5 | 71.43 ±5.1 a | 57.14 ±4.08 a | 100.00 ±7.14 a |
| BARI Sarisha-16 | 14.29 ±1.02 e | 0.00 ±0 e | 33.33 ±2.38 e |
| **SE** | 0.94 | 0.47 | 0.76 |
| **CV (%)** | 4.85 | 4.04 | 2.46 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.9 Shoot growth inhibition (%)

Experiment results had shown that *L. sativa*, *R. sativus*, and *E. colona* recorded the maximum shoot length inhibition percentage (62.26, 48.27, and 65.44 %) with the co-growth of Rai-5 variety. Whereas *L. sativa*, and *R. sativus* recorded the minimum shoot length inhibition percentage (2.97 and 4.81 %) with the co-growth of BARI Sarisha-15 variety, *E. colona* recorded shoot length inhibition percentage (1.94 %) with the co-growth of Sonali (SS-75) varietywhich was statistically similar with the co-growth of BARI Sarisha-12 veriety where *E. colona* recorded shoot length inhibition percentage (2.33 %) (Table-9).The result obtained from the present study was similar to the findings of Nijsson and Halgren (1992) and they reported that *Brassica spp*. suppresses the weeds through their vigorous growth and release of allelochemicals. The crushed tissues of five *Brassica spp*. (*B. juncea*, *B. nigra*, *B. napus*, *B. rapa var. rapifera*, and *B. oleracea*) produced volatiles which decreased germination, shoot and root length of weeds seedling.

**Table 9. Effect of mustard varieties on the shoot length inhibition percentage (%) of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Shoot length inhibition percentage (%) | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 59.84 ±2.1 b | 19.73 ±0.66 g | 57.77 ±2.02 b |
| BARI Sarisha-8 | 49.33 ±1.69 c | 20.93 ±0.74 e | 52.82 ±1.88 c |
| BARI Sarisha-13 | 45.01 ±1.6 d | 17.06 ±0.61 h | 20.39 ±0.72 e |
| BARI Sarisha-18 | 60.65 ±2.16 b | 40.26±1.43 b | 65.44 ±2.34 a |
| Tori-7 | 12.13 ±0.43 j | 12.93 ±0.46 j | 8.74 ±0.31i |
| Sonali (SS-75) | 9.97 ±0.35 l | 17.33 ±0.62 h | 1.94 ±0.06 k |
| Kallyani (TS-72) | 11.05 ±0.39 k | 10.81 ±0.38 k | 12.04 ±0.42 g |
| BARI Sarisha-6 | 23.99 ±0.85 h | 26.79 ±0.95 c | 12.04 ±0.42 g |
| BARI Sarisha-9 | 37.20 ±1.32 e | 25.33 ±0.91 d | 19.81 ±0.71 e |
| BARI Sarisha-12 | 21.83 ±0.77i | 20.41 ±0.73 f | 2.33 ±0.08 k |
| BARI Sarisha-14 | 31.81 ±1.13 f | 6.66 ±0.23 l | 6.80 ±0.24 j |
| BARI Sarisha-15 | 2.97 ±0.11 m | 4.81 ±0.17 m | 24.27 ±0.86 d |
| BARI Sarisha-17 | 29.11 ±1.03 g | 15.21 ±0.54i | 15.53 ±0.55 f |
| Rai-5 | 62.26 ±2.22 a | 48.27 ±1.72 a | 65.44 ±2.33 a |
| BARI Sarisha-16 | 36.66 ±1.31 e | 26.53 ±0.94 c | 11.07 ±0.39 h |
| **SE** | 0.51 | 0.21 | 0.29 |
| **CV (%)** | 1.92 | 1.24 | 1.46 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

### 4.1.10 Root growth inhibition (%)

The experiment result had shown that *L. sativa*, *R. sativus* and *E. colona* recorded the maximum root length inhibition percentage (69.67, 69.31, and 64.27 %) with the co-growth of Rai-5 variety which was statistically similar with the co-growth of BARI Sarisha-18 (Canola) variety where *E. colona* recorde droot length inhibition percentage (63.91 %).Whereas *L. sativa* recorded the minimum root length inhibition percentage (5.74 %) with the co-growth of Tori-7 variety, *R. sativus* recorded shoot length inhibition percentage (0.97 %)with the co-growth of Kallyani (TS-72) variety, *E. colona* recorded shoot length inhibition percentage (15.04 %)with the co-growth of BARI Sarisha-17 variety (Table-10). The variation of the result might be due to the varietal potentiality and also production and impact of alleolochemical on receiver plant. The result obtained from the present study was similar with the findings of Nijsson and Halgren (1992) and they reported that *Brassica spp*. suppresses the weeds through their vigorous growth and release of allelochemicals. The crushed tissues of five *Brassica spp*. (*B. juncea, B. nigra*, *B. napus, B. rapa var. rapifera* and *B. oleracea*) produced volatiles which decreased germination, shoot and root length of weeds seedling.

**Table 10. Effect of mustard varieties on the root growth inhibition percentage (%) of *L. sativa, R. sativus* and *E. colona***

| Treatments (Mustard varieties) | Root growth inhibition percentage (%) | | |
|---|---|---|---|
| | ***L. sativa*** | ***R. sativus*** | ***E. colona*** |
| BARI Sarisha-7 | 63.12 ±1.85 b | 58.21 ±1.72 c | 62.88 ±1.87 b |
| BARI Sarisha-8 | 49.80 ±1.51 c | 56.76 ±1.71 d | 56.20 ±1.67 c |
| BARI Sarisha-13 | 49.18 ±1.49 c | 41.03 ±1.24i | 42.67 ±1.29 e |
| BARI Sarisha-18 (Canola) | 63.93 ±1.93 b | 67.86 ±2.05 b | 63.91 ±1.93 a |
| Tori-7 | 5.74 ±0.17 k | 18.21 ±0.55 m | 26.69 ±0.81 h |
| Sonali (SS-75) | 15.57 ±0.47 j | 8.97 ±0.27 n | 20.11 ±0.61 j |
| Kallyani (TS-72) | 31.76 ±0.96 g | 0.97 ±0.02 o | 25.19 ±0.77i |
| BARI Sarisha-6 | 34.02 ±1.03 f | 54.21 ±1.64 f | 30.45 ±0.92 f |
| BARI Sarisha-9 | 42.01 ±1.27 e | 52.75 ±1.59 g | 51.13 ±1.54 d |
| BARI Sarisha-12 | 46.72 ±1.41 d | 56.07 ±1.69 e | 24.81 ±0.75i |
| BARI Sarisha-14 | 28.28 ±0.85i | 20.06 ±0.61 l | 20.12 ±0.61 j |
| BARI Sarisha-15 | 29.10 ±0.88i | 31.52 ±0.95 j | 28.57 ±0.86 g |
| BARI Sarisha-17 | 30.33 ±0.92 h | 42.48 ±1.28 h | 15.04 ±0.45 k |
| Rai-5 | 69.67 ±2.11 a | 69.31 ±2.11 a | 64.27 ±1.94 a |
| BARI Sarisha-16 | 28.28 ±0.85i | 30.55 ±0.92 k | 43.05 ±1.31 e |
| **SE** | 0.42 | 0.33 | 0.36 |
| **CV (%)** | 1.32 | 1.01 | 1.17 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

**4.2 Field experiment**: This experiment was conducted under field conditions. In this experiment effect of varietal potentiality and weed management of mustard were investigated after screening some potential varieties of mustard. The results have been presented and discussed under following headings:

### 4.2.1 Weed flora in the experimental field

Reduction in crop yields due to weeds result from their multifarious ways of interfering with crop growth and crop culture. Weeds compete with crops for one or more plant growth factors such as mineral nutrients, water, solar energy, and space and they hinder crop cultivation operations. In this experiment, the experimental field was infested with different types of weeds. Eight different weed species were observed in the experimental field where most dominating were grass and broadleaf weed species (Table 11). Among the infesting different categories of weeds species three were grasses, one sedge and four broadleaves. The weed species were belonging to the families of Poaceae, Labiatae, Boragiaceae, Asteraceae, Fabacea, and Cyperaceae. The grasses were *Echinochloa colona, Eleusine indica and Cynodon dactylon.* The sedgewas *C. rotundus and the broadleaves were E. fluctuans, Brassica kaber, Mimosa pudica and Helitropium indicum.* The result obtained from the present study was similar tothe findings of Bhawana *et al*. (2019) and they reported that the dominant weeds in the Mustard field in three species belong to the Poaceae family followed by *Chenopodiaceae, Compositae, Asteraceae, Convolvulaceae, Fabaceae, Polygonaceae* and *Cyperaceae*. Among the weeds *C. dactylon* (L.) Pers. was the predominant weed followed by *P. monspeliensis* and *P. minor*. *C. rotundus* L. was the only sedge present in the experimental field. Among the broadleaf weeds, *C. album* L. was the dominant one followed by *A. arvensis* L., *P. hysterophorus* L., *C. arvensis, M. albam, Vicia hirsute* and *Rumex* sp. Suryavanshi *et al*. (2018) found that the dominant weeds associated with gobhimustard were mainly comprised of dicot weeds like *Medicago sativa, Sonchus arvensis, Cichorium intybus* and *Physalis minima* only. The present result varied slightly from those reportsand this might be due to the location and seasonal variation.

**Table 11. Weed flora in mustard field**

| Local name | Common name | Scientific name | Family | Type |
|---|---|---|---|---|
| Chapra | Indian goosegrass | *Eleusine indica* | Poaceae | Grass |
| Chotosha ma | Jungle rice | *Echinochloa colona* | Poaceae | Grass |
| Durba | Bermuda Grass | *Cynodon dactylon* | Poaceae | Grass |
| Mutha | Purple Nutsedge | *Cyperus rotundus* | Cyperacea | Sedge |
| Hatirshur | Indian heliotrope | *Heliotropium indicum* | Boraginaceae | Broadleaf |
| Helencha | Buffalo spinach | *Enydra fluctuans* | Asteraceae | Broaleaf |
| Lojjaboti | Sensitive plant | *Mimosa pudica* | Fabaceae | Broadleaf |
| Bon mustard | Wild Mustard | *Brassica kaber* | Labiatea | Broadleaf |

### 4.2.2 Relative weed density in weedy check plot

Data on species wise weed population (No. $m^{-2}$) and relative density (%) of weeds recorded in weedy check plots at 15 DAS and 30 DAS are presented in Table 12 and Figure 1 and Figure 2. It is obvious from the data that there was a predominance of grass and sedge weeds in weedy check plots of mustard field. Among the weeds, *Cynodon dactylon* was the most dominant weed and recorded maximum weed number (68.67 and 95.33 $m^{-2}$) and relative weed density (26.75 and 20.30 %) in the weedy check plot followed by *Cyperus rotundus and Echinochloa colona* weed species both at 15 and 30 DAS. While the dominancy of *Mimosa pudica* and *Brassica kaber* at 15 and 30 DAS was least among all the weed species in the weedy check plot.

**Table 12. Species wise weedpopulation (No. m$^{-2}$) and relative weeds density (%) in weedy check plots at 15 and 30 DAS**

| Scientific name | Weed population in weedy check plot (No. m$^{-2}$) | | Relative weed density (%) | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 15 DAS | 30 DAS |
| *Brassica kaber* | 9.33 | 14.33 | 3.64 | 3.05 |
| *Eleusine indica* | 32.33 | 67.67 | 12.6 | 14.41 |
| *Echinochloa colona* | 38.67 | 80.33 | 15.06 | 17.1 |
| *Cynodon dactylon* | 68.67 | 95.33 | 26.75 | 20.3 |
| *Heliotropium indicum* | 25.33 | 57.67 | 9.87 | 12.28 |
| *Enydra fluctuans* | 24.33 | 57.33 | 9.48 | 12.21 |
| *Mimosa pudica* | 8.67 | 10.67 | 3.38 | 2.27 |
| *Cyperus rotundus* | 49.33 | 86.33 | 19.22 | 18.38 |
| **Total** | 256.66 | 469.66 | 100 | 100 |

### 4.2.3 Weed density m$^{-2}$

**Effect of variety**

Weeds grow faster compared to field crops. Because of its initial slow growth, weeds are taking advantage to utilize more resources and dominate over crops. Mainly weeds compete with the crop for nutrients, solar radiation, soil moisture etc and thus increasing dry matter accumulation. The significant affectweed density m$^{-2}$ was found in different varieties at 15 and 30 DAS (Figure 1). Among the different mustard varieties, the maximum weed density m$^{-2}$ (57.44 and 82.22 at 15 and 30 DAS) was recorded in the BARI Sarisha-15 variety. Whereas RAI-5 variety recorded the minimum weed density m$^{-2}$ (39.33 and 55.00 at 15 and 30 DAS.

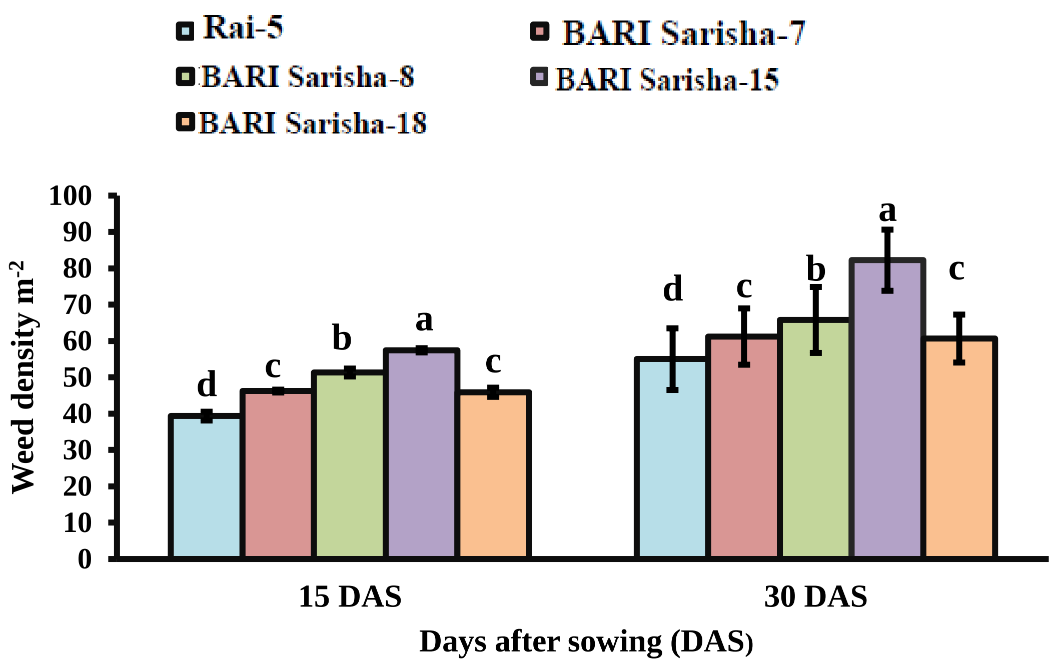


**Figure 1. Effect of variety on weed density m$^{-2}$ of mustard at different days after sowing.**

**Effect of weed management**

Weed management significantly affect the weed density m$^{-2}$ at 15 and 30 DAS (Figure 2). The experiment result had shown that no weeding recorded the maximum weed density (50.93 and 93.93 m$^{-2}$) at 15 and 30 DAS. Whereas 2 weedings recorded the minimum weed density (46.27 and 39.53 m$^{-2}$) at 15 and 30 DAS which was statistically similar with 1 weeding recorded weed density (46.93 m$^{-2}$) at 15 DAS.

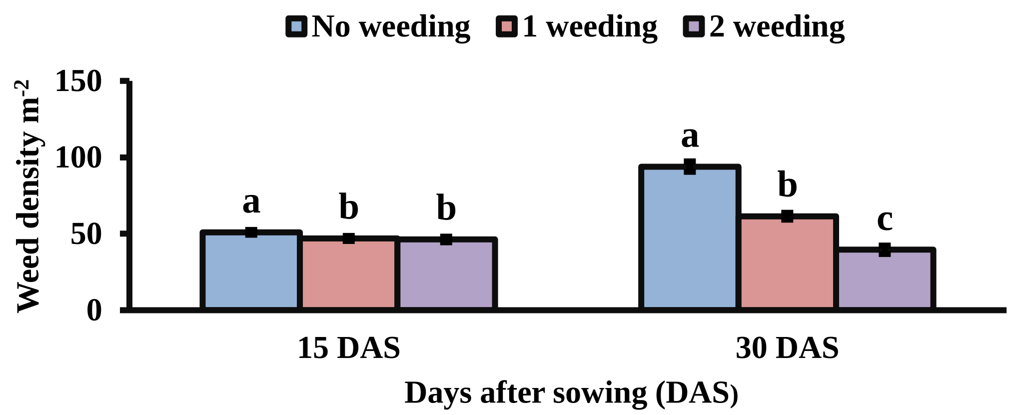


**Figure 2. Effect of weed management on weed density m$^{-2}$ of mustard at different days after sowing.**

**Combined effect of variety and weed management**

Combined effect of variety and weed management significantly affect the weed density $m^{-2}$ at 15 and 30 DAS (Table 13). The experiment result had shown that cultivation of BARI Sarisha-15 along with no weeding recorded the maximum weed density (59.00 and 114.33 $m^{-2}$) at 15 and 30 DAS. Whereas cultivation of RAI-5 along with two weedings recorded the minimum weed density (36.67 and 28.00 $m^{-2}$) at 15 and 30 DAS, which was statistically similar with the cultivation of RAI-5 along with one weeding recorded weed density (38.00 $m^{-2}$) at 15 DAS and with the cultivation of BARI Sarisha-7 along with two weedings recorded weed density (32.00 $m^{-2}$) at 30 DAS.

### 4.2.4 Weed dry weight $m^{-2}$ (g)

**Effect of variety**

Mustard varieties play an important role to control weeds to some extent levels which ultimately impacts dry weight accumulation by different weeds in the field. Mustard variety had shown significant variation in respect of weed dry weight $m^{-2}$ at 15 and 30 DAS (Figure 3). The result showed that among different mustard varieties, the BARI Sarisha-15 variety recorded the maximum weed dry weight (26.92 and 39.28 g $m^{-2}$) at 15 and 30 DAS. Whereas RAI-5 variety recorded the minimum weed dry weight (12.83 and 27.70 g $m^{-2}$) at 15 and 30 DAS. The competitive ability of different mustard varieties significantly reduces the weed population in the field which ultimately impacts the total dry matter accumulation by weed in the $m^{-2}$ area. The result found in this experiment is agreed with Rice *et al.* (2007) and they reported that seed meal of Indian mustard significantly reduced the biomass of redroot pigweed (*Amaranthus retroflexus* L.) and common lambsquarters (*Chenopodium album* L.). Sarmah *et al*. (1992) reported that several accessions of rapeseed, Indian mustard, and Ethiopian mustard (*Brassica carinata* A. Braun) suppressed the growth and biomass accumulation of different winter weeds. The suppressive effect followed an order of rapeseed > Indian mustard> Ethiopian mustard. Interestingly, the suppressive effects of these species were higher against broad-leaved weeds than narrow-leaved weeds, which might be due to the selective action of responsible allelochemicals.

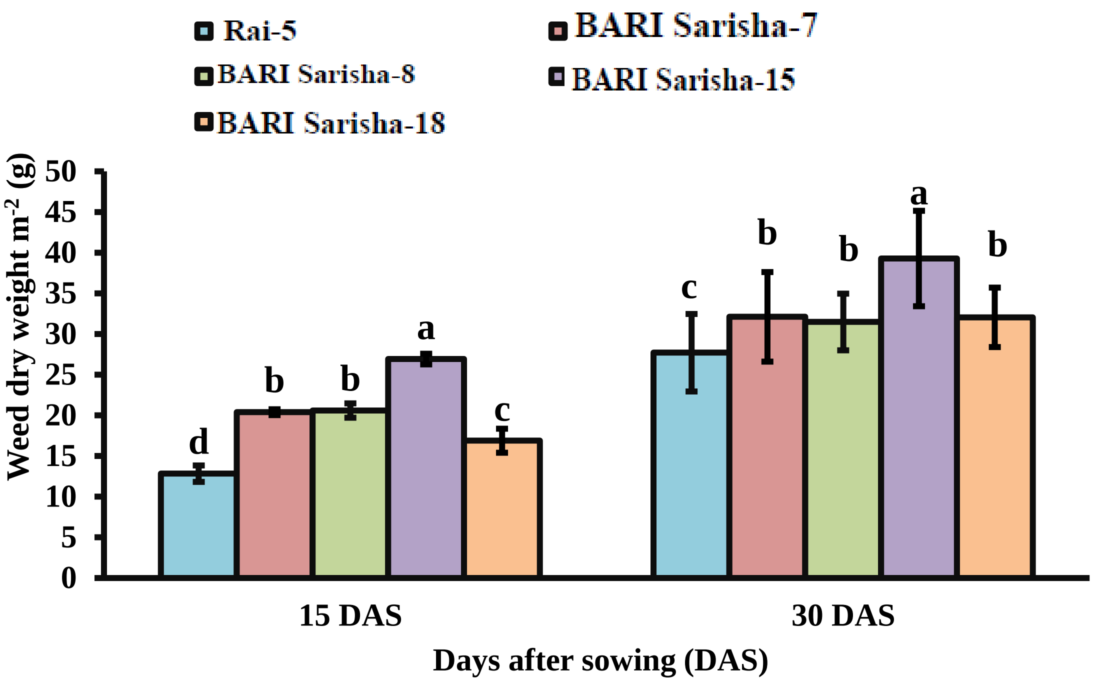


**Figure 3. Effect of variety on weed dry matter weight (g) m$^{-2}$ of mustard at different days after sowing.**

**Effect of weed management**

Different weed management significantly affect the weed dry weight m$^{-2}$ at 15 and 30 DAS (Figure 4). The experiment result had shown that no weeding recorded the maximum weed dry weight (22.15 and 48.45 g m$^{-2}$) at 15 and 30 DAS. Whereas 2 weeding recorded the minimum dry weight (17.50 and17.07 gm$^{-2}$) at 15 and 30 DAS. Untreated weedy check produced the maximum weed dry weight at all the crop growth stages because of higher weed intensity and its dominance in utilizing the sunlight, nutrients, moistureetc. Chauhan *et al.* (2005) reported that two-hand clearings at 20 and 40 DAS significantly reduce the weed dry weight 77% over the whole. Angiras *et al.* (1990) also found that weed dry weight in weed-free condition (110 gm$^{-2}$) over weedy conditions (260.5 gm$^{-2}$) in a whole crop season.

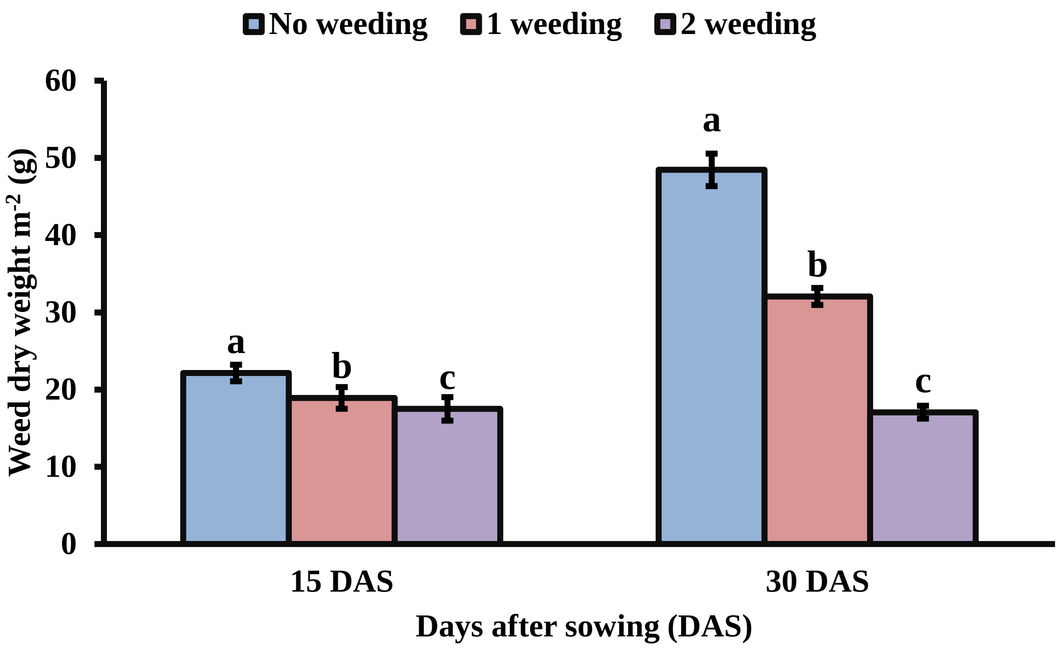


**Figure 4. Effect of weed management on weed dry matter weight (g) m$^{-2}$ of mustard at different days after sowing.**

**Combined effect of variety and weed management**

The combined effect of variety and weed management had shown a significant effect on the weed dry weight m$^{-2}$ at 15 and 30 DAS (Table 13). The experiment result had shown that cultivation of BARI Sarisha-15 along with no weeding recorded the maximum weed dry weight (28.11 and 60.79 g m$^{-2}$) at 15 and 30 DAS, which was statistically similar with BARI Sarisha-15 along with one weeding recorded weed dry weight (27.58 g m$^{-2}$) at 15 DAS. Whereas cultivation of RAI-5 along with two weeding recorded the minimum dry weight (9.90 and 11.95 g m$^{-2}$) at 15 and 30 DAS.

**Table 13. Combined effect of variety and weed management on weed density $m^{-2}$ and weed dry weight ($g\ m^{-2}$) of mustard at 15 and 30 DAS**

| Treatment Combinations | Weed density $m^{-2}$ | | Weed dry weight ($g\ m^{-2}$) | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 15 DAS | 30 DAS |
| $V_1W_0$ | 43.33 ±3.61 g | 85.00 ±11.73 c | 16.44 ±1.65 g | 44.15 ±5.57 c |
| $V_1W_1$ | 38.00 ±0.95 h | 52.00 ±1.29 g | 12.14 ±0.71 h | 27.01 ±2.59 f |
| $V_1W_2$ | 36.67 ±0.92 h | 28.00 ±0.7i | 9.90 ±0.58i | 11.95 ±0.71 j |
| $V_2W_0$ | 47.00±1.17 de | 84.67 ±2.12 c | 20.76 ±1.22 cd | 52.73 ±3.11 b |
| $V_2W_1$ | 46.00 ±1.15ef | 67.00 ±1.67 e | 20.13±1.18 d-f | 28.15 ±1.65 f |
| $V_2W_2$ | 45.67 ±1.14ef | 32.00 ±0.8i | 20.28±1.19 c-e | 15.44 ±0.91i |
| $V_3W_0$ | 55.33 ±1.38 b | 100.33 ±2.51 b | 23.82 ±1.4 b | 41.69 ±2.45 d |
| $V_3W_1$ | 50.00 ±1.25 c | 58.00 ±1.45 f | 19.13 ±1.12ef | 34.34 ±2.02 e |
| $V_3W_2$ | 48.67 ±1.22 cd | 39.00 ±0.97 h | 18.82 ±1.11 f | 18.39 ±1.08 h |
| $V_4W_0$ | 59.00±1.47 a | 114.33 ±2.85 a | 28.11 ±1.65 a | 60.79 ±3.57 a |
| $V_4W_1$ | 56.33 ±1.41 b | 74.67 ±1.87 d | 27.58 ±1.62 a | 36.26 ±2.13 e |
| $V_4W_2$ | 57.00±1.43 b | 57.67 ±1.44 f | 25.08 ±1.47 b | 20.80 ±1.22 g |
| $V_5W_0$ | 50.00±1.25 c | 85.33 ±2.13 c | 21.59 ±1.27 c | 42.89 ±2.52 cd |
| $V_5W_1$ | 44.33 ±0.12fg | 55.67 ±1.39fg | 15.62 ±0.92 g | 34.51 ±2.03 e |
| $V_5W_2$ | 43.33 ±1.92 g | 41.00 ±0.02 h | 13.44 ±2.2 h | 18.76 ±0.11 h |
| **SE** | 0.84 | 2.09 | 0.67 | 0.94 |
| **CV(%)** | 2.15 | 3.94 | 4.18 | 3.55 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.5 Weed control efficiency (%)

**Effect of variety**

Mustard variety significantly affect the weed control efficiency at 15 and 30 DAS (Figure 5). Due to different mustard varieties treatment, the weed control efficiency was ranged from 1.66 to 34.59 % over the weedy check plot. The experiment result had shown that the RAI-5 mustard variety recorded the maximum weed control efficiency (9.23 %) at 15 DAS. At 30 DAS BARI Sarisha-8 variety recorded the maximum weed control efficiency (34.59 %) which was statistically similar with RAI-5 mustard variety recorded weed control efficiency (33.55 %). Whereas BARI Sarisha-7 recorded the minimum weed control efficiency (1.66 and 27.69 %) at 15 and 30 DAS which was statistically similar with BARI Sarisha-15 variety recorded weed control efficiency (28.04 %).

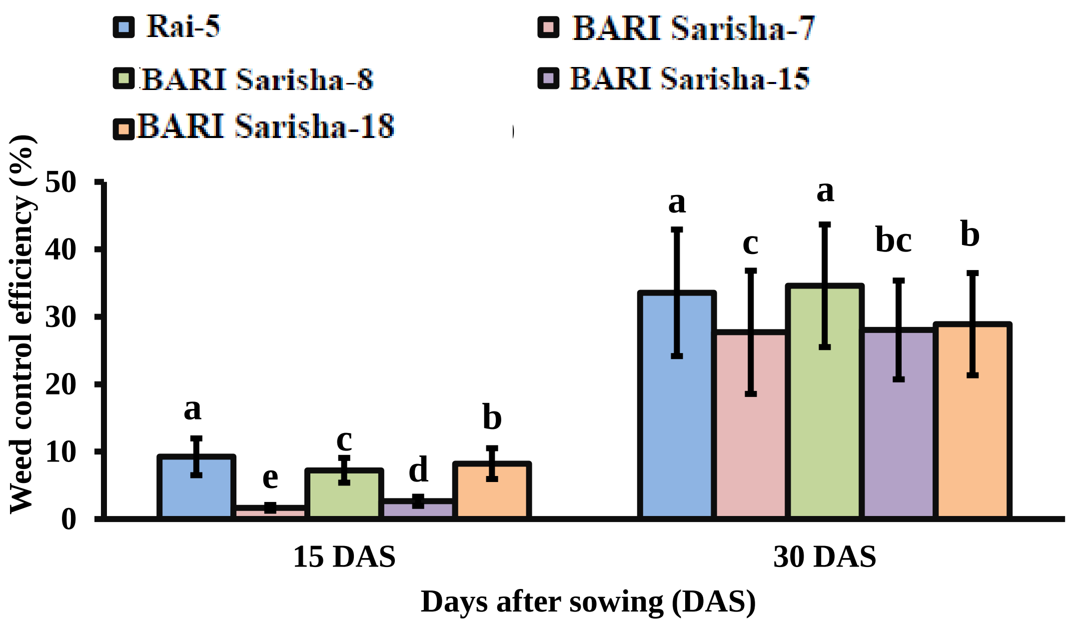


**Figure 5. Effect of variety on control efficiency (%) of mustard at different days after sowing.**

**Effect of weed management**

Different weed management systems significantly affect the weed control efficiency at 15 and 30 DAS (Figure 6). Due to different weed management treatments, the weed control efficiency was ranged from 00 to 57.88 % over the weedy check plot. Experiment results revealed that two weeding recorded the maximum weed control efficiency (9.40 and 57.88 %) at 15 and 30 DAS. Whereas no weeding recorded the minimum weed control efficiency (0.0 and 0.0 %) at 15 and 30 DAS. The differences inweed control efficiency were due to variation of weed density in the experiment plot which was attended using different weeding ondifferent days. Weeding removes weeds from the field and thus reducingweed density and increasing weed control efficiency.

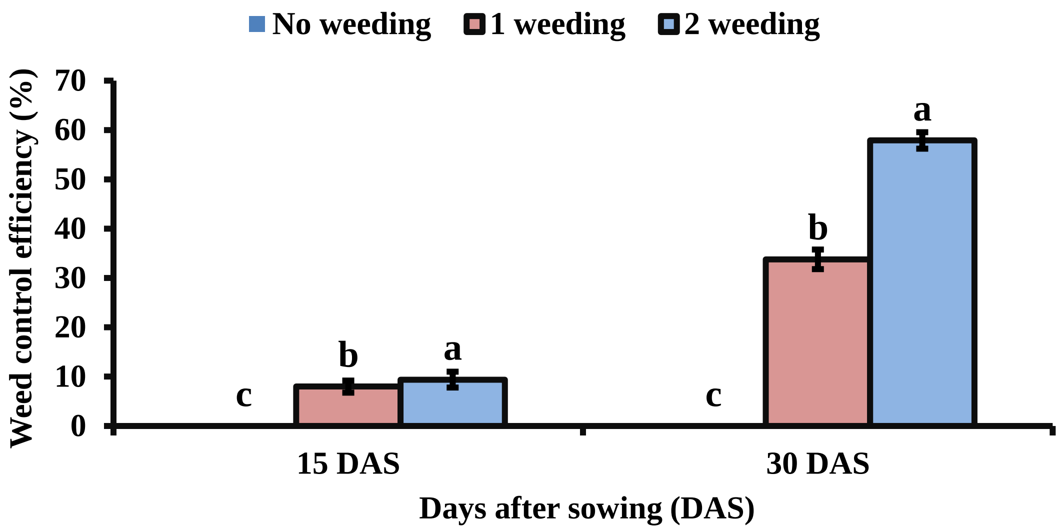


**Figure 6. Effect of weed management on control efficiency (%) of mustard at different days after sowing.**

### Combined effect of variety and weed management

Combined effect of variety and weed management had shown a significant effect on the weed control efficiency at 15 and 30 DAS (Table 14). Due to the combined effect of variety and weed management the weed control efficiency was ranged from 2.13 % to 64.25 % over the weedy check plot. Experiment results revealed that cultivation of RAI-5 variety along with two weeding recorded the maximum weed control efficiency (15.39 % and 64.25 %) at 15 and 30 DAS. Whereas BARI Sarisha-15 variety along with no weeding recorded the minimum weed control efficiency (0.0 and 0.00 %) at 15 and 30 DAS which was statistically similar with RAI-5 variety along with no weeding; BARI Sarisha-7 variety along with no weeding; BARI Sarisha-8 variety along with no weeding and BARI Sarisha-18 (Canola) variety along with no weeding recorded weed control efficiency (0.0 and 0.00 %) at 15 and 30 DAS.

### 4.2.6 Weed control index (%)

### Effect of variety

Mustard variety significantly affect the weed control index at 15 and 30 DAS (Figure 7). Due to different mustard varieties treatment, the weed control index was ranged from 1.62 to 39.11 % over weedy check plot. The experiment result had shown that the RAI-5 mustard variety recorded the maximum weed control index (22.01 %) at 15 DAS, at 30 DAS BARI Sarisha-7 variety recorded the weed control index (39.11 %). Whereas BARI Sarisha-15 recorded the minimum weed control index (1.62 %) at 15 DAS which was statistically similar with BARI Sarisha-7 variety recorded weed control index (1.78 %). At 30 DAS BARI Sarisha-8 recorded the minimum weed control index (24.51 %) which was statistically similar with BARI Sarisha-18 (Canola) variety recorded weed control index (25.56 %). Different mustard varieties may have a higher competitive ability which helps to suppress the weeds population and reduced the resources utilization of weeds thus increasing weed control index by decreasing weeds biomass production.

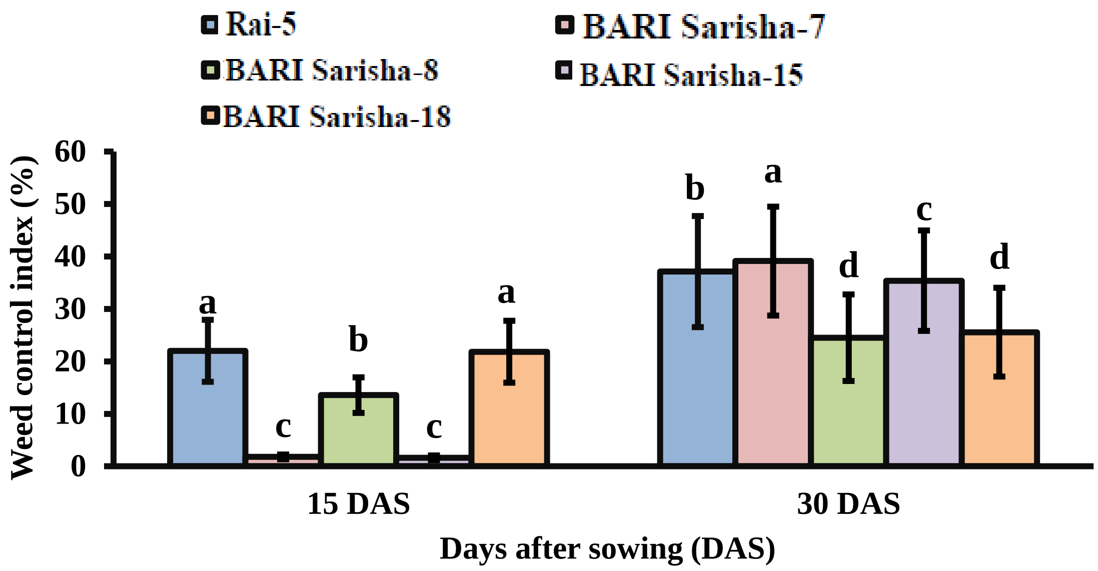


**Figure 7. Effect of variety on control index (%) of mustard at different days after sowing.**

**Effect of weed management**

Different weed management system significantly affects the weed control index at 15 and 30 DAS (Figure 8). Due to different weed management treatments the weed control index was ranged from 00 to 64.50 % over weedy check plot. Experiment results revealed that two weeding recorded the maximum weed control index (20.62 and 64.50 %) at 15 and 30 DAS. Whereas no weeding recorded the minimum weed control efficiency (0.0 and 0.0 %) at 15 and 30 DAS.The differences of weed control index weredue to different weed management on weeds helps to the reduction of weeds plant in the experiment field thus reduction of dry matter accumulation and ultimately cause reduction of weed and increasing of weed control index over weedy check plot.

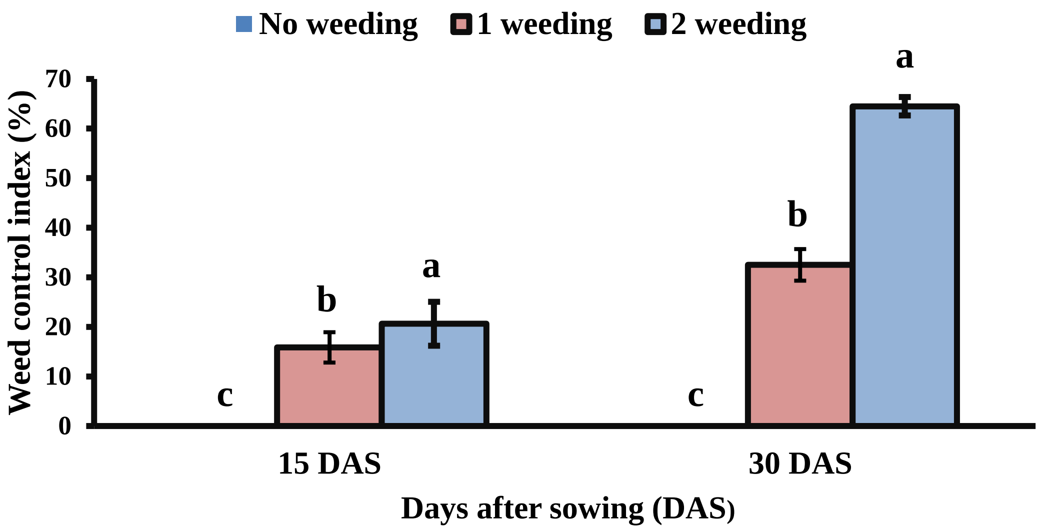


**Figure 8. Effect of weed management on control index (%) of mustard at different days after sowing.**

**Combined effect of variet and weed management**

Combined effect of variety and weed management had shown significant effect on the weed control index at 15 and 30 DAS (Table 14). Due to the combined effect of the variety and weed management, the weed control index was ranged from 1.85 to 72.93 % over weedy check plot. Experiment results revealed that cultivation of RAI-5 variety along with two weeding recorded the maximum weed control index (39.78 and 72.93 %) at 15 and 30 DAS which was statistically similar with BARI Sarisha-7 variety along with two weeding recorded weed control index (70.73 %) at 30 DAS. Whereas BARI Sarisha-15 variety along with no weeding recorded the minimum weed control index (0.0 and 0.00 %) at 15 and 30 DAS which was statistically similar with RAI-5 variety along with no weeding; with BARI Sarisha-7 variety along with no weeding; with BARI Sarisha-8 variety along with no weeding and with BARI Sarisha-18 (Canola) variety along with no weeding recorded minimum weed control index (0.0 and 0.00 %) at 15 and 30 DAS.

**Table 14: Combined effect of variety and weed management on weed control efficiency (%) and index (%) of mustard at 15 and 30 DAS**

| Treatment Combinations | Weed control efficiency (%) | | Weed control index (%) | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 15 DAS | 30 DAS |
| $V_1W_0$ | 0.00 ±0i | 0.00 ±0 h | 0.00 ±0 g | 0.00 ±0 g |
| $V_1W_1$ | 12.30±5.98 c | 36.40 ±6.63 f | 26.27 ±4.28 d | 38.40 ±6.25 e |
| $V_1W_2$ | 15.39 ±5.77 a | 64.25 ±3.56 a | 39.78 ±3.46 a | 72.93 ±2.37 a |
| $V_2W_0$ | 0.00±0i | 0.00 ±0 h | 0.00 ±0 g | 0.00 ±0 g |
| $V_2W_1$ | 2.13 ±0.01 h | 20.86 ±0.01 g | 3.03 ±0.08 f | 46.60 ±0.01 d |
| $V_2W_2$ | 2.85±0.01 g | 62.20 ±0.01 b | 2.31 ±0.08 f | 70.73 ±0.01 a |
| $V_3W_0$ | 0.00±0i | 0.00 ±0 h | 0.00 ±0 g | 0.00 ±0 g |
| $V_3W_1$ | 9.63±0.03 e | 42.19 ±0.01 e | 19.68 ±0.01 e | 17.63 ±0.04 f |
| $V_3W_2$ | 12.05±0.04 c | 61.59 ±0 b | 20.99 ±0.01 e | 55.91 ±0.15 c |
| $V_4W_0$ | 0.00 ±0i | 0.00 ±0 h | 0.00 ±0 g | 0.00 ±0 g |
| $V_4W_1$ | 4.52 ±0.01 f | 34.69 ±0.01 f | 1.85 ±0.01 f | 40.35 ±0.01 e |
| $V_4W_2$ | 3.38 ±0.01 g | 49.42 ±0.01 d | 3.00 ±0.01 f | 65.78 ±0.01 b |
| $V_5W_0$ | 0.00 ±0i | 0.00 ±0 h | 0.00 ±0 g | 0.00 ±0 g |
| $V_5W_1$ | 11.34 ±2.01 d | 34.75 ±0 f | 28.48 ±3.55 c | 19.54 ±0.01 f |
| $V_5W_2$ | 13.33 ±6.01 b | 51.95 ±1.17 c | 37.00 ±3.95 b | 57.15 ±2.34 c |
| **SE** | 0.29 | 0.87 | 0.76 | 1.13 |
| **CV(%)** | 6.30 | 3.48 | 7.66 | 4.29 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.7 Simpson's Diversity Index (SDI)

To quantify biodiversity for ecological studies, number of species present in the mustard plot during the experiment as well as the abundance of each species were recorded. Data showed that cultivation of RAI-5 variety along with two weeding recorded the maximum SDI (0.91 and 0.97) at 15 and 30 DAS where cultivation of RAI-5 variety along with zero weeding recorded the minimum SDI (0.87 and 0.74) at 15 and 30 DAS.

**Table 15. Simpson diversity index (SDI) of different weeds found in different treated plots during field experiment**

| Treatment Combinations | Simpson diversity index | | | |
|---|---|---|---|---|
| | **15 DAS** | **(%)** | **30 DAS** | **(%)** |
| $V_1W_0$ | 0.87 | 87 | 0.74 | 74 |
| $V_1W_1$ | 0.9 | 90 | 0.9 | 90 |
| $V_1W_2$ | 0.91 | 91 | 0.97 | 97 |
| $V_2W_0$ | 0.89 | 89 | 0.79 | 79 |
| $V_2W_1$ | 0.89 | 89 | 0.87 | 87 |
| $V_2W_2$ | 0.89 | 89 | 0.97 | 97 |
| $V_3W_0$ | 0.87 | 87 | 0.74 | 74 |
| $V_3W_1$ | 0.9 | 90 | 0.91 | 91 |
| $V_3W_2$ | 0.9 | 90 | 0.96 | 96 |
| $V_4W_0$ | 0.88 | 88 | 0.79 | 79 |
| $V_4W_1$ | 0.89 | 89 | 0.9 | 90 |
| $V_4W_2$ | 0.89 | 89 | 0.95 | 95 |
| $V_5W_0$ | 0.87 | 87 | 0.78 | 78 |
| $V_5W_1$ | 0.9 | 90 | 0.91 | 91 |
| $V_5W_2$ | 0.9 | 90 | 0.95 | 95 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.7 Crop growth characters

#### 4.2.7.1 Plant height (cm)

**Effect of variety**

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From the experiment, result revealed that, plant height showed significant variation due to effect of different mustard varieties. (Figure 9). Experiment result had shown that RAI-5 variety recorded the maximum plant height (16.70 cm) at 15 DAS. At 30 DAS BARI Sarisha-15 variety recorded the maximum plant height (47.83 cm). AT 45 DAS and at harvest respectively RAI-5 recorded the maximum plant height (149.38 and 166.89 cm). Whereas BARI Sarisha-8 variety recorded the minimum plant height (7.90, 31.56 and 90.99 cm) at 15, 30 and 45 DAS. At harvest BARISarisha-7 recorded the minimum plant height (95.22 cm). The variation of plant height is probably due to the genetic make-up of the variety. Similar result also observed by Das *et al.* (2019). They reported that height of a plant is determined by genetical character and under a given set of environment different variety will acquire their height according to their genetical make up. Tyeb *et al.* (2013) also reported that the variation in plant height due to the effect of varietal differences. The variation of plant height is probably due to the genetic make-up of the cultivars.

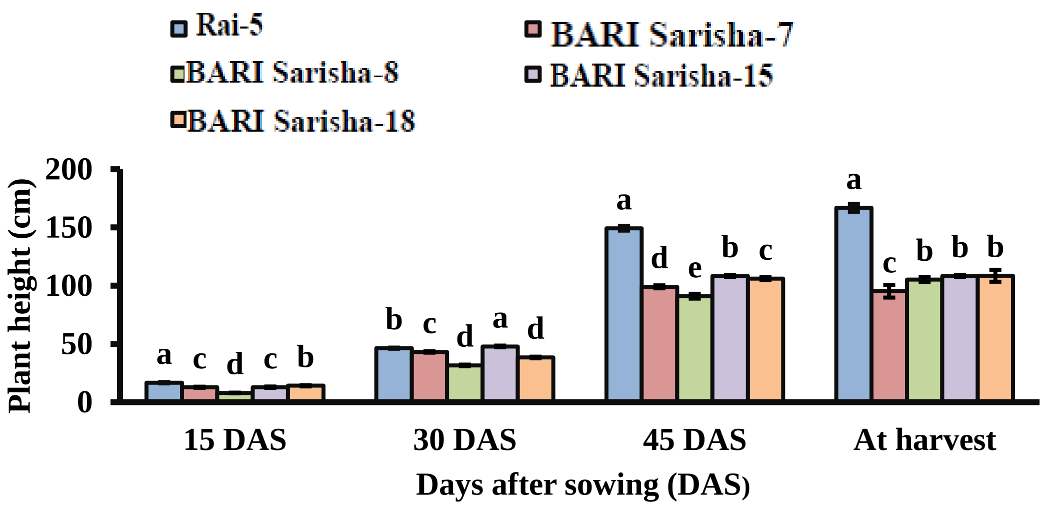


**Figure 9. Effect of variety on plant height (cm)of mustard at different days after sowing.**

**Effect of weed management**

Weed management significantly affect the plant height at different days after sowing (Figure 10). Experiment result had shown that no weeding recorded the maximum plant height (13.78 cm) at 15 DAS. At 30, 45 DAS and at harvest respectively two weeding recorded the maximum plant height (42.66, 115.26 and 121.93 cm) which was statistically similar with one weeding recorded plant height (120.65 cm) at harvest. Whereas that two weeding recorded the minimum plant height (12.24 cm) at 15 DAS which was statistically similar with one weeding recorded plant height (12.53 cm). At 30, 45 DAS and at harvest respectively no weeding recorded the minimum plant height (40.43, 106.16 and 107.96 cm). The result obtained from the present study was similar with the findings of Raj *et al*. (2020) and reported that growth, yield attributes, yields, and quality increased significantly under two hand weeding at 20 and 40 DAS.

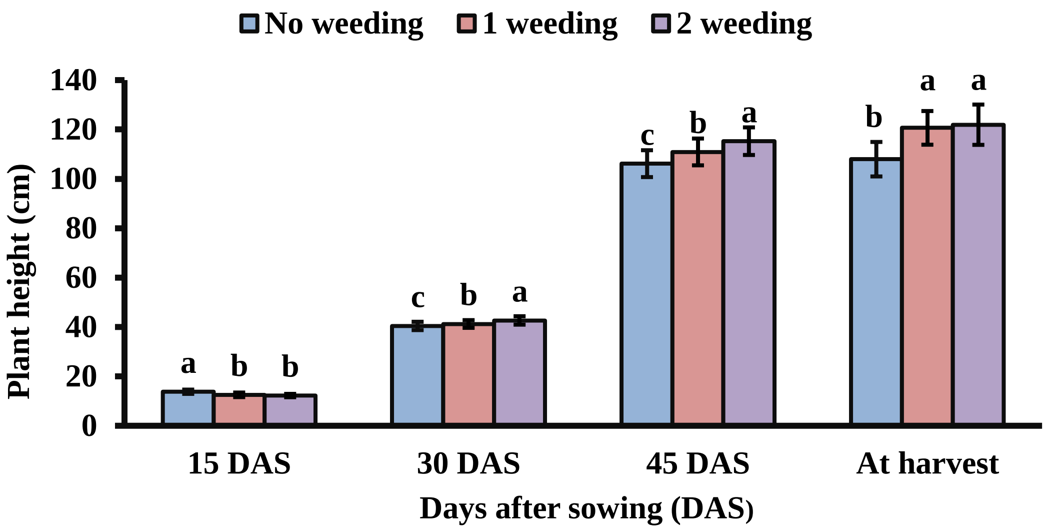


**Figure 10. Effect of weed management on plant height (cm)of mustard at different days after sowing.**

### Combined effect of variety and weed management

Different mustard varieties along with different weed management significantly affect the plant height of mustard at different DAS. (Table 16). Experiment result had shown that cultivation of RAI-5 variety along with no weeding recorded the maximum plant height (17.95 cm) which was statistically similar with cultivation of RAI-5 variety along with one weeding recorded plant height (17.44 cm) at 15 DAS. At 30 DAS BARI Sarisha-15 variety along with two weeding recorded the maximum plant height (49.71 cm). At 45 DAS and at harvest respectively RAI-5 variety along with two weeding recorded the maximum plant height (155.16 and 175.50 cm). Whereas BARI Sarisha-8 variety along with one weeding recorded the minimum plant height (7.32 cm) which was statistically similar with cultivation of BARI Sarisha-8 variety along with two weeding recorded plant height (7.90 cm) at 15 DAS. At 30 and 45 DAS, BARI Sarisha-8 along with no weeding recorded the minimum plant height (29.77 and 83.55 cm). At harvest BARI Sarisha-7 along with no weeding recorded the minimum plant height (73.67 cm).

**Table 16. Combined effect of variety and weed management on plant height (cm) of mustard at different DAS**

| Treatment Combinations | Plant height (cm) | | | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | At harvest |
| $V_1W_0$ | 17.95±0.94 a | 46.38 ±0.4bc | 143.23 ±6.63 c | 153.75 ±2.64 b |
| $V_1W_1$ | 17.44 ±1.48 a | 45.53 ±1.84 c | 149.75 ±1.88 b | 171.43 ±2.14 a |
| $V_1W_2$ | 14.69 ±0.87 c | 47.15 ±1.87 b | 155.16 ±1.92 a | 175.50 ±2.19 a |
| $V_2W_0$ | 13.73±1.08 c-e | 41.93 ±1.78 e | 94.64 ±1.75jk | 73.67 ±0.92 e |
| $V_2W_1$ | 11.11 ±0.74 g | 43.10 ±1.8 de | 99.69 ±1.74 hi | 104.17 ±1.3 cd |
| $V_2W_2$ | 13.53 ±0.82 de | 44.23 ±1.82 d | 102.71 ±1.74gh | 107.82 ±1.34 cd |
| $V_3W_0$ | 8.48 ±0.87 h | 29.77 ±1.61i | 83.55 ±1.79 l | 97.09 ±1.21 d |
| $V_3W_1$ | 7.32 ±0.77i | 31.73 ±1.64 h | 91.94±1.76 k | 109.42 ±1.37 cd |
| $V_3W_2$ | 7.90 ±0.76 hi | 33.17 ±1.65 g | 97.48 ±1.75ij | 109.27 ±1.37 cd |
| $V_4W_0$ | 12.93 ±1.13ef | 46.26 ±1.85bc | 106.52±1.73 e-g | 109.61 ±1.37 cd |
| $V_4W_1$ | 14.53 ±0.59 cd | 47.51 ±1.87 b | 108.15 ±1.73 d-f | 109.41 ±1.36 cd |
| $V_4W_2$ | 11.0 ±1.34 g | 49.71 ±1.91 a | 110.28 ±1.73 de | 105.91 ±1.32 cd |
| $V_5W_0$ | 15.80 ±0.58 b | 37.79 ±1.72 f | 102.89 ±1.74gh | 105.69 ±1.32 cd |
| $V_5W_1$ | 12.25 ±0.73 f | 38.23 ±1.73 f | 104.95 ±4.27fg | 108.83 ±1.36 cd |
| $V_5W_2$ | 14.09 ±0.67 cd | 39.00 ±3.46 f | 110.67 ±4.85 d | 111.15 ±28.61 c |
| **SE** | 0.50 | 0.61 | 1.82 | 6.32 |
| **CV(%)** | 4.75 | 1.80 | 2.02 | 6.63 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.7.2 Number of primary branches plant$^{-1}$

### Effect of variety

Number of primary branches plant$^{-1}$ was significantly differed due to different mustard varieties (Figure 11). Experiment result had shown that BARI Sarisha-15 variety recorded the maximum number of primary branches plant$^{-1}$ (6.16 and 5.82) at 45 DAS and at harvest respectively. Whereas BARI Sarisha-8 variety recorded the minimum number of primary branches plant$^{-1}$ (3.40 and 3.07) at 45 DAS and at harvest respectively which was statistically similar with BARI Sarisha-7 recorded number of primary branches plant$^{-1}$ (3.53 and 3.24) at 45 DAS and at harvest respectively. The differences of number of primary branches plant$^{-1}$ might be associated with the variety characteristics or genetic makeup of the plant. Helal *et al.* (2016) also found similar result which supported the present finding and reported that higher number of branchesplant$^{-1}$ is the result of genetic makeup of the crop and environmental conditions which play a remarkable role towards the final seed yield of the crop.

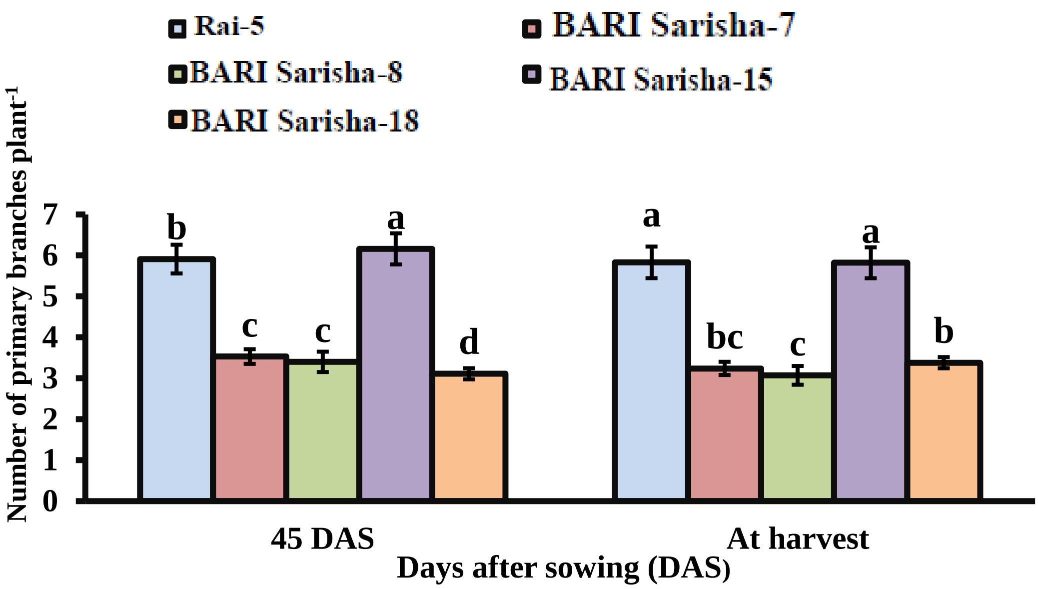


**Figure 11. Effect of variety on number of primary branches plant$^{-1}$of mustard at different days after sowing.**

**Effect of weed management**

Weed management significantly affect the number of primary branches plant$^{-1}$at different days after sowing (Figure 12). Experiment result had shown that 2 weeding recorded the maximum number of primary branches plant$^{-1}$(4.75 and 4.79) at 45 DAS and at harvest respectively. Whereas no weeding recorded the minimum number of primary branches plant$^{-1}$(4.20 and 3.78) at 45 DAS and at harvest respectively which was statistically similar with 1 weeding recorded number of primary branches plant$^{-1}$(4.32) at 45 DAS. Effective weed management technique reduced weeds density and weed crop competition thus helps plant to utilizes its resources properly which improve crop growth characters and increasing number of primary branches plant$^{-1}$ comparable to weedy check plot.

The result obtained from the present study was similar with the findings of Raj *et al*. (2020) and reported that growth, yield attributes, yields, and quality increased significantly under two hand weeding at 20 and 40 DAS.

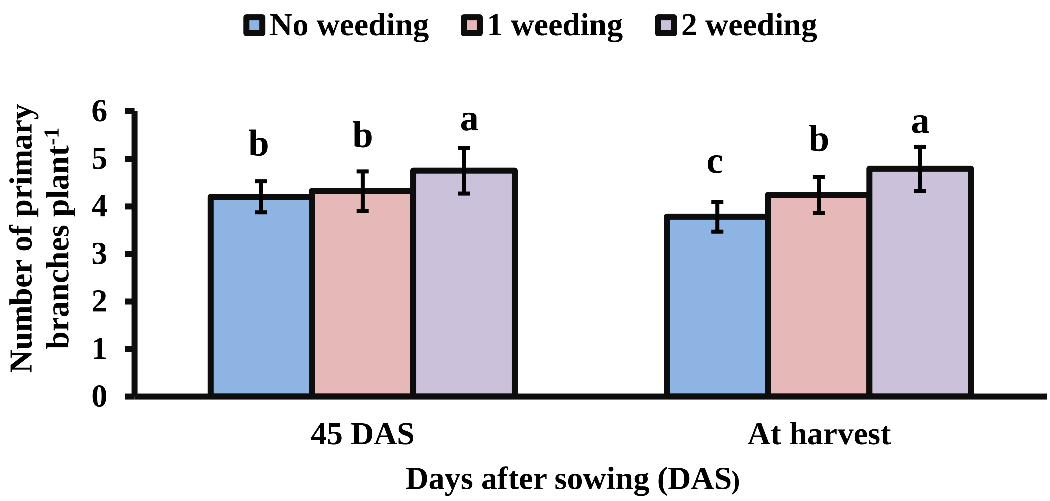


**Figure 12. Effect of weed management on number of primary branches plant$^{-1}$of mustard at different days after sowing.**

**Combined effect of variety and weed management**

Different mustard varieties along with different weed management significantly affect the number of primary branches plant$^{-1}$of mustard at different days after sowing (Table 17). Experiment result had shown that cultivation of BARI Sarisha-15 variety along with 2 weeding recorded the maximum number of primary branches plant$^{-1}$ (6.87) which was statistically similar with cultivation of RAI-5 along with 2 weeding recorded number of primary branches plant$^{-1}$ (6.60) at 45 DAS. Cultivation of RAI-5 variety along with 2 weeding recorded the maximum number of primary branches plant$^{-1}$ (6.73) at 45 DAS and at harvest respectively which was statistically similar with cultivation of BARI Sarisha-15 variety along with 2 weeding recorded the maximum number of primary branches plant$^{-1}$ (6.67). Whereas cultivation of BARI Sarisha-18 (Canola) along with no weeding recorded the minimum number of primary branches plant$^{-1}$ (2.80) at 45 DAS which was statistically similar with cultivation of BARI Sarisha-18 (Canola) variety along with 1 weeding recorded number of primary branches plant$^{-1}$ (2.93) and Cultivation of BARI Sarisha-8 variety along with 1 weeding recorded number of primary branches plant$^{-1}$ (2.93) at 45 DAS. BARI Sarisha-8 variety along with no weeding recorded the minimum number of primary branches plant$^{-1}$ (2.93) at 45 DAS and at harvest respectively.

#### 4.2.7.3 Number of secondary branches plant$^{-1}$

**Effect of variety**

Number of secondary branches plant$^{-1}$ was significantly differed due to different mustard varieties (Figure 13). Experiment result had shown that RAI-5 variety recorded the maximum number of secondary branches plant$^{-1}$ (5.47 and 4.42) at 45 DAS and at harvest respectively. Whereas cultivation of BARI Sarisha-8 variety recorded the minimum number of secondary branches plant$^{-1}$ (1.42) at 45 DAS and at harvest respectively. Cultivation of BARI Sarisha-8 variety recorded the minimum number of secondary branches plant$^{-1}$ (0.0). The differences of number of secondary branches plant$^{-1}$ might be associated with the variety characteristics or genetic makeup of the plant.

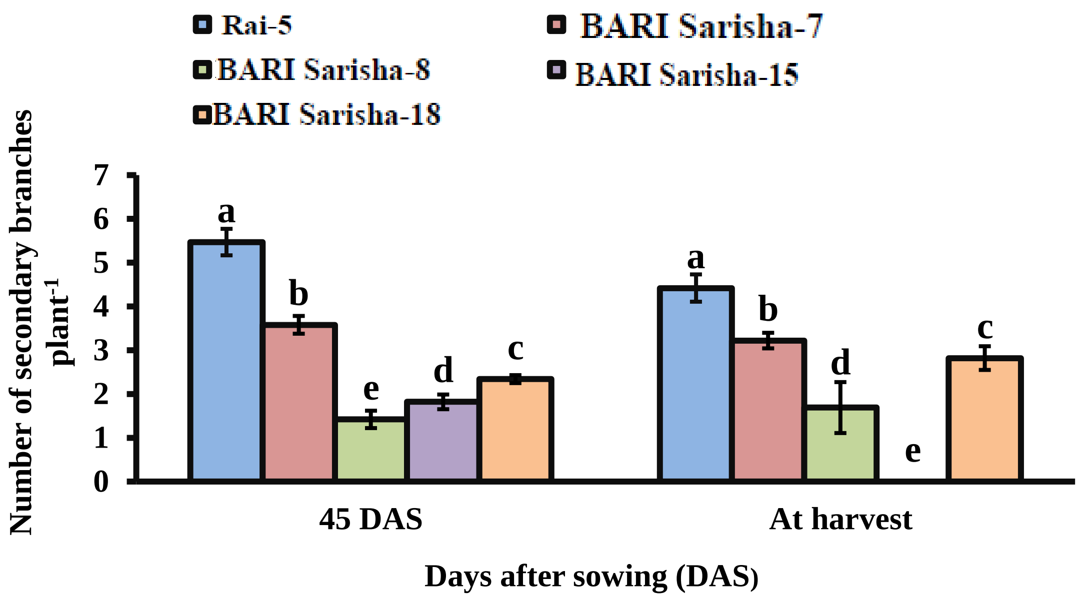


**Figure 13. Effect of variety on number of secondary branches plant$^{-1}$of mustard at different days after sowing.**

**Effect of weed management**

Weed management significantly affect the number of secondary branches plant$^{-1}$at different days after sowing (Figure 14). Experiment result had shown that 2 weeding recorded the maximum number of secondary branches plant$^{-1}$(3.18 and 3.19) at 45 DAS and at harvest respectively. Whereas 1 weeding recorded the minimum number of secondary branches plant$^{-1}$(2.72) at 45 DAS. At harvest no weeding recorded the minimum number of secondary branches plant$^{-1}$(1.80).

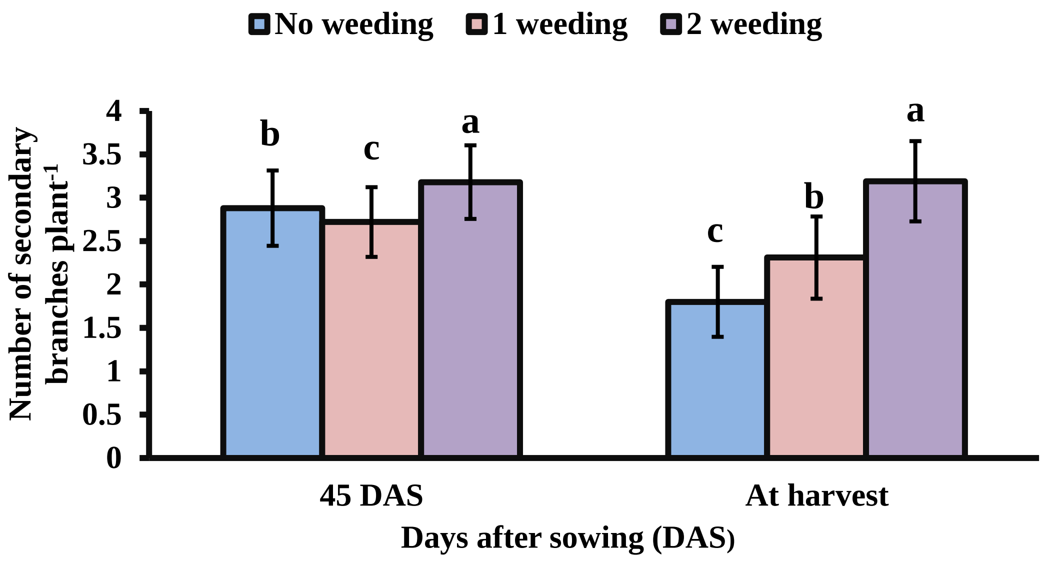


**Figure 14. Effect of weed management on number of secondary branches plant$^{-1}$ of mustard at different days after sowing.**

**Combined effect of variety and weed management**

Different mustard varieties along with different weed management significantly affect the number of secondary branches plant$^{-1}$of mustard at different days after sowing (Table 17). Experiment result had shown that cultivation of RAI-5 variety along with 2 weeding recorded the maximum number of secondary branches plant$^{-1}$ (6.00 and 4.93) at 45 DAS and at harvest respectively which was statistically similar with cultivation of RAI-5 along with 1 weeding recorded number of secondary branches plant$^{-1}$ (4.80) at 45 DAS.Whereascultivation of BARI Sarisha-8 along with no weeding recorded the minimum number of secondary branches plant$^{-1}$ (0.73) at 45 DAS and at harvest respectively.Cultivation of BARI Sarisha-15 along with no weeding, 1 weeding and 2 weeding recorded the minimum number of secondary branches plant$^{-1}$ (0.00, 0.00 and 0.00) which was statistically similar with cultivation of BARI Sarisha-8 variety along with no weeding recorded minimum number of secondary branches plant$^{-1}$ (0.20).

**Table 17. Combined effect of variety and weed management on number of primary and secondary branches of mustard at 45 DAS and at harvest**

| Treatment Combinations | No. of primary branches | | No. of secondary branches | |
|---|---|---|---|---|
| | 45 DAS | At harvest | 45 DAS | At harvest |
| **$V_1W_0$** | 5.47 ±1.1 cd | 5.03 ±0.96 c | 5.20 ±0.94 b | 3.53 ±0.62 cd |
| **$V_1W_1$** | 5.67 ±0.94 c | 5.73 ±0.95 b | 5.20 ±0.86 b | 4.80 ±0.8 a |
| **$V_1W_2$** | 6.60 ±1.09 ab | 6.73 ±1.15 a | 6.00 ±1 a | 4.93 ±0.82 a |
| **$V_2W_0$** | 3.33 ±0.55gh | 3.20 ±0.53 e-g | 4.00 ±0.66 c | 3.20 ±0.53 de |
| **$V_2W_1$** | 3.73 ±0.62 f | 3.13 ±0.52fg | 3.40 ±0.56 d | 3.53 ±0.58 cd |
| **$V_2W_2$** | 3.53 ±0.58fg | 3.40 ±0.56 d-f | 3.33 ±0.55 d | 2.93 ±0.48 e |
| **$V_3W_0$** | 4.13 ±0.68 e | 2.47 ±0.41 h | 0.73 ±0.12 j | 0.20 ±0.03 h |
| **$V_3W_1$** | 2.93 ±0.48ij | 3.07 ±0.51 g | 1.53 ±0.25 h | 0.93 ±0.15 g |
| **$V_3W_2$** | 3.13 ±0.52 hi | 3.67 ±0.61 d | 2.00 ±0.33 g | 3.93 ±0.65bc |
| **$V_4W_0$** | 5.27 ±0.87 d | 4.93 ±0.82 c | 2.20 ±0.36fg | 0.00 ±0 h |
| **$V_4W_1$** | 6.33 ±1.05 b | 5.87 ±0.97 b | 1.27 ±0.21i | 0.00 ±0 h |
| **$V_4W_2$** | 6.87 ±1.14 a | 6.67 ±1.11 a | 2.00 ±0.33 g | 0.00 ±0 h |
| **$V_5W_0$** | 2.80 ±0.46 j | 3.27 ±0.54 e-g | 2.27 ±0.37 f | 2.07 ±0.34 f |
| **$V_5W_1$** | 2.93 ±0.48ij | 3.40 ±0.56 d-f | 2.20 ±0.36fg | 2.27 ±0.37 f |
| **$V_5W_2$** | 3.60 ±7.02fg | 3.47 ±0.17 de | 2.55 ±0.1 e | 4.13 ±0.21 b |
| **SE** | 0.15 | 0.14 | 0.25 | 0.40 |
| **CV(%)** | 4.21 | 3.98 | 5.00 | 9.62 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.7.4 Number of leaves plant$^{-1}$

### Effect of variety

Differentmustard variety significantly affect the number of leaves plant$^{-1}$ at different days after sowing (Figure 15). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum number of leaves (3.89) at 15 DAS. At 30 and 45 DAS cultivation of BARI Sarisha-15 variety recorded the maximum number of leaves (3.89). Whereas cultivation of BARI Sarisha-8 recorded the minimum number of leaves (2.89, 5.69 and 13.71) at 15, 30 and 45 DAS which was statistically similar with cultivation of BARI Sarisha-18 (Canola) recorded the minimum number of leaves (14.22) at 45 DAS.The differences of number of leaves plant$^{-1}$ due to the result of genetic makeup of the crop and environmental conditions which play a remarkable role towards the final seed yield of the crop. Helal *et al.* (2016) reported that each variety/line responded independently from one stage to another stage to the environment in respect of growth of plant, branching and leaf number and ultimately differed in dry matter production.

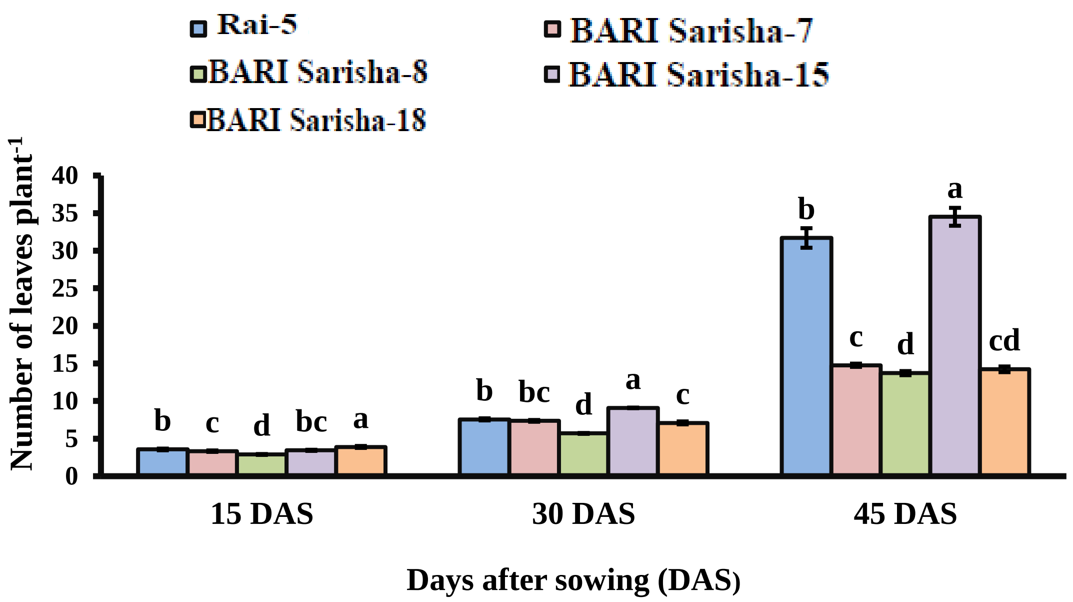


**Figure 15. Effect of variety on number of leaves plant$^{-1}$ of mustard at different days after sowing.**

**Effect of weed management**

Different weed management significantly affect the number of leaves plant$^{-1}$ at different days after sowing (Figure 16). Experiment result had shown that 2 weeding recorded the maximum number of leaves plant$^{-1}$(3.53, 7.55 and 22.19) at 15, 30 and 45 DAS which was statistically similar with no weeding recorded number of leaves plant$^{-1}$ (3.47 and 22.13) at 15 and 45 DAS. Whereas 1 weeding recorded the minimum number of leaves plant$^{-1}$ (3.27, 7.24 and 21.01) at 15, 30 and 45 DAS was statistically similar with no weeding recorded number of leaves plant$^{-1}$ (7.28) at 30 DAS.

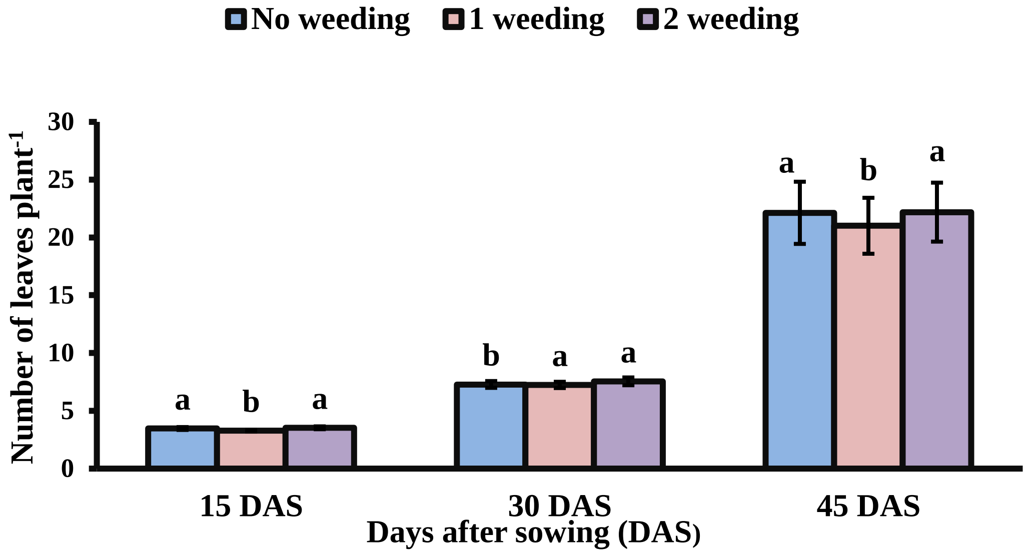


**Figure 16. Effect of weed management on number of leaves plant$^{-1}$ of mustard at different days after sowing.**

**Combined effect of variety and weed management**

Different mustard varieties along with different weed management significantly affect the number of leaves plant$^{-1}$of mustard at different days after sowing (Table 18). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum number of leaves plant$^{-1}$ (4.33) at 15 DAS. At 30 and 45 DAS, cultivation of BARI Sarisha-15 variety along with no weeding recorded the maximum number of leaves plant$^{-1}$ (9.20 and 39.13) which was statistically similar with cultivation of BARI Sarisha-15 variety along with 2 weeding recorded number of leaves plant$^{-1}$ (9.13) and cultivation of BARI Sarisha-15 variety along with 1 weeding recorded number of leaves plant$^{-1}$ (8.93). Whereas cultivation ofBARI Sarisha-8 along with no weeding recorded the minimum number of leaves plant$^{-1}$ (2.67) at 15 DAS. At 30 DAS cultivation of BARI Sarisha-8 along with 2 weeding recorded the minimum number of leaves plant$^{-1}$ (5.47) which was statistically similar with cultivation of BARI Sarisha-8 along with 1 weeding recorded number of leaves plant$^{-1}$ (5.80) and cultivation of BARI Sarisha-8 along with no weeding recorded number of leaves plant$^{-1}$ (5.80) at 30 DAS. At 45 DAS cultivation of BARI Sarisha-18(Canola)along with 1 weeding recorded the minimum number of leaves plant$^{-1}$ (12.87) which was statistically similar with cultivation of BARI Sarisha-8 along with no weeding recorded number of leaves plant$^{-1}$(13.13), cultivation of BARI Sarisha-8 along with 1 weeding recorded number of leaves plant$^{-1}$ (13.20) and cultivation of BARI Sarisha-7 along with 2 weeding recorded number of leaves plant$^{-1}$ (13.93) at 45 DAS.

**Table 18. Combined effect of variety and weed management on no. of leaves plant$^{-1}$ of mustard at 15, 30 and 45 DAS**

| Treatment Combinations | No. of leaves plant$^{-1}$ at | | |
|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS |
| $V_1W_0$ | 4.00 ±1 b | 7.13 ±0.5 d-f | 28.00 ±2.46 e |
| $V_1W_1$ | 3.33 ±0.58 d | 7.47 ±0.42 cd | 30.87 ±9.07 d |
| $V_1W_2$ | 3.33 ±0.58 d | 8.07 ±0.46 b | 36.20 ±5.86 b |
| $V_2W_0$ | 3.33 ±0.58 d | 7.40 ±0.92 c-e | 15.40 ±1.1 f |
| $V_2W_1$ | 3.00 ±0 e | 6.93 ±0.95ef | 14.93 ±3.11fg |
| $V_2W_2$ | 3.67 ±0.58 c | 7.73 ±2bc | 13.93 ±1.45gh |
| $V_3W_0$ | 2.67 ±0.58 f | 5.80 ±0.4 g | 13.13 ±0.76 h |
| $V_3W_1$ | 3.00 ±0 e | 5.80 ±0.72 g | 13.20 ±1 h |
| $V_3W_2$ | 3.00 ±1 e | 5.47 ±0.12 g | 14.80 ±3.81fg |
| $V_4W_0$ | 3.67 ±0.58 c | 9.20 ±0.87 a | 39.13 ±10.1 a |
| $V_4W_1$ | 3.33 ±0.58 d | 8.93 ±0.5 a | 33.20 ±1.97 c |
| $V_4W_2$ | 3.33 ±0.58 d | 9.13 ±0.95 a | 31.20 ±8.9 d |
| $V_5W_0$ | 3.67 ±1.15 c | 6.87 ±0.58 f | 15.00 ±5.04fg |
| $V_5W_1$ | 3.67 ±0.58 c | 7.07 ±0.61 d-f | 12.87 ±0.81 h |
| $V_5W_2$ | 4.33 ±0.58 a | 7.33 ±0.42 c-f | 14.80 ±1.06fg |
| **SE** | 0.09 | 0.23 | 0.66 |
| **CV(%)** | 3.33 | 3.88 | 3.75 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.7.5 Above ground dry matter weight plant$^{-1}$ (g)

**Effect of variety**

Above ground dry matter weight plant$^{-1}$ (g) at different days after sowing was significantly varied due to the effect of different mustard variety (Figure 17). Experiment result had shown that cultivation of BARI Sarisha-7 variety recorded the maximum above ground dry matter weight plant$^{-1}$ (0.68 g) at 15 DAS. At 30 and 45 DAS cultivation of RAI-5 variety recorded the maximum above ground dry matter weight plant$^{-1}$ (2.77 and 12.10 g), which was statistically similar with cultivation of BARI Sarisha-18 (Canola) variety recorded above ground dry matter weight plant$^{-1}$ (2.71 and 12.07 g) at 30 and 45 DAS and at harvest BARI Sarisha-18 (Canola) variety recorded above ground dry matter weight plant$^{-1}$ (17.70 g). Whereas cultivation of BARI Sarisha-8 variety recorded the minimum above ground dry matter weight plant$^{-1}$ (0.43, 1.31 and 5.38 g) at 15, 30 and 45 DAS respectively. Cultivation of BARI Sarisha-7 variety recorded the minimum above ground dry matter weight plant$^{-1}$ (11.44 g) at harvest. Rashid *et al.* (2010) reported that dry matter (DM) accumulation varied among varieties.

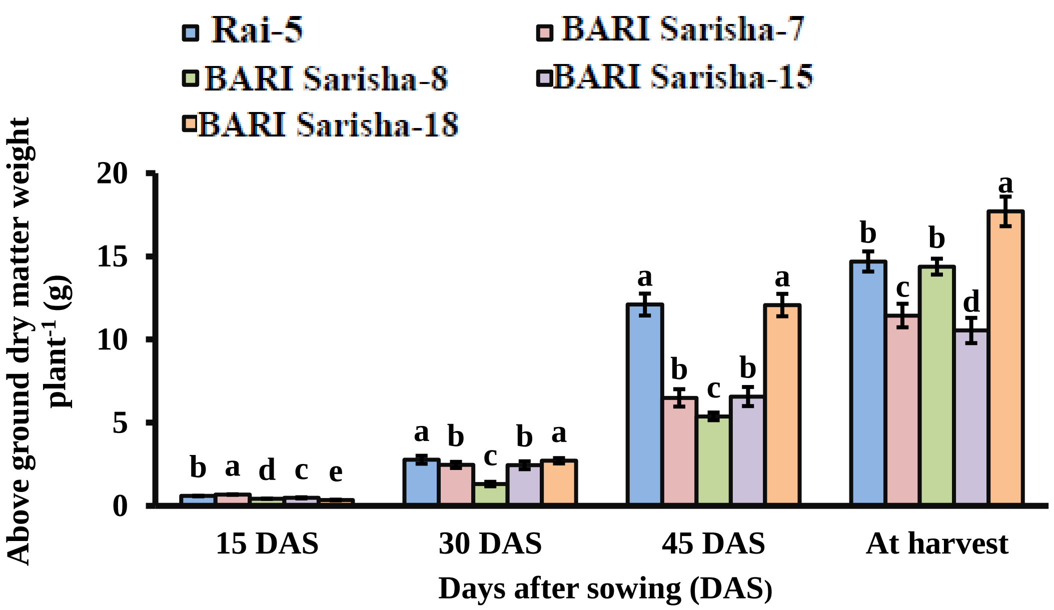


**Figure 17. Effect of variety on above ground dry matter weight plant$^{-1}$ (g) of mustard at different days after sowing.**

**Effect of weed management**

Different weed management significantly affect the above ground dry matter weight plant$^{-1}$ (g) at different days after sowing (Figure 18). Experiment result had shown that 2 weeding recorded the maximum above ground dry matter weight plant$^{-1}$(0.57, 2.66, 9.93 and 15.28 g) at 15, 30, 45 DAS and at harvest respectively. Whereas no weeding recorded the minimum above ground dry matter weight plant$^{-1}$ (0.44, 2.02, 6.88 and 11.80 g) at 15, 30, 45 DAS and at harvest respectively. The above ground dry matter weight plant$^{-1}$ (g) differ over weedy check ($w_0$) treatment was due to reason that different weed management reduced weed density which ultimatly help undisturbed plant growth by utilizing its surrounded resources.

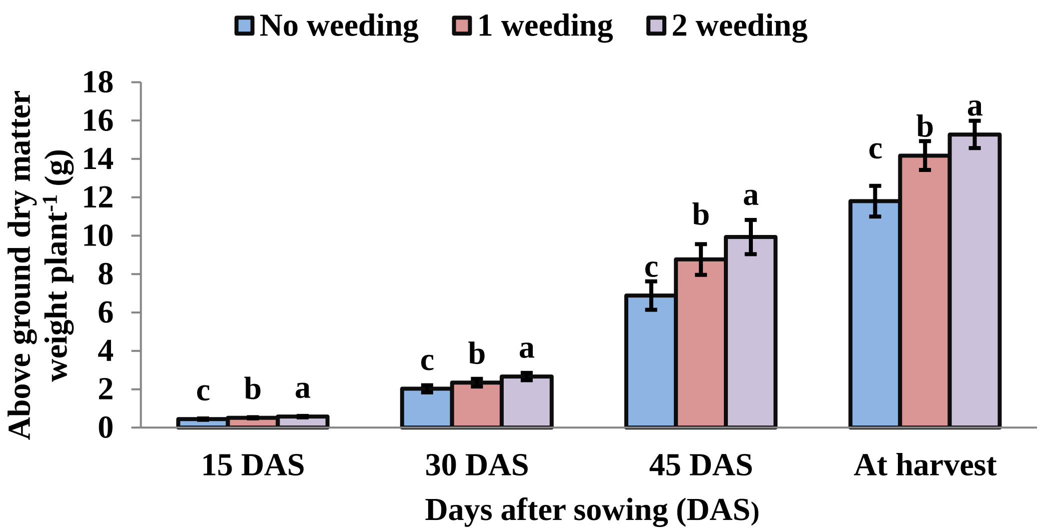


**Figure 18. Effect of weed management on above ground dry matter weight plant$^{-1}$ (g) of mustard at different days after sowing.**

**Combined effect of variety and weed management**

Different mustard varieties along with different weed management significantly affect the above ground dry matter weight plant$^{-1}$ (g) of mustard at different days after sowing (Table 19). Experiment result had shown that cultivation of BARI Sarisha-7 variety along with 2 weeding recorded the maximum above ground dry matter weight plant$^{-1}$ (g) (0.74 g) at 15 DAS. At 30 DAS cultivation of RAI-5 variety along with 2 weeding recorded the maximum above ground dry matter weight plant$^{-1}$(3.24 g). At 45 DAS and at harvest respectively cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum above ground dry matter weight plant$^{-1}$

(14.10 and 20.33 g) which was statistically similar with cultivation of RAI-5 variety along with 2 weeding recorded above ground dry matter weight plant$^{-1}$(14.00 g) at 45 DAS. Whereas cultivation of BARI Sarisha-18(Canola) variety along with no weeding recorded the minimum above ground dry matter weight plant$^{-1}$(0.28 g) at 15 DAS. At 30 DAS cultivation of BARI Sarisha-8 variety along with no weeding recorded the minimum above ground dry matter weight plant$^{-1}$ (1.04 g) which was statistically similar with cultivation of BARI Sarisha-8 variety along with 1 weeding recorded above ground dry matter weight plant$^{-1}$ (1.22 g). At 45 DAS and at harvest respectively cultivation of BARI Sarisha-15 along with no weeding recorded the minimum above ground dry matter weight plant$^{-1}$ (4.55 and 7.92 g) which was statistically similar with cultivation of BARI Sarisha-7 variety along with no weeding recorded above ground dry matter weight plant$^{-1}$ (4.66 g), Cultivation of BARI Sarisha-8 variety along with no weeding recorded above ground dry matter weight plant$^{-1}$ (5.00 g), cultivation of BARI Sarisha-8 variety along with 1 weeding recorded above ground dry matter weight plant$^{-1}$ (5.29 g) at 45 DAS and with cultivation of BARI Sarisha-7 variety along with no weeding recorded above ground dry matter weight plant$^{-1}$ (9.06 g) at harvest respectively.

**Table 19. Combined effect of variety and weed management on dry matter weight plant$^{-1}$ of mustard at 15, 30, 45 DAS and at harvest respectively**

| Treatment Combinations | Dry matter weight plant$^{-1}$ (g) | | | |
|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | At harvest |
| $V_1W_0$ | 0.53 ±0.01 d | 2.39 ±0.63ef | 10.78 ±1.38 c | 13.78 ±2.1 de |
| $V_1W_1$ | 0.60 ±0.02bc | 2.70 ±0.67 cd | 11.49 ±1.43 c | 14.49 ±1.61 d |
| $V_1W_2$ | 0.65 ±0.02 b | 3.24 ±0.81 a | 14.00 ±1.75 a | 15.81 ±1.75 c |
| $V_2W_0$ | 0.64 ±0.02 b | 2.30 ±0.57 f | 4.66 ±0.58 h | 9.06 ±1 h |
| $V_2W_1$ | 0.65 ±0.02 b | 2.50 ±0.62 d-f | 7.15 ±0.89ef | 12.30 ±1.36fg |
| $V_2W_2$ | 0.74 ±0.02 a | 2.59 ±0.65 c-e | 7.66 ±0.95ef | 12.96 ±1.44ef |
| $V_3W_0$ | 0.41 ±0.01 e | 1.04 ±0.26 h | 5.0 ±0.62gh | 14.00 ±1.55 de |
| $V_3W_1$ | 0.42 ±0.01 e | 1.22 ±0.31 h | 5.29 ±0.66gh | 14.29 ±1.58 d |
| $V_3W_2$ | 0.46 ±0.01 e | 1.67 ±0.42 g | 5.84 ±0.72 g | 14.84 ±1.64 cd |
| $V_4W_0$ | 0.34 ±0.01 f | 1.82 ±0.45 g | 4.55 ±0.56 h | 7.92 ±0.87 h |
| $V_4W_1$ | 0.54 ±0.01 d | 2.68 ±0.67 cd | 7.13 ±0.89 f | 11.27 ±1.25 g |
| $V_4W_2$ | 0.56 ±0.01 cd | 2.81 ±0.7bc | 8.03 ±1 e | 12.44 ±1.38 f |
| $V_5W_0$ | 0.28 ±0.01 g | 2.54 ±0.63 de | 9.41 ±1.17 d | 14.23 ±1.58 d |
| $V_5W_1$ | 0.34 ±0.02 f | 2.60 ±0.65 c-e | 12.71 ±1.58 b | 18.52 ±2.05 b |
| $V_5W_2$ | 0.44 ±0.11 e | 2.98 ±0.24 b | 14.10 ±0.23 a | 20.33 ±0.04 a |
| **SE** | 0.02 | 0.11 | 0.42 | 0.52 |
| **CV(%)** | 6.07 | 5.63 | 6.07 | 4.71 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.8 Yield contributing characters

#### 4.2.8.1 Siliqua length plant$^{-1}$ (cm)

**Effect of variety**

Different variety significantly affect the siliqua length plant$^{-1}$ (cm) of mustard (Figure 19). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum siliqua length plant$^{-1}$ (7.55 cm) while cultivation of RAI-5 variety recorded the minimum siliqua length plant$^{-1}$ (3.36 cm). Different mustard varieties have different siliqua length plant$^{-1}$ was due to the genetic makeup of the variety.

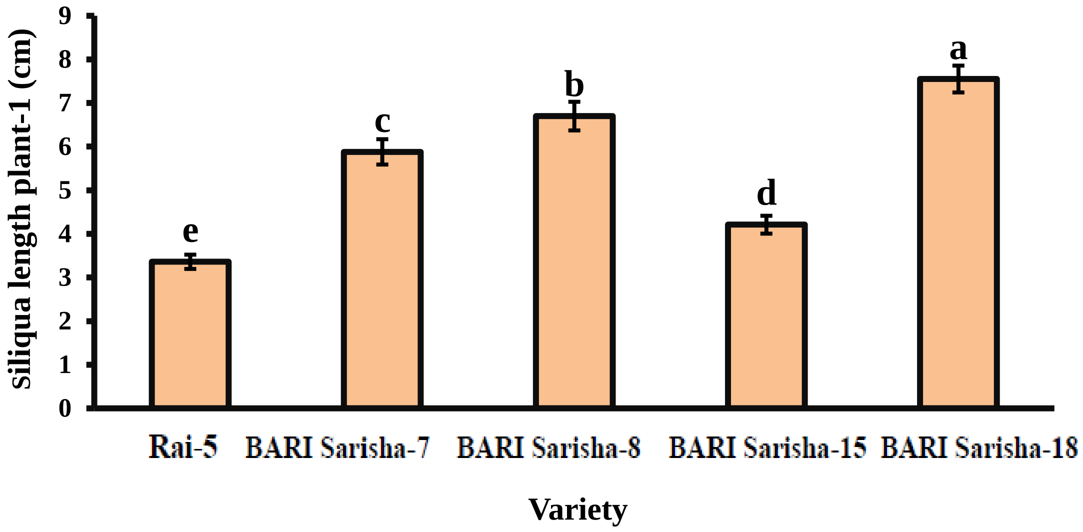


**Figure 19. Effect of variety on siliqua length plant$^{-1}$ (cm) of mustard.**

**Effect of weed management**

Different weed management significantly affect the siliqua length plant$^{-1}$ (cm) of mustard (Figure 20). Experiment result had shown that 2 weeding recorded the maximum siliqua length plant$^{-1}$ (5.55 cm) while no weeding recorded the minimum siliqua length plant$^{-1}$ (5.54 cm).

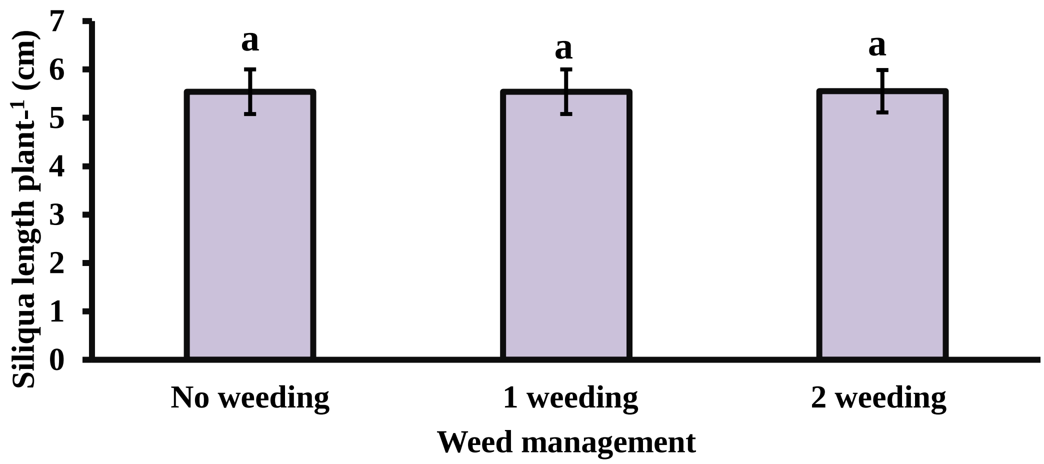


**Figure 20. Effect of weed management on siliqua length plant$^{-1}$ (cm) of mustard.**

### Combined effect of variety and weed management

Different varieties along with different weed management significantly affectthe siliqua length plant$^{-1}$ (cm) of mustard (Table 19). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) along with 2 weeding recorded the maximum siliqua length plant$^{-1}$ (7.66 cm), which was statistically similar with cultivation of BARI Sarisha-18 (Canola) along with 1 weeding recorded siliqua length plant$^{-1}$ (7.53 cm) and with cultivation of BARI Sarisha-18 (Canola) along with no weeding recorded siliqua length plant$^{-1}$ (7.53 cm). Whereas cultivation of RAI-5 along with no weeding recorded the minimum siliqua length plant$^{-1}$ (3.33 cm), which was statistically similar with cultivation of RAI-5 along with 2 weeding recorded the minimum siliqua length plant$^{-1}$ (3.33 cm) and with cultivation of RAI-5 along with 1 weeding recorded the minimum siliqua length plant$^{-1}$ (3.44 cm).

### 4.2.8.2 Number of siliqua plant$^{-1}$

### Effect of variety

Cultivation of different variety significantly affect the number of siliqua plant$^{-1}$ of mustard (Figure 21). Experiment result had shown that cultivation of RAI-5 variety recorded the maximum number of siliqua plant$^{-1}$ (132.07) while cultivation of BARI Sarisha-15 variety recorded the minimum number of siliqua plant$^{-1}$ (56.04) which was statistically similar with cultivation of BARI Sarisha-18 (Canola) recorded number of siliqua plant$^{-1}$ (61.91). Different mustard varieties have different number of siliqua plant$^{-1}$ was due to the genetic makeup of the variety and higher number of siliqua plant$^{-1}$ is obtained from high yielding varieties comparable to low yielding mustard varieties. The result obtained from the present study was similar with the findings of Alam *et al.* (2014) who reported that varieties of mustard significantly influence on yield and yield attributes and among different varieties maximum number of siliquae/plant (108 and 90) was recorded in BJDH -05 which differed significantly from other varieties. Mamun *et al.* (2014) also found similar result with the present study and reported that the number of siliqua plant$^{-1}$ of mustard was significantly affected by different varieties.

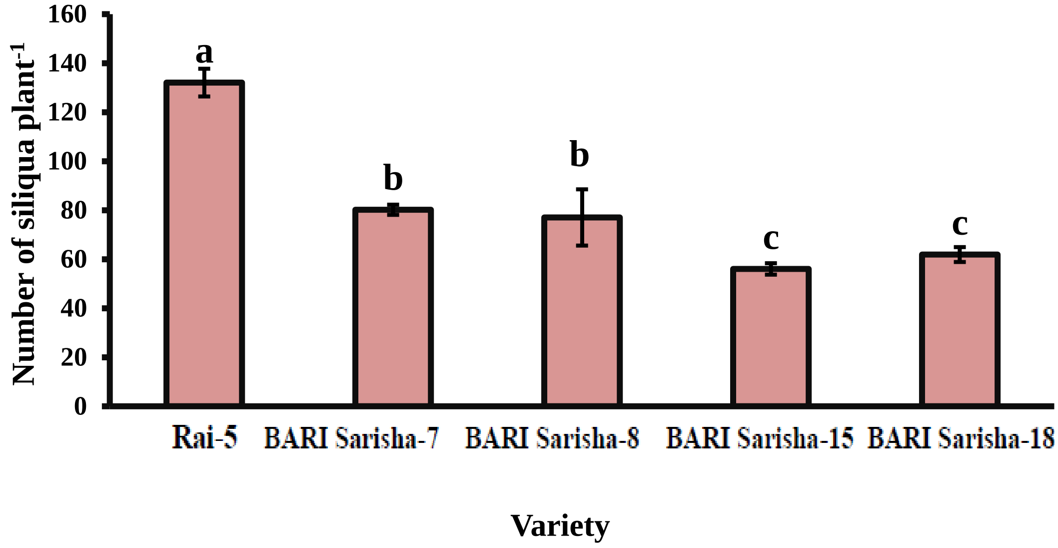


**Figure 21. Effect of variety on number of siliqua plant$^{-1}$ of mustard.**

**Effect of weed management**

Different weed management significantly affect the number of siliqua plant$^{-1}$ of mustard (Figure 22). Experiment result had shown that 2 weeding recorded the maximum number of siliqua plant$^{-1}$ (97.95) while no weeding recorded the minimum number of siliqua plant$^{-1}$ (69.97). The result obtained from the present study was similar with the findings of Singh *et al.* (2020) and they reported that maximum number of siliqua plant$^{-1}$ was recorded under Two hand weeding at 20 & 40 DAS followed by treatment having pendimethalin (PE) 1.00 kg ha$^{-1}$ + Hand weeding at 30 DAS.

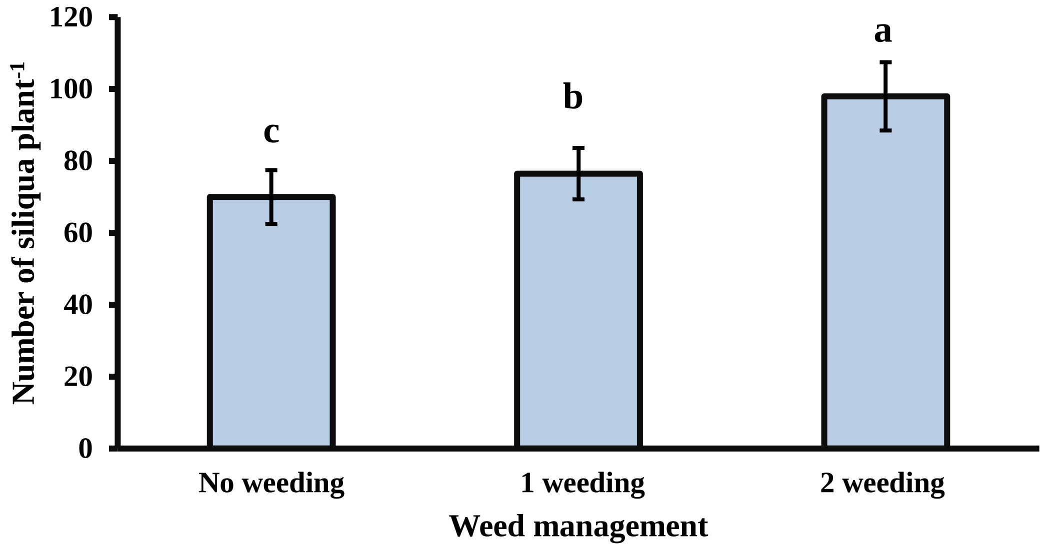


**Figure 22. Effect of weed management on number of siliqua plant$^{-1}$of mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management significantly affect the number of siliqua plant$^{-1}$ of mustard. (Table 20). Experiment result had shown that cultivation of RAI-5 variety along with 2 weeding recorded the maximum number of siliqua plant$^{-1}$ (151.02) whereas cultivation of BARI Sarisha-8 variety along with no weeding recorded the minimum number of siliqua plant$^{-1}$ (45.16),which was statistically similar with cultivation of BARI Sarisha-15 along with no weeding recorded number of siliqua plant$^{-1}$ (48.20) and with cultivation of BARI Sarisha-18 (Canola) along with no weeding recorded number of siliqua plant$^{-1}$ (54.27).

### 4.2.8.3 Number of seeds siliqua$^{-1}$

**Effect of variety**

Cultivation of different variety significantly affect the number of seeds siliquae$^{-1}$ of mustard (Figure 23). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum number of seeds siliquae$^{-1}$ (26.07) while cultivation of RAI-5 variety recorded the minimum number of seeds siliquae$^{-1}$(11.59). The differences of number of seeds siliqua$^{-1}$were due to the genetic makeup of the varieties. Similar result observed by Helal *et al.* (2016) and reported that, variations in terms of number of seeds siliqua$^{-1}$among all the varieties due to reason of difference in the genetic makeup of the variety, which is primarily influenced by heredity.

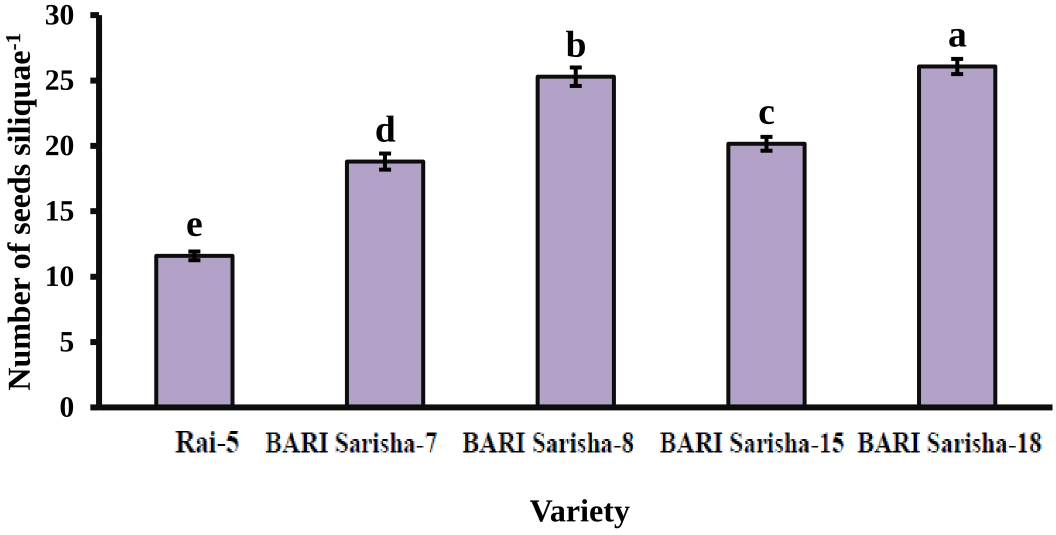


**Figure 23. Effect of variety on number of seeds siliqua$^{-1}$of Mustard.**

### Effect of weed management

Different weed management non significantly affect the number of seeds siliqua$^{-1}$ of mustard (Figure 24). Experiment result had shown that 2 weeding recorded the maximum number of seeds siliquae$^{-1}$ (20.53) while no weeding recorded the minimum number of seeds siliquae$^{-1}$ (20.25).

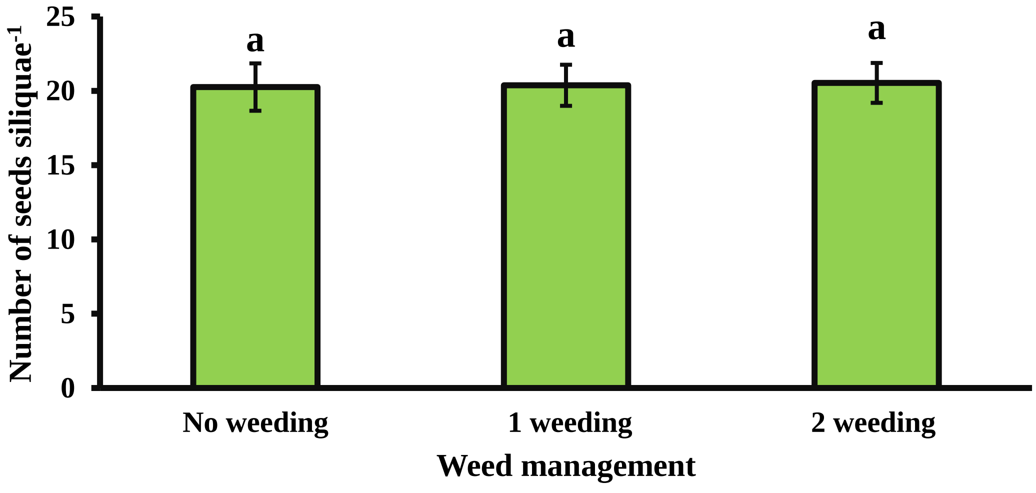


**Figure 24. Effect of weed management on number of seeds siliqua$^{-1}$ of mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management significantly affect the number of seeds siliquae$^{-1}$ of mustard. (Table 20). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum number of seeds siliquae$^{-1}$ (26.41) which was statistically similar with cultivation of BARI Sarisha-18 (Canola) variety along with no weeding recorded number of seeds siliquae$^{-1}$ of (26.34) and with cultivation of BARI Sarisha-18 (Canola) along with no weeding recorded number of seeds siliquae$^{-1}$ (26.23).Whereas cultivation of RAI-5 variety along with no weeding recorded the minimum number of seeds siliquae$^{-1}$ (11.07),which was statistically similar with cultivation of RAI-5 variety along with 1 weeding recorded number of seeds siliquae$^{-1}$ (11.80) and with cultivation of RAI-5 variety along with 2 weeding recorded number of seeds siliquae$^{-1}$ (11.92).

**4.2.8.4. 1000 seeds weight (g)**

**Effect of variety**

Different variety had shown significant effect on the 1000-seed weight (g) of mustard (Figure 25). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum 1000 seed weight (4.14 g) which was statistically similar with cultivation of BARI Sarisha-8 variety recorded 1000 seed weight (4.12 g) while cultivation of BARI Sarisha-15 variety recorded the minimum 1000 seed weight (2.77 g). The differences of the 1000 seed weight among different mustard varieties may be attributes to the varietal performance and genetic makeup of the varieties. Similar result observed by Mamun *et al.* (2014) who reported that among different varieties BARI Sarisha-13 had the highest 1000- seed weight (4.00 g) whereas the lowest (2.82 g) - in SAU Sarisha-3. Mondal and Wahab (2001) described that, weight of 1000 seeds varied from variety to variety and species to species.

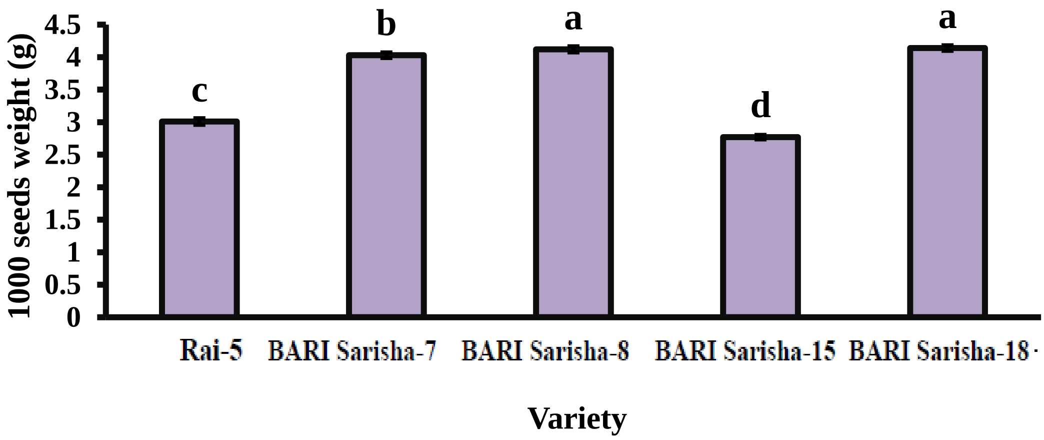


**Figure 25. Effect of variety on 1000 seeds weight (g)of mustard.**

**Effect of weed management**

Weed management had shown significant effect on the 1000 seed weight (g) of mustard (Figure 26). Experiment result had shown that 2 weeding recorded the maximum 1000 seed weight (3.73 g) while no weeding recorded the minimum 1000 seed weight (3.53 g). The result obtained from the present study was similar with the findings of Raj *et al*. (2020) and reported that growth, yield attributes, yields, and quality increased significantly under two hand weeding at 20 and 40 DAS. Singh *et al*. (2020) also reported that the maximum test weight 5g recorded under Two hand weeding at 20 &40 DAS followed by treatment having pendimethalin (PE) 1.00 kg $ha^{-1}$ + Hand weeding at 30 DAS.

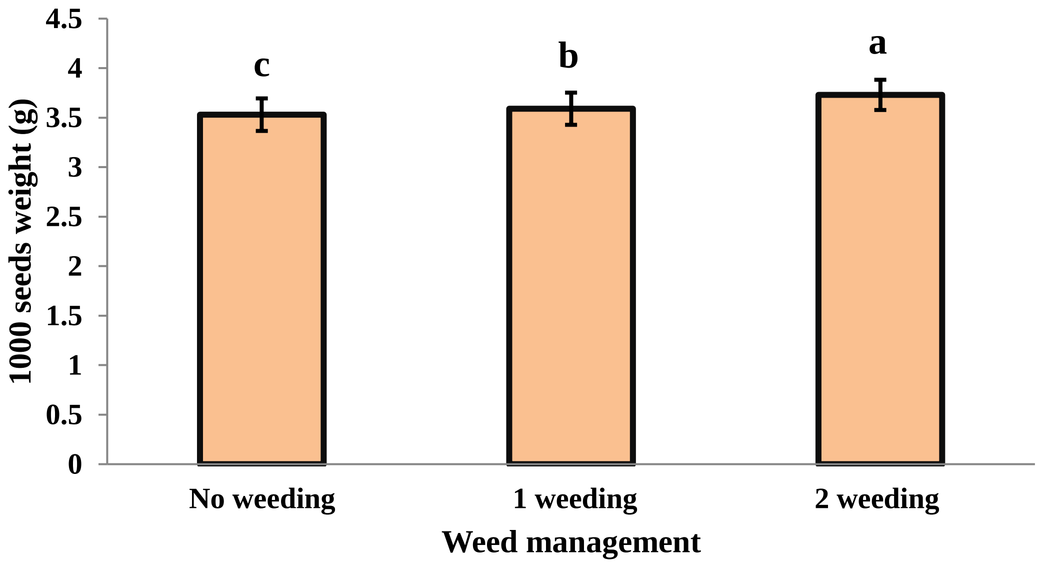


**Figure 26. Effect of weed management on 1000 seeds weight (g) of mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management had significanteffect on the 1000 seed weight (g) of mustard. (Table 20). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum 1000 seeds weight (4.28 g) which was statistically similar with cultivation of BARI Sarisha-8 variety along with 2 weeding recorded 1000 seed weight (4.25 g).Whereas cultivation of BARI Sarisha-15 variety along with no weeding recorded the minimum 1000 seed weight (2.67 g),which was statistically similar with cultivation of BARI Sarisha-15 variety along with 1 weeding recorded 1000 seed weight (2.77 g).

**Table 20. Combined effect of variety and weed management on siliqua length, No. of siliqua plant$^{-1}$, seeds siliquae$^{-1}$ and 1000 seed weight of mustard**

| Treatment Combinations | Siliqua length (cm) | No. of siliqua plant$^{-1}$ | No. of seeds siliquae$^{-1}$ | 1000 seed weight (g) |
|---|---|---|---|---|
| $V_1W_0$ | 3.33 ±0.56 g | 117.07 ±11.36 c | 11.07 ±1.01 f | 2.91 ±0.09 f |
| $V_1W_1$ | 3.44 ±0.57 g | 128.13 ±7.12 b | 11.80 ±1.07 f | 2.94 ±0.07 f |
| $V_1W_2$ | 3.33 ±0.55 g | 151.02 ±8.39 a | 11.92 ±1.08 f | 3.19 ±0.07 e |
| $V_2W_0$ | 5.67 ±0.94 e | 85.13 ±4.73 d | 17.33 ±1.57 e | 3.91 ±0.09 d |
| $V_2W_1$ | 5.87 ±0.97 de | 74.05 ±4.11ef | 19.45 ±1.76 d | 4.13 ±0.1bc |
| $V_2W_2$ | 6.11 ±1.02 d | 81.40 ±4.52 de | 19.61 ±1.78 d | 4.04 ±0.1 cd |
| $V_3W_0$ | 6.90 ±1.15 b | 45.16 ±2.51 j | 26.23 ±2.38ab | 4.11 ±0.1 c |
| $V_3W_1$ | 6.71 ±1.12bc | 64.80 ±3.6fg | 24.96 ±2.26 c | 4.00 ±0.09 cd |
| $V_3W_2$ | 6.47 ±1.08 c | 121.20 ±6.73bc | 24.69 ±2.24 c | 4.25 ±0.11 ab |
| $V_4W_0$ | 4.33 ±0.72 f | 48.20 ±2.67ij | 20.29 ±1.84 d | 2.67 ±0.06 h |
| $V_4W_1$ | 4.14 ±0.69 f | 56.93 ±3.16 g-i | 20.17 ±1.83 d | 2.77 ±0.07gh |
| $V_4W_2$ | 4.17 ±0.69 f | 63.00 ±3.5gh | 20.00 ±1.81d | 2.87 ±0.07fg |
| $V_5W_0$ | 7.46 ±1.18 a | 54.27 ±3.01 h-j | 26.34 ±2.39ab | 4.03 ±0.1 cd |
| $V_5W_1$ | 7.53 ±1.25 a | 58.33 ±3.24gh | 25.47 ±2.31bc | 4.11 ±0.1 c |
| $V_5W_2$ | 7.66 ±0.62 a | 73.13 ±15.93ef | 26.41 ±0.55a | 4.28 ±0.18 a |
| **SE** | 0.13 | 4.47 | 0.43 | 0.06 |
| **CV(%)** | 2.92 | 6.72 | 2.57 | 2.18 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.2.9 Yield characters

#### 4.2.9.1 Seed yield (t ha$^{-1}$)

**Effect of variety**

Cultivation of different variety significantly affect the seed yield (t ha$^{-1}$) of mustard (Figure 27). Experiment result had shown that cultivation of BARI Sarisha-18(Canola) variety recorded the maximum seed yield (1.81 t ha$^{-1}$) while cultivation of BARI Sarisha-15 variety recorded the minimum seed yield (0.86 t ha$^{-1}$). Different Sarisha variety have individual genetic makeup which influenced the growth and yield among different varieties. Biswas *et al.* (2019) also found similar result which supported the present finding and reported that seed yield differed among different varieties of mustard. Junjariya (2014) reported that seed yield of Indian mustard was influenced significantly with different cultivars. Zaman *et al.* (1991) who reported that seed yield of mustards was varied with different varieties.

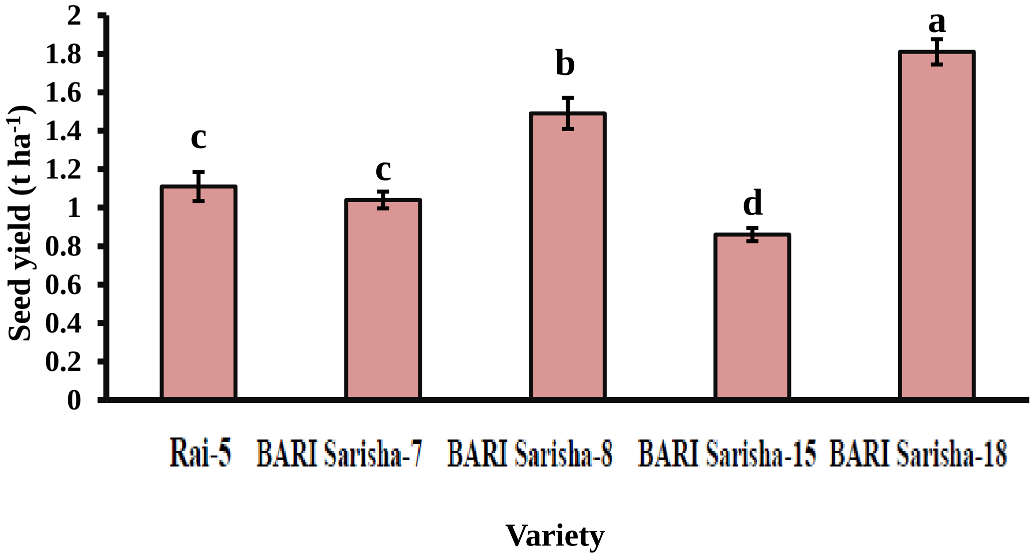


**Figure 27. Effect of variety on seed yield (t ha$^{-1}$) of mustard.**

**Effect of weed management**

Weed management hadnon-significant effect on the seed yield (t ha$^{-1}$) of mustard (Figure 28). Experiment result had shown that 2 weeding recorded the maximum seed yield (1.28 t ha$^{-1}$) while no weeding recorded the minimum seed yield (1.24 t ha$^{-1}$).

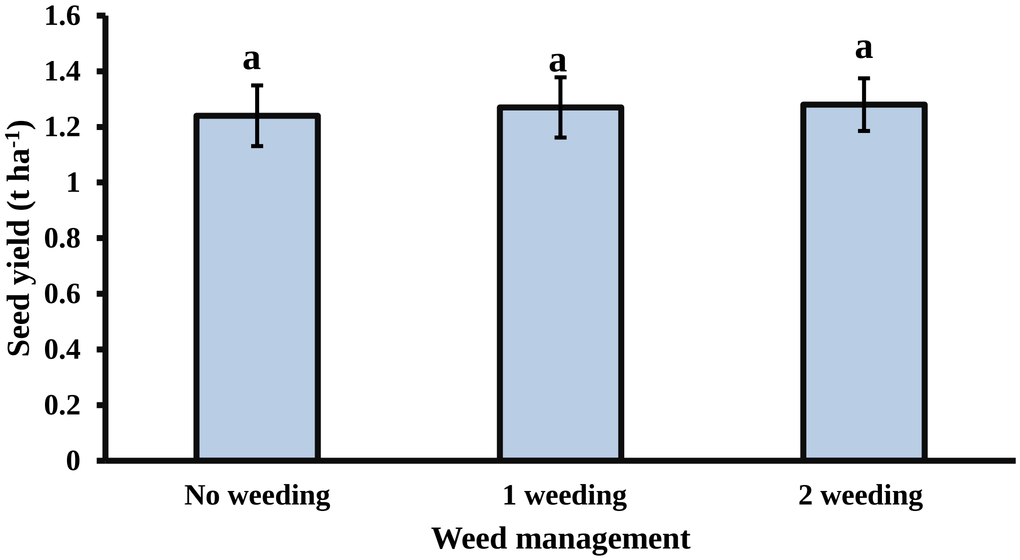


**Figure 28. Effect of weed management on seed yield (t ha$^{-1}$) of mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management on-significantly affect the seed yield (t ha$^{-1}$) of mustard. (Table 21). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum seed yield (1.85 t ha$^{-1}$). Whereas cultivation of BARI Sarisha-15 variety along with no weeding recorded the minimum seed yield (0.81 t ha$^{-1}$).

### 4.2.9.2 Stover yield (t ha$^{-1}$)

**Effect of variety**

Cultivation of different variety significantly affect the stover yield (t ha$^{-1}$) of mustard (Figure 29). Experiment result had shown that the cultivation of BARI Sarisha-8variety recorded the maximum stover yield (3.47 t ha$^{-1}$) which was statistically similar with cultivation of BARI Sarisha-18 (Canola) variety recorded stover yield (3.45 t ha$^{-1}$) while cultivation of BARI Sarisha-7 variety recorded the minimum stover yield (2.04 t ha$^{-1}$) which was statistically similar with cultivation of BARI Sarisha-15 variety recorded stover yield (2.04 t ha$^{-1}$). Sultana *et al.* (2009) also found similar result with present study and reported that stover yield of mustards were varied with different varieties.

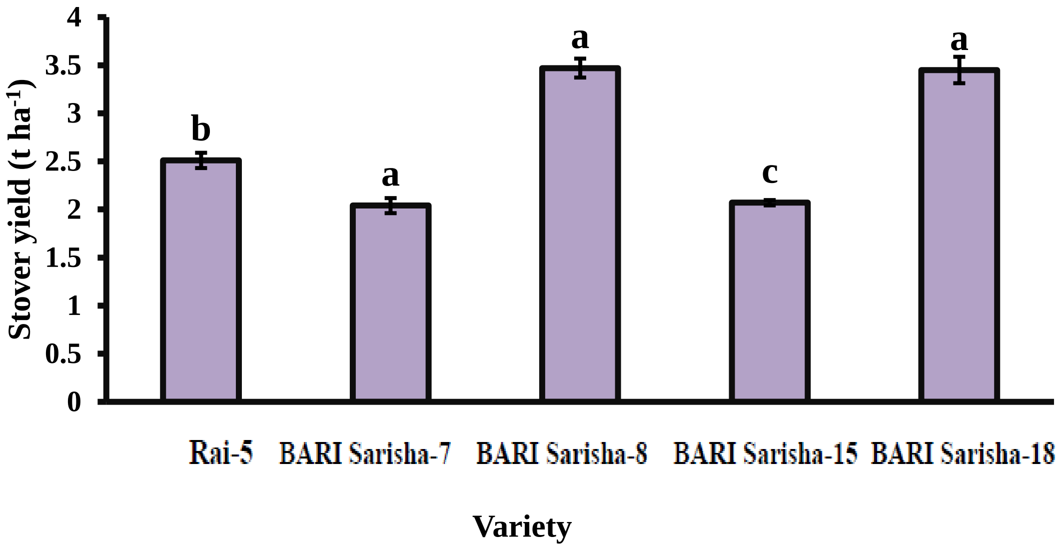


**Figure 29. Effect of variety on stover yield (t ha$^{-1}$) of mustard.**

**Effect of weed management**

Weed management had shown significant effect on the stover yield (t ha$^{-1}$) of mustard (Figure 30). Experiment result had shown that 1 weeding recorded the maximum stover yield (2.88 t ha$^{-1}$) which was statistically similar with 2 weeding recorded stover yield (2.80 t ha$^{-1}$) while no weeding recorded the minimum stover yield (2.44 t ha$^{-1}$). Gupta *et al*. (2018) also found similar result which supported the present finding and that weeding influences stover yield of mustard.

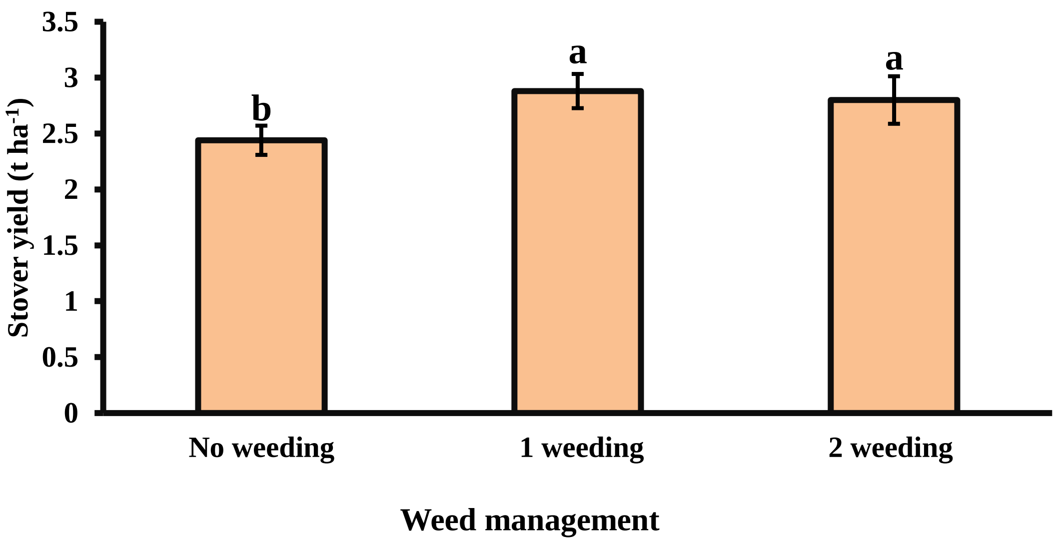


**Figure 30. Effect of weed management on stover yield (t ha$^{-1}$) of mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management had shown significant effect on the stover yield (t $ha^{-1}$) of mustard. (Table 21). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with 2 weeding recorded the maximum stover yield (3.88 t $ha^{-1}$). Whereas cultivation of BARI Sarisha-7 variety along with no weeding recorded the minimum stover yield (1.89 t $ha^{-1}$) which was statistically similar with cultivation of BARI Sarisha-7 variety along with 2 weeding recorded stover yield (1.89 t $ha^{-1}$); with cultivation of BARI Sarisha-15 variety along with 2 weeding recorded stover yield (2.01 t $ha^{-1}$); with cultivation of BARI Sarisha-15 variety along with no weeding recorded stover yield (2.05 t $ha^{-1}$) and with cultivation of BARI Sarisha-15 variety along with 1 weeding recorded stover yield (2.14 t $ha^{-1}$).

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

**Effect of variety**

Different variety cultivation had shown significant effect on the biological yield (t $ha^{-1}$) of mustard (Figure 31). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum biological yield (5.27 t $ha^{-1}$) while cultivation of BARI Sarisha-15 variety recorded the minimum biological yield (2.92 t $ha^{-1}$) which was statistically similar with cultivation of BARI Sarisha-8 variety recorded biological yield (3.08 t $ha^{-1}$). The variation of biological yield by different varieties might be due to the contribution of cumulative favorable effects of the crop characteristics viz., seed and stover yield of the crop. Tobe *et al.* (2013) also found similar result which supported the present finding and reported that variation in biological yield differ among cultivars of *B. napus*. Rana and Pachauri (2001) also quoted that cv. Bio 902 recorded higher biological yield (7250 kg $ha^{-1}$) as compared to cv. TERI (OE) M 21 (6850 kg $ha^{-1}$).

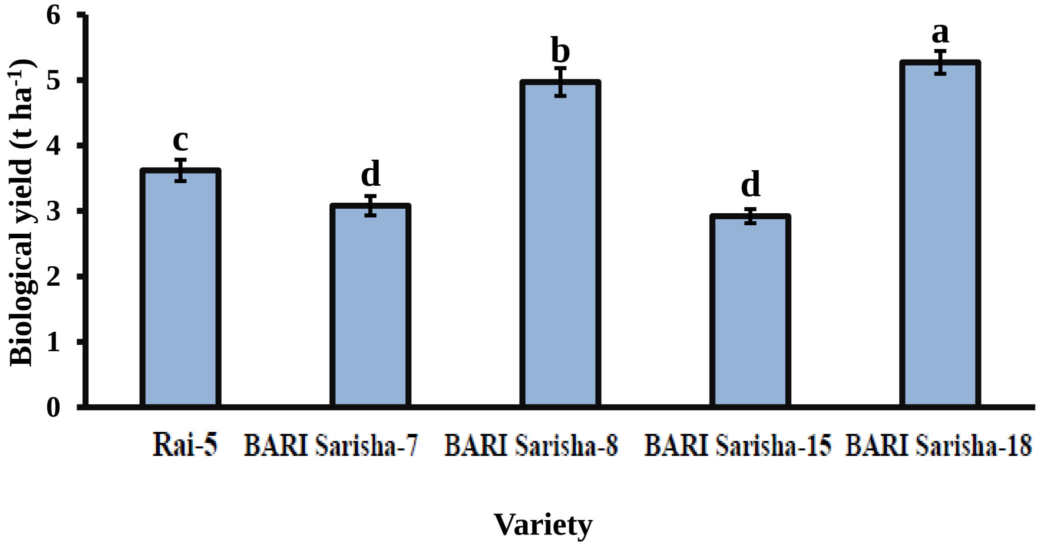


**Figure 31. Effect of variety on biological yield (t ha$^{-1}$) of mustard.**

**Effect of weed management**

Weed management had shown significant effect on the biological yield (t ha$^{-1}$) of mustard (Figure 32). Experiment result had shown that 1 weeding recorded the maximum biological yield (4.16 t ha$^{-1}$) which was statistically similar with 2 weeding recorded biological yield (4.08 t ha$^{-1}$) while no weeding recorded the minimum stove yield (3.68 t ha$^{-1}$). The variation of biological yield might be due to the effectiveness of the different weed management which influences the growth, development and proper nutrient utilization by the plant by removing weeds in crop field.

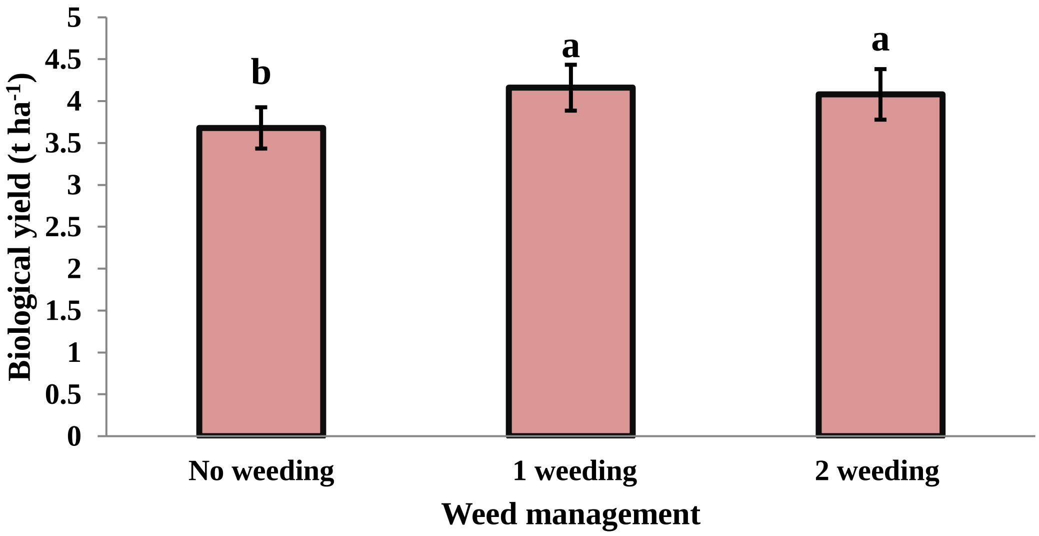


**Figure 32. Effect of weed management on biological yield (t ha$^{-1}$) of mustard.**

### Combined effect of variety and weed management

Cultivation of different varieties along with different weed management had shown significant effect on the biological yield (t $ha^{-1}$) of mustard. (Table 21). Experiment result showed that cultivation of BARI Sarisha-18 (Canola)variety along with 2 weeding recorded the maximum biological yield (5.73 t $ha^{-1}$). Whereas cultivation of BARI Sarisha-15 variety along with no weeding recorded the minimum biological yield (2.85 t $ha^{-1}$) which was statistically similar with cultivation of BARI Sarisha-7 variety along with no weeding recorded biological yield (2.88 t $ha^{-1}$); with cultivation of BARI Sarisha-7 variety along with 2 weeding recorded biological yield (2.90 t $ha^{-1}$); with cultivation of BARI Sarisha-15 variety along with 2 weeding recorded biological yield (2.92 t $ha^{-1}$) and with cultivation of BARI Sarisha-15 variety along with 1 weeding recorded stover yield (3.00 t $ha^{-1}$).

#### 4.2.9.4 Harvest index (%)

### Effect of variety

Different variety cultivation had shown significant effect on the harvest index (%) of mustard (Figure 33). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety recorded the maximum harvest index (34.72 %) which was statistically similar with cultivation of BARI Sarisha-7 variety recorded harvest index (33.93 %) while cultivation of BARI Sarisha-15 variety recorded the minimum harvest index (29.30 %) which was statistically similar with cultivation of BARI Sarisha-8 variety recorded harvest index (30.17 %) and with cultivation of RAI-5 variety recorded harvest index (30.62 %). The harvest index differed significantly among the varieties due to its genetic variability. Thakur *et al.* (2021) also found similar result which supported the present finding and reported that the different varieties have different yield potential, which is the reason for yield variation among different varieties which ultimately impact on harvest index. Uddin *et al.* (2011) reported that the harvest index differed significantly among the varieties due to its genetic variability. Shah *et al.* (1991) also reported that variety had a great influence on harvest index.

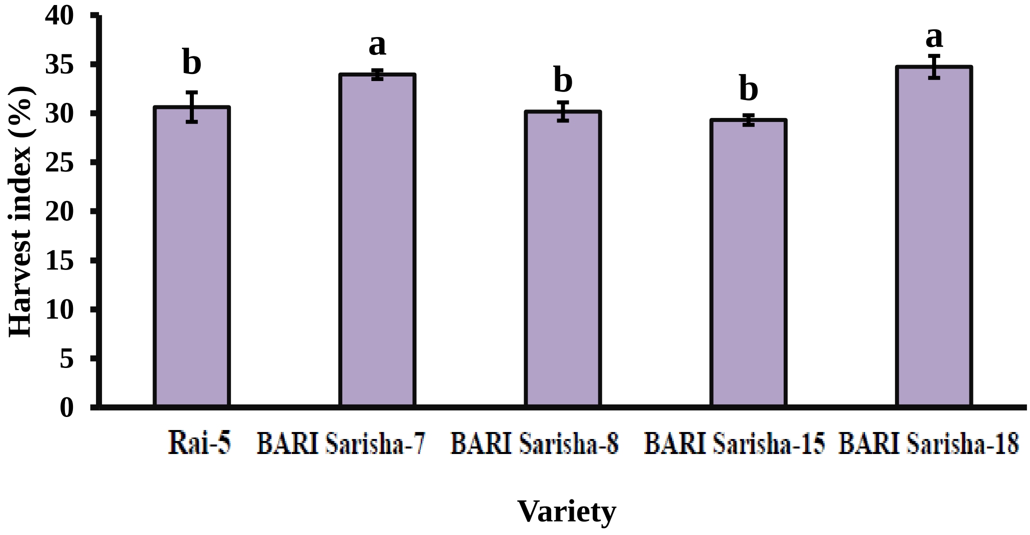


**Figure 33. Effect of variety on harvest index (%) of mustard.**

**Effect of weed management**

Weed management had shown significant effect on the harvest index (%) of mustard (Figure 34). Experiment result had shown that no weeding recorded the maximum on harvest index (33.16 %) which was statistically similar with 2 weeding recorded harvest index (31.67 %) while 1 weeding recorded the minimum harvest index (30.41 %).

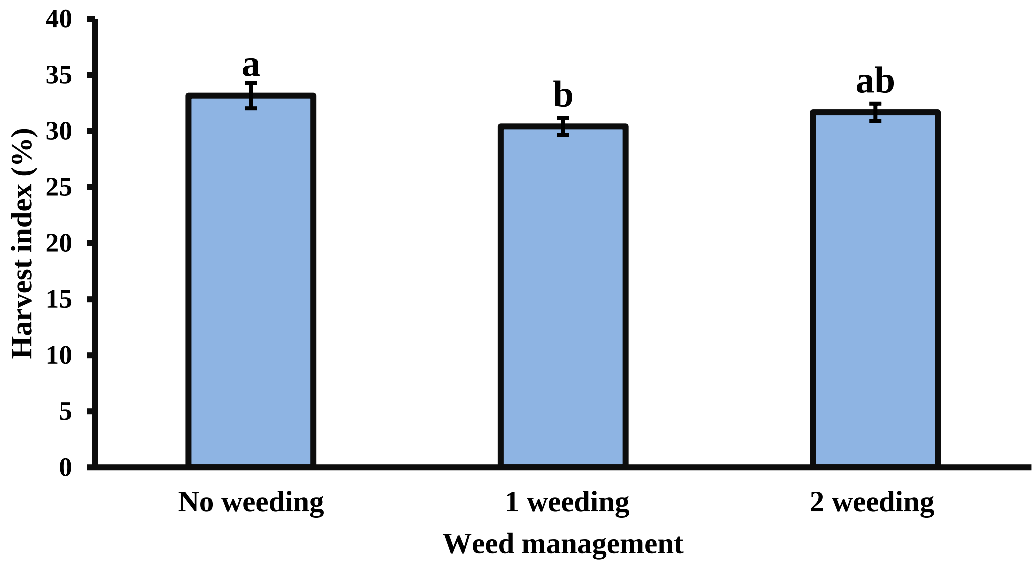


**Figure 34. Effect of variety on harvest index (%) of Mustard.**

**Combined effect of variety and weed management**

Cultivation of different varieties along with different weed management had shown non-significant effect on the harvest index (%) of mustard. (Table 21). Experiment result had shown that cultivation of BARI Sarisha-18 (Canola) variety along with no weeding recorded the maximum harvest index (37.97 %). Whereas cultivation of RAI-5 variety along with 1 weeding recorded the minimum harvest index (27.60 %).

**Table 21. Combined effect of variety and weed management on seed yield, strover yield, biological yield and harvest index of mustard**

| Treatment Combinations | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$V_1W_0$** | 1.12±0.4 | 2.24 ±0.06 e-g | 3.36 ±0.59 e | 33.32±2.58 |
| **$V_1W_1$** | 1.05±0.13 | 2.76 ±0.09 cd | 3.82 ±0.47 d | 27.60±0.75 |
| **$V_1W_2$** | 1.15±0.14 | 2.53 ±0.08 de | 3.68 ±0.46 de | 31.34±0.85 |
| **$V_2W_0$** | 0.99±0.12 | 1.89 ±0.06 h | 2.88 ±0.36 f | 34.40±0.93 |
| **$V_2W_1$** | 1.13±0.14 | 2.34 ±0.08ef | 3.47 ±0.43 e | 32.52±0.88 |
| **$V_2W_2$** | 1.01±0.12 | 1.89 ±0.06 h | 2.90 ±0.36 f | 34.89±0.94 |
| **$V_3W_0$** | 1.46±0.18 | 3.06 ±0.1 c | 4.52 ±0.56 c | 32.27±0.87 |
| **$V_3W_1$** | 1.55±0.32 | 3.66 ±0.07 ab | 5.21 ±0.65 b | 29.69±1.56 |
| **$V_3W_2$** | 1.48±0.18 | 3.70 ±0.12 ab | 5.17 ±0.65 b | 28.54±0.77 |
| **$V_4W_0$** | 0.81±0.11 | 2.05 ±0.07 f-h | 2.85 ±0.35 f | 28.23±0.76 |
| **$V_4W_1$** | 0.86±0.11` | 2.14 ±0.07 f-h | 3.00 ±0.37 f | 28.66±0.77 |
| **$V_4W_2$** | 0.91±0.11 | 2.01 ±0.06gh | 2.92 ±0.36 f | 31.01±0.84 |
| **$V_5W_0$** | 1.82±0.22 | 2.97 ±0.09 c | 4.79 ±0.59 c | 37.97±1.03 |
| **$V_5W_1$** | 1.78±0.22 | 3.51 ±0.12 b | 5.29 ±0.66 b | 33.60±0.91 |
| **$V_5W_2$** | 1.85±0.23 | 3.88 ±0.57 a | 5.73 ±0.02 a | 32.58±2.88 |
| **SE** | 0.08 | 0.15 | 0.16 | 1.85 |
| **CV(%)** | 7.62 | 6.84 | 4.95 | 7.12 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

### 4.3 Economic viability of different treatments combination

The economic performance of different treatment combinationswas determined on per hectare area basis, which includes total cost of production, gross returns, net returns and benefit cost ratio (profit over per taka investment) under treatments imposed (Table 21).

### 4.3.1 Total cost of production

Cost of production varied due to different mustard variety cultivation and weed management. The cost of production was varied mainly for the weed management. In case of no weeding, there was no involvement of cost for labor. In this experiment highest total cost of production was occurred 2 weeding treatment (57088 Tk) and lowest in no weeding.

### 4.3.2 Gross return (Tk)

Gross return was influenced by different mustard variety cultivation along with different weed management. The highest gross return (115140Tk) was recorded under cultivation of BARI Sarisha-18 (Canola) variety along with no weeding management while the minimum (52700Tk) cultivation of in BARI Sarisha-15 along with no weeding.

### 4.3.3 Net return (Tk)

Net return was varied by different mustard variety cultivation along with different weed management. The highest net return (74852Tk) was recorded under cultivation of BARI Sarisha-18 (Canola) variety along with no weeding, while the minimum (1532Tk) in cultivation of in BARI Sarisha-15 along with 2 weeding.

### 4.3.4 Benefit cost ratio (BCR)

Benefit cost ratio varied in different mustard variety cultivation along with different weed management. The highest benefit cost ratio (2.86) was recorded under cultivation of BARI Sarisha-18 (Canola) variety along with no weeding while the lowest benefit cost ratio (1.03) was recorded in cultivation of in BARI Sarisha-15 along with 2 weeding. In Allelopathic mustard varieties weed management had no significant effect on yield so its advisable for farmer to getting higher benefit, mustard crop may be cultivated alone without any consideration of weed management system.

**Table 22. Gross return, cost of production, net return and benefit cost ratio (BCR) of mustard varieties under different weed management treatments**

| Treatment | Gross return (Tk) | Total cost of production | Net return | BCR |
|---|---|---|---|---|
| $V_1W_0$ | 71680 | 40288 | 31392 | 1.78 |
| $V_1W_1$ | 68520 | 52888 | 15632 | 1.30 |
| $V_1W_2$ | 74060 | 57088 | 16972 | 1.30 |
| $V_2W_0$ | 63180 | 40288 | 22892 | 1.57 |
| $V_2W_1$ | 72480 | 52888 | 19592 | 1.37 |
| $V_2W_2$ | 64380 | 57088 | 7292 | 1.13 |
| $V_3W_0$ | 93720 | 40288 | 53432 | 2.33 |
| $V_3W_2$ | 100320 | 52888 | 47432 | 1.90 |
| $V_3W_2$ | 96200 | 57088 | 39112 | 1.69 |
| $V_4W_0$ | 52700 | 40288 | 12412 | 1.31 |
| $V_4W_1$ | 55880 | 52888 | 2992 | 1.06 |
| $V_4W_2$ | 58620 | 57088 | 1532 | 1.03 |
| $V_5W_0$ | 115140 | 40288 | 74852 | 2.86 |
| $V_5W_1$ | 113820 | 52888 | 60932 | 2.15 |
| $V_5W_2$ | 118760 | 57088 | 61672 | 2.08 |

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.

Here, NS: Non Significant, V1: RAI-5, V2: BARI Sarisha-7 , V3: BARI Sarisha-8, V4: BARI Sarisha-15, V5: BARI Sarisha-18 (Canola), $W_0$: no weeding, $W_1$: 1 weeding at 15 days and $W_2$: 2 weeding at 15 and 30 days.

# CHAPTER V

## SUMMARY AND CONCLUSION

A series of experiments were carried out in the laboratory and agronomic field of the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, from October-2019 to February 2020 in the *Rabi* season to investigate the effect of weed management through allelopathic interaction of mustard varieties. The experimental design in laboratory bioassay was a completely randomized design (CRD) with three replications. Whereas in field experiment consisted of two factors. Factor-A: Mustard varieties (5) *Viz:* RAI-5, BARI Sarisha-7, BARI Sarisha-8, BARI Sarisha-15 (Lowest allelopathic potential), BARI Sarisha-18 (Canola) and factor-B: Weed management (3) *Viz:* No weeding, 1 weeding at 15 days and 2 weeding at 15 and 30 days. The field experiment was laid out in split-plot design having 3 replications. Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of mustard varieties (Droner crop) on *Lactuca sativa, Raphanus sativus* and *Echinochloa colona* (Receiver crops) in lab experiment whereas significant variation were observed on growth, yield and yield contributing characteristics of mustard due to the effect of different mustard varieties, weed managements and their combinations in field experiment.

Based on the results of the present experiment, the following conclusion can be drawn:

In case of lab experiment, among 15 mustard varieties, RAI-5, BARI Sarisha-7, BARI Sarisha-8, BARI Sarisha-15, BARI Sarisha-18 (Canola) varieties performed well and showed potential allelopatic effect for reduction of germination behavior and seedling growth of *L. sativa*, *R. sativus and E. colona* (Receiver crops).

There was dominance of *Cynodon dactylon, Cyperus rotundus and Echinochloa colona* weed species in mustard field. However, weeds like *Mimosa pudica* and *Brassica kaber* also marked their presence in less numbers.

Among different mustard varieties, BARI Sarisha-18 (Canola) variety recorded the maximum seed yield (1.81 t $ha^{-1}$), biological yield (5.27 t $ha^{-1}$) harvest index (34.72 %) comparable to others mustard varieties.

In case of weed management had shown non-significant effect on the seed yield (t $ha^{-1}$) of mustard

In case of yield characteristics cultivation of different varieties along with different weed management had shown non-significant effect on the seed yield (t $ha^{-1}$) of mustard.

Among different treatment combination cultivation of BARI Sarisha-18 (Canola) variety along with no weeding was the most economically viable treatment and recorded highest gross return (115140 Tk.), net return (74852 Tk.), and benefit cost ratio (2.86) comparable to other treatments combination.

In Allelopathic mustard varieties weed management had no significant effect on the yield so it is advisable to farmer for getting higher benefit, mustard crop may be cultivated alone without any consideration of weed management system.

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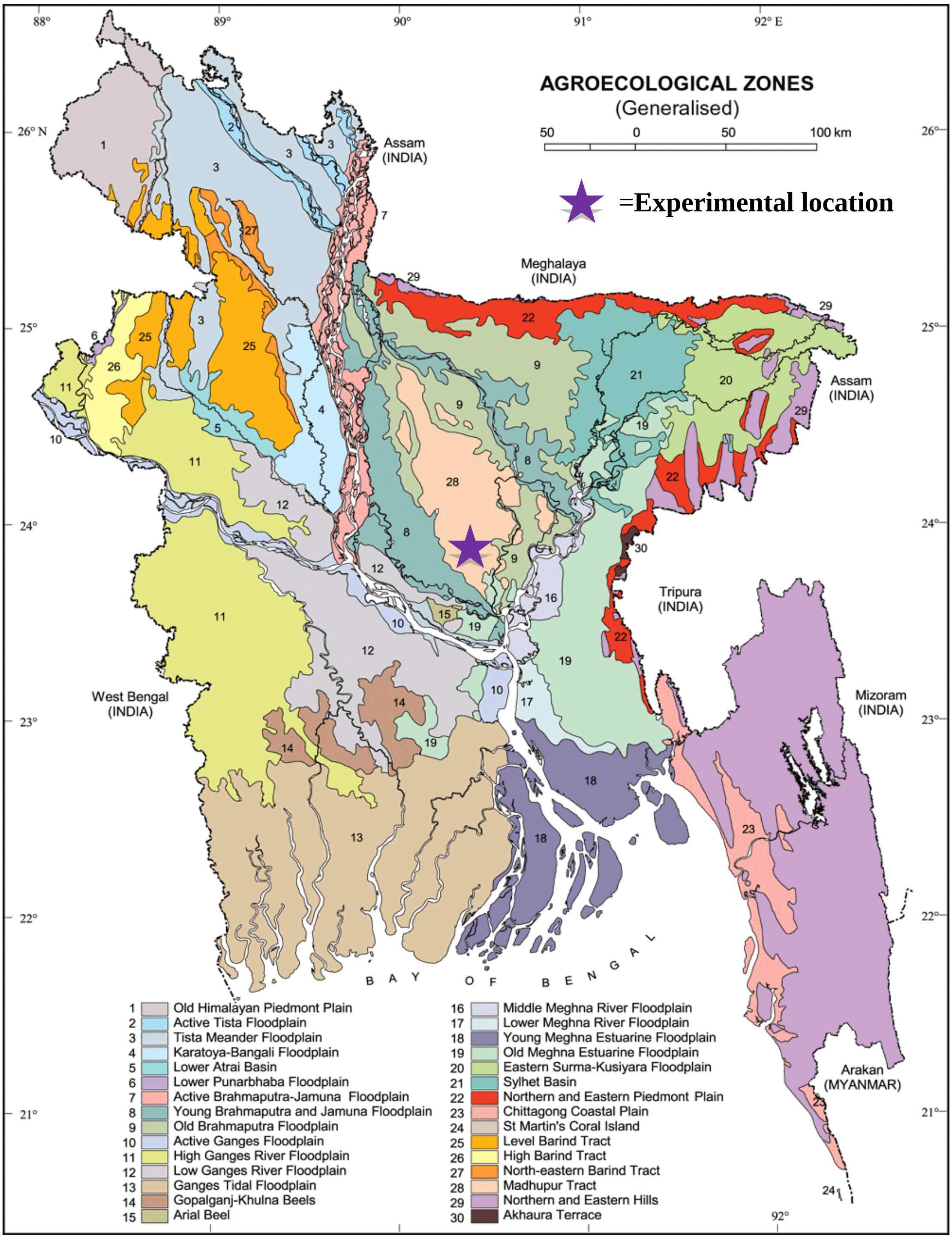
# APPENDICES

## Appendix I. Map showing the experimental location under study



**Appendix II. Soil characteristics of the experimental field**

**A. Morphological features of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow 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)**

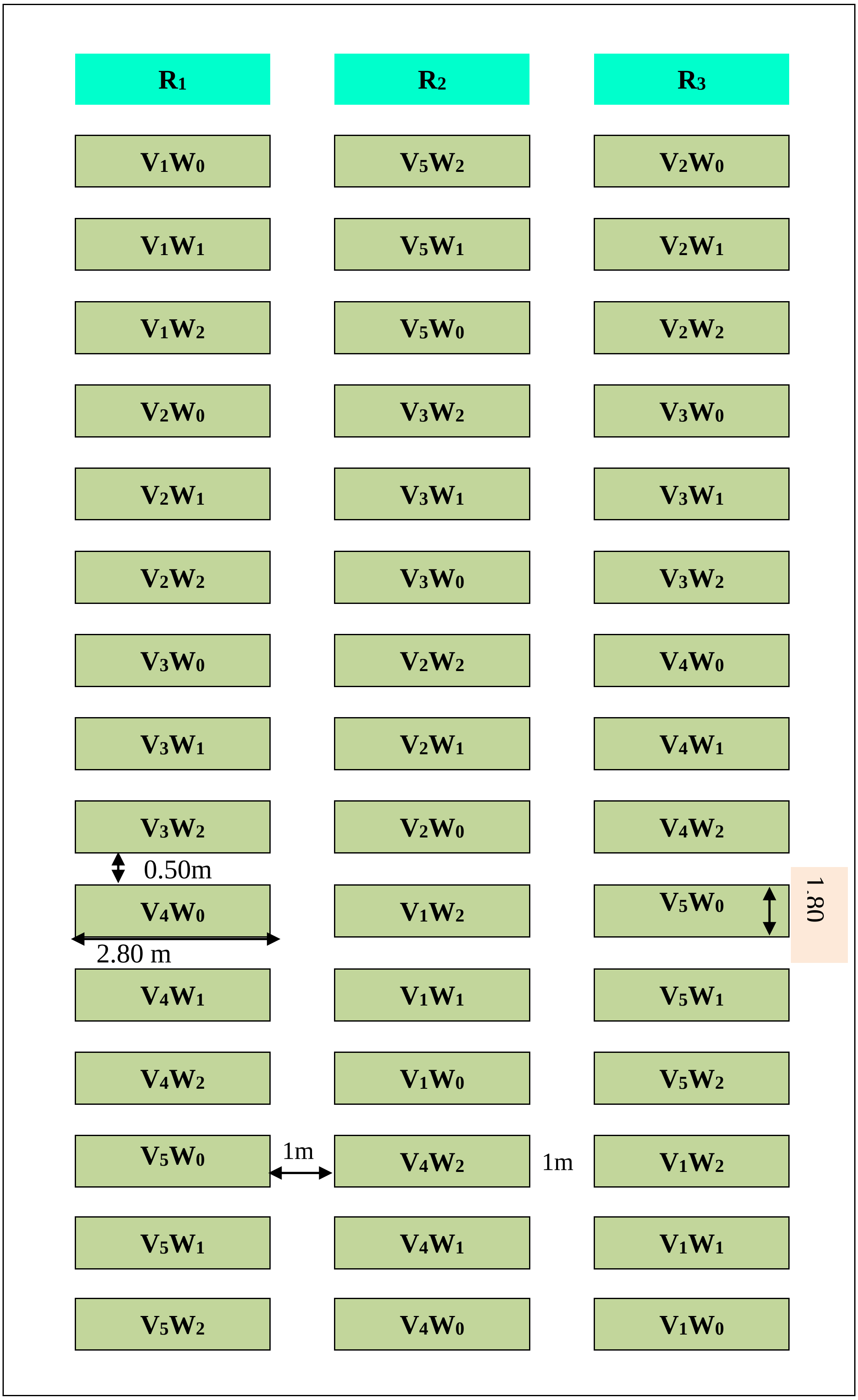
| **Physical characteristics** | |
|---|---|
| **Constituents** | **Percent** |
| Sand | 26 % |
| Silt | 45 % |
| Clay | 29 % |
| Textural class | Silty clay |
| **Chemical characteristics** | |
| **Soil characteristics** | **Value** |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20.54 |
| Exchangeable K (mg/100 g soil) | 0.10 |

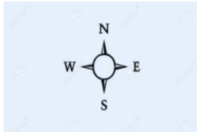
**Appendix III.Monthly meteorological information during the period from October, 2019 to February 2020**

| Year | Month | Air temperature ($^{0}C$) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2019 | October | 31.2 | 23.9 | 76 | 52 |
| | November | 29.6 | 19.8 | 53 | 00 |
| | December | 28.8 | 19.1 | 47 | 00 |
| 2020 | January | 25.5 | 13.1 | 41 | 00 |
| | February | 25.9 | 14 | 34 | 7.7 |

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

## Appendix IV. Layout of the experimental field




**LEGEND**

**Mustard variety (5) viz;**

$V_1$: RAI-5

$V_2$: BARI Mustard-7

$V_3$: BARI Mustard-8

$V_4$: BARI Mustard-15

V5: BARI Mustard-18 (Canola)

**Weed management (3) viz;**

$W_0$: No weeding

$W_1$: 1 weeding at 15 days

$W_2$: 2 weeding at 15 and 30 days

**Appendix V. Analysis of variance of the data of germination percentage (%) of *L. sativa, R. sativus and E. colona***

| Mean square of germination percentage (%) of | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1282.80** | 1037.90** | 1615.14** |
| Error | 30 | 0.60 | 0.33 | 0.20 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix VI. Analysis of variance of the data of relative seed germination (%) of *L. sativa, R. sativus and E. colona***

| Mean square of relative seed germination (%) of | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1282.80** | 1137.03** | 2198.31** |
| Error | 30 | 1.33 | 3.53 | 0.87 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix VII. Analysis of variance of the data of coefficient of the rate of germination of receiver plant**

| Mean square of coefficient of the rate of germination of receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 0.01373** | 8.685E-03** | 0.61769** |
| Error | 30 | 0.00009 | 6.667E-05 | 0.00009 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix VIII. Analysis of variance of the data of speed of germination of the receiver plant**

| Mean square of speed of germination of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 13.5836** | 12.9093** | 8.41738** |
| Error | 30 | 0.0040 | 0.0087 | 0.00333 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix IX. Analysis of variance of the data of relative elongation ratio of shoot of the receiver plant**

| Mean square of relative elongation ratio of shoot of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1147.47** | 406.783** | 1589.90** |
| Error | 30 | 1.67 | 2.267 | 1.40 |
| Total | 44 | | | |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix X. Analysis of variance of the data of relative elongation ratio of root of the receiver plant**

| Mean square of relative elongation ratio of root of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 978.871** | 1369.75** | 922.847** |
| Error | 30 | 1.200 | 0.93 | 1.133 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XI. Analysis of variance of the data of Germination index of the receiver plant**

| Mean square of relative germination index of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1566.99** | 1952.01** | 1077.55** |
| Error | 30 | 0.89 | 0.65 | 0.32 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XII. Analysis of variance of the data of germination inhibition (%) of the receiver plant**

| Mean square of germination inhibition (%) of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1282.80** | 1137.03** | 2198.31** |
| Error | 30 | 1.33 | 0.33 | 0.87 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XIII. Analysis of variance of the data of shoot length inhibition (%) of the receiver plant**

| Mean square of shoot length inhibition (%) of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 1147.47** | 406.800** | 1591.59** |
| Error | 30 | 0.40 | 0.067 | 0.13 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XIV. Analysis of variance of the data of root length inhibition (%) of the receiver plant**

| Mean square of root length inhibition (%) of the receiver plant | | | | |
|---|---|---|---|---|
| Source | DF | *L. sativa* | *R. sativus* | *E. colona* |
| treatment | 14 | 978.871** | 1369.75** | 923.393** |
| Error | 30 | 0.267 | 0.17 | 0.200 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XV. Analysis of variance of the data of weed density ($m^{-2}$) and weed dry weight ($g\ m^{-2}$) at 15 and 30 DAS**

| **Mean square of** | | | | | |
|---|---|---|---|---|---|
| Source | | **Weed density ($m^{-2}$) at** | | **Weed dry weight ($g\ m^{-2}$) at** | |
| | Df | 15 DAS | 30 DAS | 15 DAS | 30 DAS |
| Replication (A) | 2 | 0.867 | 5.4 | 0.467 | 2.47 |
| Variety (V) | 4 | 411.811** | 968.1** | 244.001** | 158.49** |
| Error | 8 | 1.867 | 6.9 | 0.717 | 2.55 |
| Weeding(W) | 2 | 95.556** | 11236.3** | 84.921** | 3695.28** |
| V×W | 8 | 6.278** | 100.2** | 8.373** | 64.28** |
| Error | 20 | 1.067 | 6.6 | 0.667 | 1.33 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XVI. Analysis of variance of the data of weedcontrol efficiency (%) and weed control index(%) at 15 and 30 DAS**

| **Mean square of** | | | | | |
|---|---|---|---|---|---|
| Source | | **Weed control efficiency (%) at** | | **Weed control index(%) at** | |
| | Df | 15 DAS | 30 DAS | 15 DAS | 30 DAS |
| Replication (A) | 2 | 0.067 | 0.9 | 0.47 | 2.0 |
| Variety (V) | 4 | 105.390** | 95.8** | 925.77** | 416.2** |
| Error | 8 | 0.150 | 1.2 | 0.97 | 1.9 |
| Weeding (W) | 2 | 385.273** | 12680.7** | 1748.06** | 15601.3** |
| V×W | 8 | 28.440** | 111.9** | 258.76** | 138.3** |
| Error | 20 | 0.133 | 1.1 | 0.87 | 1.9 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XVII. Analysis of variance of the data of plant height of mustard at different DAS**

| Mean square of plant height at | | | | | |
|---|---|---|---|---|---|
| Source | Df | **15 DAS** | **30 DAS** | **45 DAS** | **At harvest** |
| Replication (A) | 2 | 30.8808 | 30.872 | 116.25 | 57.88 |
| Variety (V) | 4 | 91.6562** | 393.580** | 4606.52** | 7308.39** |
| Error | 8 | 0.2688 | 0.656 | 1.53 | 60.63 |
| Weeding (W) | 2 | 10.0092** | 19.145** | 310.43** | 894.58** |
| V×W | 8 | 6.3659** | 1.473* | 13.39* | 186.76* |
| Error | 20 | 0.3719 | 0.556 | 5.00 | 60.08 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XVIII. Analysis of variance of the data of number of primary and secondary branches of mustard at 45 DAS and at harvest**

| Mean square of | | | | | |
|---|---|---|---|---|---|
| | | **No. of primary branches** | | **No. of secondary branches** | |
| Source | Df | **45 DAS** | **At harvest** | **45 DAS** | **At harvest** |
| Replication (A) | 2 | 0.0187 | 0.0496 | 0.0147 | 0.0487 |
| Variety (V) | 4 | 19.7444** | 18.3358** | 24.0815** | 25.2102** |
| Error | 8 | 0.0387 | 0.0396 | 0.0231 | 0.0562 |
| Weeding (W) | 2 | 1.2382** | 3.8096** | 0.8079** | 7.3849** |
| V×W | 8 | 0.9404** | 0.4518** | 0.5745** | 2.5782** |
| Error | 20 | 0.0347 | 0.0289 | 0.0214 | 0.0547 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XIX. Analysis of variance of the data of number of leaves plant$^{-1}$ of mustard at different DAS**

| Mean square of number of leaves plant$^{-1}$ at | | | | |
|---|---|---|---|---|
| Source | Df | **15 DAS** | **30 DAS** | **45 DAS** |
| Replication (A) | 2 | 0.03800 | 0.0740 | 0.467 |
| Variety (V) | 4 | 1.18889** | 13.2600** | 971.633** |
| Error (A×V) | 8 | 0.01550 | 0.0832 | 0.717 |
| Weeding (W) | 2 | 0.28889** | 0.4169** | 6.585** |
| V×W | 8 | 0.28889** | 0.2680** | 26.239** |
| Error (A×V×W) | 20 | 0.01300 | 0.0813 | 0.667 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XX. Analysis of variance of the data of above ground dry matter weight plant$^{-1}$ (g)of mustard at different DAS**

| Mean square of above ground dry matter weight plant$^{-1}$ (g)at | | | | | |
|---|---|---|---|---|---|
| Source | Df | **15 DAS** | **30 DAS** | **45 DAS** | **At harvest** |
| Replication (A) | 2 | 0.00135 | 0.01400 | 0.2540 | 0.2660 |
| Variety (V) | 4 | 0.14916** | 3.15806** | 97.1537** | 73.0759** |
| Error | 8 | 0.00130 | 0.01817 | 0.2707 | 0.4577 |
| Weeding (W) | 2 | 0.06293** | 1.52966** | 35.4089** | 47.3579** |
| V×W | 8 | 0.00557** | 0.10903** | 2.1747** | 3.8577** |
| Error | 20 | 0.00095 | 0.01733 | 0.2673 | 0.4193 |

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XXI. Analysis of variance of the data of siliqua length, No. of siliqua plant$^{-1}$ , seeds siliquae$^{-1}$ and 1000 seed weight of mustard**

| Mean square of above ground dry matter weight plant$^{-1}$ (g)at | | | | | |
|---|---|---|---|---|---|
| Source | Df | **Siliqua length (cm)** | **No. of siliqua plant$^{-1}$** | **No. of seeds siliquae$^{-1}$** | **1000 seed weight (g)** |
| Replication (A) | 2 | 0.0321 | 20.60 | 0.271 | 0.00685 |
| Variety (V) | 4 | 26.9644** | 8124.16** | 306.663** | 3.99483** |
| Error | 8 | 0.0331 | 32.27 | 0.276 | 0.00602 |
| Weeding (W) | 2 | 0.0004$^{Ns}$ | 3218.72** | 0.288 $^{Ns}$ | 0.15810** |
| V×W | 8 | 0.0902* | 728.14** | 2.027** | 0.01971* |
| Error | 20 | 0.0262 | 29.93 | 0.275 | 0.00619 |

Ns= Non significant
**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XXII. Analysis of variance of the data of seed yield, strover yield, biological yield and harvest index of mustard**

| Mean square of above ground dry matter weight plant$^{-1}$ (g)at | | | | | |
|---|---|---|---|---|---|
| Source | Df | **Seed yield ($t\ ha^{-1}$)** | **Stover yield ($t\ ha^{-1}$)** | **Biological yield ($t\ ha^{-1}$)** | **Harvest index (%)** |
| Replication (A) | 2 | 0.01522 | 0.04951 | 0.0247 | 10.9253 |
| Variety (V) | 4 | 1.33768** | 4.59171** | 10.5482** | 52.5520** |
| Error | 8 | 0.00777 | 0.03048 | 0.0422 | 3.6581 |
| Weeding (W) | 2 | 0.00734Ns | 0.83657** | 0.9927** | 28.3930** |
| V×W | 8 | 0.00891Ns | 0.15115** | 0.1622** | 10.2452Ns |
| Error | 20 | 0.00926 | 0.03428 | 0.0387 | 5.1115 |

Ns= Non significant
**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

**Appendix XXIII. Wages and price of different items used in the experiment**

**A. Non-material cost**

| Treatment | No. of labor required | Amount taka |
|---|---|---|
| $W_0$ | 0 | 0 |
| $W_1$ | 30 | 12000 |
| $W_2$ | 50 | 20000 |

**B. Material cost**

| Sl. No. | Items Cost (Tk/kg) | Quantity (kg ha-1 ) | Cost (Tk/ha) |
|---|---|---|---|
| Seed rate ha$^{-1}$ | 60 | 10 | 600 |
| Fertilizers | | | |
| Urea | 16 | 250 | 4000 |
| TSP | 22 | 170 | 3740 |
| MP | 15 | 85 | 1275 |
| Gypsum | 8 | 150 | 1200 |
| Zinc sulphate | 250 | 5 | 1250 |
| Boric Acid | 300 | 10 | 3000 |
| Decomposed cow-dung | 300 | 8 | 2400 |
| Irrigation | 3000 | 3 | 9000 |
| Tractor | 4000 | 1 | 4000 |
| Pesticide | 2000 | 2 | 4000 |
| | | | Grand total= 34465 |

**Overhead cost**

In this experiment Over head cost was 12500 Tk.

**Miscellaneous cost (**5% of input cost**)**

| Non-material cost | Material cost | Total input cost | Miscellaneous cost | Total cost of production |
|---|---|---|---|---|
| 0 | 34465 | 34465 | 1723 | 36188 |
| 12000 | 34465 | 46465 | 2323 | 48788 |
| 20000 | 34465 | 54465 | 2723 | 57188 |

## Appendix XXIV. Gross return from mustard cultivation

**Gross Return from mustard**
Seed value = 1 kg 60 taka so 1 ton = 60000 taka

Stover value= 1 kg 2 taka so 1 ton = 2000 taka

| Treatment | Seed yield (t/ha) | Value | Stover yield (t/ha) | value | Gross retrun (Tk) |
|---|---|---|---|---|---|
| $V_1W_0$ | 1.12 | 67200 | 2.24 | 4480 | 71680 |
| $V_1W_1$ | 1.05 | 63000 | 2.76 | 5520 | 68520 |
| $V_1W_2$ | 1.15 | 69000 | 2.53 | 5060 | 74060 |
| $V_2W_0$ | 0.99 | 59400 | 1.89 | 3780 | 63180 |
| $V_2W_1$ | 1.13 | 67800 | 2.34 | 4680 | 72480 |
| $V_2W_2$ | 1.01 | 60600 | 1.89 | 3780 | 64380 |
| $V_3W_0$ | 1.46 | 87600 | 3.06 | 6120 | 93720 |
| $V_3W_2$ | 1.55 | 93000 | 3.66 | 7320 | 100320 |
| $V_3W_2$ | 1.48 | 88800 | 3.70 | 7400 | 96200 |
| $V_4W_0$ | 0.81 | 48600 | 2.05 | 4100 | 52700 |
| $V_4W_1$ | 0.86 | 51600 | 2.14 | 4280 | 55880 |
| $V_4W_2$ | 0.91 | 54600 | 2.01 | 4020 | 58620 |
| $V_5W_0$ | 1.82 | 109200 | 2.97 | 5940 | 115140 |
| $V_5W_1$ | 1.78 | 106800 | 3.51 | 7020 | 113820 |
| $V_5W_2$ | 1.85 | 111000 | 3.88 | 7760 | 118760 |

## PLATES

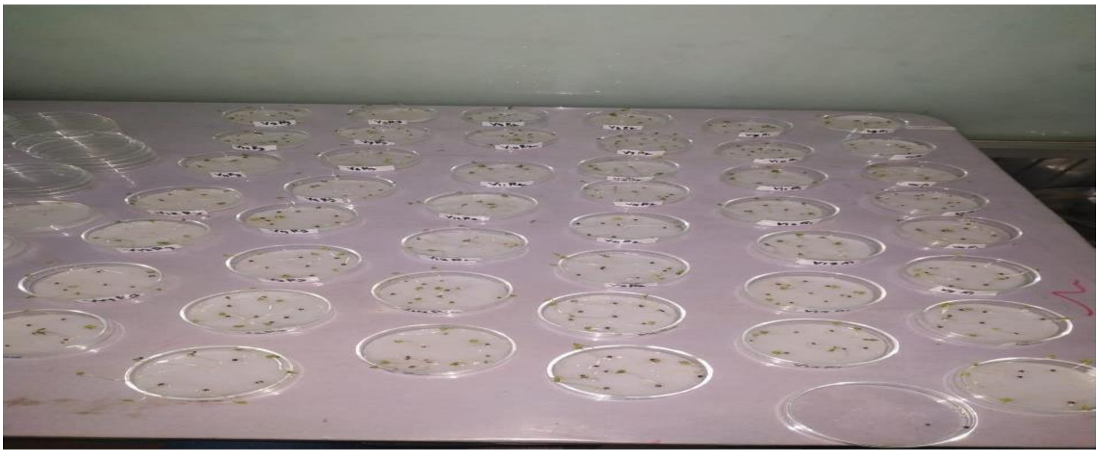


Plate 1. Picture showing L. sativa, R. sativus and E. colona seeds were placed in different mustard varieties in Petri dish

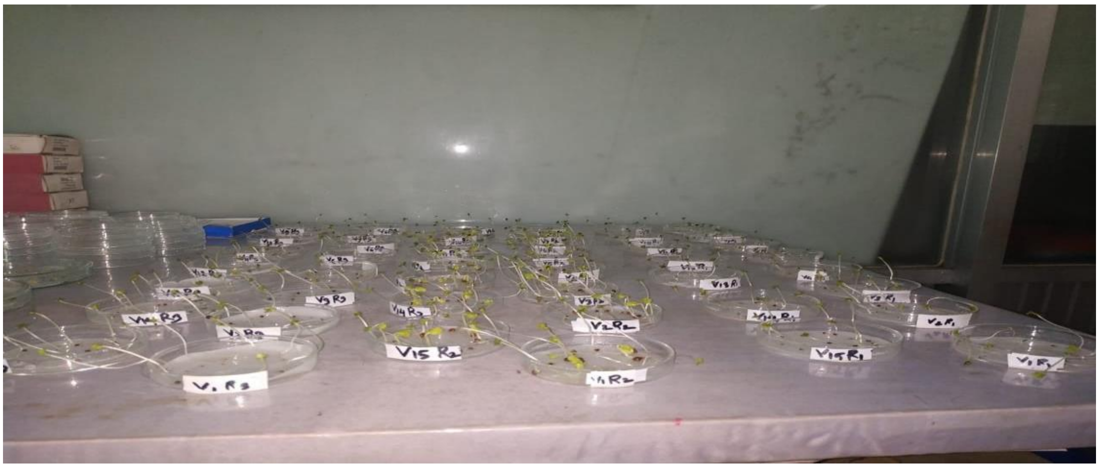


Plate 2. Picture showing L. sativa, R. sativus and E. colona seeds were germinated at different mustard varieties in Petri dish

Plate 3. Picture showing seed sowing in the experimental field

Plate 4. Picture showing thinning of seedlings of mustard