# SYSTEM OF MUSTARD INTENSIFICATION AS INFLUENCED BY VARIETY AND VERMICOMPOST

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## *CERTIFICATE*

*This is to certify that the thesis entitled, "**SYSTEM OF MUSTARD INTENSIFICATION AS INFLUENCED BY VARIETY AND VERMICOMPOST**" 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. IFTEKHAIRUL ISLAM, Registration no.19-10183** 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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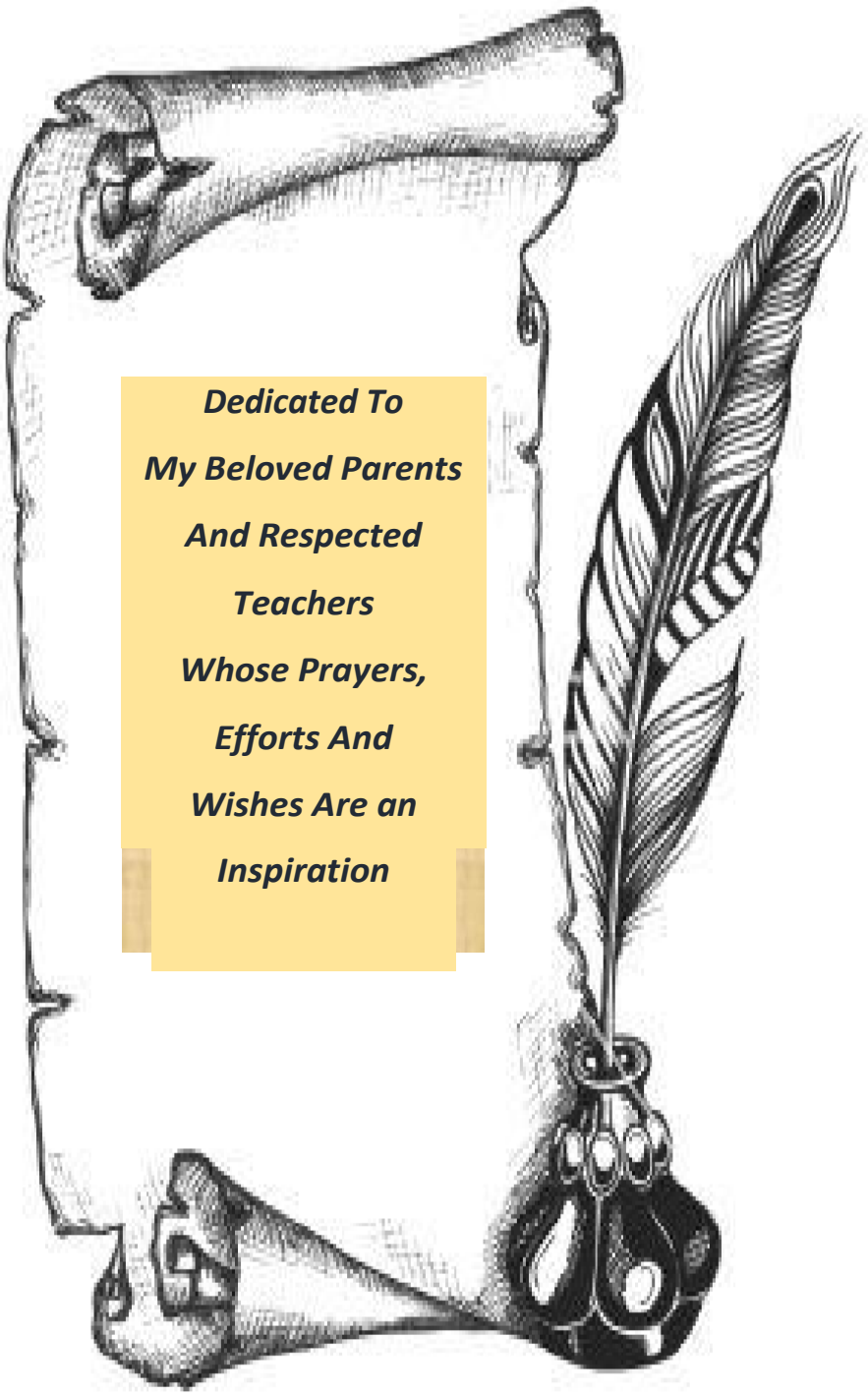

*Dedicated To*

*My Beloved Parents*

*And Respected*

*Teachers*

*Whose Prayers,*

*Efforts And*

*Wishes Are an*

*Inspiration*

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*The Author*

# SYSTEM OF MUSTARD INTENSIFICATION AS INFLUENCED BY VARIETY AND VERMICOMPOST

## ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka to study the system of mustard intensification as influenced by variety and vermicompost during the period from October 2020 to February 2021 in rabi season. The experiment consisted of two factors following randomized complete block design (RCBD) with three replications as factor A: variety (3) *viz;* $V_1$ = BARI sarisha-9, $V_2$ = BARI sarisha-14 and $V_3$= BARI sarisha-15 and factor B: different vermicompost doses (4) *viz;* $F_1$= recommended doses of fertilizer + no vermicompost,$F_2$= recommended dose of fertilizer+2 t $ha^{-1}$ vermicompost, $F_3$= recommended doses of fertilize+3 t $ha^{-1}$ vermicompost, $F_4$= recommended dose of fertilizer+4 t $ha^{-1}$ vermicompost. Data on different parameters were collected for assessing results for this experiment and showed significant variation in respect of growth yield and yield contributing characteristics of mustard due to the effect of variety, vermicompost doses and their combinations. Among different variety, BARI sarisha-9 recorded the maximum number of siliqua $plant^{-1}$ (597.46), length of siliqua (5.15 cm),seed yield (2.59 t $ha^{-1}$), stover yield (4.35 t $ha^{-1}$), biological yield (6.93t $ha^{-1}$) and harvest index (37.24%) and BARI Sarisha 14 recorded maximum seeds $siliqua^{-1}$ (32.05), 1000 seeds weight (3.55 g).In case of different vermicompost doses, application of recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot recorded the maximum number of siliqua $plant^{-1}$ (382.8), length of siliqua (5.77 cm), number of seeds $siliqua^{-1}$ (29.67), 1000 seeds weight (3.96 g), seed yield (2.26 t $ha^{-1}$), stover yield (3.84 t $ha^{-1}$), biological yield (6.10 t $ha^{-1}$) and harvest index (36.87 %).In case of combined effect, the maximum number of siliqua $plant^{-1}$ (655.07), length of siliqua (6.46 cm), seed yield (2.96 t $ha^{-1}$), stover yield (4.65 t $ha^{-1}$), biological yield (7.62 t $ha^{-1}$) and harvest index (38.92 %) were recorded in BARI Sarisha-9 ($V_1$) along with recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost ($F_4$) treated plot. Whereas number of seeds $siliqua^{-1}$ (32.67), 1000 seeds weight (4.16 g) were with BARI Sarisha-14 along with recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot. Thus for cultivation of mustard, BARI Sarisha-9 ($V_1$) along with ($F_4$) recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost performed well for higher seed production of mustard.

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## ABBREVIATIONS

| | |
|---|---|
| AEZ | Agro-Ecological Zone |
| SMI | System of Mustard Intensification |
| BARI | Bangladesh Agricultural Research Institute |
| BAU | Bangladesh Agricultural University |
| BBS | Bangladesh Bureau of Statistics |
| Co | Cobalt |
| CV% | Percentage of coefficient of variance |
| cv. | Cultivar |
| DAE | Department of Agricultural Extension |
| DAS | Days after sowing |
| $^0$C | Degree Celsius |
| *et al*. | And others |
| FAO | Food and Agriculture Organization |
| g | gram(s) |
| $ha^{-1}$ | Per hectare |
| HI | Harvest Index |
| 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 |
| TSP | Triple Super Phosphate |
| UPOV | Union for the Protection of Plant Varieties |
| Wt. | Weight |

# CHAPTER-I

# INTRODUCTION

Mustard (*Brassica spp*. L.) is a worldwide-cultivated thermos 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 (FAO, 2018).Edible oils play vital roles in human nutrition by providing calories and aiding in digestion of several fat-soluble vitamins, for example Vitamin A (NRC, 1989). The per capita recommended dietary allowance of oil is 6 g/day for a diet with 2700 Kcal (BNNC, 1984). Oilseeds were cultivated in less than 2.20 % of total arable land under rice-based cultivation system in Bangladesh, where three fourth of total cultivable land was engaged in rice production in 2015-16 (BBS, 2019). Mustard 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 (FAO, 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 in 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 USD 2371 million in 2018-19, which were 4.99 and 4.23 % of the total value of imports, respectively (BB, 2020). Yield of mustard has increased from 0.75 t $ha^{-1}$ in 2001 to 1.15 t $ha^{-1}$ in 2019 (MoA, 2008; BBS, 2019). Bangladesh was not in the advantageous position in the case of mustard production (Miah and Rashid, 2015). Under these circumstances, it becomes imperative to increase the productivity of mustard per unit area per unit time by exploiting the yield potential of existing cultivars with unconventional agronomic manipulations.

The system of mustard intensification (SMI) is a new approach for enhancement of oilseed production over the conventional planting system. Though the optimum time of sowing of the oilseed *Brassica* is the first fortnight of October in northern Asia but sowing of these crops, get delayed to November– the first week of December owing to the delayed harvest of *kharif* crops particularly rice, soybean and cotton, due to which productivity declines. In order to accommodate multiple cropping systems on

scarcely available land, transplanting of seedlings rather than direct seeding of rapeseed-mustard shall be practiced. Root intensification by transplanting the seedlings could offer such an option to boost the seedling growth and yield, which is already being practiced by raising a nursery in a seed-bed or trays or polythene bags in some irrigated rapeseed-mustard growing regions in India like Umaria and Sehore districts of Madhya Pradesh (Chaudhary *et al*., 2016), but needs to study the scope in Bangladesh.

Aside from modifying seedling growth, transplanting also has other benefits. For example, a seedbed occupies a small field area during sowing, thereby saving field area and improving land utilization efficiency. Seedbeds can even be arranged with specific substrates in a seedling factory. Thus, transplanting is much more flexible than direct seeding in terms of space utilization. Transplanting can, to some extent, alleviate the seasonal contradiction in a rice and canola rotation system. Rice canola (*Brassica napus* L.) rotation is essential for canola production in China. The delayed harvesting time of rice in recent years has seriously affected the seeding time of canola (Huang *et al.,* 2009). Consequently, rice harvesting should be completed before canola sowing. However, delayed planting of canola can reduce seed yield (Chen *et al.,* 2005). In contrast to direct seeding, seed sowing can be designed according to the optimal transplanting time on transplanting method. Therefore, transplanting is also more advantageous than direct sowing in terms of time management.

Although there are many benefits of transplanting in mustard production systems, the proper variety of mustard for transplanting remains unknown. Thus, it necessitates to find out the suitable variety and evaluating its effect on seed yield. Cultivation of low yielder local varieties with poor fertilizer management are the major causes for poor yield of mustard in the country (Alam and Rahman, 2006). High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, Bangladesh Agricultural Research Institute (BARI) has developed a number of high yielding varieties of mustard with yield potential up to 2.5 t $ha^{-1}$. The present national average yield of mustard is only 0.79 t $ha^{-1}$ (Anon., 2006). In the Old Brahmaputra Floodplain (AEZ-9), the major cropping patterns are Mustard-Boro-T.Aman rice under medium high land and Mustard Boro rice under medium low land. In those patterns, the farmers are using local variety of mustard with very poor fertilizer management and harvest very poor yield of mustard. By introducing the high yielding

varieties with better fertilizer management packages the yield of mustard can be increased manifold. Over-application of inorganic fertilizer has led to environmental contamination of water supplies and soils. In Bangladesh, soil fertility is diminishing gradually due to soil erosions, loss of nutrients, accumulation of salts and other toxic elements, water logging and unbalanced nutrient compensation. Organic manure and vermicompost are the alternate sources to meet the nutrient requirement of crops and to bridge future gaps. Vermi technology is the of surface and subsurface application varieties of earthworm in composting and management of soil (Ismail, 2005). Earthworms have important influence on soil structure, forming aggregates and improving the physical conditions for plant growth and nutrient uptake (Ansari and Sukhraj, 2010). During vermicomposting, earthworms eat, grind, and digest organic wastes with the help of aerobic and some anaerobic microflora, converting them into a much finer, humified, and microbial active material. The generated product is stable and homogeneous; having desirable aesthetics such as reduced levels of contaminants, and this converted product can be used as a fertilizer or as a source of nitrogen for microbial populations, which can be beneficial to plant growth (Ravindran *et al*., 2008). Vermicompost can meet the nutrient demand of field crops and significantly reduce the use of fertilizers (Chanda *et al.*, 2011;Hernandez *et al.*, 2010) increasing amount of readily available water, induction of N, P and K exchange there by resulting better growth of the plants (Papafotiou *et al.*, 2005; Manivannan *et al*., 2009;Buchanan *et al*., 1988). Vermicompost application improves physical, chemical and biological properties of soil (Nagavallemma *et al*., 2004). Limited information are available in Bangladesh on the effect of application of vermicompost on the growth, yield, chemical composition and oil content of oil producing *Brassica* spp.

By considering the above fact, the proposed research work was undertaken to achieve the following objectives:

**Objectives:**

i. To find out the suitable variety of mustard in System of Mustard Intensification (SMI) technique.
ii. To determine the optimum vermicompost doses for optimum growth and yield of mustard under SMI technique.
iii. To observe the combined effects of different variety and vermicompost doses on the growth and yield of mustard under SMI technique.

# CHAPTER II

# REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding the system of mustard intensification as affected by variety and vermicompost doses to gather knowledge that would be helpful in conducting the piece of work mentioned above.

## 2.1 Effect of variety

### Plant height

Nugraha *et al*. (2021) conducted a field experiment with different planting spaces; control without planting spaces, planting space of 20x20, 25x25, 30x30, 35x35, and 40x40 $cm^2$. The outcomes revealed that the mean values of mustard green plant height (13.38 cm) had significant differences to the control treatment (10 cm plant height). The results showed that the optimum planting space of organic mustard cultivation was 40x40$cm^2$, which achieved significantly higher plant height than the control without planting spaces.

Aziz *et al*. (2011) conducted a field trial after harvest of T.aman rice at the BARI Technology Village of Khagrachari, ARS, Ramgorh and at the farmers field of Dighinala of Khagrachari during the period from November 2007 to February 2008 to evaluate the performance of mustard varieties in the hill valley areas. Five varieties of mustard (Improved Tori-7, BARI Sarisha-6, BARI Sarasha-9, BARI Sarisha-11 and local) were tested. Among the varieties, BARI Sarisha-11 showed maximum plant height.

### Number of leaf $plant^{-1}$

Nugraha *et al*. (2021) performed a field experiment with different planting spaces: control without planting spaces, planting space of 20x20, 25x25, 30x30, 35x35, and 40x40 $cm^2$. The outcomes revealed that the mean values of the number of leaves (9 strands) had significant differences to the control treatment (seven strands number of leaf). The results showed that the optimum planting space of organic mustard cultivation was 40x40 $cm^2$, which achieved significantly higher number of leaves than the control without planting spaces.

Alam (2015) conducted an experiment during the period from November 2014 to March 2015 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to evaluate effort of varieties and salicylic acid (SA) on morphophysiology and yield of mustard. Who found that the among 5 varieties of mustard ($V_1$: Tori 7, $V_2$: BARI Sarisha-13, $V_3$: BARI Sarisha-14 and $V_4$: BARI Sarisha-15, $V_5$: BARI Sarisha-16), highest leaf number per plant were found in $V_5$ (BARI Sarisha 16).

**Branches and sub branches plant$^{-1}$**

Alam (2015) at SAU, conducted the experiment with 5 varieties of mustard ($V_1$: Tori 7, $V_2$: BARI Sarisha-13, $V_3$: BARI Sarisha-14 and $V_4$: BARI Sarisha-15, $V_5$: BARI Sarisha-16) and reported that the highest number of branches per plant were found in $V_5$ (BARI Sarisha 16).

**Aboveground dry matter**

Islam *et al*. (2019) conducted two experiments in two consecutive winter seasons of 2013 and 2014 at the Regional Agricultural Research Station, Ishwardi, Pabna .In this study four mustard varieties (viz.,'BARI Sharisha-14','BARI Sharisha-15','BARI Sharisha-16'and'Tori-7') were grown in two consecutive growing to assess the impact of thermal unit indices on crop growth and development, and to select the suitable variety for better yield under optimum sowing condition. Among the varieties, 'BARI Sharisha-16' produced higher dry matter**.**

**Number of Siliqua plant$^{-1}$**

Biswas *et al*. (2019) conducted an experiment at Sher-e-Bangla Agricultural University farm to observed the performance of five rapeseed and mustard varieties under two different planting techniques. The five-rapeseed and mustard varieties namely Improved Tori-7, BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU SR-3. The maximum number of siliqua plant$^{-1}$ (143.67) was obtained from BARI Sarisha -16 that was similar to SAU SR-03 (134.15) and Improved Tori-7 (116.90).

A field trial was conducted by Banerjee *et al*.(2018) at Kakdwip, West Bengal in 2014-15 and 2015-16arranging as a randomized complete block design with eight rapeseed-mustard cultivars, out of which four are BARC-released gamma-mutant

genotypes of rapeseed-mustard (TM 106, TM 217, TM 143 and TM 204) and four popular high yielding cultivars (RB50, Pusa Bold, Kranti and B85) replicated thrice. Results revealed that TM 143 produced significantly ($p \leq 0.05$) higher number of siliqua than rest others. This indicated that there was a varietal/ genotypic effect on the number of siliqua plant$^{-1}$.

**Length of siliqua**

Aziz (2014) studied with the variety BARI Sarisha-11, BARI Sarisha-13, BARI Sarisha-15 and SAU Sarisha-2. Sowing technique treatments were broadcasting, line sowing, raised bed and System of Mustard Intensification (SMI). Result showed that the biggest siliqua length was recorded at BARI Sarisha-13 and the smallest siliqua length was observed at BARI Sarisha11. -15.

**Seed Siliqua$^{-1}$**

Mamun *et al*. (2014) carried out a field experiment to evaluate the effect of variety and different plant densities on growth and yield of rapeseed mustard during Rabi 2011-12 under rain fed conditions at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities (10, 40, 70 and 100 plants m$^{-2}$) were applied during the course of study. Observed that both variety and plant density has significant effects on growth seeds siliqua$^{-1}$ (25.36).

Islam (2015) at Golapnagar char of the Padma River performed a field experiment from November 2012 to May 2013 and five mustard varieties viz., BARI Sarisha-11, BARI Sarisha-13, BARI Sarisha-14, BARI Sarisha-15 and BARI Sarisha-16 were evaluated separately in five trials for their adaptation in char land. Among the variety, BARI Sarisha-11performed better in the char land under climate change situation in Bangladesh. Number of Seeds siliqua$^{-1}$was higher than other variety in BARI Sarisha-11.

**1000 seeds weight**

Ahmed and Kashem (2017) conducted a varietal trial of mustard at Noagaon village of Dekharhaor areas of south Sunamganjupazila of Sunamganj district during November 2015 to March 2016, to find out the suitable mustard varieties. Total five varieties viz., BADC 1, SAU Sarisha-3, BARI Sarisha-11, BARI Sarisha-14 and

BARI Sarisha-15 were tested in the farmer's field. The variety BARI Sarisha-11 produced the maximum 1000-seed weight resulting the highest seed yield.

**Seed Yield**

Rathore *et al*. (2022) performed a field experiment at ICAR –Indian Agricultural Research Institute (IARI), New Delhi, on a system of mustard intensification (SMI) with a two-factor split-plot design and three replications. OSB species Brasicacarinata (PC 6), Brassicanapus (GSC 7), and Brassica juncea (var. Pusa Vijay) and crop geometries included three configurations, i.e., 60 cm × 60 cm and 45 × 45 cm as transplanted oilseed brassica, and were compared with the standard practice of direct seeding at the 45 × 15 cm crop spacing. The results revealed that Brassica carinata gave a maximum seed productivity (3173.8 kg $ha^{-1}$) under a crop geometry of 60 cm × 60 cm.

A field experiment was conducted by Islam *et al*. (2013) at farmer's field of Kushtia Sadar upazila with five mustard varieties viz., Improved Tori -7, BARI Sarisha-9, BARI Sarisha-11, BARI Sarisha-14 and BARI Sarisha-15 were intercropped with sugarcane. Results showed that different intercropping combinations significantly influenced yield and yield components, the highest seed yield (2199 kg/ha) in variety BARI Sarisha-11.

Basak (2007) conducted a field experiment to find out the performance of three mustard varieties viz., BARI Sarisha-9, BARI Sarisha-12 and Tori-7 (Local) and three fertilizer doses as : $F_1$= 120-34-64-32-1.5 kg/ha NPKSB (HYG), $F_2$= 86-26-44-26-1.0 kg $ha^{-1}$ NPKSB (MYG) and $F_3$ = 54-60- 15 kg $ha^{-1}$ NPK. Maximum seed yield produce in the variety BARI sarisha-9.

Halder *et al*. (2007) a field experiment was conducted at Agricultural Research Station, Jessore with four varieties of mustard viz., BARI Sharisha-6, 7, 8 and 9 and 4 levels each of boron with a blanket dose of N,P,K,S and cow dung 5 t $ha^{-1}$ were taken in the study. Results showed that BARI Sharisha-6 integrated with 1.5 kg B $ha^{-1}$ was found to be superior to all other treatment combinations. The maximum mean seed yield (1.96 t $ha^{-1}$) was recorded.

**Stover Yield**

Helal *et al*. (2016) conducted an experiment at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and Binasarisha-4 were evaluated. among this variety Improved Tori, BARI Sharisa-8, BARI Sharisa-14 and BARI Sharisa-15 produced the highest straw yield .

A field study was conducted by Chaudhary *et al*. (2016) at Norman E. Borlaug Crop Research Centre of GB Pant, University of Agriculture & Technology, Pantnagar to find out the system of root intensification under transplanting system in Brassica species during winter (rabi) season of 2014–15. The growth and yield parameters of Brassica species were affected significantly by methods of planting. The maximum seed and stover yields were obtained in 'RP 09' (*Brassica carinata*) transplanted at 60 cm × 60 cm spacing.

**Biological Yield**

Aziz (2014) performed a field experiment at SAU, investigate the growth, and yield performance of mustard and rapeseed varieties as influenced by different sowing techniques. There were four variety and 4 sowing technique. The variety were $V_1$= BARI Sarisha-11, $V_2$= BARI Sarisha-13, $V_3$= BARI Sarisha-15, $V_4$= SAU Sarisha 2. Sowing technique were $S_1$= Broadcasting, $S_2$= Line Sowing, $S_3$= Raised Bed, $S_4$= System of Mustard Intensification (SMI). Results showed that height biological yield (16.06 t $ha^{-1}$) were obtained by the combination of BARI Sarisha-11 and SMI technique.

**Harvest Index**

Tasneem (2018) performed a field experiment at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during from Rabi, 2017-18 to studythe yield performance of mustard and rapeseed varieties as influenced by different planting methods and different levels of bio char. There were 2 variety, 2 planting method and 3 levels of biochar. The varieties were $V_1$= BARI Sarisha-11 and $V_2$= BARI Sarisha-14. Planting methods were $P_1$= Line Sowing and $P_2$= System of Mustard Intensification (SMI) at 30 x 30 cm (transplanting). Biochar treatments were $B_0$ =

Control (No biochar application), $B_1$= application of biochar 5.00 t $ha^{-1}$ and $B_2$= application of biochar 10.00 t $ha^{-1}$. Results revealed that height harvest index (30.18%) was obtained at the combination of BARI Sarisha-14 with SMI method and 10 t $ha^{-1}$ of biochar.

## 2.2 Effect of vermicompost

### Plant height

Haque and Ali (2020) performed a field experiment in three Agro ecological zones (AEZ) at Farmer's field, Rangpur (AEZ-3), Farmer's field, Ishurdi (AEZ-11) and BINA farm, Mymensingh (AEZ-9) to investigate the integrated effect of vermicompost and chemical fertilizers (CF) on Mustard (Brassica napus L.) .The treatments for the crops used in the experiments were $T_1$: Native soil fertility, $T_2$:100% chemical fertilizer (CF),$T_3$: 75% CF, $T_4$: 75% CF + Vermicompost (VC) @ 4 t $ha^{-1}$ , $T_5$:85% CF ,$T_6$: 85% CF + VC @ 4 t $ha^{-1}$ $T_7$: 75% CF +VC @ 2 t $ha^{-1}$ and $T_8$: 85% CF+VC @ 2 $tha^{-1}$ . Among the treatments $T_6$ (85% CF + VC @ 4 t $ha^{-1}$) gave the tallest plant height.

Sari *et al.* (2020) performed a field experiment in Faculty of Agriculture, Merdeka University Surabaya .investigated the effect of the best results were shown in the treatment dose of 15% urban waste organic fertilizer and 85% soil . Treatment of urban waste organic fertilizer at a dose of 15% and soil 85% has a very significant effect on plant height at 14 DAS and plant wet weight at harvest.

A pot experiment was concluded by Bosekeng (2019) at North East District of Botswana in Impala Research Station to study the response of Ethiopian mustard (*Brassica carinata* A. Braun) to different levels of vermicompost. The experimental treatments comprised of pure soil (Treatment ($T_1$)) and homogeneous mixture of vermicompost and sandy loam soil ($T_2$ = 25% VC, $T_3$ = 50% VC, $T_4$ = 75% VC and $T_5$ = 100% VC). The results showed that increasing the dosage of vermicompost, significantly increased plant height.

Parihar *et al*. (2014) conducted an experiment at College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner (Rajasthan) during rabi

season. Growth and yield attributes, seed yield as well as net returns in mustard also increased considerably with every increase in levels of vermicompost.

Kansotia *et al*. (2013) performed a field experiment during Rabi season on Indian mustard (*Brassica juncea* L.) at Agronomy Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner. Reported that application of vermicompost up to 6 t $ha^{-1}$ and 80 kg N/ha+ 40 kg $P_2O_5$ $ha^{-1}$ significantly increased the growth parameters.

Gour *et al*. (2017) conducted a field experiment following randomized block design with three replications. The treatments consisting of three levels of vermicompost (control, 2.5 and 5t $ha^{-1}$) and five levels of different nutrients (control, S @ 40kg $ha^{-1}$, S @ 40kg $ha^{-1}$ + iron @ 9.5kg $ha^{-1}$, S @ 40kg $ha^{-1}$ + zinc @ 5kg $ha^{-1}$, S @ 40kg $ha^{-1}$ + iron @ 9.5kg $ha^{-1}$ + zinc @ 5kg $ha^{-1}$) were applied to the mustard var. Bio-902 as soil application with uniform application of NPK as per recommended doses. Noticed that the increasing levels of vermicompost application increased the plant height.

**Number of leaf $plant^{-1}$**

A field experiment was carried out by Chavan (2021) to study the influence of different nutrient sources on growth and yield attributes and yield of mustard (*Brassica juncea* L.) during rabi 2020-2021 at experimental farm, Agronomy, Oilseeds Research Station, Latur. The treatments were $T_1$ – Control, $T_2$ - RDF + FYM @ 5 t $ha^{-1}$ , $T_3$ - RDF + Vermicompost @ 2.5 t $ha^{-1}$ , $T_4$ - RDF + Poultry manure @ 5 t $ha^{-1}$ , $T_5$- RDF + Elemental sulphur @ 20 kg $ha^{-1}$ , $T_6$ - RDF + $ZnSO_4$ @ 20 kg $ha^{-1}$ , $T_7$- RDF + FeSO4 @ 20 kg $ha^{-1}$ and $T_8$ - RDF + Gypsum @ 500 kg $ha^{-1}$ . The results of the experiment indicated that combined application of RDF + Vermicompost @ 2.5 t $ha^{-1}$ ($T_3$) observed significantly height number of leaf per plant.

Joshi *et al*. (2014) carried out a field experiment and observed that vermicompost is an excellent soil amendment and a biocontrol agent, which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. Vermicompost is an ideal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Leaf number $plant^{-1}$ was increasing gradually to increasing vermicompost dose.

**Branches plant$^{-1}$**

Kansotia *et al*. (2013) performed a field experiment at Agronomy Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during Rabi season on Indian mustard (*Brassica juncea* L). Application of vermicompost up to 6 tha$^{-1}$alongwith 80 kg Nha$^{-1}$and 40 kg $P_2O_5$ha$^{-1}$ significantly increased the yield attributing character like number of branches plant$^{-1}$.

Kansotia (2015) conducted a field experiment at Agronomy Farm, College of Agriculture, Bikaner during rabi season. Application of vermicompost up to 6 tha$^{-1}$alongwith 80 kg Nha$^{-1}$ and40 kg $P_2O_5$ ha$^{-1}$ significantly increased the number of branches plant$^{-1}$.

Beenish *et al.* (2018) performed a field experiment at the Research Farm of Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18 to study the organic manures and bio fertilizers: Effect on the growth and yield of Indian mustard varieties. The experiment was laid out two factors viz., 5 varieties ($V_1$ = Rudra 99D, $V_2$ = Shikhar, $V_3$ = Rani, $V_4$ – Varuna and Vs = Yellow Goldey) and 10 fertilizer treatments ($T_1$ = control, $T_2$ = RDF, $T_3$ = 75% N through FYM, $T_4$ = 75% N through Vermicompost, $T_5$ = 50% N through FYM+ Azotobacter, $T_6$ = 50%N Through FYM+ PSB, $T_7$ = 50% N through vermicompost + Azotobacter, $T_8$ = 50% N Through Vermicompost + PSB, $T_9$ = 25% N through FYM + Azotobacter + PSB and $T_{10}$ = 25% N through vermicompost + Azotobacter + PSB. Amongst fertilizer treatments $T_7$ (75% N through vermicompost + Azotobacter) produced significantly the highest number of primary and secondary branches plant$^{-1}$.

**Dry matter**

Joshi *et al*. (2014) performed an experiment and concluded that vermicompost is an excellent soil amendment and a biocontrol agent, which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. Vermicompost is an ideal organic manure for better growth and yield of many plants. It can increase the dry weight gradually by increasing vermicompost dose.

Yadav (2013) performed a field experiment at SKN College of Agriculture, Jobner (Rajasthan) to study the effect of FYM and vermicompost on growth and yield of taramira . Sixteen treatment combinations comprising four levels of each FYM

(control, 3.0, 6.0 and 9.0 t $ha^{-1}$) and vermicompost (control, 1.0, 2.0 and 3.0 t $ha^{-1}$) were evaluated. Result showed that the progressive increase in level of FYM from control to 6.0 t $ha^{-1}$ resulted significant improvement in growth and yield attributes and higher dry matter accumulation in plant.

Chand *et al*. (2011) conducted a field experiment under simulated condition to study the influence of vermicompost on growth, yield and heavy metal accumulation by chamomile (*Matricariachamomilla*) applied at 20 mg $kg^{-1}$ soil significantly enhanced the dry matter yield of the crop as compared to the control (no heavy metal). The results found that addition of vermicompost (at 2.5 g $kg^{-1}$ soil) enhanced the heavy metal accumulation by chamomile in metal-treated soil.

**Number of siliqua plant$^{-1}$**

Chauhan *et al*. (2012) conducted a field experiment during rabi seasons of 2007-08 and 2008-09 to see the effect of vermicompost on mustard crop (*Brassica juncea* L). The treatment of the experiment was laid out keeping four levels of residual vermicompost (0, 1.5, 3.0 and 4.5 t $ha^{-1}$) as a main plot and seven levels of thiourea ( 0, seed soaking @ 500 ppm, seed soaking @ 1000 ppm, foliar spray @ 500 ppm, foliar spray @ 1000 ppm, seed soaking and foliar spray @ 500 ppm each , seed soaking and foliar spray @ 1000 ppm each). Result concluded that a significant difference due to vermicompost residue left after the application in the preceding crop up to a dose of 3.0 $tha^{-1}$. However, with further increase in residual vermicompost level to 4.5 $tha^{-1}$, no significant difference in growth characters as well as maximum no. of siliqua $plant^{-1}$ were observed.

Nagar (2021) performed a field experiment on effect of nutrient management on soil fertility and productivity of Indian mustard (*Brassica juncea* L.) at Instructional Farm, Agronomy, Rajasthan College of Agriculture, Udaipur during rabi 2020-21.The treatment combinations viz. $T_1$ (control),$T_2$ (100% RDF), $T_3$ (50% RDF + 20 kg S $ha^{-1}$ ), $T_4$ (50% RDF + 20 kg S $ha^{-1}$ + 2 t vermicompost $ha^{-1}$ + 10% foliar spray of vermiwash), $T_5$ (50% RDF + 20 kg S $ha^{-1}$ + 4 t vermicompost $ha^{-1}$ + 10% foliar spray of vermiwash), $T_6$ (75% RDF + 20 kg S $ha^{-1}$ , $T_7$ 75% RDF 20 kg S $ha^{-1}$ + 2 t vermicompost $ha^{-1}$ + 10% foliar spray of vermiwash), $T_8$ (75% RDF 20 kg S $ha^{-1}$ + 4 t vermicompost $ha^{-1}$ + 10% foliar spray of vermiwash). Found that the significant

increase the number of siliqua plant$^{-1}$ with the application of $T_8$ (75% RDF 20 kg S ha$^{-1}$ + 4 t vermicompost ha$^{-1}$ + 10% foliar spray of vermiwash).

A field experiment was conducted by Kumar (2018) at Crop Research Centre and SardarVallabhbhai Patel University of Agriculture Technology to study the effect of organic and inorganic sources of nutrients on yield, quality and nutrients uptake by mustard (*Brassicajuncea* L.) during rabi season, 2016-17. The experiment consists of fourteen treatments and the experimental results revealed that number of siliqua plant$^{-1}$ were recorded with application of 50% RDF+ FYM 6 tha$^{-1}$ + Vermicompost 2 tha$^{-1}$bio-fertilizer higher than the rest of the treatments.

**Length of Siliqua**

Chavan (2021) conducted a field experiment at Experimental Farm, Agronomy, Oilseeds Research Station, Latur to study the influence of different nutrient sources on growth, yield attributes and yield of mustard (*Brassica juncea* L.) during rabi 2020-2021. The treatments were $T_1$ – Control, $T_2$ - RDF + FYM @ 5 t ha$^{-1}$ , $T_3$ - RDF + Vermicompost @ 2.5 t ha$^{-1}$ , $T_4$ - RDF + Poultry manure @ 5 t ha$^{-1}$ , $T_5$- RDF + Elemental Sulphur @ 20 kg ha$^{-1}$, $T_6$ - RDF + ZnSO4 @ 20 kg ha$^{-1}$ , $T_7$- RDF + FeSO4 @ 20 kg ha$^{-1}$ and $T_8$ - RDF + Gypsum @ 500 kg ha$^{-1}$. The results of the experiment indicated that combined application of RDF + Vermicompost @ 2.5 t ha$^{-1}$ ($T_3$) showed significantly the highest length of siliqua.

**Seed seliqua$^{-1}$**

Gour (2017) conducted a field experiment following randomized Block Design with three replications. The treatments consisting of three levels of vermicompost (control, 2.5 and 5t ha$^{-1}$) and five levels of different nutrients (control, S @ 40kg ha$^{-1}$, S @ 40kg ha$^{-1}$ + iron @ 9.5kg ha$^{-1}$, S @ 40kg ha$^{-1}$ + zinc @ 5kg ha$^{-1}$, S @ 40kg ha$^{-1}$ + iron @ 9.5kg ha$^{-1}$ + zinc @ 5kg ha$^{-1}$),which were applied to the mustard var. Bio-902 as soil application with uniform application of nitrogen, phosphorus and potassium as per recommended doses. Result observed that the increasing levels of vermicompost application increased the number of seeds per siliqua.

**1000- grain weight**

Beenish (2019) performed a field experiment at the central Research Field of Sam Higginbottom university of Agriculture, Technology and Sciences, Prayagraj during

2016-17 and 2017-18 to study the'' Impact of nutrient management system on the growth, yield and quality of Indian mustard (*Brassica juncea* L) .The experiment was laid out in a factorial randomized block design with three replications along inorganic, organic and bio fertilizers with 10 different treatment combinations like ($T_1$ = control, $T_2$ = RDF, $T_3$ = 75% N through FYM, $T_4$ = 75% N through Vermicompost, $T_5$ = 50% N through FYM+ Azotobacter, $T_6$ = 50%N through FYM+ PSB, $T_7$ = 50% N through vermicompost + Azotobacter, $T_8$ = 50% N through Vermicompost + PSB, $T_9$ = 25% N through FYM + Azotobacter + PSB and $T_{10}$ = 25% N through vermicompost + Azotobacter + PSB.He found that the $T_6$ (50% N through vermicompost + Azotobacter) exhibited significantly highest 1000- seed weight.

A field experiment was carried out by Ali (2012) at SAU Farm, Dhaka 1207 during the rabi season of 2007-2008 to study the effect of vermicompost on growth, yield, chemical composition and oil content of rapeseed (*Brassica campestris* var. SAU Sharisha-1). The treatments used were 4 levels of vermicompost viz. 0, 2, 4 and 6 t $ha^{-1}$. The results showed that increasing dose of vermicompost increased the 1000- seed weight and the highest value (3.95 g) was found in $V_2$ combination.

**Seed Yield**

Reza *et al*.(2022) carried out a field experiment at Bangladesh Institute of Nuclear Agriculture (BINA) substation Satkhira during the rabi season of 2020-2021 to observe the effect of organic and inorganic fertilizers on the yield of mustard (*Brassica napus* L.) The experiment was carried out with five treatments ($T_1$= Absolute control, $T_2$=recommended dose chemical fertilizer (RDCF), $T_3$=50% RDCF+5t $ha^{-1}$ vermicompost, $T_4$=50% RDCF+ 5$tha^{-1}$ poultry manure, $T_5$=50% RDCF+5 t $ha^{-1}$ cowdung) with three replications were executed to conduct the study. Mustard (*Brassica napus* L.) was responded significantly to $T_3$ treatment (50% RDCF+5t $ha^{-1}$ vermicompost). The maximum mustard yield was recorded (2.14 t $ha^{-1}$) from $T_3$ treatment.

Chavan *et al*.(2021) performed a field experiment during rabi 2020-2021 at Experimental Farm, Agronomy, Oilseeds Research Station, Latur, to investigated the effect influence of different nutrient sources on seed and oil yield and economics of mustard (*Brassica juncea* L.). The experiment was laid out with 8 treatments each with three replications. The treatments were $T_1$ – Control, $T_2$ - RDF + FYM @ 5 t $ha^{-}$

$^{1}$, $T_3$ - RDF + Vermicompost @ 2.5 t $ha^{-1}$, $T_4$ - RDF + Poultry manure @ 5 t $ha^{-1}$, $T_5$- RDF + Elemental sulphur @ 20 kg $ha^{-1}$, $T_6$ - RDF + ZnSO4 @ 20 kg $ha^{-1}$, $T_7$- RDF + FeSO4 @ 20 kg $ha^{-1}$ and $T_8$ - RDF + Gypsum @ 500 kg $ha^{-1}$. Theyfound that the combined application of RDF + Vermicompost @ 2.5 t $ha^{-1}$ ($T_3$) observed significantly maximum seed yield (kg $ha^{-1}$).

Ajnar and Namdeo (2020) carried out a field experiment during rabi–season 2019-2020 at Institute of Agriculture Sciences, SAGE university Indore (Madhya Pradesh) to study the effect of two levels of RDF (100% and 75%) with two organic manure (poultry manure and vermicompost) and two bio fertilizer (*Azotobacter* and *Azospirillium*) on indian Hybrid Mustard NRCH $B_50_6$ (*Brassicajuncea* L.). They reported that treatment combination 75% RDF+S @ 40 kg $ha^{-1}$+Vermicompost @ 5 t $ha^{-1}$+Azotobacter+PSB produced theremarkable highest yield attributes and stover yield as well as seed yield followed by treatment combination75% RDF + S@ 40 kg $ha^{-1}$ + Vermicompost @ 5t $ha^{-1}$.

Thaneshwar *et al.* (2016) conducted a field experiment at Kanpur during rabi season 2011-2012.Result showed that significantly better growth attributes, yield attributes and grain yield (22.75 $qha^{-1}$) was obtained with combined application of RDF + vermicompost @ 5.0 $tha^{-1}$ over rest of the treatments. The minimum grain yield (19.15 $qha^{-1}$) was foundin treatment RDF (120:60:40:30 $kgha^{-1}$ NPKS).

Kansotia *et al*. (2015) laid out an experiment at the Agronomy Farm, College of Agriculture, Bikaner during Rabi season of 2010-11 to evaluate the effect of vermicompost and inorganic fertilizers on soil properties and yield of Indian mustard (*Brassica juncea* L.). Seven treatments consisted of two controls, three levels of vermicompost (0, 2, 4 and 6t $ha^{-1}$), and two levels of inorganic fertilizers (40 kg N + 20 kg $P_2O_5$ $ha^{-1}$ and 80 kg N + 40 kg $P_2O_5ha^{-1}$). Amongst the treatments, application of vermicompost up to 6 t $ha^{-1}$, and 80 kg N+ 40 kg $P_2O_5$ $ha^{-1}$, significantly increased seed yield.

**Stover Yield**

A field experiment was conducted by Sharma *et al*. (2016)to study the effect of the different organic nutrient sources on productivity and profitability of Indian mustard. Eight treatments having three organic sources viz., farmyard manure, vermicompost

and poultry manure was with or without biodynamic manure, 500 and 501 was laid out in a randomized block design replicated in three. Stover yield (5169 kg $ha^{-1}$) of mustard was significantly maximum with poultry manure @ 1.7 $tha^{-1}$ + BD 500 + BD 501 over the no manure application and superior over rest organic treatments.

Sharma *et al*. (2017) performed a field experiment at the Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur, Rajasthan during the rabi season using randomized block design with three replications to study the effect of applied vermicompost and nutrients on soil properties, yield, uptake and quality of mustard. Treatments consisted of three levels of vermicompost viz., zero (control), 2.5 and 5.0 t $ha^{-1}$ and five levels of nutrients viz., no nutrients, 40 kg S $ha^{-1}$, 40 kg S + 9.5 kg Fe $ha^{-1}$, 40 kg S + 5.0 kg Zn $ha^{-1}$and 40 kg S + 9.5 kg Fe + 5.0 kg Zn $ha^{-1}$. Noticed that the vermicompost and nutrients, individually and in combination, significantly increased the seed and stover yield.

**Biological Yield**

Gora *et al*. (2022) carried out a field experiment at the Agronomy Research Block of RashtriyaKisan (P.G.) College, Shamli, Utter Pradesh during rabi season of 2019-2020.Therewere nine treatment combinations viz., control ($T_0$), 75% RDF ($T_1$) 100% RDF ($T_2$), Vermicompost @ 2 t $ha^{-1}$ ($T_3$), FYM 10 t $ha^{-1}$ + Azotobacter ($T_4$), 75% RDF + Vermicompost (2 t $ha^{-1}$ ) + Azotobacter ($T_5$), 100% RDF + Vermicompost (2 t $ha^{-1}$ ) + Azotobacter ($T_6$), 75% RDF + FYM 10 t $ha^{-1}$ + Azotobacter ($T_7$) and 100% RDF + FYM 10 t $ha^{-1}$ + Azotobacter ($T_8$) were applied. Results found that the maximum biological yield (5.50 $tha^{-1}$) of mustard was significantly increased with the application of 100% RDF + Vermicompost (2 t $ha^{-1}$) + Azotobacter ($T_6$), which was remained at par with $T_2$, $T_5$, $T_7$ and $T_8$ and superior to all other treatments.

**Harvest Index**

Mondal *et al*. (2015) conducted an experiment at Burdwan University, Burdwan, West Bengal, India where they investigated the effect different reduced doses of chemical fertilizer combined with bio fertilizers and vermicompost. The performance of the crop was adjudged in terms of harvest index (HI) was higher in vermicompost ($T_4$) treatment along with 25%less chemical fertilizer.

A field experiment was carried out by Reddy and Singh (2018) during the rabi season of 2017 on mustard crop (var. DHARA) at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Allahabad (U.P.).Treatments consisted as followed that$T_1$: 80 kg N through urea (control),$T_2$:50 kg N (U) + 30 kg N (VC) + Azotobacter (SI), $T_3$:50 kg N (U) + 30 kg N (PM) + Azotobacter (SI),$T_4$:50 kg N (U) + 30 kg N (FYM) + Azotobacter (SI), $T_5$:50 kg N (U) +30 kg N (VC),T6:50 kg N (U) + 30 kg N (PM), $T_7$:50 kg N (U) + 30 kg N (FYM). The result concluded that application of 50 kg nitrogen through urea + 30 kg nitrogen through poultry manure + Azotobacter (seed inoculation) gave higher growth attribute like harvest index.

Singh *et al*. (2016) performed a field experiment during rabi season of 2011-12 and 2012-13 at Azad University of agriculture and technology, Kanpurto assess the effect of inorganic fertilizer, vermicompost and farm yard manure (FYM) on production and productivity of mustard and evaluate the economics of the treatments. Eight treatments consisted different doses of vermicompost @ 2.0, 3.0 and 5.0 $tha^{-1}$ along with recommended dose of fertilizer and farm yard manure (FYM) @ 3.0, 4.0 and 5.0 $tha^{-1}$ along with and without vermicompost and RDF compared to only recommended dose of fertilizer treatment (control), replicated 3 times in RBD. The maximum harvest index (25.00% and 25.11%) was recorded in treatment (RDF: 120:60:40:30 NPKS $kgha^{-1}$) and minimum harvest index (21.83% and 22.16%) was received in RDF + vermicompost @ 5.0 $tha^{-1}$ during 2011-12 and 2012-13, respectively.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka to study the system of mustard intensification as influence by variety and vermicompost. 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 2020 to February 2021 in Rabi season.

## 3.2 Description of the experimental site

### 3.2.1 Geographical location

The experiment was conducted at the 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 meter 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). It 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 better understanding about the experimental site, it 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 experimentation, was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

### 3.2.5 System of mustard intensification

The system, known as System of Mustard Intensification (SMI) allows resource poor farmers to use less water and seeds and yet achieve significantly higher yields. This technology essentially advocates a radically different package of practices and has earlier been successfully tried in crops like rice and wheat. The principal of the SMI method is based on low seed rate, seed priming, transplanting young seedlings, wide a uniform spacing of single plants and application of enough organic manure.

### 3.3 Test crop

Mustard varieties namely BARI Sarisha-9, BARI Sarisha-14 and BARI Sarisha-15 ware used as test crop for this experiment. The important characteristics of there varieties are mentioned below:

**BARI Sarisha-9**

BARI Sarisha-9 was developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. It is developed by crossing between *B. campestris* and Swedish *B. oleraceae / B. albogleabra* and released, in the year of 2000. Plant height 85-95 cm, 5-6 primary branches are present in each plant, leaf light green, smooth, blooming flower in upright position on axils, stem coated by pedicel of leaf, flower is yellow, number of siliqua /plant 80-100, one chamber are present in pod, seed/siliqua 15-20, seed color pink, 1000-seed weight 2.9-3.5 g are the main characteristics of this crop. It's planting in rabi season from mid-October to mid-November. Harvesting

requires 80-85 days from seed sowing and yields 1.4-1.6 $tha^{-1}$. Oil content in seeds is 43-44% and tolerant to moderately waterlog condition.

**BARI Sarisha-14**

BARI Sarisha-14 was developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. It was developed by crossing between Tori and Sonali sarisha and released in the year of 2006. Plant height 75-85 cm, 5-6 primary branches are present in each plant, leaf light green, smooth, blooming flower in upright position on axils, stem coated by pedicel of leaf, number of siliqua $plant^{-1}$ 80-102, two chamber are present in pod but as like as four chamber, seed $siliqua^{-1}$ 22-26, seed color pink, 1000-seed weight 3.5-3.8 g are the main characteristics of this crop. It's planting in rabi season from mid-October to mid-November. Harvesting requires 75-80 days from seed sowing and yields 1.4-1.6 $tha^{-1}$. Oil content in seeds is 43-44% and tolerant to moderately waterlog condition.

**BARI Sarisha-15**

BARI Sarisha-15 was developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh.It is developed by selection from local germplasm and released, in the year of 2006.Plant height 90-100 cm, siliqua $plant^{-1}$ 70-80, two chamber are present in pod, seed/siliqua20-22,pod is narrow and taller than BARI sarisa-14,seed color yellow, 1000 seed weight 3.25-3.50 g , crop duration 80-85 days , after harvesting aman and before transplant Boro , it is easily cultivated because of short duration. It's planting in Rabi season from mid-October to mid-November. Harvesting requires 75-80 days from seed sowing and yields 1.55-1.65 $tha^{-1}$. Oil content in seeds 43-44% and tolerant to moderately waterlog condition.

### 3.4 Seed collection

Seeds of BARI Sarisha-9, BARI Sarisha-14 and BARI Sarisha-15 were collected from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Gazipur.

### 3.5 Experimental treatment

There were two factors in the experiment namely varieties of mustard and different vermicompost doses as mentioned below:

**Factor A**: Variety

$V_1$=BARI Sarisha-9

$V_2$=BARI Sarisha-14

$V_3$=BARI Sarisha-15

**Factor B**: Four doses of vermicompost and fertilizer *viz;*

$F_1$ = Recommended doses of fertilizer no vermicompost

$F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost

$F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost

$F_4$ = Recommended dose of fertilizer + 4 $tha^{-1}$ vermicompost

### 3.6 Detail of experimental preparation

#### 3.6.1 Raising and transplanting of mustard seedlings

Seeds were sown in small area of well-prepared seedbed inside of the main field. Seedbed was well ploughed and enough fertilizers for germination of seedlings. Seed sowing in the seedbed was 8$^{th}$ November 2020.Seeds were germinated in 12$^{th}$ November 2020.The seedlings were grown under natural light, temperature, and moisture. The seedlings were thinned to one after the true leaf appeared in each well. The soil was monitored by a soil moisture detector to avoid drought stress. Soil with moisture less than 70% was considered to have light drought stress and was supplied with water (Sapeta *et al.* 2013). Weeds and pests were controlled by normal practices.

#### 3.6.2 Land preparation and seedling transplanting

The experimental land was opened with a power tiller on 17$^{th}$ November, 2020. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 25$^{th}$ November 2020 and was ready for transplanting seedling. The 15 days old seedlings were uprooted and transplanted on 27$^{th}$ November 2020 following SMI principals. Main transplanting spacing 30×30 cm.

#### 3.6.3 Experimental design

The experiment was laid out in Randomized complete block design (RCBD) with 2 factor and three replications. There are 12 treatment combinations and 36 unit plots.

The unit plot size was 3.15 $m^2$ (2.1 m × 1.5 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.

| Recommended dose of fertilizer | |
|---|---|
| Fertilizers | Quantity/requirement (kg/ha) |
| Urea | 250 |
| TSP | 170 |
| MP | 85 |
| Gypsum | 150 |
| Zinc sulphate | 5 |
| Boric Acid | 10 |

(Source: (BARI, 2019)

### 3.6.4 Fertilizer application

Fertilizers wereS applied as par treatment requirement.

### 3.7 Intercultural operations

### i) Weeding

Weeding were done after 15 and 40 Days After Transplanting ( DAT).

### ii) Irrigation

Optimum irrigation was given to every plot for ensure soil moisture by using water cane. Continuously four days irrigation was given for establishing the young seedlings. Then after Irrigation was given in the following days. First irrigation was given at 15 days after transplanting (DAT) and the second irrigation was given at 40-45 (DAT). A little irrigation was given at 55-60 (DAT).

### iii) Application of pesticides

In the experimental field, mustard crops were attacked by aphids (*Lipaphis erysimi*, K.). Malathion 57 EC at the rate of 2 ml/litre of water was applied for controlling aphids attack in the field. Spraying of pesticide was done in the afternoon when the pollinating bees were away from the experimental field.

### 3.8 General observations of the experimental field

Regular observations were made to see the growth condition of the crop. In general, the field looked nice with normal green plants, which were vigorous and luxuriant.

### 3.9 Harvesting and processing

From the experimental field, mustard crop was harvested at maturity when 80% of the siliqua turned into straw yellowish in colour. Harvesting was done in the morning to avoid shattering. Crops were harvested from the pre-demarcated area of 1 $m^2$ at the centre of each plot at ground level with the help of a sickle for grain and stover yield.

Prior to harvesting, five plants were sampled randomly from each plot, were bundled separately, tagged them and brought to a clean cemented threshing floor from which different yield parameters were recorded. The crop was sun dried properly by spreading them over 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 stover were also dried in the sun. Seed and stover yield were recorded. The biological yield was calculated as the sum of the seed yield and stover yield.

### 3.10 Data collection

The data were recorded on the following parameters;

**a) Growth parameters**

i. Plant height (cm)
ii. Number of branches and sub branches plant$^{-1}$
iii. Number of leaf plant$^{-1}$
iv. Above ground dry matter weight plant$^{-1}$ (g)

**b) Yield contributing characters**

i. Siliqua plant$^{-1}$ (no.)
ii. Length of siliqua (cm)
iii. Seeds siliqua$^{-1}$ (no.)
iv. 1000-seed weight (g)

**c) Yield characters**

i. Seed yield (t ha$^{-1}$)
ii. Stover yield (t ha$^{-1}$)
iii. Biological yield (t ha$^{-1}$) and
iv. Harvest index (%)

### 3.11 Procedure of recording data

**i) Plant height (cm)**

The height of the 5 randomly selected plants was measured from the ground level to the tip of the plants at 15, 30, 45 DAT and harvest. Mean plant height of mustard were calculated and expressed in cm.

**ii) No. of branches plant$^{-1}$**

The branches plant$^{-1}$were counted from five randomly sampled plants. It was done by counting total number of secondary branches of all sampled plants then the average data were recorded. Data on this parameter were recorded at 15, 30, 45 DAT and harvest.

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

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

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

Siliqua plant$^{-1}$was counted from the10 randomly selected plant samples and then the average siliqua number was calculated.

**v) Length of siliqua (cm)**

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

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

Seeds siliqua$^{-1}$was counted from splitting 10 siliqua, which were collected randomly from sample plants and then mean value was calculated.

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

1000-seed were counted randomly from the seeds of each sample plant, then weighed it in an electrical balance in gram (g).

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

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

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

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

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

The summation of seed yield and above ground stover yield is regarded as the biological yield. It was calculated as,

Biological yield =Grain yield + Stover yield.

**xii) Harvest index (%)**

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

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

Here, Biological yield = Grain yield + stover yield

### 3.12 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program named Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

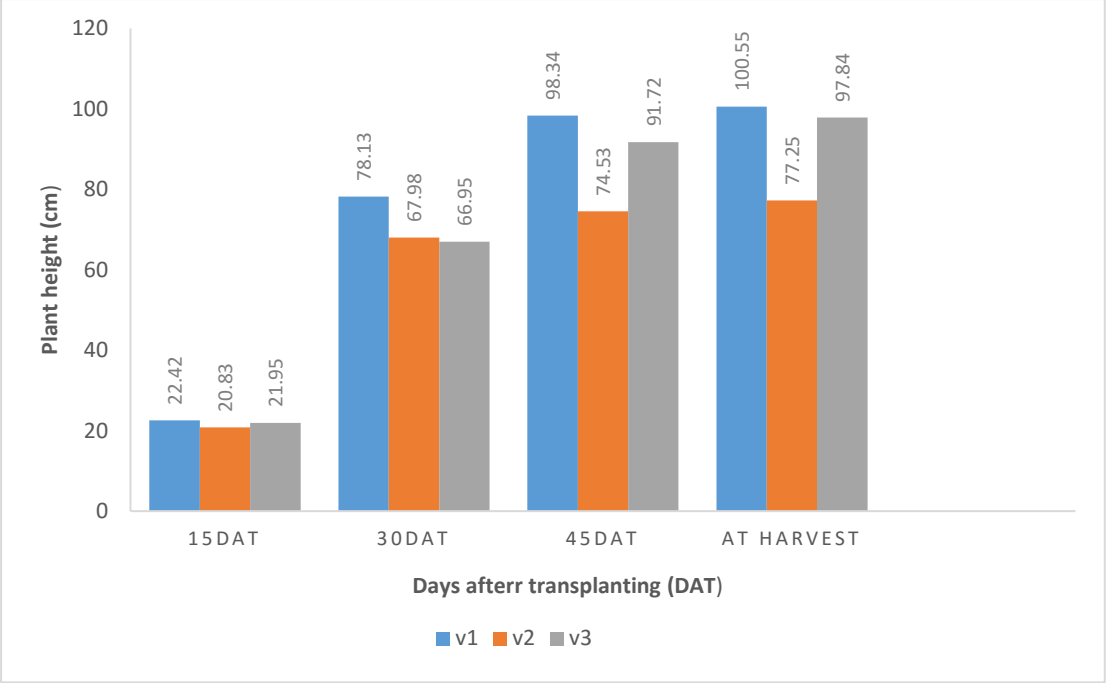
Results obtained from the present study have been presented and discussed in this chapter with a view to study the system of mustard intensification as affected by variety and different doses of vermicompost. The results have been discussed, and possible interpretations are given under the following headings.

## 4.1 Plant growth parameters

### 4.1.1 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. Different variety had significant effect on plant height of mustard. Plant height recorded at 15, 30, 45 DAT and at harvest and presented in (Figure 1). The figure shows that plant height increased straightly up to 45 DAT after that the rate of increase was much slower. The taller plants were recorded 22.54, 78.18, 98.34 and 100.55 cm at 15, 30, 45 DAT and at harvest stage, respectively from BARI Sarisha-9. Whereas, the shorter plant were recorded 20.83, 67.98, 74.53 and 77.25 cm at 15, 30, 45 DAT and at harvest stage, respectively from BARI Sarisha-14. The highest plant height in $V_1$ may perhaps the longer characteristics in this variety. Aziz *et al*. (2011) reported that BARI Sarisha-11 had higher plant height, which confirms the present findings. Nugraha *et al.* (2021) also reported that plant height differed significantly among cultivars and different cultivation technique gradually increased plant height.



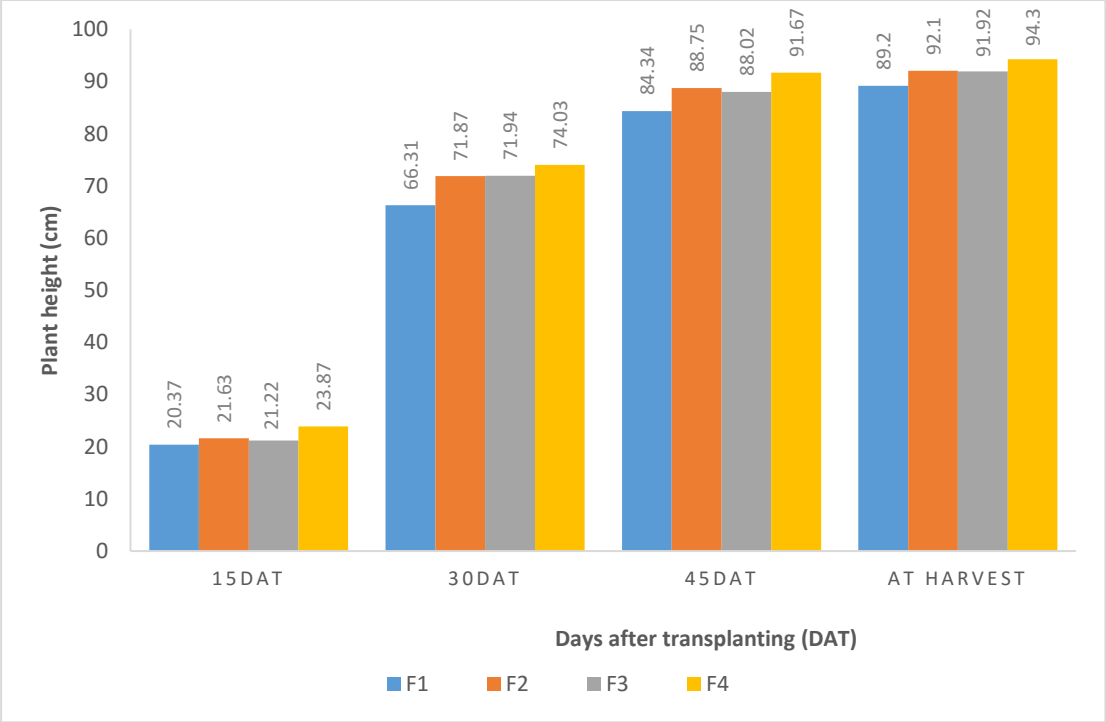

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 1. Effect of variety on plant height of mustard at different DAT under SMI [LSD $_{(0.05)}$ = 1.18, 2.40, 3.47and 2.01at 15, 30, 45 DAT and at harvest, respectively].**

**Effect of vermicompost**

The plant height was significantly influenced by different levels of vermicompost application at all growth stages of mustard shown in (Figure 2). At 15, 30, 45 DAT and at harvest, the highest plant height 23.87, 74.03, 91.67 and 94.30 cm, respectively was recorded in $F_4$ (application of vermicompost 4 t $ha^{-1}$ ) where the lowest was measured at 15, 30, 45 DAT and at harvest (20.37, 66.31, 84.34 and 89.20 cm, respectively) in $F_1$ (no vermicompost application) and $F_2$ showed the plant height that is similar to $F_3$ . Plant height increased with increased fertility levels due to greater availability of nutrients in soil might have enhanced meristematic activity (multiplication and elongation of cells) leading to increased plant height. Sari *et al.* (2020) also found similar result, which supported the present finding and reported that the treatment of urban waste organic fertilizer at a dose of 15% and soil 85% has a very significant effect on plant length growth. Haque and Ali (2020) reported that the treatment T6 (85% CF + VC @ 4 t $ha^{-1}$) gave the tallest plant height. Bosekeng (2019) also found similar results that showed that increasing the dosage of vermicompost, significantly increased plant height, leaf length, leaf width. Kansoti ,*et al.* (2013) reported that the application of vermicompost up to 6 t $ha^{-1}$ and 80 kg N $ha^{-}$

$^{1}$ + 40 kg $P_2O_5$ $ha^{-1}$ significantly increased the growth parameters. Parihar *et al*. (2014) and Gour *et al*. (2017) also reported that the main findings that the increasing levels of vermicompost application increased the plant height.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 2. Effect of vermicompost on plant height of mustard at different DAT [LSD $_{(0.05)}$ = 1.37, 2.77, 4.01and 2.32at 15, 30, 45 DAT and at harvest, respectively].**

## Combined effect of variety and vermicompost

Different varieties along with different doses of vermicompost application had significant effect on plant height of mustard (Table 1). Experimental results showed that, BARI Sarisha-9 ($V_1$) along with recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost ($F_4$) treated plot recorded the maximum plant height (24.5, 81.2, 102.6 and 102.9 cm) at 15, 30, 45 DAT and at harvest, respectively, which was statistically similar to that of $V_3F_4$ treated plot recorded plant height (22.7 cm) at 15 DAT. On the other hand, the shortest plant (64.53 cm) was obtained from the combination of BARI Sarisha-14 and vermicompost 0 t $ha^{-1}$ and recommendation dose of fertilizer ($V_2F_1$). Combination of BARI Sarisha-9 and 4 t $ha^{-1}$ vermicompost ($V_1F_3$) scored the tallest

plant (102.90 cm) at harvest stage and that is similar to the ($V_1F_2$) are respectively 15, 30, 45,and harvest stage of plant and that is also similar like $V_3F_{(2-4)}$ at 15 DAT . Shortest plant (58.96 cm) was recorded at the combination of BARI Sarisha-15 and 0 t $ha^{-1}$ vermicompost ($V_3F_1$). At 30 DAT, tallest plant (102.90cm) was obtained from the combination of BARI Sarisha-9 and recommended doses of fertilizer +4 t $ha^{-1}$ vermicompost ($V_1F_4$).

**Table 1. Interaction effect of variety and vermicompost on plant height at different DAT of mustard under SMI**

| Treatment combination | Plant height (cm) | | | |
|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | At harvest |
| **$V_1F_1$** | 21.50 bc | 75.43 bc | 95.50 c | 98.23 bc |
| **$V_1F_2$** | 21.43 bc | 76.96 ab | 96.00a-c | 99.70 ab |
| **$V_1F_3$** | 22.73 ab | 79.13 ab | 99.27 ab | 101.39 ab |
| **$V_1F_4$** | 24.50 a | 81.20 a | 102.60 a | 102.90 a |
| **$V_2F_1$** | 19.66 cd | 64.53 e | 71.03 e | 74.07 e |
| **$V_2F_2$** | 21.06 bc | 70.53 d | 76.40 e | 78.50 d |
| **$V_2F_3$** | 18.13 d | 67.06 de | 73.53 e | 76.83 de |
| **$V_2F_4$** | 24.46 a | 69.80 d | 77.17 e | 79.60 d |
| **$V_3F_1$** | 19.96 cd | 58.96 f | 86.50 d | 95.30 c |
| **$V_3F_2$** | 22.40 ab | 68.13 de | 93.87 bc | 98.10 bc |
| **$V_3F_3$** | 22.80 ab | 69.63 d | 91.27 cd | 97.57 bc |
| **$V_3F_4$** | 22.66 ab | 71.10 cd | 95.27 bc | 100.40 ab |
| **$LSD_{(.05)}$** | 2.37 | 4.812 | 6.95 | 4.02 |
| **CV** | 6.44 | 4.00 | 4.66 | 2.59 |

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

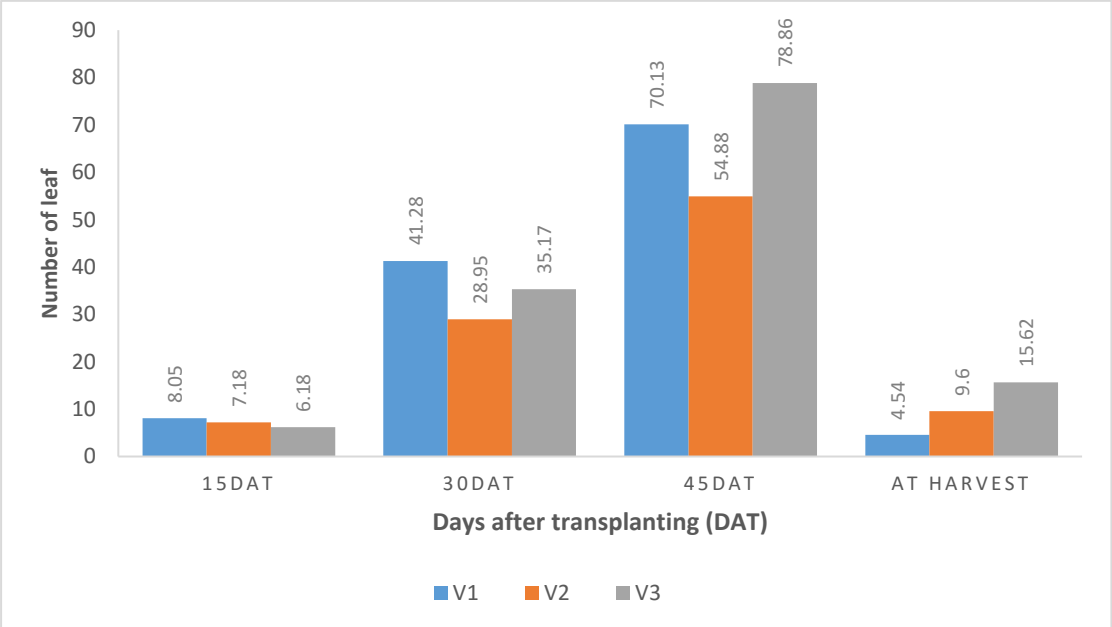
**Notes *viz:*** $V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;

$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t $ha^{-1}$

### 4.1.2Number of leaf plant$^{-1}$

**Effect of variety**

Number of leaf is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. Different variety had significant effect on number of leaf of mustard. Number of leaf recorded at 15, 30, 45 DAT and at harvest of mustard plants have been presented in (Figure 3). The figure shows that number of leaf increased straightly up to 45 DAT after that the rate is gradually decreased. The higher number of leaf were recorded 8.058, 41.28 at 15, 30DAT and 78.86, 15.62 leaf plant$^{-1}$ at 45DAT and at harvest stage respectively from BARI Sarisha-9 and BARI Sarisha-15. Whereas, the less number of leaf were recorded 6.18, 28.95, 54.88and 4.5 at 30, 40, 50, 60 DAT and at harvest stage, respectively from BARI Sarisha 15, BARI Sarisha-14 and BARI Sarisha-9. Alam (2015) also reported that the highest plant height, leaf number per plant were found in $V_5$ (BARI Sarisha-16).which confirms the present findings.

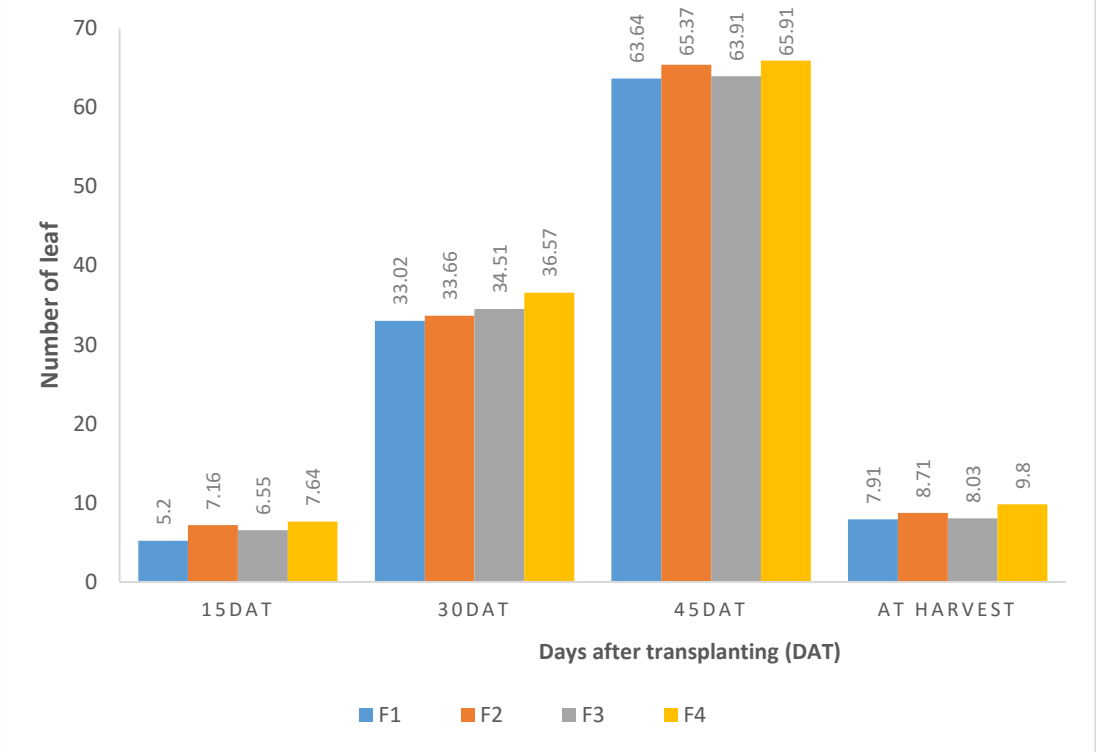



Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 3. Effect of variety on number of leaf at different DAT of mustard under SMI [LSD $_{(0.05)}$ = 0.85, 4.41, 6.13and 3.25at 15, 30, 45 DAT and at harvest, respectively**

**Effect of vermicompost**

Number of leaf was significantly influenced by different level of vermicompost application at all growth stages of mustard shown in (Figure 4). At 15, 30, 45 DAT and at harvest, the highest number of leaf 7.64, 36.57, 65.91 and 9.8 respectively was recorded in $F_4$ (application of vermicompost 4 t $ha^{-1}$ ) where the lowest was measured at 15,30,45 DAT and at harvest (5.2, 33.02, 63.44 and 7.914 respectively) in $F_1$ (no vermicompost application).And $F_2$ showed the number of leaf is similar to $F_3$ .Number of leaf increased with increased fertility levels due to greater availability of nutrients in soil might have enhanced meristematic.Chavan (2021) reported that the results of the experiment indicated that combined application of RDF + Vermicompost @ 2.5 t $ha^{-1}$ ($T_3$) observed significantly maximum number of leaf per plant. Joshi, *et al*. (2014) also reported that environment. Plant number of leaf increasing gradually to increasing vermicompost dose.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 4. Effect of vermicompost on number of leaf of mustard at different DAT [LSD $_{(0.05)}$ = 0.98, 5.09, 7.08 and 3.75 at 15, 30, 45 DAT and at harvest, respectively].**

**Combined effect of variety and vermicompost**

Different variety along with different doses of vermicompost application significant effect number of leaf of mustard (Table 2).Experimental results showed that, BARI Sarisha-9 ($V_1$) along with recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost ($F_4$) treated plot recorded the maximum number of leaf 8.63 at 15 DAT and $V_3F_4$ number of leaf are 85.86,18.6 at 45 DAT, at harvest stage also maximum number of leaf which was statistically similar to that of $V_1F_3$ and $V_2F_4$ treated plot recorded number of leaf. On the other hand, the lowest number of leaf 28.26, 47.66 at 30 DAT , 45 DAT of BARI Sarisha-14 and vermicompost 0 t $ha^{-1}$ and recommendation dose of fertilizer ($V_2F_1$) combination and also lowest number of leaf 5.86, 26.3, 51.8 at 15, 30, 45 DAT in of BARI Sarisha-14 and vermicompost 3 t $ha^{-1}$ and recommendation dose of fertilizer ($V_2F_3$) combination. Combination of BARI Sarisha-9 and 3 t $ha^{-1}$ vermicompost ($V_1F_3$) scored height number of leaf $plant^{-1}$7.86, 42.46 and 73.6 at 15,30,45 DAT and that is similar to the ($V_1F_2$) 7.60, 44.0, 78.33 are respectively 15,30,45,DAT of plant . Higher number of leaf 8.63 and 85.86 at 15DAT and 45 DAT was recorded at the combination of BARI Sarisha-9 and 4 t $ha^{-1}$ vermicompost ($V_1F_4$) and BARI Sarisha-15 and 4 t $ha^{-1}$ vermicompost ($V_3F_4$).

**Table 2. Interaction effect of variety and vermicompost on number of leaf at different DAT of mustard under SMI**

| Treatment combination | number of leaf | | | |
|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | At harvest |
| $V_1F_1$ | 8.13 ab | 37.46 a-d | 69.53 b-d | 4.76 cd |
| $V_1F_2$ | 7.60 a-d | 44.00 a | 78.33a-c | 3.46 d |
| $V_1F_3$ | 7.86 a-c | 42.46 ab | 73.60 a-c | 3.73 d |
| $V_1F_4$ | 8.63 a | 41.20 ab | 59.06 de | 6.20 cd |
| $V_2F_1$ | 7.46 a-e | 28.26 e | 47.66 e | 10.33 bc |
| $V_2F_2$ | 7.56 a-e | 31.06 de | 67.53 b-d | 9.20 b-d |
| $V_2F_3$ | 5.86 e | 26.80 e | 51.53 e | 14.26 ab |
| $V_2F_4$ | 7.83 a-c | 29.66 de | 52.80 e | 4.60 cd |
| $V_3F_1$ | 6.00 de | 32.00 c-e | 79.73 ab | 15.33 ab |
| $V_3F_2$ | 6.33 c-e | 34.93 b-e | 83.26 a | 13.46 ab |
| $V_3F_3$ | 5.93 de | 34.26 b-e | 66.60 cd | 15.10 ab |
| $V_3F_4$ | 6.46 b-e | 40.06 a-c | 85.86 a | 18.60 a |
| $LSD_{(.05)}$ | 1.71 | 8.82 | 12.27 | 6.50 |
| CV | 14.15 | 14.81 | 10.66 | 38.70 |

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

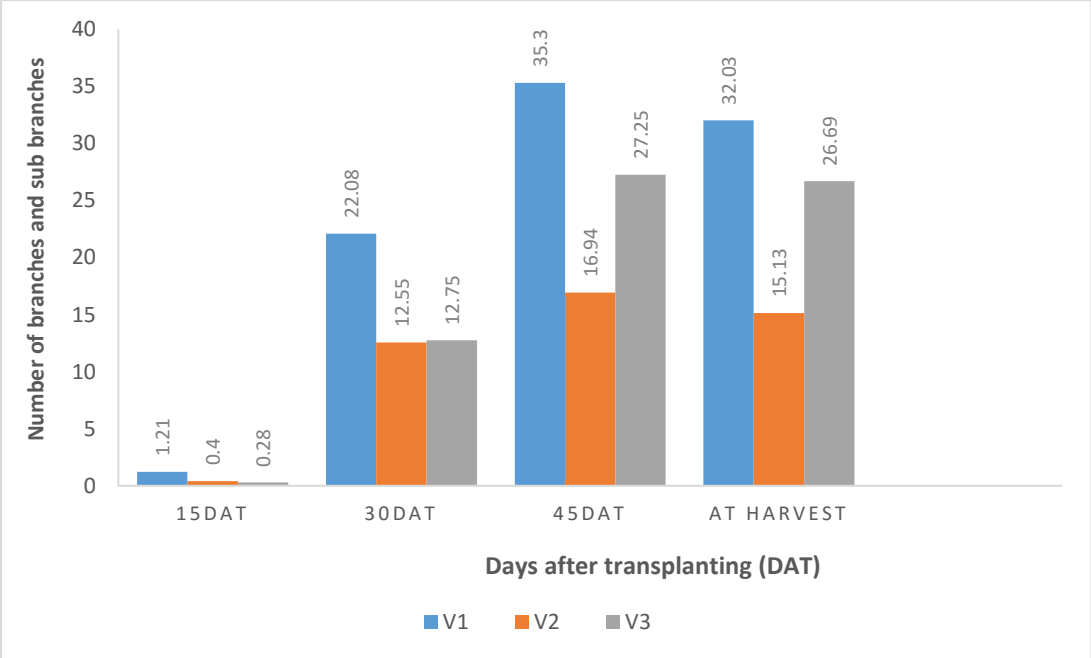
**Notes *viz:***
$V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;
$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t $ha^{-1}$

### 4.1.3Number of branches and sub branches $plant^{-1}$

### Effect of variety

The number of branches and sub branches $plant^{-1}$ was significantly influenced by different varieties at 15, 30, 45 DAT and at harvest time (Figure 5). The figure shows that the highest number branches and sub branches $plant^{-1}$ 1.21, 22.08, 35.3 and 32.03 were obtained from BARI Sarisha-9 ($V_1$) at 15, 30, 45 DAT and at harvest

respectively. On the other hand the lowest number of branches and sub branches plant$^{-1}$ .28, 12.55, 16.94 and 15.13 were obtained from BARI Sarisha-14 ($V_2$) at 15, 30, 45 DAT and at harvest respectively. Alam (2015)agreed with this result who reported that significant differences were found among the mustard varieties for number of branches plant$^{-1}$ ,the highest number of branches per plant were found in $V_5$ (BARI Sarisha-16).




Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

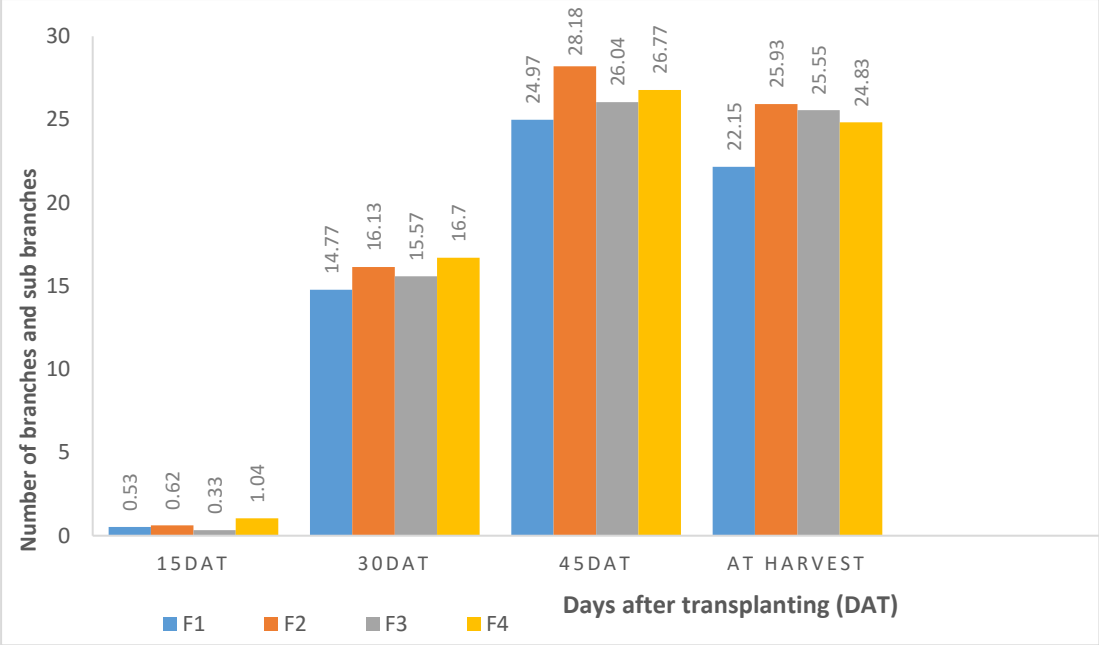
**Figure 5. Effect of variety on number of branches and sub branches at different DAT of mustard under SMI [LSD $_{(0.05)}$ = 0.38, 2.79, 2.89and 2.75at 15, 30, 45 DAT and at harvest, respectively**

**Effect of vermicompost**

Different vermicompost dose had significant influence on number of branches and sub branches plant$^{-1}$ of mustard at 15 DAT but the influence was insignificant at all other different days after transplanting studied (Figure 6). Experimental results showed that, the maximum number of branches and sub branches plant$^{-1}$ (16.13, 28.19 and 25.93) at 30, 45 DAT and at harvest, respectively were recorded in $F_2$ Recommended doses of fertilizer + 2 t ha$^{-1}$ vermicompost). Recommended doses of fertilizer + 3 t ha$^{-1}$ vermicompost ($F_3$ ) and Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost($F_4$) were statistically similar to that of treated plot ($F_4$) recorded number of branches and sub branches plant$^{-1}$ (16.7, 26.7 and 24.83) at 30, 45 DAT

and at harvest. Whereas the minimum number of branches and sub branches plant$^{-1}$ (.5, 14.77, 24.97 and 22.15) at 15, 30, 45 DAT and at harvest, respectively were recorded in ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. The increasing nutrient supply through application of vermicompost increased the number of branches and sub branches in the mustard plant. The nutrient helps in initiating buds in plants. These buds ultimately become active branches from where leaves emerge as photosynthetic organs and the flowering nodes are developed. Thus, it plays a vital role in increasing the crop yield. Beenish, *et al* (2018) also found similar result, which supported the present findings and reported that (75% N through vermicompost + Azotobacter) produced significantly the highest number of primary and secondary branches/plant.

Kansotia (2015) found significant increase in primary branches plant$^{-1}$ due to application of vermicompost up to 6 t1ha and 80 kg N+ 40 kg P20 5 ha$^{-1}$ significantly increased the number of branches/plant .Kansotia *et al*.(2013) reported that application of vermicompost up to 6 t ha$^{-1}$ and 80 kg N ha$^{-1}$ + 40 kg $P_2O_5$ /ha significantly increased the yield attributing character like number of branches per plant.




Here, $F_1$ = Recommended doses of fertilizer + no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 6. Effect of vermicompost on number of branches and sub branches of mustard at different DAT [LSD $_{(0.05)}$ = 0.44, 3.22, 2.89 and 3.18 at 15, 30, 45 DAT and at harvest, respectively].**

### Combined effect of variety and vermicompost

Interaction effect between varieties and different levels of vermicompost exerted not significantly effect on number of primary and secondary branches $plant^{-1}$ at 15, 30, and 45 and at harvest (Table 3). Maximum number of primary and secondary branches per plant 1.66, 21.2, were observed at 15 and 30 DAT respectively from the variety BARI Sarisha-9 cultivated with application of vermicompost 4 $tha^{-}1$ ($V_1F_4$) which is statistically similar with $V_1F_3$. Minimum number of primary and secondary branches per plant 15.73,12.06 at 45 DAT and at harvest were observed from the variety BARI Sarisha-14 with ($F_1$) recommended doses of fertilizer and no vermicompost which is statistically similar with $V_2F_2$ combination .

**Table 3. Interaction effect of variety and vermicompost on number of branches and sub branches at different DAT of mustard under SMI**

| Treatment combination | number of branches and sub branches | | | |
|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | At harvest |
| $V_1F_1$ | 1.40 ab | 21.40 a | 35.80 ab | 27.60 cd |
| $V_1F_2$ | 1.13 abc | 22.46 a | 37.86 a | 33.13 ab |
| $V_1F_3$ | 0.66 b-e | 23.26 a | 36.20 ab | 34.93 a |
| $V_1F_4$ | 1.66 a | 21.20 a | 31.33 bc | 32.46 a-c |
| $V_2F_1$ | 0.13 e | 10.53 b | 15.73 f | 12.06 e |
| $V_2F_2$ | 0.53 c-e | 14.33 b | 18.16 ef | 16.86 e |
| $V_2F_3$ | 0.00 e | 10.60 b | 15.86 f | 15.20 e |
| $V_2F_4$ | 0.93 a-d | 14.73 b | 18.00 ef | 16.40 e |
| $V_3F_1$ | 0.06 e | 12.40 b | 23.40 de | 26.80 d |
| $V_3F_2$ | 0.20 de | 11.60 b | 28.53 cd | 27.80 bcd |
| $V_3F_3$ | 0.33 de | 12.86 b | 26.06 cd | 26.53 d |
| $V_3F_4$ | 0.53 c-e | 14.16 b | 31.00 bc | 25.63 d |
| $LSD_{(.05)}$ | 0.76 | 5.58 | 5.780 | 5.519 |
| CV | 71.09 | 20.89 | 12.88 | 13.23 |

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

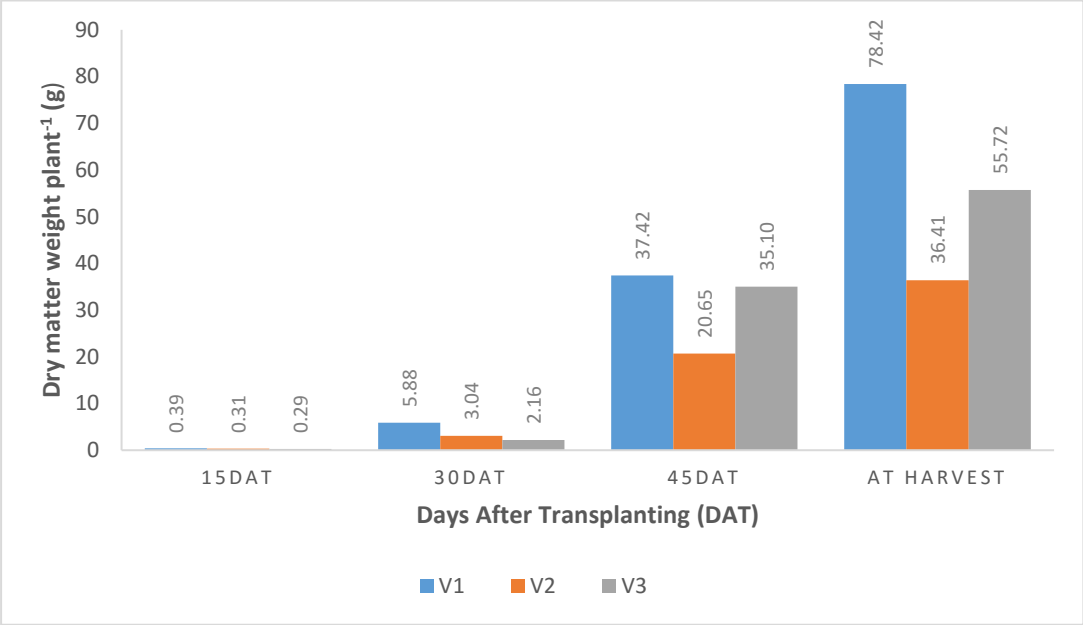
**Notes *viz:***
$V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;
$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t $ha^{-1}$

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

#### Effect of variety

The above ground dry matter weight plant$^{-1}$ consists of all its constituents excluding water. Significant variation was observed in above ground dry matter weight plant$^{-1}$ of mustard at different variety (Figure 7). Experimental results showed that, the maximum above ground dry matter weight (.39, 5.88, 37.42 and 78.42 g plant$^{-1}$) at 15, 30, 45 and at harvest, respectively was recorded in BARI Sarisha-9 ($V_1$), which was statistically similar to that BARI Sarisha 15 ($V_3$) (35.17 g plant$^{-1}$) at 45 DAT.

Whereas the minimum above ground dry matter weight plant$^{-1}$ (20.68, 36.41 g) at 45 and at harvest respectively was recorded in BARI Sarisha-14 ($V_2$). Islam *et al.*(2019) also found similar result which supported the present finding and reported that the maximum dry matter production among the studied varieties, 'BARI Sharisha-16' produced higher dry matter.



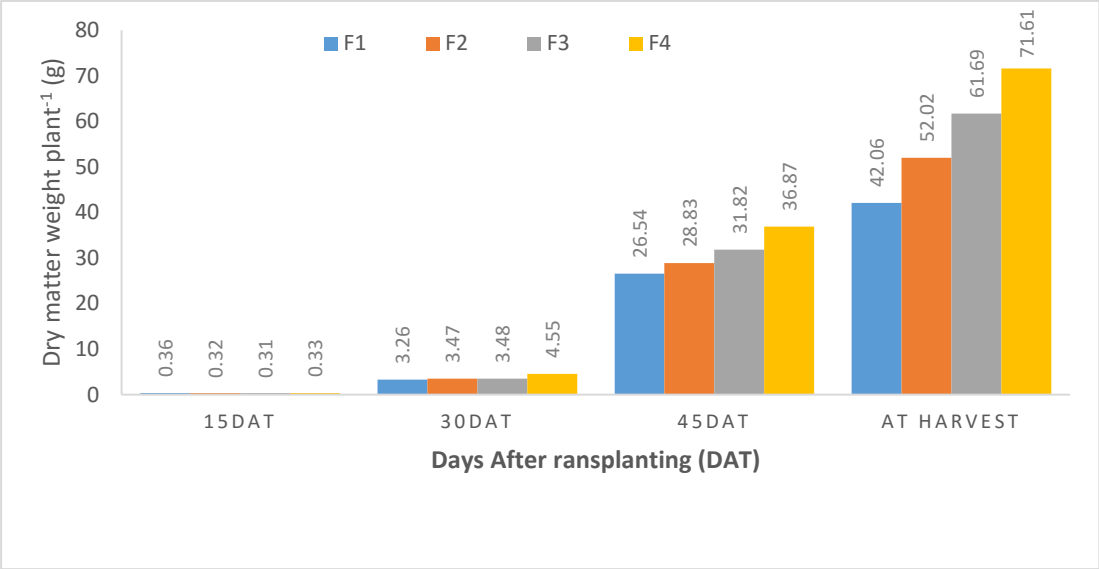

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 7. Effect of variety on plant dry matter weight at different DAT of mustard under SMI [LSD $_{(0.05)}$ = 0.08, 0.89, 3.66 and 7.24at 15, 30, 45 DAT and at harvest, respectively**

**Effect of vermicompost**

Vermicompost play an important role for the growth and development of the plant. In this experiment, results showed that, different dose of vermicompost significantly influenced above ground dry matter weight plant$^{-1}$ of mustard at different days after transplanting (Figure 8). Results showed that, the maximum above ground dry matter weight plant$^{-1}$ (4.56, 36.87, 71.61 g) at 30, 45 DAT and at harvest, respectively were recorded in ($F_4$) recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost. Whereas the minimum above ground dry matter weight plant$^{-1}$ (3.26, 26.54, 42.54 g) at 30, 45 DAT and at harvest respectively was recorded in, ($F_1$) Recommended doses of fertilizer no vermicompost. The higher values of above ground dry matter weight plant$^{-1}$ is the result of higher nutrient availability resulted in better growth and more translocation of photosynthetic from source to sink. The result obtained from the

present study was similar to the findings of Joshi, *et al*. (2014) who reported that the Vermicompost is an ideal organic manure for better growth and yield of many plants. It can increase the production of crops and plant dry weight increasing gradually to increasing vermicompost dose. Yadav (2013) who reported that the progressive increase in level of FYM and vermicompost from control to 6.0 t ha-1 resulted significant improvement in growth and yield attributes and height dry matter accumulation in plant.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 8. Effect of vermicompost on plant dry matter weight at different DAT of mustard under SMI [LSD $_{(0.05)}$ = 0.10, 1.03, 4.22 and 8.37 at 15, 30, 45 DAT and at harvest, respectively].**

**Combined effect of variety and vermicompost**

Combined effect of variety and vermicompost had not significant effect on above ground dry matter weight $plant^{-1}$ of mustard at different days after transplanting. (Table 4). Experimental results revealed that, the maximum above ground dry matter weight $plant^{-1}$ (2.78, 5.79 and 34.71, 0.41, 7.13, 44.14 and 101.13g) at 15,30, 45 DAT and at harvest, respectively were recorded in ($V_1F_4$) BARI Sarisha-9 and recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot, which were statistically similar, to that of ($V_1F_3$ ) BARI Sarisha-9 and recommended doses of fertilizer + 3 t $ha^{-1}$ vermicompost treated plot recorded above ground dry matter weight $plant^{-1}$ ( 42.73g), with $V_3F_4$ BARI Sarisha-15 and recommended doses of fertilizer +

4 t $ha^{-1}$ vermicompost respectively. Whereas the minimum above ground dry matter weight $plant^{-1}$ (19.81, 24.93 g) at 45 DAT and at harvest, respectively were recorded in ($V_1F_1$) BARI Sarisha 9 and recommended doses of fertilizer and no vermicompost treated plot, which were statistically similar, with ($V_1F_2$) BARI Sarisha-9 and recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost ,treated plot (1.91 g) at 30 DAT $V_3F_1$ BARI Sarisha-15 and recommended doses of fertilizer and no vermicompost treated (2.01 g) at 30 DAT; BARI Sarisha-15 with recommended doses of fertilizer and no vermicompost respectively.

**Table 4. Interaction effect of variety and vermicompost dry matter at different DAT of mustard under SMI**

| Treatment combination | dry matter | | | |
|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | At harvest |
| **$V_1F_1$** | 0.42 a | 5.54 a-c | 28.05 de | 55.73 b-d |
| **$V_1F_2$** | 0.35 a-c | 4.87 b-d | 36.88 a-c | 70.12 b |
| **$V_1F_3$** | 0.37 ab | 5.97 ab | 40.61 ab | 86.71 a |
| **$V_1F_4$** | 0.41 a | 7.13 a | 44.14 a | 101.13 a |
| **$V_2F_1$** | 0.31 a-c | 2.34 ef | 19.83 f | 24.93 f |
| **$V_2F_2$** | 0.31 a-c | 3.52 d-f | 19.58 f | 36.20 ef |
| **$V_2F_3$** | 0.22 bc | 2.28 ef | 19.46 f | 35.48 ef |
| **$V_2F_4$** | 0.38 ab | 4.03 c-e | 23.75 ef | 49.03 c-e |
| **$V_3F_1$** | 0.36 a-c | 1.91 f | 31.75 cd | 45.53 de |
| **$V_3F_2$** | 0.28 a-c | 2.01 f | 30.18 c-e | 49.76 c-e |
| **$V_3F_3$** | 0.34 a-c | 2.19 f | 35.39 bc | 62.89 bc |
| **$V_3F_4$** | 0.19 c | 2.52 ef | 42.73 a | 64.70 b |
| **$LSD_{(.05)}$** | 0.17 | 1.79 | 7.32 | 14.49 |
| **CV** | 1.84 | 28.61 | 13.94 | 15.06 |

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

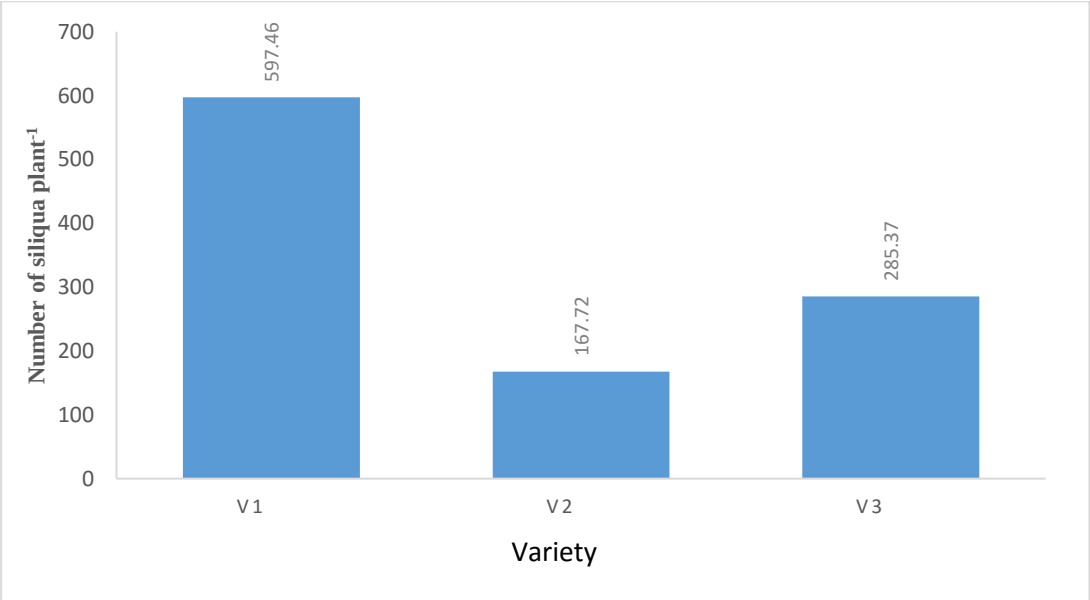
**Notes *viz:***
$V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;
$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t $ha^{-1}$

## 4.2 Yield contributing characters

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

**Effect of variety**

The number of siliqua plant-$^{1}$was significantly influenced by different varieties of mustard and rapeseed at harvest (Figure 9). This was due to the variation in genetic makeup of different varieties affecting number of siliqua plant$^{-1}$. The highest number of siliqua plant$^{-1}$ (597.46) was obtained from BARI Sarisha-9 and the lowest number of siliqua per plant (167.72) was obtained from BARI Sarisha-14. Biswas *et al*. (2019) were also found that different varieties significantly affected the number of siliqua plant$^{-1}$ of mustard and rapeseed. The highest number of siliqua plant-$^{1}$ was obtained from BARI Sarisha-16 that was similar to SAU SR-03 and Improved Tori-7. Banerjee *et al*. (2018) also found that TM 143 produced significantly higher number of siliqua than rest others.



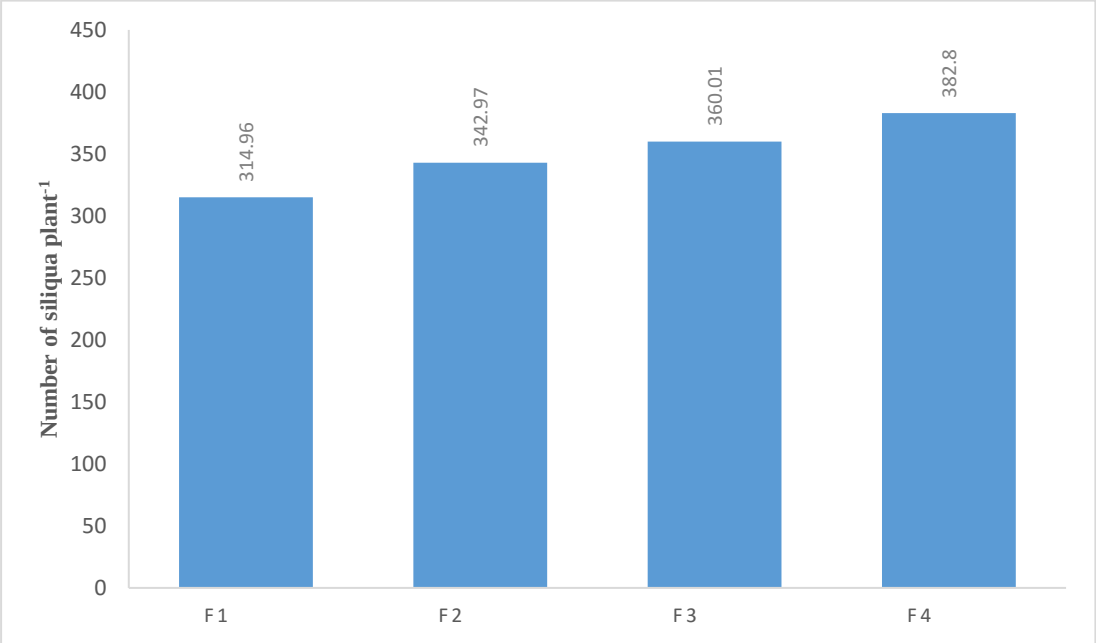

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 9. Effect of variety on number of siliqua plant$^{-1}$ of mustard under SMI [LSD $_{(0.05)}$ = 20.90].**

**Effect of vermicompost**

Different vermicompost doses had significant effect on number of siliqua plant$^{-1}$ of mustard. (Figure. 10). Experimental results showed that, the maximum number of siliqua plant$^{-1}$ (382.8) was recorded in ( $F_4$ ) recommended dose of fertilizer + 4 t ha$^{-1}$

vermicompost treated plot whereas the minimum number of siliqua plant$^{-1}$ (314.96) was recorded in ( $F_1$ ) Recommended doses of fertilizer + no vermicompost treated plot. The higher values of yield attributes is the result of higher nutrient availability resulted in better growth and more translocation of photosynthetic from source to sink. Nagar (2021) and Chauhan *et al.*(2012) also found similar result which supported the present finding and reported that increasing fertilizer dose significant increasing in crop yield and yield attributes (siliqua plant$^{-1}$, test weight, siliqua length and seed yield plant$^{-1}$) over control treatment. Kumar (2018) reported that number of siliqua plant$^{-1}$ were recorded with application of 50% RDF+ FYM 6 t ha$^{-1}$ + Vermicompost 2 t ha$^{-1}$+ bio-fertilizer that was higher than the rest of the treatments.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 tha$^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 tha$^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost

**Figure 10. Effect of vermicompost on number of siliqua plant$^{-1}$ of mustard under SMI [LSD $_{(0.05)}$ = 24.13].**

**Combined effect of variety and vermicompost**

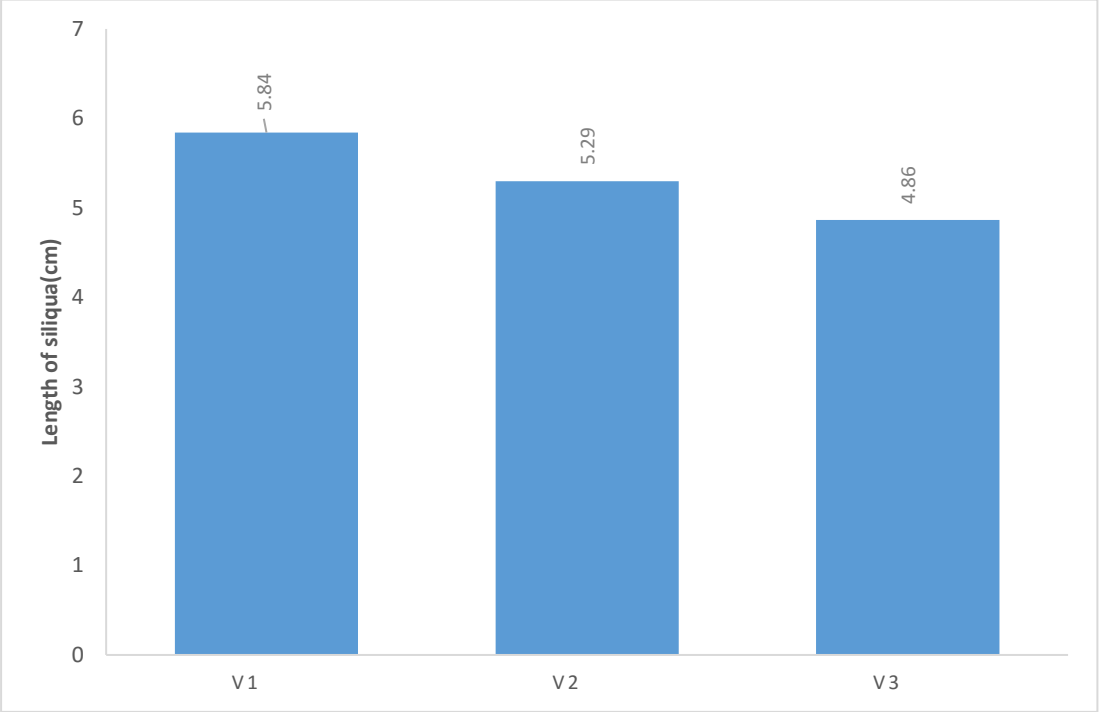
Different variety along with different dose of vermicompost application significantly influenced the number of siliqua plant$^{-1}$(Table 5). Experimental results revealed that, the maximum number of siliqua plant$^{-1}$ (655.07) was recorded in BARI Sarisha-9 ($V_1$) along with recommended dose of fertilizer + 4 t ha$^{-1}$, vermicompost treated plot. Whereas the minimum number of siliqua plant$^{-1}$ (153.07) was recorded in BARI Sarisha-14 ($V_2$) along with Recommended doses of fertilizer no vermicompost treated

plot, which was statistically similar with BARI Sarisha-14 ($V_2$) along with Recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot, recorded number of siliqua $plant^{-1}$ (162.27) and with BARI Sarisha-14 ($V_2$) along with Recommended doses of fertilizer + 3 t $ha^{-1}$ vermicompost treated plot recorded number of siliqua $plant^{-1}$ (172.0).

### 4.2.2 Length of siliqua (cm)

**Effect of variety**

Different variety had significant effect on length of siliqua (cm) of mustard (Figure 11). Experimental results showed that, the maximum length of siliqua (5.14 cm) was recorded in BARI Sarisha-9 ($V_1$) whereas the minimum length of siliqua (4.8642 cm) was recorded in BARI Sarisha 15 ($V_3$). BARI (1999) and Aziz (2014) also reported that rapeseed and mustard varieties showed significant variations in respect of length of siliqua.

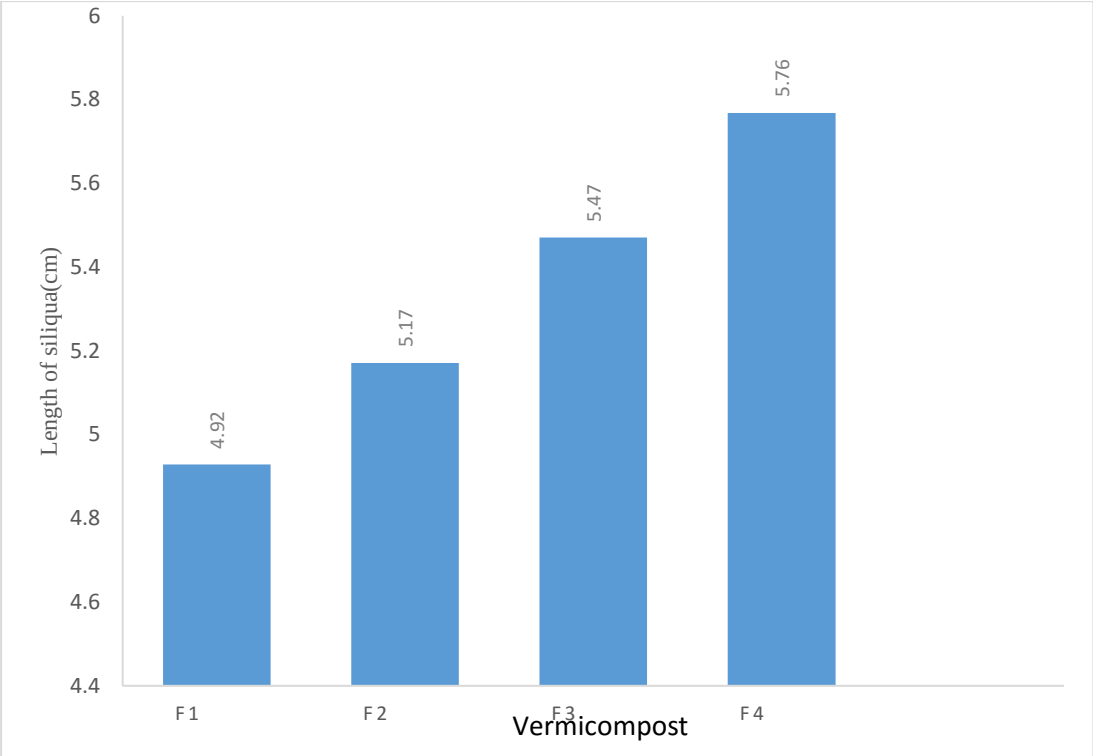



Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 11. Effect of variety on length of siliqua $plant^{-1}$ of mustard under SMI [LSD $_{(0.05)}$ = 0.18].**

**Effect of vermicompost**

Different vermicompost dose significantly influenced the length of siliqua (cm) of mustard (Figure 12). Experimental results showed that, the maximum length of siliqua (5.76 cm) was recorded in ($F_4$) recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot whereas the minimum length of siliqua (4.92 cm) was recorded in ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. Increasing levels of fertilizer improved the yield attributing characters of mustard. The result obtained from the present study was similar with the findings of Chavan (2021) who reported that the results of the experiment indicated that combined application of RDF + Vermicompost @ 2.5 t $ha^{-1}$ ($T_3$) observed significantly maximum growth of length of siliqua..




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 12. Effect of vermicompost on length of siliqua of mustard under SMI [LSD $_{(0.05)}$ = 0.21].**

**Combined effect of variety and vermicompost**

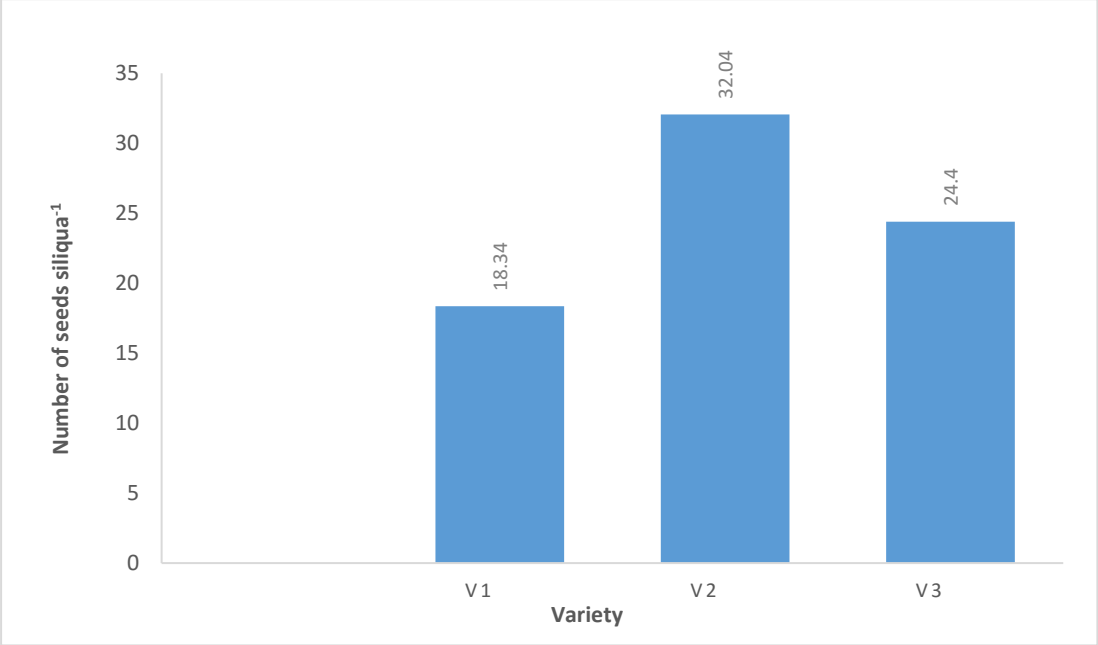
Different variety along with different dose of vermicompost application significantly influenced the length of siliqua (cm) of mustard (Table 5). Experimental results

revealed that, the maximum length of siliqua (6.46 cm) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_4$) recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot. Whereas the minimum length of siliqua (4.74 cm) was recorded in BARI Sarisha-15 ($V_3$) along with ($F_2$), recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot.

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

**Effect of variety**

Number of seeds siliqua$^{-}$1 of rapeseed and mustard plant was significantly affected by variety (Figure 13). Maximum number of seeds siliqua$^{-}$1 (32.04) was recorded at BARI Sarisha-14 and minimum number of seeds siliqua$^{-1}$ (18.34) was observed at BARI Sarisha-9. Islam (2015) reported similar result that there was significant difference among the varieties with respect to number of seeds siliqua$^{-1}$. Mamun *et al*. (2014) also reported that both variety and plant density has significant effects on growth seeds siliqua$^{-1}$ (25.36).

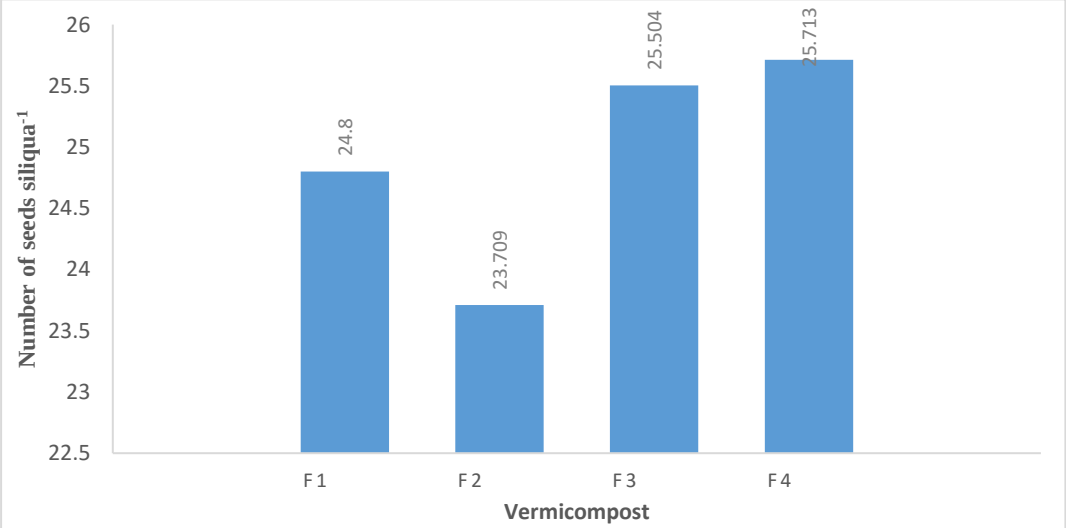



Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure13. Effect of variety on number of seed siliqua$^{-1}$ of mustard under SMI [LSD $_{(0.05)}$ = 0.62].**

**Effect of vermicompost**

Different vermicompost dose significantly effect on number of seeds siliqua$^{-1}$ of mustard (Figure. 14). Experimental result showed that, the maximum number of seeds siliqua$^{-1}$ (25.71) was recorded in the treatment consisting Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot ($F_4$), whereas the minimum number of seeds siliqua$^{-1}$ (23.7) was recorded in ($F_2$) Recommended doses of fertilizer + 2 t ha$^{-1}$ vermicompost treated plot. Increasing fertilizer dose increasing number of seeds siliqua$^{-1}$ might be due to source sink interaction, meaning maximum proportion of various nutrient sources were used to produce maximum seeds siliqua$^{-1}$ and grain filling. The result obtained from the present study was similar with the findings of Gour (2017) the increasing levels of vermicompost application increased the number of seeds per siliqua.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 tha$^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 tha$^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost

**Figure 14. Effect of vermicompost on number of seed siliqua$^{-1}$ of mustard under SMI [LSD $_{(0.05)}$ = 0.71].**

**Combined effect of variety and vermicompost**

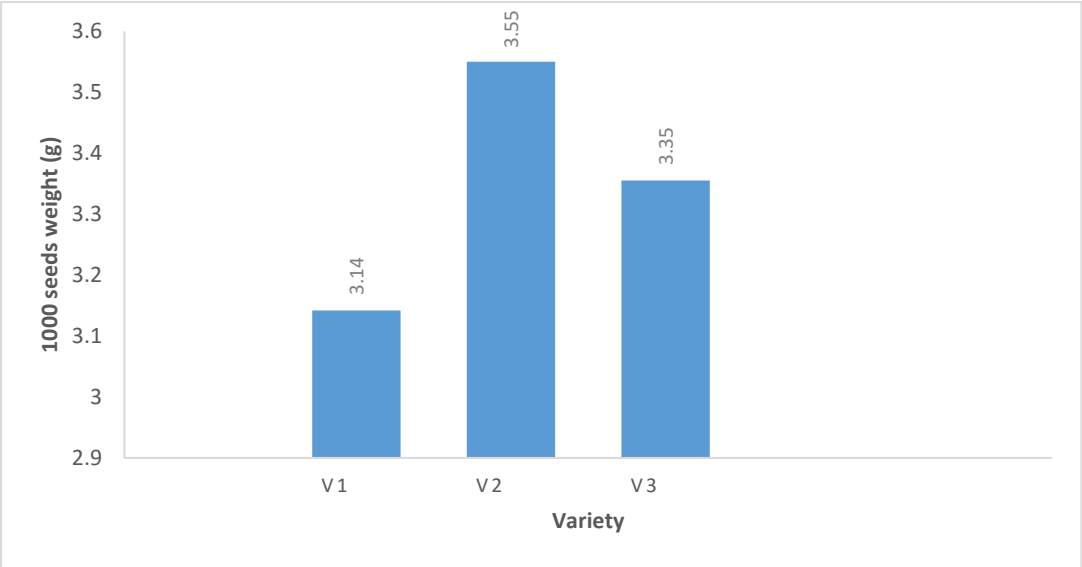
Different variety along with different dose of vermicompost application significantly influenced the number of seeds siliqua$^{-1}$ of mustard. (Table 5). Experimental results revealed that, the maximum number of seeds siliqua$^{-1}$ (32.61) was recorded in BARI Sarisha 14 ($V_2$) along with ($F_4$) Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot that is statistically similar to ($V_2F_1$, $V_2F_2$ and $V_2F_3$

combination. Whereas the minimum number of seeds siliqua$^{-1}$ (15.3) was recorded in BARI Sarisha 9 ($V_1$) along with ($F_2$) Recommended doses of fertilizer + 2 t ha$^{-1}$ vermicompost.

### 4.2.4 Weight of 1000 seeds (g)

**Effect of variety**

Thousand seed weight (g) was significantly affected by different variety (Figure 15). Higher weight of thousand seeds (3.55 g) were obtained at BARI Sarisha-14. Lower weight of thousand seeds (3.14 g) were recorded at BARI Sarisha-9.The result agreed with Ahmed and Kashem (2017) who found that weight of 1000 seeds of rapeseed and mustard varied from variety to variety and species to species.



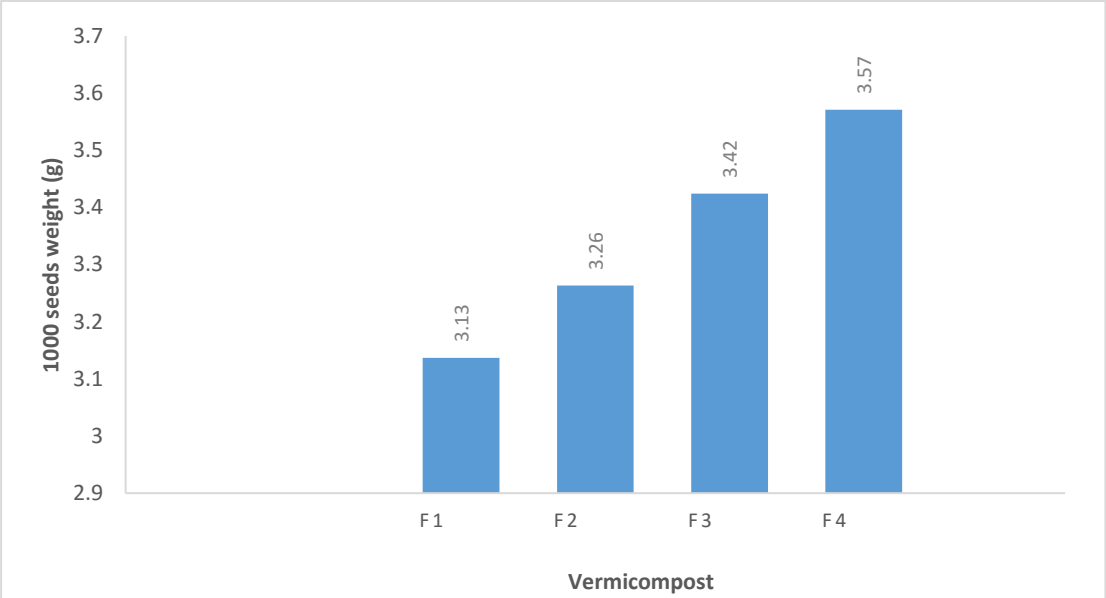

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 15. Effect of variety on 1000 seeds weight (g) of mustard under SMI [LSD $_{(0.05)}$ = 0.06].**

**Effect of vermicompost**

Different vermicompost dose had significant effect on 1000 seeds weight (g) of mustard (Figure 16). Experimental results showed that, the maximum 1000 seeds weight (3.57g) was recorded in $F_4$ = Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot whereas the minimum 1000 seeds weight (3.13 g) was recorded in ($F_1$ ) recommended doses of fertilizer no vermicompost treated plot. However, the plants that did not receive any fertilization gave the lowest values of 1000 seeds weight (g). It could be concluded that increasing fertilization resulted in an

increase in the amount of metabolites synthesized by mustard plant and this, in turn, might account much for the superiority of 1000 seeds weight (g). The results obtained from the present study was similar with the findings of Beenish (2019) that the result of the study revealed that the $T_6$ (50% N through vermicompost + Azotobacter) exhibited significantly higher in 1000-seed weight (g). Ali (2012) also reported that the results demonstrated that increasing dose of vermicompost increased highest (3.95 g) 1000-seed weighting treatment $V_2$ combination.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 16. Effect of vermicompost on 1000 seeds weight (g) of mustard under SMI [LSD $_{(0.05)}$ = 0.08].**

**Combined effect of variety and vermicompost**

Combined effect of variety and vermicompost doses showed significant effect on number of 1000 seeds weight (g) of mustard (Table 5). Experimental results revealed that, the maximum 1000 seeds weight (3.7 g) was recorded in BARI Sarisha-14 ($V_2$) along with ($F_4$) recommended doses of fertilizer + 4 t $ha^{-1}$, vermicompost treated plot. Whereas the minimum number of seeds $siliqua^{-1}$ (2.83 g) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_1$) Recommended doses of fertilizer and no vermicompost treated plot, which was statistically similar with BARI Sarisha-9($V_1$) along with ($F_2$) recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot recorded 1000 seeds weight (2.96 g).

**Table 5. Combined effect of variety and vermicompost on number of siliqua plant$^{-1}$, length of siliqua, number of seeds siliqua$^{-1}$ and 1000 seeds weight of mustard under SMI**

| Treatment Combinations | Number of siliqua plant$^{-1}$ | Length of siliqua (cm) | Number of seeds siliqua$^{-1}$ | 1000 seeds weight (g) |
|---|---|---|---|---|
| **$V_1F_1$** | 527.37 c | 4.98 de | 19.46 d | 2.83 f |
| **$V_1F_2$** | 591.20 b | 5.75 c | 15.30 e | 2.96 f |
| **$V_1F_3$** | 616.20 ab | 6.17 ab | 19.48 d | 3.30 de |
| **$V_1F_4$** | 655.07 a | 6.46 a | 19.13 d | 3.46 bc |
| **$V_2F_1$** | 153.07 f | 4.98 de | 31.68 a | 3.40 cd |
| **$V_2F_2$** | 162.27 f | 5.02 de | 31.68 a | 3.53 bc |
| **$V_2F_3$** | 172.00 f | 5.30 d | 32.22 a | 3.56 ab |
| **$V_2F_4$** | 183.53 f | 5.88 bc | 32.61 a | 3.70 a |
| **$V_3F_1$** | 264.43 e | 4.82 e | 23.25c | 3.17 e |
| **$V_3F_2$** | 275.43 de | 4.74 e | 24.14 bc | 3.29 de |
| **$V_3F_3$** | 291.83 de | 4.94 de | 24.80 b | 3.40 cd |
| **$V_3F_4$** | 309.80 d | 4.95 de | 25.39 b | 3.54 b |
| **$LSD_{(0.05)}$** | 41.80 | 0.37 | 1.24 | 0.13 |
| **CV (%)** | 7.05 | 4.15 | 2.95 | 2.45 |

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

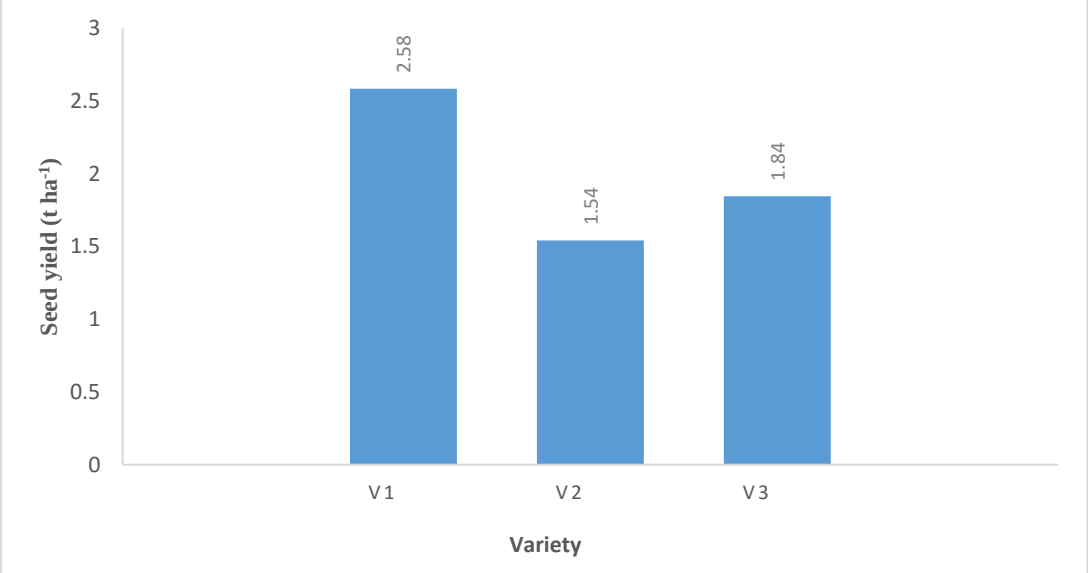
**Notes *viz:***
$V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;
$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t ha$^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t ha$^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t ha$^{-1}$

### 4.3 Yield characters

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

**Effect of variety**

Varietal differences significantly affected on the seed yield of mustard (Figure 17). BARI Sarisha-9 produced higher seed yield (2.58 t ha$^{-1}$ and BARI Sarisha-14 (1.54 t ha-1) produced lower seed yield. These yields might be attributed to number of siliqua plant$^{-1}$, length of siliqua (cm), number of seeds siliqua$^{-1}$ and 1000 seeds weight (g). The result agreed with Rathore *et al*. (2022) who reported that seed yield of rape and mustard were varied with different varieties. Islam *et al*. (2013) also found similar result which supported the present finding and reported that The mustard variety BARI Sarisha-11 produced the highest seed yield (2199 kg ha$^{-1}$).And better quality. Halder *et al*. (2007) also found significant varietal effect on seed yield of mustard.



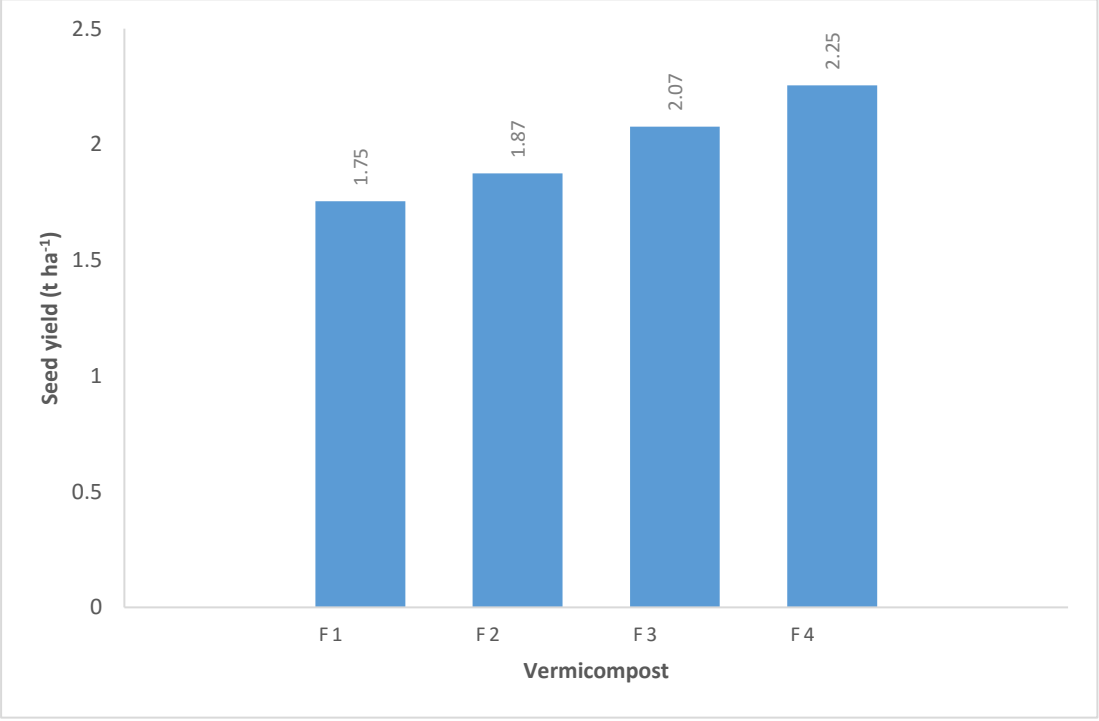

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 17. Effect of variety on seed yield of mustard under SMI [LSD $_{(0.05)}$ = 0.03].**

**Effect of vermicompost**

Vermicompost application at different doses had significant influenced on the seed yield (t ha$^{-1}$) of mustard (Figure 18). Experimental results showed that, the maximum seed yield (2.25 t ha$^{-1}$) was recorded in ($F_4$) Recommended dose of fertilizer + 4 t ha$^{-}$

[1] vermicompost treated plot whereas the minimum seed yield (1.75 t $ha^{-1}$) was recorded in ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. The higher values of yield is the result of higher nutrient availability resulted in better growth and more translocation of photosynthetic from source to sink. Chavan *et al*. (2021) reported that the results of the experiment indicated that combined application of RDF + Vermicompost @ 2.5 t $ha^{-1}$ ($T_3$) observed significantly maximum seed yield (kg $ha^{-1}$) . Reza *et al*. (2022) also reported that the highest mustard yield was recorded (2.14 t $ha^{-1}$) from $T_3$ treatment whereas the lowest mustard (*Brassica napus* L.) yield (0.81 $ha^{-1}$) was obtained from $T_1$= (absolute control) treatment. Ajnar and Namdeo (2020) was observed that remarkable highest yield attributes and stover yield as well as seed yield followed by Treatment T8 75% RDF + S@ 40 kg $ha^{-1}$ + Vermicompost @ 5t $ha^{-1}$. Thaneshwar *et al*. (2016) observed that the minimum grain yield (19.15 q $ha^{-1}$) was received in treatment RDF (120:60:40:30 kg/ha NPKS). Kansotia *et al*. (2015) also observed that application of vermicompost up to 6 t $ha^{-1}$, and 80 kg N+ 40 kg $P_2$ $O_5$ $ha^{-1}$, significantly increased yield.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 18. Effect of vermicompost on seed yield of mustard under SMI [LSD $_{(0.05)}$ = 0.04].**

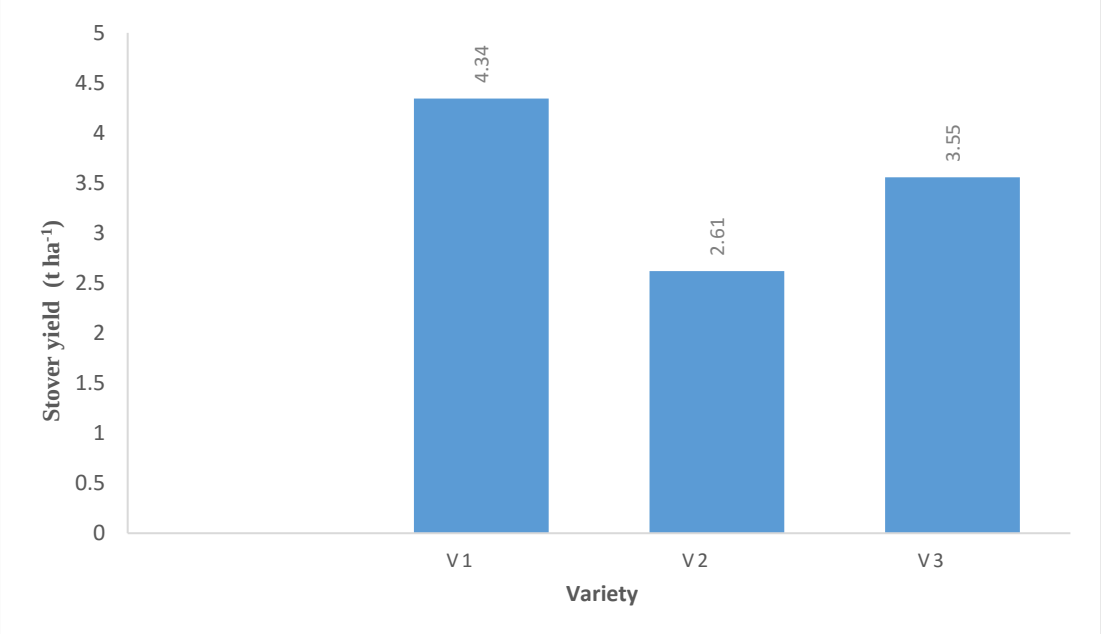
**Combined effect of variety and vermicompost**

Variety along with vermicompost significant influenced the seed yield (t $ha^{-1}$) of mustard (Table 6). Experiment result revealed that, the maximum seed yield (2.96 t $ha^{-1}$) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_4$) Recommended dose of fertilizer + 4 $tha^{-1}$ vermicompost treated plot. Whereas the minimum seed yield (1.31 t $ha^{-1}$) was recorded in BARI Sarisha-14 ($V_2$) along with ($F_{1)}$ Recommended doses of fertilizer no vermicompost treated plot.

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

**Effect of variety**

Stover yield was significantly influenced by the varieties (Figure 19). Experimental results showed that, the BARI Sarisha-9 gave higher stover yield (4.34 t $ha^{-1}$) and lower stover yield (2.61 t $ha^{-1}$) was observed in BARI Sarisha-14. This finding agreed with Chaudhary *et al*. (2016) who found that variety affect significantly on stover yield. The result obtained from the present study was similar ro the findings of Helal *et al.* (2016) and reported that the variety Improved Tori, BARI Sharisa-8, BARI Sharisa-14 and BARI Sharisa-15 produced the highest straw yield.

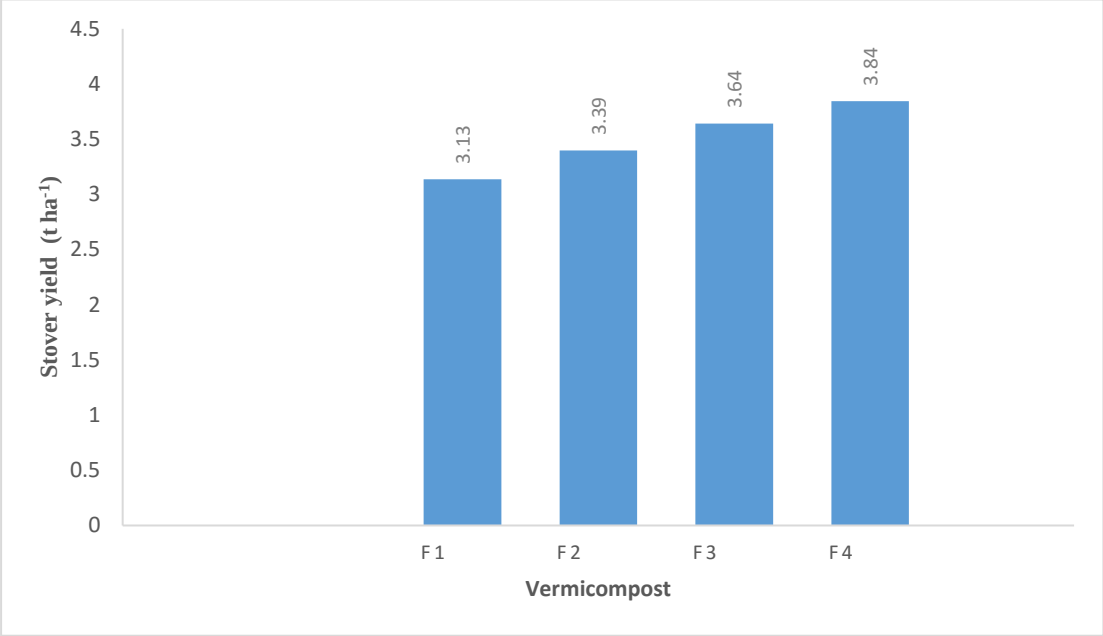



Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure 19. Effect of variety on stover yield of mustard under SMI [LSD $_{(0.05)}$ = 0.09].**

**Effect of vermicompost**

Vermicompost application at different dose had significant influenced the stover yield (t $ha^{-1}$) of mustard (Figure 20). Experimental results showed that, the maximum stover yield (3.84 t $ha^{-1}$) was recorded in ($F_4$) recommended dose of fertilizer + 4 t $ha^{-1}$, vermicompost treated plot. Whereas the minimum stover yield (3.13 t $ha^{-1}$) was recorded in ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. Sharma *et al*. (2017) results revealed that vermicompost and nutrients, individually and in combination, significantly increased the seed and stover yield. Sharma *et al*. (2016) also reported that stover yield (5169 kg ha-1) of mustard were significantly higher with poultry manure @ 1.7 t $ha^{-1}$ + BD 500 + BD 501 over the no manure application and superior over rest organic treatments.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure 20. Effect of vermicompost on stover yield of mustard under SMI [LSD $_{(0.05)}$ = 0.11].**

**Combined effect of variety and vermicompost**

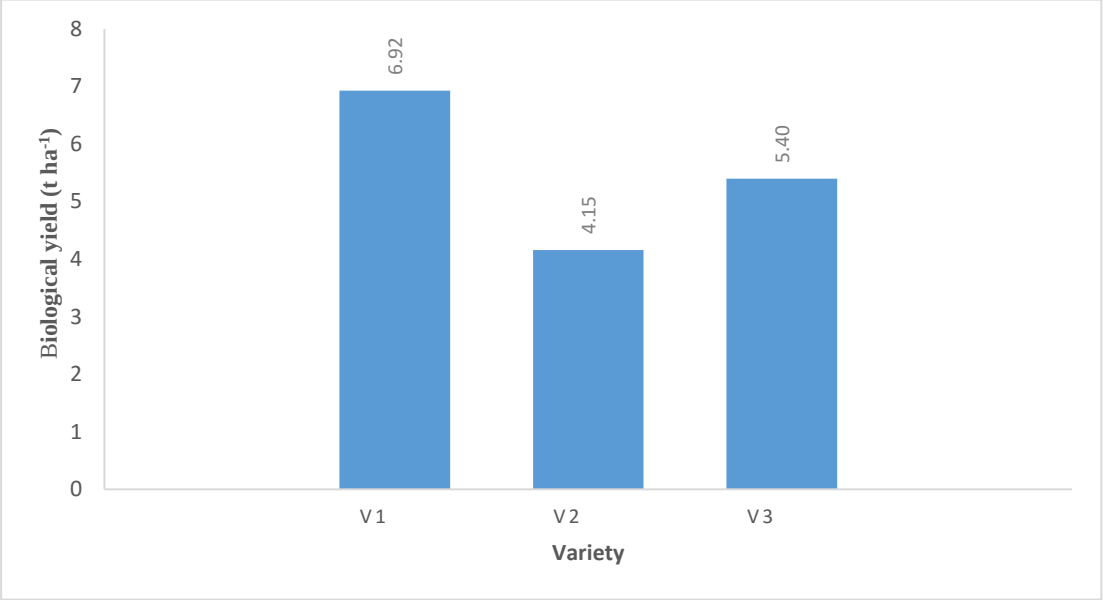
Variety along with vermicompost significant influenced the stover yield (t $ha^{-1}$) of mustard. (Table 6).Experimental results revealed that, the maximum stover yield (4.65 t $ha^{-1}$) was recorded in BARI Sarisha-9 ($V_1$) along with, ($F_4$) Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot. Whereas the minimum stover yield

(2.40 t $ha^{-1}$) was recorded in BARI sarisha-14 ($V_2$) along with ($F_1$) Recommended doses of fertilizer no vermicompost treated plot, which was statistically similar with BARI Sarisha-14 ($V_2$) along with ($F_2$) Recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot recorded stover yield (2.47 t $ha^{-1}$).

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

**Effect of variety**

Biological yield (t $ha^{-1}$) was significantly varied due to the effect of different variety of mustard (Figure 21). Experimental results showed that the maximum biological yield (6.92 t $ha^{-1}$) was recorded in BARI Sarisha-9 ($V_1$). Whereas the minimum biological yield (4.15t $ha^{-1}$) was recorded in BARI Sarisha-14 ($V_3$). Aziz (2014) also found similar result, which supported the present finding and reported that Results showed that Maximum biological yield (16.06 t $ha^{-1}$) was obtained by the combination of BARI Sarisha-11 and SMI technique.



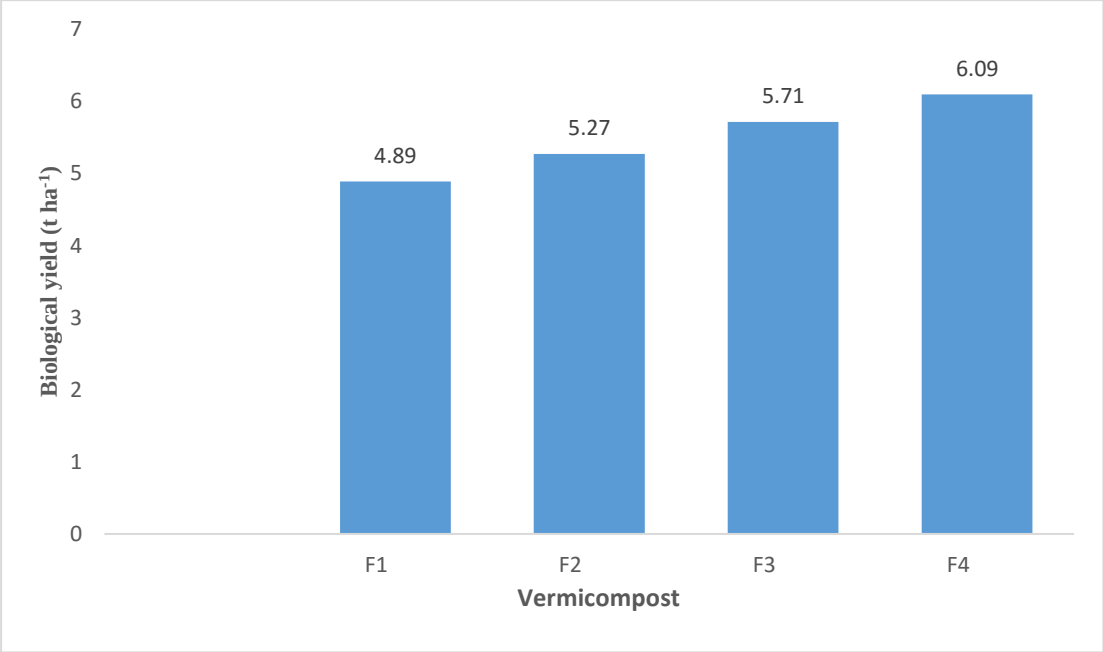

Here,$V_1$= BARI Sarisha-9 , $V_2$= BARI Sarisha-14 , $V_3$= BARI Sarisha-15

**Figure21. Effect of variety on biological yield of mustard under SMI [LSD $_{(0.05)}$ = 0.10].**

**Effect of vermicompost**

Vermicompost application at different dose significantly influenced the biological yield (t $ha^{-1}$) of mustard (Figure 22). Experimental results showed that, the maximum

biological yield (6.09 t ha$^{-1}$) was recorded in, ($F_4$) Recommended dose of fertilizer + 4 tha$^{-1}$, vermicompost treated plot. Whereas the minimum biological yield (4.89 t ha$^{-1}$) was recorded in, ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. Gora *et al*. (2022) reported that results showed that the highest biological yield (5.50 Mg ha$^{-1}$ ) of mustard was significantly increased with the application of 100% RDF + Vermicompost (2 t ha$^{-1}$ ) + Azotobacter ($T_6$) which was remained at par with $T_2$, $T_5$, $T_7$ and $T_8$ and superior to all other treatments.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 tha$^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 tha$^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost

**Figure 22. Effect of vermicompost on biological yield of mustard under SMI [LSD $_{(0.05)}$ = 0.11].**

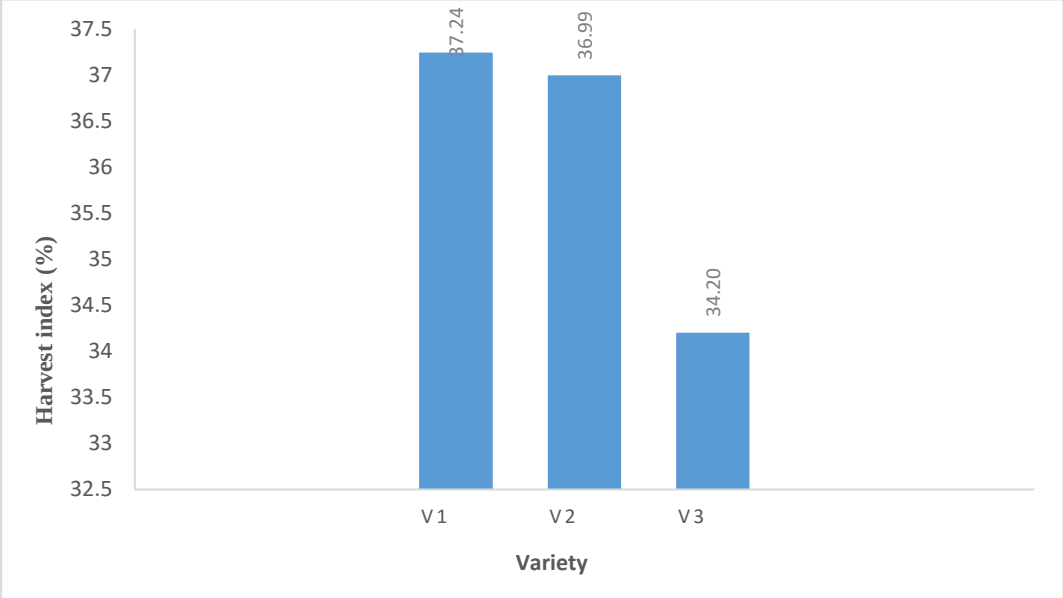
**Combined effect of variety and vermicompost**

Combined effect of variety and vermicompost doses showed significant effect on biological yield (t ha$^{-1}$) of mustard (Table 6). Experimental results revealed that, the maximum biological yield (7.61 t ha$^{-1}$) was recorded in BARI Sarisha-9 ($V_1$) along with (F4) Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot. Whereas the minimum biological yield (3.72 t ha$^{-1}$) was recorded in BARI Sarisha-14 ($V_2$) along with ($F_1$) Recommended doses of fertilizer no vermicompost treated plot.

### 4.3.4 Harvest index (%)

**Effect of variety**

Harvest Index of mustard plant was significantly affected by different variety (Figure 23). Higher harvest index (37.24%) was observed at BARI Sarisha-9 and lower harvest index (34.20%) was obtained at BARI Sarisha-15. The result agreed with the findings of Tasneem (2018) who reported that the Maximum harvest index (30.18%) was obtained at the combination of BARI Sarisha-14 with SMI method and 10 t $ha^{-1}$ of biochar.



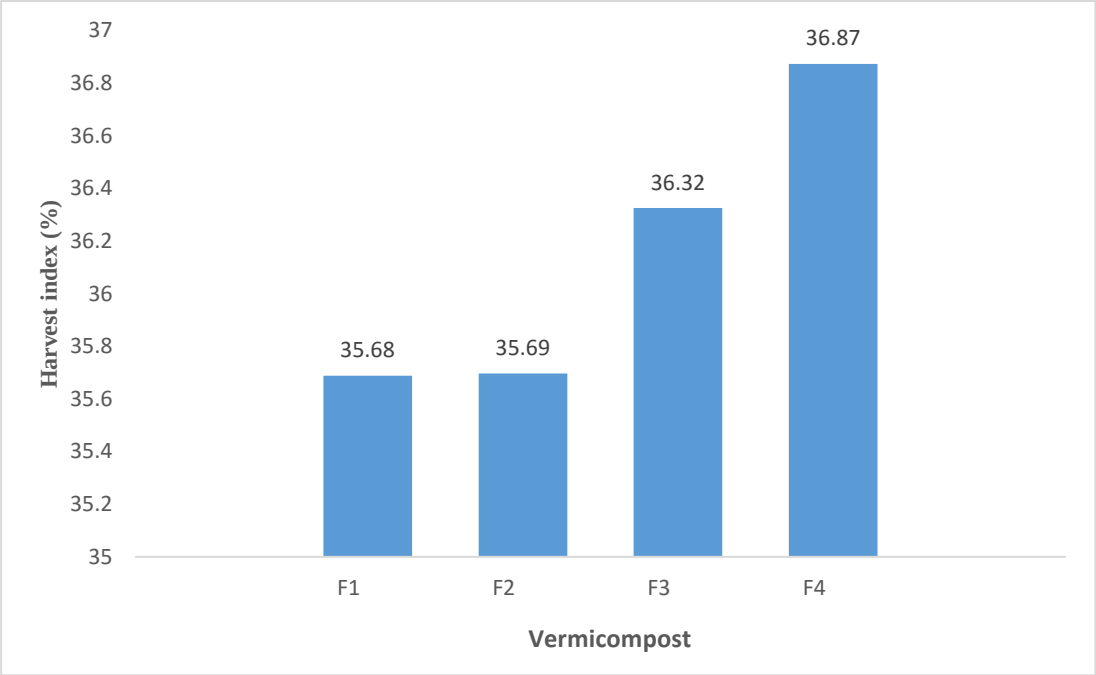

Here, $V_1$= BARI Sarisha-9, $V_2$= BARI Sarisha-14, $V_3$= BARI Sarisha-15

**Figure23. Effect of variety on harvest index of mustard under SMI [LSD $_{(0.05)}$ = 0.75].**

**Effect of vermicompost**

Vermicompost application at different dose significantly influenced the harvest index (%) of mustard (Figure 24). Experimental results showed that, the maximum harvest index (36.87 %) was recorded in ($F_4$) recommended dose of fertilizer + 4 $tha^{-1}$, vermicompost treated plot. Whereas the minimum harvest index (35.68 %) was recorded in ($F_1$) recommended doses, of fertilizer, no vermicompost treated plot, which was statistically similar with, ($F_2$) recommended doses of fertilizer + 2 $ha^{-1}$ vermicompost treated plot recorded harvest index (35.68 %).The significant increase in seed and stover yields of mustard were largely a function of improved growth and

the consequent increase in different yield components due to adequate supply of major plant nutrient under successive increase in nutrient doses, which finally resulted in higher seed yield, stover yield ultimately, resulted increased biological yield and harvest of mustard crop. Mondal *et al*. (2015) reported that. The performance of the crop was adjudged in terms of harvest index (HI) was higher in vermicompost ($T_4$) treatment along with 25%less chemical fertilizer. Reddy and Singh, (2018) the result showed that Application of 50 kg nitrogen through urea + 30 kg nitrogen through poultry manure + Azotobacter (seed inoculation) gave higher growth attribute like harvest index. Singh *et al*. (2016) also reported that the maximum harvest index (25.00% and 25.11%) was recorded in treatment (RDF: 120:60:40:30 NPKS kg/ha) and minimum harvest index (21.83% and 22.16%) was received in RDF+ vermicompost @ 5.0 t $ha^{-1}$ during 2011-12 and 2012-13, respectively.




Here, $F_1$ = Recommended doses of fertilizer no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 $tha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 $tha^{-1}$ vermicompost, $F_4$ = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost

**Figure24. Effect of vermicompost on harvest index of mustard under SMI [LSD $_{(0.05)}$ = 0.87].**

**Combined effect of variety and vermicompost**

Different variety along with vermicompost doses significantly influenced the harvest index (%) of mustard (Table 6). Experimental results revealed that, the maximum harvest index (38.92 %) was recorded form BARI Sarisha-9 ($V_1$) along with, ($F_4$) recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot. Whereas the

minimum harvest index (33.92 %) was recorded in BARI Sarisha-15 ($V_3$) along with ($F_4$) recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot, which was statistically similar with BARI Sarisha-15 ($V_3$) along with ($F_3$) Recommended doses of fertilizer +3 t $ha^{-1}$ vermicompost treated plot recorded harvest index (33.95%).

**Table 6. Combined effect of variety and vermicompost on seed yield, stover yield, biological yield and harvest index of mustard under SMI**

| Treatment Combinations | Seed yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$V_1F_1$** | 2.30 d | 3.90 cd | 6.21 d | 37.09 b |
| **$V_1F_2$** | 2.40 c | 4.36 b | 6.77 c | 35.57 c |
| **$V_1F_3$** | 2.65 b | 4.44 b | 7.10 b | 37.37 b |
| **$V_1F_4$** | 2.96 a | 4.65 a | 7.61 a | 38.92 a |
| **$V_2F_1$** | 1.31 j | 2.40 h | 3.72 j | 35.33 cd |
| **$V_2F_2$** | 1.46 i | 2.47 h | 3.94 i | 37.22 b |
| **$V_2F_3$** | 1.64 h | 2.72 g | 4.36 h | 37.65 ab |
| **$V_2F_4$** | 1.73 g | 2.86 g | 4.59 g | 37.76 ab |
| **$V_3F_1$** | 1.64 h | 3.09 f | 4.73 g | 34.63 cd |
| **$V_3F_2$** | 1.74 g | 3.34 e | 5.09 f | 34.29 cd |
| **$V_3F_3$** | 1.93 f | 3.75 d | 5.68 e | 33.95 d |
| **$V_3F_4$** | 2.06 e | 4.02 c | 6.08 d | 33.92 d |
| **$LSD_{(0.05)}$** | 0.07 | 0.19 | 0.20 | 1.50 |
| **CV(%)** | 2.11 | 3.21 | 2.22 | 2.46 |

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

**Notes *viz:***
$V_1$ = BARI Sarisha- 9, $V_2$ = BARI Sarisha- 14, $V_3$ BARI Sarisha- 15;

$F_1$ = Recommended doses of fertilizer and no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$vermicompost, $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$vermicompost, $F_4$= Recommended doses of fertilizer + 4 t $ha^{-1}$

# CHAPTER V

## SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University farm SAU, Dhaka to study the system of mustard intensification as influence by variety and vermicompost during the period from October 2020 to February 2021 in Rabi season. The experiment was consisted of two factors and followed randomized complete block design (RCBD) with three replications. Factor A: variety (3) *viz;* $V_1$ = BARI Sarisha-9, $V_2$ = BARI Sarisha-14 and $V_3$= BARI Sarisha-15 and Factor B: different vermicompost doses (4) *viz;*$F_1$ = Recommended doses of fertilizer+ no vermicompost, $F_2$ = Recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost $F_3$ = Recommended doses of fertilizer + 3 t $ha^{-1}$ vermicompost, F4 = Recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost. Data on different parameters were collected for assessing results for the experiment and showed significant variation in respect of growth, yield and yield contributing characteristics of mustard due to the effect of variety, different vermicompost dose and their combinations.

In case of variety of mustard, the maximum plant height (22.54, 78.18, 98.34 and 100.55 cm at 15, 30, 45 DAT and at harvest stage, respectively were obtain from BARI Sarisha-9. Higher number of leaves were recorded 8.05, 41.28 at 15, 30DAT and 78.86, 15.62 leaf $plant^{-1}$ at 45, at harvest stage respectively from BARI Sarisha-9 and BARI Sarisha-15. The highest number of branches and sub branches $plant^{-1}$ 1.216, 22.08, 35.3 and 32.03 were obtained from BARI Sarisha-9 ($V_1$) at 15, 30, 45 DAT and at harvest respectively. The maximum above ground dry matter weight (.39, 5.88, 37.42 and 78.42 g $plant^{-1}$) at 15, 30, 45 and at harvest, respectively was recorded in BARI Sarisha-9. The highest number of siliqua $plant^{-1}$ (597.46) was obtained from BARI Sarisha-9 maximum length of siliqua (5.14 cm) was recorded in BARI Sarisha-9 ($V_1$). Maximum number of seeds $siliqua^{-1}$ (32.04) was recorded at BARI Sarisha-14 .The highest weight of thousand seeds (3.55 g) were obtained at BARI Sarisha-14. BARI Sarisha-9 produced higher seed yield (2.58 t $ha^{-1}$). The BARI Sarisha-9 gave higher stover yield (4.34 t $ha^{-1}$); the maximum biological yield (6.92 t $ha^{-1}$) was recorded in BARI Sarisha-9 ($V_1$) and highest harvest index (37.24%) was observed at BARI Sarisha-9.

Whereas, BARI Sarisha-14 ($V_2$) recorded the minimum plant height were recorded 20.83, 67.98, 74.53 and 77.25 cm at 30, 40, 50, 60 DAT and at harvest stage, respectively. The less number of leaf were recorded 6.18, 28.95, 54.88and 4.5 at 30, 40, 50, 60 DAT and at harvest stage, respectively from BARI Sarisha-15,BARI Sarisha-14 and BARI Sarisha-9.The lowest number of branches and sub branches plant$^{-1}$ .28, 12.55, 16.94 and 15.13 were obtained from BARI Sarisha-14(V2) at 15,30,45 DAT and at harvest respectively . The minimum above ground dry matter weight plant$^{-1}$ (20.68, 36.41 g) at 45 and at harvest respectively was recorded in BARI Sarisha-14 ($V_2$).The minimum number of siliqua plant$^{-1}$ (167.72) was obtained from BARI Sarisha-14. Minimum length of siliqua (4.86 cm) was recorded in BARI Sarisha-15 ($V_3$). Minimum number of seeds siliqua$^{-1}$ (18.34) was observed at BARI Sarisha-9. Lower weight of thousand seeds (3.14 g) were recorded at BARI Sarisha-9.The lower seed yield (1.54 t ha$^{-1}$), stover yield (2.61 t ha$^{-1}$), biological yield (4.15t ha$^{-1}$) was recorded in BARI Sarisha-14 ($V_3$).And lower harvest index (34.20%) was obtained at BARI Sarisha-15.

In case of different vermicompost dose applied in mustard, at 15, 30, 45 DAT and at harvest, the highest plant height 23.87, 74.03, 91.67 and 94.3 cm, respectively , at 15, 30, 45 DAT and at harvest the highest number of leaf 7.64, 36.57, 65.91 and 9.8 respectively was recorded in $F_4$ (application of vermicompost 4 t ha$^{-1}$ ). The maximum number of branches and sub branches plant$^{-1}$ (16.13, 28.19, and 25.93) at 30, 45 DAT and at harvest, respectively were recorded in ($F_2$) Recommended doses of fertilizer + 2 t ha$^{-1}$ vermicompost. ($F_3$) Recommended doses of fertilizer + 3 t ha$^{-1}$ vermicompost and ($F_4$) recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost. The maximum above ground dry matter weight plant$^{-1}$ (4.56, 36.87, 71.61 g) at 30, 45 DAT and at harvest, respectively ,number of siliqua plant$^{-1}$ (382.8) , length of siliqua (5.76 cm) , number of seeds siliqua$^{-1}$ (25.71) ,1000 seeds weight (3.57g) , seed yield (2.25 t ha$^{-1}$, stover yield (3.84 t ha$^{-1}$) ,biological yield (6.09t ha$^{-1}$) and harvest index (36.87 %) was recorded in ($F_4$) Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot.

Whereas the lowest was measured at 15, 30, 45 DAT and at harvest (20.37, 66.31, 84.34 and 89.2 cm, respectively) , number of leaf was measured at 15, 30, 45 DAT and at harvest (5.2, 33.02, 63.44and 7.914 respectively) , number of branches and sub branches plant$^{-1}$ (.5, 14.77, 24.97 and 22.15) at 15, 30, 45 DAT and at harvest, above ground dry matter weight plant$^{-1}$ (3.26, 26.54, 42.54 g) at 30, 45 DAT and at harvest

respectively was recorded in, ($F_1$) Recommended doses of fertilizer no vermicompost. The minimum number of siliqua plant$^{-1}$ (314.96), length of siliqua (4.92 cm) was recorded in ($F_1$) Recommended doses of fertilizer no vermicompost treated plot. The minimum number of seeds siliqua$^{-1}$ (23.7) was recorded in ($F_2$) Recommended doses of fertilizer + 2 t ha$^{-1}$, vermicompost treated plot. The minimum 1000 seeds weight (3.13 g), seed yield (1.75 t ha$^{-1}$), stover yield (3.13 t ha$^{-1}$), biological yield (4.89 t ha$^{-1}$), harvest index (35.68 %) was recorded in, ($F_1$) Recommended doses of fertilizer no vermicompost treated plot.

In case of combined effect plant height (24.5, 81.2, 102.6 and 102.9 cm) at 15, 30, 45 DAT and at harvest, respectively and number of leaf 8.63 at 15 DAT and $V_3F_4$ number of leaf are 85.86, 18.6 at 45 DAT, at harvest stage , number of primary and secondary branches per plant 1.66, 21.2, which is statistically similar with $V_1F_3$ , above ground dry matter weight plant$^{-1}$ (2.78, 5.79 and 34.71 .418, 7.13, 44.14 and 101.13g) at 15, 30, 45 DAT and at harvest, respectively were recorded in ($V_1F_4$) BARI Sarisha 9 and Recommended doses of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot. The maximum number of siliqua plant$^{-1}$ (655.07), length of siliqua (6.46 cm) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_4$) Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot. The maximum number of seeds siliqua$^{-1}$ (32.61) ,that is statistically similar to ($V_2F_1$,$V_2F_2$ and $V_2F_3$ combination , 1000 seeds weight (3.7 g) was recorded in BARI Sarisha-14 ($V_2$) along with ($F_4$) recommended doses of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot. The maximum seed yield (2.96 t ha$^{-1}$), stover yield (4.65t ha$^{-1}$), biological yield (7.61 t ha$^{-1}$) and harvest index (38.92 %) was recorded form BARI Sarisha-9 ($V_1$) along with, ($F_4$) Recommended dose of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot. Whereas the lowest was measured plant height (64.53 cm) , number of leaf 28.26, 47.66 at 30 DAT , 45 DAT , number of primary and secondary branches per plant 15.73, 12.06 at 45 DAT and at harvest were observed from the Variety BARI Sarisha-14 with ($F_1$) recommended doses of fertilizer and no vermicompost which is statistically similar with $V_2F_2$ combination . The minimum above ground dry matter weight plant$^{-1}$ (19.81, 24.93 g) at 45 DAT and at harvest, respectively were recorded in ($V_1F_1$) BARI Sarisha-9 and recommended doses of fertilizer and no vermicompost treated plot. The minimum number of siliqua plant$^{-1}$ (153.07) was recorded in BARI Sarisha-14 ($V_2$) along with recommended doses of fertilizer no vermicompost treated plot, which was statistically similar with

BARI Sarisha-14 ($V_2$) along with recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot. The minimum length of siliqua (4.74 cm) was recorded in BARI Sarisha-15 ($V_3$) along with ($F_2$) recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot. The minimum number of seeds $siliqua^{-1}$ (15.3) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_2$) recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost. The minimum number of seeds $siliqua^{-1}$ (2.83 g) was recorded in BARI Sarisha-9 ($V_1$) along with ($F_1$) recommended doses of fertilizer and no vermicompost treated plot, which was statistically similar with BARI Sarisha-9($V_1$) along with ($F_2$) Recommended doses of fertilizer + 2 t $ha^{-1}$ vermicompost treated plot recorded 1000 seeds weight (2.96 g). The minimum seed yield (1.31 t $ha^{-1}$), stover yield (2.40 t $ha^{-1}$) and biological yield (3.72 t $ha^{-1}$) was recorded in BARI Sarisha-14 ($V_2$) along with ($F_1$) recommended doses of fertilizer no vermicompost treated plot. The minimum harvest index (33.92 %) was recorded in BARI Sarisha-15 ($V_3$) along with ($F_4$) Recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot.

Based on the above results of the present study, the following conclusions may be drawn:

Among different variety, BARI Sarisha-9 recorded the maximum number of siliqua $plant^{-1}$ (597.46), length of siliqua (5.14 cm), seed yield (2.58 t $ha^{-1}$), stover yield (4.34 $tha^{-1}$), maximum biological yield (6.92 t $ha^{-1}$) and harvest index (37.24%).and BARI Sarisha-14 recorded maximum seeds $siliqua^{-1}$ (32.04), 1000 seeds weight (3.55 g),

In case of different vermicompost doses, application of recommended dose of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot recorded the maximum number of siliqua $plant^{-1}$ (382.8), length of siliqua (5.76 cm), number of seeds $siliqua^{-1}$ (29.67), 1000 seeds weight (3.96 g), seed yield (2.25 $tha^{-1}$), stover yield (3.84 $tha^{-1}$), biological yield (6.09 t $ha^{-1}$) and harvest index (36.87 %).

In case of combined effect, the maximum number of siliqua $plant^{-1}$ (655.07), length of siliqua (6.46 cm), seed yield (2.96 t $ha^{-1}$),stover yield (4.65 t $ha^{-1}$), biological yield (7.61 t $ha^{-1}$) and harvest index (38.92 %) were recorded in BARI Sarisha-9 ($V_1$) along with ($F_4$) recommended doses of fertilizer + 4 t $ha^{-1}$ vermicompost treated plot. And

number of seeds siliqua$^{-1}$ (32.67), 1000 seeds weight (4.16 g) BARI Sarisha-14 along with recommended doses of fertilizer + 4 t ha$^{-1}$ vermicompost treated plot.

Thus for cultivation of mustard, BARI Sarisha-9 ($V_1$) along with ($F_4$) Recommended doses of fertilizer + 4 t ha$^{-1}$ vermicompost perform well for higher seed production of mustard.

Further experiment may be conducted on system of mustard intensification (SMI) with different fertilizer combinations and different variety in different location in Bangladesh.

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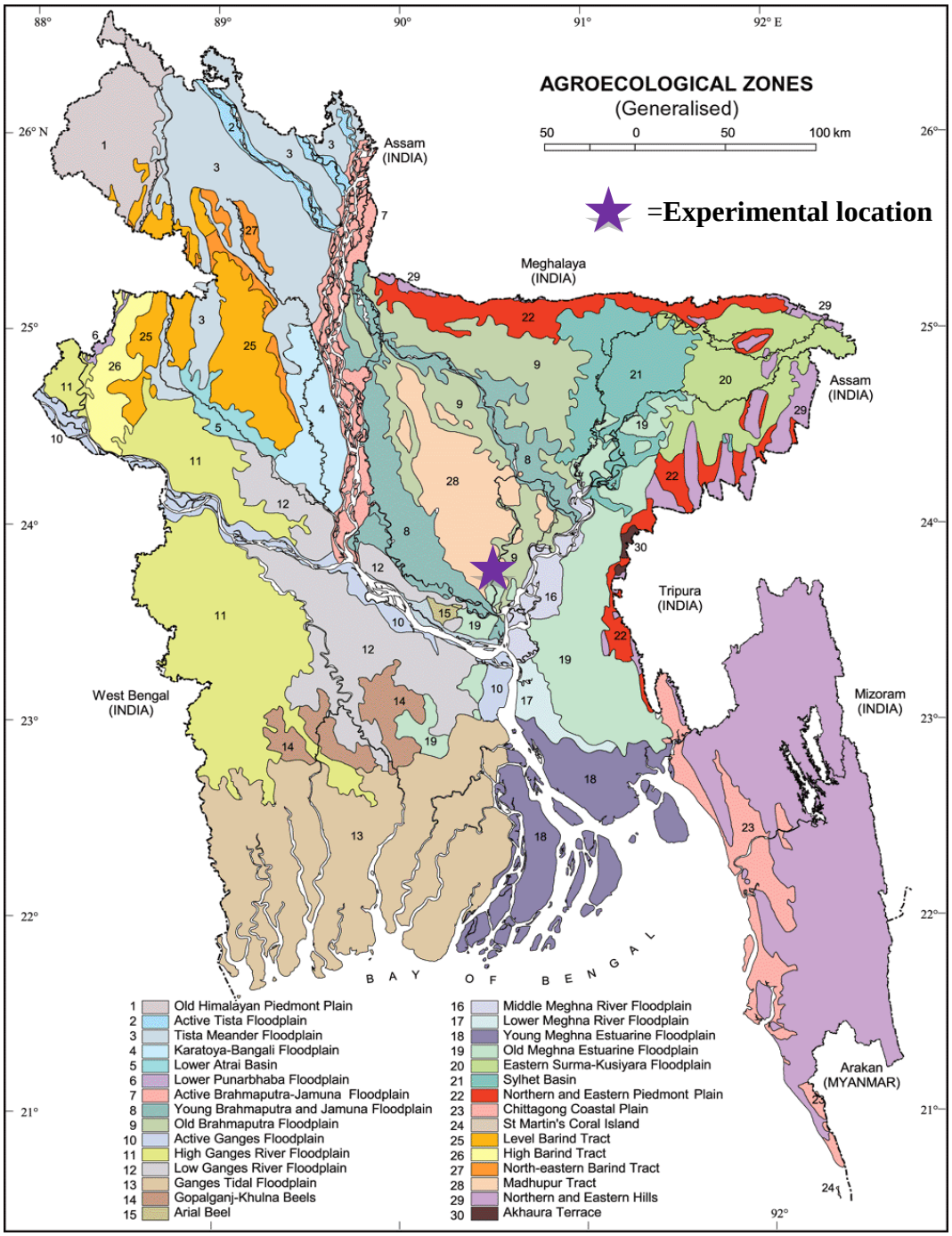
# APPENDICES

## 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 |
|---|---|
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow Red Brown Terrace Soil |
| Land type | High land |
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| 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** |
| Clay | 29 % |
| Sand | 26 % |
| Silt | 45 % |
| Textural class | Silty clay |
| **Chemical characteristics** | |
| **Soil characteristics** | **Value** |
| Available P (ppm) | 20.54 |
| Exchangeable K (mg/100 g soil) | 0.10 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| pH | 5.6 |
| Total nitrogen (%) | 0.03 |

**Appendix III. Monthly meteorological information during the period from October 2020 to February 2021.**

| Year | Month | Air temperature ($^0$C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|---|
| | | Maximum | Minimum | | |
| 2020 | October | 31.2 | 23.9 | 76 | 52 |
| | November | 29.6 | 19.8 | 53 | 00 |
| | December | 28.8 | 19.1 | 47 | 00 |
| 2021 | January | 25.5 | 13.1 | 41 | 00 |
| | February | 25.9 | 14 | 34 | 7.7 |

Source: Métrological Centre, Agargaon, Dhaka (Climat Division)

## Appendix IV. Layout of the experimental field


| R1 | | | .25cm | R2 | | | R3 | | |
|---|---|---|---|---|---|---|---|---|---|
| V1F1 | | V1F2 | | V3F2 | | V2F3 | V3F4 | | V1F3 |
| .25cm | | | | | | | | | |
| V2F3 | | V2F1 | | V1F3 | | V2F2 | V2F2 | | V3F2 |
| V1F4 | | V3F2 | | V2F4 | | V3F4 | V2F1 | | V1F1 |
| V2F2 | | V1F3 | | V3F1 | | V3F3 | V3F3 | | V1F4 |
| V3F4 | | V2F2 | | V1F1 | | V1F2 | V2F4 | | V2F3 |
| V3F3 | | V3F1 | | V1F4 | | V1F1 | V3F1 | | V2F2 |

**LEGENDS:**

$V_1$ = BARI sarisha9, $V_2$ = BARI sarisha14, BARI sarisha15;

$F_1$ = Recommendation dose of fertilizer no vermicompost, $F_2$ = Recommendation dose of fertilizer+2 t $ha^{-1}$ vermicompost,, $F_3$ =Recommendation dose of fertilizer+3 t $ha^{-1}$ vermicompost, $F_4$ = Recommendation dose of fertilizer+4 t $ha^{-1}$ vermicompost .

**Appendix V. Analysis of variance of the data of plant height of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of plant height at | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **15 DAT** | **30 DAT** | **45 DAT** | **At harvest** |
| Replication (R) | 2 | 1.042 | 8.20 | 15.09 | 2.04 |
| Variety (A) | 2 | 18.097* | 924.37** | 3624.68** | 3898.01** |
| Vermicompost (B) | 3 | 60.296** | 295.58** | 245.70** | 117.81** |
| A×B | 6 | 40.096* | 97.86 | 56.87 | 10.75 |
| Error | 22 | 43.231 | 177.72 | 371.14 | 124.24 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

**Appendix VI. Analysis of variance of the data of number of leaf plant$^{-1}$ of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of number of leaf Plant$^{-1}$ | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **15 DAT** | **30 DAT** | **45 DAT** | **At harvest** |
| Replication (R) | 2 | 1.0950 | 32.13 | 160.83 | 38.42 |
| Variety (A) | 2 | 21.1250* | 912.99** | 3536.14** | 738.91* |
| Vermicompost (B) | 3 | 5.4031 | 113.95 | 871.31** | 24.89 |
| A×B | 6 | 4.0928 | 90.80 | 1076.70* | 172.97 |
| Error | 22 | 22.4717 | 597.45 | 1155.49 | 324.32 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

**Appendix VII. Analysis of variance of the data of number of branches plant$^{-1}$ of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of number of branches and sub branches plant$^{-1}$ | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **15 DAT** | **30DAT** | **45 DAT** | **At harvest** |
| Replication (R) | 2 | 0.2600 | 8.29 | 212.52 | 37.04 |
| Variety (A) | 2 | 6.2067** | 711.53** | 2032.37** | 1790.95** |
| Vermicompost (B) | 3 | 2.4222* | 18.14 | 49.09 | 78.47 |
| A×B | 6 | 1.1711 | 48.09 | 132.56 | 59.12 |
| Error | 22 | 4.4600 | 239.64 | 256.41 | 233.53 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

**Appendix VIII. Analysis of variance of the data of above ground dry matter weight of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of above ground dry matter weight at | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **15DAT** | **30 DAT** | **45 DAT** | **At harvest** |
| Replication (R) | 2 | 0.00369 | 5.468 | 340.47 | 161.0 |
| Variety (A) | 2 | 0.06514 | 90.524** | 1972.08** | 10612.9** |
| Vermicompost (B) | 3 | 0.01498 | 9.282 | 535.60** | 4350.4** |
| A×B | 6 | 0.08632 | 6.301 | 214.12 | 843.2 |
| Error | 22 | 0.24738 | 24.612 | 411.74 | 1612.6 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

**Appendix IX. Analysis of variance of the data of number of siliqua plant$^{-1}$length of siliqua (cm), number of seeds siliqua$^{-1}$ and 1000 seeds weight (g) of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **Number of siliqua plant$^{-1}$** | **Length of siliqua** | **Number of seeds siliqua$^{-1}$** | **1000 seeds weight** |
| Replication (R) | 2 | 2433 | 0.0121 | 1.20 | 0.00536 |
| Variety (A) | 2 | 1183670** | 5.7573** | 1131.50** | 1.00109** |
| Vermicompost(B) | 3 | 22082** | 3.5768** | 22.06** | 0.96704** |
| A×B | 6 | 8850* | 1.8007** | 24.75** | 0.16509** |
| Error | 22 | 13407 | 1.0793 | 11.93 | 0.14778 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

**Appendix X. Analysis of variance of the data of seed yield, stover yield biological yield (t ha$^{-1}$) and harvest index (%) of mustard as influenced by variety, vermicompost and their interaction at different DAT**

| Mean square values of | | | | | |
|---|---|---|---|---|---|
| **Source** | **Df** | **Seed yield** | **Stover yield** | **Biological yield** | **Harvest index** |
| Replication (R) | 2 | 0.06529 | 0.1145 | 0.3265 | 3.226 |
| Variety (A) | 2 | 6.88975** | 17.9153** | 46.1197** | 68.417** |
| Vermicompost(B) | 3 | 1.31845** | 2.5201** | 7.4473** | 8.750* |
| A×B | 6 | 0.08885** | 0.2983** | 0.3165* | 20.734** |
| Error | 22 | 0.03862 | 0.2788 | 0.3275 | 17.453 |
| Total | 35 | | | | |

*indicates 5% level of significance; ** indicates 1% level of significance

## PLATES

**Plate 1:** Photograph showing preparation of seedbed

**Plate 2:** Photograph showing seedling growth in the seedbed

**Plate 3:** Photograph showing final land preparation for transplanting seedling from seed bed

**Plate 4:** Photograph showing uprooted seedling transplanted in main field


**Plate 5:** Photograph showing data recoding for experiment


**Plate 6:** Photograph showing general view of experimental plot with signboard




**Plate 7:** Photograph showing that sun drying in harvested plants and siliqua of mustard