GROWTH AND YIELD OF MUSTARD AS AFFECTED BY VERMICOMPOST WITH DIFFERENT LEVELS OF FERTILIZER

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD OF MUSTARD AS AFFECTED BY VERMICOMPOST WITH DIFFERENT LEVELS OF FERTILIZER,*** *Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTERS OF SCIENCE (M.S.)*** *in* ***AGRONOMY,*** *embodies the result of a piece of bonafide research work carried out by* ***MD RIPON ALI,*** *Registration No.* ***19-10385*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Date:
Place: Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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GROWTH AND YIELD OF MUSTARD AS AFFECTED BY VERMICOMPOST WITH DIFFERENT LEVELS OF FERTILIZER

ABSTRACT

The experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Bangladesh to find out the growth and yield of mustard as affected by vermicompost with different levels of fertilizer during the period from November 2021 to March 2022. Two factors experiment was laid out in Split Plot Design with three replications. Three mustard varieties *viz*. V_1 (BARI sarisha-14), V_2 (BARI sarisha-16) and V_3 (BARI sarisha-18) in association with four treatments of inorganic fertilizers with or without vermicompost *viz*. control treatment T_0 (RDF), T_1 (RDF + vermicompost 2.5 t ha^{-1}), T_2 (75% RDF + vermicompost 2.5 t ha^{-1}) and T_3 (50% RDF + vermicompost 2.5 t ha^{-1}) were considered for the present study. Among three varieties, V_3 (BARI sarisha-18) showed best performance for most of the parameters and gave the highest shoot fresh weight $plant^{-1}$, shoot dry weight $plant^{-1}$, SPAD value, siliqua length, number siliqua $plant^{-1}$, 1000-seed weight, seed yield, stover yield and harvest index compared to V_1 (BARI sarisha-14) and V_2 (BARI sarisha-16). However, among the different treatments applied to mustard, T_1 (RDF + vermicompost 2.5 t ha^{-1}) showed best results on different growth yield contributing parameters and yield of mustard and gave the highest plant height, number of leaves $plant^{-1}$, shoot fresh weight $plant^{-1}$, shoot dry weight $plant^{-1}$, SPAD value, siliqua length, number of siliqua $plant^{-1}$, number of seeds $siliqua^{-1}$, 1000-seed weight, seed yield, stover yield and harvest index compared to other treatments. Regarding treatment combination of variety and inorganic fertilizer with vermicompost, V_3T_1 showed the best performance on different growth, yield and yield contributing parameters in comparison to other treatment combinations. The maximum shoot fresh weight $plant^{-1}$ (354.30 g), shoot dry weight $plant^{-1}$ (39.61 g), siliqua length (8.39 cm), number of siliqua $plant^{-1}$ (154.30), 1000-seed weight (4.55 g), seed yield (2480.00 kg ha^{-1}), stover yield (2813.00 kg ha^{-1}) and harvest index (46.80%) were obtained from the treatment combination of V_3T_1 whereas the lowest was from the treatment combination of V_1T_3. So, it can be concluded that the application of (RDF + vermicompost 2.5 t ha^{-1}) to the variety BARI sarisha-18 can be considered to achieve higher mustard yield.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Mustard is one of the most vital oil seed crop next to soybean throughout the world (FAO, 2014). Among the oil seed crops grown in Bangladesh, mustard is considered as the principal oil seed crop which belongs to the genus *Brassica* of the family Brassicaceae. It is well adapted to all agro-climatic zones of the country and is grown in Rabi season (November-March). Mustard seeds have high energy content, having 28–32% oil with relatively high protein content (28–36%) by weight, although these values can vary slightly between varieties, growing regions and crop years (Sarker *et al*., 2021).

Mustard is covering above 69.94% of the oil cropped area and producing 38.80% of the total oil seed production in Bangladesh. The per capita consumption of edible oil in Bangladesh is 10-12g day^{-1}. The internal production of edible oil only meet less than one-third of the annual requirement (Mondal and Wahab, 2001). The major reasons for low yield of mustard in Bangladesh are lack of high yielding variety, appropriate population density and inadequate knowledge of sowing time, sowing methods and proper management practices including proper nutrition (Mamun *et al*., 2014). There is a great scope of increasing yield of mustard by selecting appropriate high yielding varieties, soil topography, weather condition with improved management practices (Bhuiyan *et al*., 2011).

Among the oilseed crops, mustard is the major oilseed crop, which covers about 60% of the oilseed production in Bangladesh and it occupies first position of the list in respect of area and production among the oil seed crops (BBS, 2019). In the year of 2017-18, mustard covered 760 thousand acres land and the production was 352 thousand metric ton (BBS, 2018). Major mustard growing districts of Bangladesh are Cumilla, Tangail, Jashore, Sirajgong, Sylhet, Faridpur, Pabna, Madaripur, Jamalpur, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur and Dhaka (BBS 2019).

Brassica has three species that produce edible oil, they are *B. napus*, *B. campestris* and *B. juncea*. Of these, *B. napus* and *B. campestris* are of the greatest importance in the world's oil seed trade. In this subcontinent, *B. juncea* is also an important oil seed crop. Until recently, mustard varieties such as Tori-7, Sampad (*Brassica campestris*) and Doulat (*Brassica juncea*) were mainly grown in this country. Recently several varieties of high yielding potential characteristics have been developed by BARI. Seed yield and other yield contributing characters significantly varied among the varieties of rapeseed and mustard (BARI, 2001). A significant yield difference among the varieties of rapes and mustard with the same species (Uddin *et al*., 1987). Oil content variation due to different variety and different method (Singh *et al*., 1999). There are some HYVs of mustard, which have been released by the Sher-e-Bangla Agricultural University (SAU), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). Yield contributing characters and yield of different variety varied significantly (BARI, 2001; Mamun *et al*., 2014).

Nutrient management is one of the most important factors that affect the mustard productivity. Soil fertility quality can be improved by adding organic matter. The addition of organic matter to the soil has a very important function in fertilizing the topsoil layer, increasing the population of microorganisms in the soil, increasing the water absorption capacity and overall improving the quality of soil fertility. The addition of organic matter to mustard planting has the potential to reduce the use of synthetic chemical fertilizers (Agustina *et al*., 2012). But application of all the needed fertilizer through chemical fertilizers had deleterious effect on soil fertility and unsustainable yields. It is necessary to use organic matter source like cowdung, farmyard manure, vermicompost, poultry manure etc. which are good source of nutrients required by plants for quality produce. Cowdung is a good source of organic matter and play a vital role in soil fertility improvement as well as supplying primary, secondary and micronutrients for crop production. Cowdung application has been known to

improve physical, chemical and biological properties of soil (Zamil, 2004). Vermicompost is an organic fertilizer that has advantages over other organic fertilizers (Lun, 2005). The vermicompost contains macro and micronutrients, which are useful for plant growth. Plants will more effectively utilize organic fertilizers combined with inorganic fertilizers.

Use of chemical fertilizers in combination with organic manure is essentially required to improve the soil health (Prasad *et al.* 2010). Balanced nutrient management through conjunctive use of organic, inorganic and bio-fertilizers facilitate profitable and sustainable crop production and also maintain soil quality (Singh and Sinsinwar, 2006). The interaction of vermicompost fertilizer and NPK fertilizer has the potential to have a positive effect where the application of vermicompost fertilizer as an organic material can improve soil fertility physically, such as improving soil structure, porosity, permeability, increasing water retention capacity so that the ability of the roots to absorb nutrients in the soil will be better. Thus, NPK fertilizer will be more efficiently absorbed by plant roots so that the available nutrients can increase plant growth.

Keeping all the above facts in view, the present investigation was undertaken to study the growth and yield of mustard as affected by vermicompost with different levels of fertilizer**.** with the following objectives:

1. To investigate the effects of varietal performance on growth and yield of mustard
2. To investigate the effects of vermicompost in association with inorganic fertilizer on yield contributing characters and yield of mustard

CHAPTER II

REVIEW OF LITERATURE

Mustard is an important oil crop in Bangladesh which can contribute largely in the national economy. Investigation on the growth and yield of mustard as affected by vermicompost with different levels of fertilizer have been progressed in many countries of the world. The proper agronomic practices accelerate its growth and influenced its yield. Therefore, available findings of the effect of variety and nutrient management through vermicompost with inorganic fertilizer to the present study have been briefly reviewed under the following heads.

2.1 Varietal performance of mustard

Sarker *et al*. (2021) conducted a study and showed that the highest plant height (131.33 cm), leaf number (24.67), seed yield (1813.33 kg ha^{-1}) and stover yield (3876.67 kg ha^{-1}) were found in BARI Sarisha-16. BARI Sarisha-11 was found better in respect of maximum siliqua $plant^{-1}$, weight of seeds $plant^{-1}$, 1000-seed weight and harvest index. Besides this, BARI Sarisha-14 showed the maximum number of seeds $siliqua^{-1}$.

Lal *et al*. (2020) reported that higher plant height than other varieties. Among varieties, RGN-73 had significantly higher number of branches per plant, dry matter accumulation $plant^{-1}$, siliqua $plant^{-1}$, seed yield, stover yield, biological yield and harvest index than other varieties.

Priyanka *et al*. (2020) carried out a research comprised of mustard varieties *viz*. Kranti, Giriraj, CS-54 and CS-58 with three fertilizer doses *viz*. recommended fertilizer dose (RDF), i.e., 60:20:20, 125% of recommended fertilizer dose and 150% of recommended fertilizer dose. Statistical analysis devised that variety had significant effect on plant height, number of primary branches $plant^{1}$, number of secondary branches $plant^{-1}$, number of siliqua $plant^{-1}$, number of seeds $silique^{-1}$, seed and straw yield.

Ahamed *et al*. (2019) studied the tallest plant of mustard was found form BARI sarisha-15. The maximum branches plant^{-1}, dry matter weight plant^{-1}, siliqua plant^{-1}, seed silliqua^{-1}, and length of silliqua were obtained from BARI sarisha-15. The highest yield of seed (0.95 t ha^{-1}) was obtained from BARI sarisha -15.

Ahmed and Kashem (2017) conducted a study with five mustard varieties *viz*. BADC 1, SAU Sarisha-3, BARI sarisha-11, BARI sarisha-14 and BARI sarisha-15 to find out the suitable mustard variety/varieties on growth and yield. Significant differences were found among the mustard varieties for number of branches plant^{-1}, number of capsules plant^{-1}, capsule length, 1000-seed weight and seed yield. The mustard var. BARI Sarisha-11 produced the highest number of branches plant^{-1}, number of capsules plant^{-1}, 1000-seed weight resulting the highest seed yield (1.64 t ha^{-1}), followed by BARI sarisha-15 (1.47 t ha^{-1}). The seed yield of BARI Sarisha-11 and BARI sarisha-15 was not differed significantly, but the growth duration of BARI sarisha-15 was shorter than the others.

Helal *et al*. (2016) indicated that, growth as well as yield and yield attributes of rapeseed mustard were significantly differed. The variety Improved Tori, BARI sharisa-8, BARI Sharisa-14 and BARI sharisa-15 produced the highest seed yield and took minimum days to mature and their growth parameters were also highly significant and positive correlation was observed in seed yield with siliqua/plant, straw yield, biological yield, 1000-seed weight and harvest index. So, Improved Tori, BARI sarisha-8, BARI sarisha-14 and BARI sarisha-15 are suitable for cultivation in north-east region (Sylhet) of Bangladesh.

Kumar *et al*. (2015) conducted a field experiment on two varieties of rapeseed (NC-1, B-9) and four varieties of mustard (SEJ-2, NPJ-112, JD-6 and NRCHB 101) and reported that mustard variety JD-6 recorded significantly higher plant height (180.32 cm) and was on par with NRCHB 101 (178.03 cm). NRCHB-101 achieved maximum number of siliqua plant^{-1} (146.10) and seed yield (1.54 t ha^{-1}).

Salam *et al*. (2014) stated that the highest seed yield (1.61 t ha^{-1}) was obtained from the variety BARI sarisha-14 which was statistically identical with BARI sarisha-15. The lowest seed yield (1.20 t ha^{-1}) was obtained from the variety Tori-7. Significant differences were observed among the varieties in respect of plant height (cm), number of branches $plant^{-1}$, number of siliqua $plant^{-1}$, siliqua length (cm), number of seeds $siliqua^{-1}$, 1000-seed weight (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (t ha^{-1}), harvest index (%) and days to maturity. Among the varieties, BARI sarisha-16 produced the tallest plant (127.7 cm) compared with the other varieties whereas BARI sharisa-14 produced the shortest plant (60.1 cm) which was statistically similar to Tori-7 (60.5 cm).

Alam *et al*. (2014) carried out a field experiment with 30 varieties/genotypes of rapeseed-mustard under three dates of sowing to determine changes in crop phenology, growth and yield of mustard genotypes under late sown condition. Yield and yield attributes of different varieties varied significantly. Among the varieties, BARI sarisha-16 of *Brassica juncea* gave significantly the highest seed yield (1495 and 1415 kg ha^{-1}), which was statistically identical to BJDH-11, BJDH-12, BJDH-05, BJDH-20, and BARI sarisha-6 and significantly different from all other varieties.

Singh *et al*. (2012) tested three Indian mustard cultivars ('Kranti', 'Bio-902' and 'Rohini') with 4 levels of sulphur. The variety 'Rohini'gave higher plant height, number of branches $plant^{-1}$, siliqua $plant^{-1}$, seeds $siliqua^{-1}$, 1000-grain weight, harvest index and resulted significantly higher seed and stover yield, oil and protein content than 'Bio-902' and 'Kranti'.

Jahan and Zakaria (2010) and Mondal *et al*. (2008) found that the highest number of siliqua $plant^{-1}$ in BLN-900 and the lowest was in Semu- 249/84. They also noted the lowest number of siliqua $plant^{-1}$ was in the variety SS-75. Alam (2004), Ali *et al*. (1996) and Bhuiyan (1989) observed significant variations in terms of plant height in different varieties of rapeseed-mustard.

Khaleque (1989) found different number of branches of 3.9 and 3.1 plant^{-1} in TS-72 and Sonali sarisha, respectively. Length of siliqua, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight and seed yields significantly differed among the varieties and advanced line.

Pooran *et al*. (2000) studied six cultivars of mustard and found that among the mustard cultivars, GM-1 gave the highest seed yield (1050 kg ha^{-1}), followed by Kranti and Pusa Bold (790 and 760 kg ha^{-1}, respectively) and Varuna and Sita produced comparably lower yields (680 and 610 kg ha^{-1}, respectively).

2.2 Effect of vermicompost with inorganic fertilizers

According to Sugianti and Zulhaedar, (2021), combined application of organic and inorganic fertilizers resulted in significantly higher yield of mustard greens, compared to the standard fertilization regimen using inorganic fertilizers and treatments only with organic fertilizer at different doses.

Alim *et al*. (2020) conducted an experiment using two mustard varieties BARI Sarisha-14 (V_1) and BARI Sarisha-16 (V_2) in combination with six integrated nutrient managements (INM) *viz*., 75% RDF (Recommended dose of fertilizer) (T_1), 75% RDF + Vermicompost (VC) @ 2.5 t ha^{-1} (T_2), RDF (90:27:32:15:1, N:P:K:S:Zn:B) - (T_3), RDF + Vermicompost (VC) @ 2.5 t ha^{-1} (T_4), 125% RDF (T_5) and 125% RDF + Vermicompost (VC) @ 2.5 t ha^{-1} (T_6) to the sub-plot. The highest seed yield (1.82 t ha^{-1}) was obtained from BARI sarisha-16 and the lower seed yield (1.51 t ha^{-1}) was observed in BARI sarisha-14. Among the INM treatments, the highest seed yield (1.91 t ha^{-1}) was recorded from T_2 which was statistically similar to T_4. Therefore, BARI sarisha-16 should be grown with 75% RDF + Vermicompost (VC) @ 2.5 t ha^{-1} for obtaining higher yield.

Beenish *et al*. (2018) observed the growth and yield of Indian mustard varieties. The treatments consisted of five mustard varieties and 10 fertilizer

treatments. Regarding fertilizer treatments T_7 (75% N through vermicompost + Azotobacter) produced significantly tallest plants, the highest number of primary, secondary branches/plant and yield attributing characters.

Kumar *et al*. (2018) revealed that the maximum growth parameters (plant height, branches plant^{-1}, dry matter accumulation and leaf area index) were recorded with application of 50% RDF+ FYM 6 t ha^{-1} + Vermicompost 2 t ha^{-1}+ bio-fertilizer than the rest of the treatments. Maximum yield attributes (siliqua length, siliqua plant^{-1}, seeds siliqua^{-1} and test weight) and yield parameters (grain and stover) ere recorded with application of 50% RDF+ FYM 6 t/ha + Vermicompost 2 t ha^{-1}+ bio-fertilizer than the rest of the treatments. The increment in seed yield with application of 50% RDF+ FYM 6 t/ha + Vermicompost 2 t ha^{-1} + Bio-fertilizers was 168.35% over control. Maximum gross return, net return were recorded with the application of 50% RDF+ FYM 6 t ha^{-1} + Vermicompost 2 t ha^{-1} + Bio-fertilizers, however B: C ratio was lower than the use of RDF only but in application of FYM and vermicompost improved the physiochemical properties of soil which may improved the sustainability of production system.

Chandan *et al.* (2018) reported that the treatment receiving application of 75 percent RDF + 40 kg Sulphur + 5 t ha^{-1} vermicompost with superimposition of Azotobacter and PSB recorded the highest silique plant^{-1} (274).

Singh *et al*. (2018) found that application of RDF 100 percent + FYM 5 t ha^{-1} + vermicompost 2.5 t ha^{-1} + Azotobacter produced the highest number of silique plant^{1} (240) as compared to number of silique (193) observed in the control treatment. The treatment receiving application of 75 percent RDF + 40 kg Sulphur + 5 t ha^{-1} vermicompost with superimposition of Azotobacter and PSB recorded the highest seed yield of 17.80 q ha^{-1} and highest stover yield (61.50 q ha^{-1}). They further reported that the treatment receiving application of RDF + 40 kg sulphur + 2 t poultry manure + Azotobacter + PSB produced higher (16.70 q ha^{-1}) seed yield of mustard. They also found that application of RDF

100 percent + FYM 5 t ha^{-1} + vermicompost 2.5 t ha^{-1} + Azotobacter also produced highest seed yield (2316 kg ha^{-1}) of mustard.

Sahoo *et al.* (2018) opined that the treatment receiving the application of 75 percent STR + FYM @ 5 t ha^{-1} + zinc @ 5 kg ha^{-1} + Azotobacter registered the higher seed yield and stover yield of mustard (24.15 and 4993.83 kg ha^{-1}, respectively).

Thaneshwar *et al.* (2017) observed significant increase in the plant height of mustard from 126.33 to 143.10 cm when the three levels of vermicompost were applied along with RDF. They further noted that the treatment receiving application of vermicompost 5 t ha^{-1} produced the tallest plants (143.10 cm) of mustard. The application of RDF (N:P:K @ 120:60:40:30 kg ha^{-1}) + vermicompost 5 t ha^{-1} also produced maximum dry matter yield (24.37 g) $plant^{1}$ and also produced maximum number of siliqua on primary branches (164.61), maximum total number of silique (286.3) $plant^{-1}$, while application of RDF + vermicompost 2 t ha^{-1} produced maximum number of siliqua on secondary branch (102.38). Application of RDF (N:P:K @ 120:60:40:30 kg ha^{-1}) + vermicompost 5 t ha^{-1} also produced maximum seed yield (22.75 q ha^{-1}) and maximum stover yield (79.26 q ha^{-1}).

Khambalkar *et al.* (2017) reported that the treatment receiving application of 50 percent RDF (60:30:30:20 N:P:K:S kg ha^{-1}) + FYM 6 t ha^{-1} + Vermicompost 2 t ha^{-1} + Azotobacter and PSB recorded the highest plant height values of 31.50, 134.33, 193.50 and 198.66 cm, at 30, 60, 90 and at harvest of mustard, respectively.

Pal and Pathak (2016) studied the effect of integrated nutrient management on yield and economics of mustard and concluded that the application of compost and PSB along with 80 kg phosphorus and 60 kg sulphur recorded the maximum number of silique per plant (476.50) and highest seed yield of mustard (2633.36 kg ha^{-1}).

Saha *et al.* (2015) conducted a trial to study the effect of integrated nutrient management on growth and productivity of rapeseed-mustard cultivars at pulse and oilseed research station, Berhampore, West Bengal during robi season on Entisols (pH 6.6) and observed that the treatment receiving application of 100:50:50:30 N:P:K:S kg ha^{-1} + Azotobacter + PSB recorded the highest plant height (132 cm)), maximum number of silique per plant, highest seed yield and stover yield of mustard.

Lepcha *et al.* (2015) conducted a field experiment entitled influence of different organic and inorganic sources of nitrogen on yield attributes of Indian mustard and observed that application of 20 percent nitrogen through FYM + 20 percent nitrogen through vermicompost + 20 percent nitrogen through neem cake + 20 percent nitrogen through poultry manure + 20 percent nitrogen through inorganics produced the highest number of silique $plant^{1}$ (522.83), seed yield (21.52 q ha^{-1}), stover yield (57.91 q ha^{-1}) of mustard over rest of the treatment combinations.

Kansotia *et al.* (2015) observed that the sole application of vermicompost @ 2, 4 and 6 t ha^{-1} found to be beneficial for producing higher seed yield of mustard (1058.67, 1241.56 and 1456.00 kg ha^{-1}, respectively) over rest of the treatment combinations. They also observed that the sole application of vemicompost @ 2.0, 4.0, and 6.0 t ha^{-1} was found beneficial for producing higher stover yield of mustard from 1426.2 to 1933.6 kg ha^{-1} with average value of 1679.9 kg ha^{-1}.

Singh *et al.* (2014) observed that the application of RDF + vermicompost @ 5 t ha^{-1} registered the highest seed yield (17.40 q ha^{-1}) and stover yield (79.26 q ha^{-1}) of mustard. They further reported that the treatment receiving application of RDF + vermicompost @ 5 t ha^{-1} produced the highest number of silique $plant^{1}$ (286.53) and highest dry matter yield, maximum seed yield and stover yield of mustard.

Rundala *et al.* (2013) reported that the significantly maximum values of yield attributes of mustard were recorded under application of 75% RDF through

FYM + 25% through fertilizers being at par with 50% RDF through FYM + 50% through fertilizers. Results further indicated that dual inoculation with *Azotobacter+PSB* significantly increased siliquae plant^{-1}, seeds siliqua^{-1} and test weight of mustard over control.

Kansotia *et al*. (2013) recorded that the application of vermicompost increased the growth parameters, yield attributes, yields, nutrient content, nutrient uptake in seed, straw and total nitrogen and phosphorus uptake and protein content and observed that available nitrogen, phosphorus and potassium of soil after harvest of mustard were significant higher than over control and lower levels. The combined effect of vermicompost × inorganic fertilizer was found significant pertaining to seed yield, N content and uptake in seed, P uptake in stover and protein content in seed.

Babar and Dongale (2013) reported that application of different levels of RDF (125, 100, 75 and 50 percent) along with graded levels of FYM (50 and 25 percent on the basis of nitrogen content) caused variation in the seed yield 0.27 to 1.10 t ha^{-1} and stover yield from 0.62 to 2.79 t ha^{-1} of mustard. Among the various treatment combinations the application of 100 percent NPK through inorganics + 25 percent N through FYM produced the highest seed yield (1.10 t ha^{-1}), stover yield (2.79 t ha^{-1}) and harvest index (44.40%) of mustard..

De and Sinha (2012) observed that the treatment receiving application of 50 percent RDF (60:30:30 N:P:K) kg ha^{-1} + FYM 2.5 t ha^{-1} + Vermicompost 1.25 t ha^{-1} + Neem cake 1.25 t ha^{-1} + Poultry manure 1.25 t ha^{-1} registered the highest seed yield (13.47 q ha^{-1}) of mustard. Further they also reported that the seed yield of mustard varied significantly from 12.46 to 13.47 q ha^{-1} due to the integration of inorganics with organics.

Tripathi *et al.* (2011) reported that the application of 100% recommended dose of fertilizer along with FYM, sulphur, zinc, boron and Azotobacter (seed treatment) resulted in maximum seeds per siliqua and 1000-seed weight of mustard. The maximum seed yield (1809 kg ha^{-1}) of mustard was also observed

in the treatment receiving application of 100 percent RDF + 2 t FYM + 40 kg sulphur + 25 kg zinc sulphate + 1 kg boron + Azotobacter (seed inoculation).

Haque *et al*. (2010) evaluated the effects of biofertilizer (BioF) such as BioF/compost (household/kitchen wastes composted with *Trichoderma harzianum* T22) and BioF/liquid (*T. harzianum* T22 broth culture contains spores and mycelia) alone or in combination with NPK fertilizer for the growth, dry matter production, yield and yield attributes of mustard (*Brassica campestris*) grown under field condition. Recommended doses of NPK and 50% BioF/compost + 50% NPK showed similar effects on growth, dry matter accumulation and yield of mustard. Seed yield plant^{-1} was increased by 5.34% over the recommended dose of NPK, when the crop was fertilized with 50% BioF/compost along with 50% NPK. Since 20% reduced yield is accepted in organic farming worldwide, the treatments namely BioF/compost, 50% BioF/compost + 50% NPK and 75% BioF/compost + 25% NPK might be recommended for mustard cultivation in Bangladesh.

Singh *et al*. (2006) carried out a field experiment to evaluate the response of Indian mustard 'RH-30'to FYM (2.5 and 5 t ha^{-1}) and inorganic N (0, 40, 80 kg/ha) applied alone or in combination with biofertilizers (*Azotobacter chroococcum* and *Azospirillum*). Siliquae plant^{-1}, seeds siliqua^{-1}, 1000-seed weight, seed oil content, oil yield, and yield of seed and stover significantly increased with the application of FYM + biofertilizers (5 t increased + *Azotobactor chroococcum* + *Azospirillum*) over the control.

Gudadhe *et al.* (2005) studied the effect of biofertilizers on growth and yield of mustard and reported that application of graded levels of recommended dose of fertilizers alone or in combinations of Azotobacter and PSB alone or both recorded plant height of mustard varied from131.8 to 156.3 cm and the highest plant height (156.3 cm) was observed in the treatment receiving application of 100 percent RDF + Azotobacter and PSB.

Vyas (2005) carried out a field experiment on interactive effects of nitrogen

and biofertilizers on Indian mustard and stated that the maximum number of silique per plant (193.4) in mustard were observed in the treatment receiving application of NP @ 90:40 kg + Azotobacter. They further reported that the treatment receiving application of 40 kg P_2O_5 + Azotobacter and PSB recorded the higher number of silique (173.6) per plant.

Murudkar (2002) reported that the periodical plant height varied significantly from 6.54 to 8.12 cm at 30 DAS, 136.08 to 164.33 cm at 60DAS and 167.31 to 187.38 cm due to the various treatment combinations of integrated nutrient management. The maximum number of silique plant^{-1} were produced (184.17) due to the application of recommended dose of fertilizer along with glyricidia @ 5 t ha^{-1}.

Mondal and Wahhab (2001) explained the performance of the crop was adjudged in terms of various parameters *viz*. leaf number, leaf area index (LAI), leaf area duration (LAD), leaf area ratio (LAR), crop growth rate (CGR), net assimilation rate (NAR), photosynthetic rate (PR)) and biochemical attributes such as total chlorophyll, sugar and proline content of physiologically active leaves of mustard by using organic fertilizer.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2021 to March 2022 to study the growth and yield of mustard as affected by vermicompost with different levels of fertilizer**.** The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix II.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter 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). Details on the meteorological data of air

temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.4 Experimental details

3.4.1 Treatments

Factor A: Variety

1. V_1 = BARI sarisha-14 (*Brassica campestries*)
2. V_2 = BARI sarisha-16 (*Brassica juncea*)
3. V_3 = BARI sarisha-18 (*Brassica napus*)

Factor B: Vermicompost with inorganic fertilizer

1. T_0 = Control [RDF (recommended doses of fertilizer)]
2. T_1 = RDF + VC (vermicompost 2.5 t ha^{-1})
3. T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1})
4. T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

3.4.2 Experimental design and layout

The experiment was laid out in Split Plot Design with three replications. The layout of the experiment was prepared for distributing the combination of different mustard varieties and vermicompost with inorganic fertilizer. The 12 treatment combinations of the experiment were assigned at random into 36 plots. Variety was assigned into main plot and treatments were assigned into sub-plot. The size of each unit plot was (2.5 m × 2 m). The distance between blocks and plots were 0.75 m and 0.50 m respectively. The layout of the experiment field is presented in Figure 1.

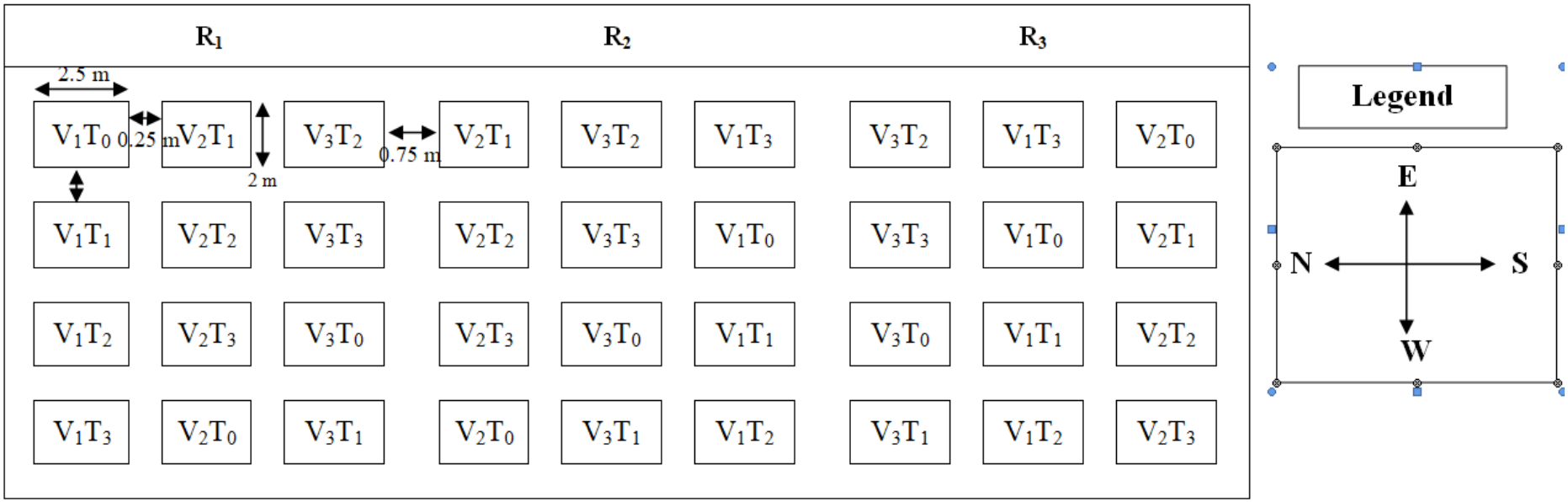


Fig. 1. Layout of the experimental plot

3.4.3 Collection of seeds

BARI sarisha-14, BARI sarisha-16 and BARI sarisha-18; high yielding varieties of mustard developed by Bangladesh Agricultural Research Institute (BARI), Gazipur were used as test crops. Seeds were collected from BARI, Joydebpur, Gazipur.

3.5 Preparation of the main field

The plot selected for the experiment was opened in the first week of November, 2021 with a power tiller, and was exposed to the sun for a few days, after that the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for sowing seeds. The land operation was completed on 14 November 2021. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.6 Fertilizers and manure application

The N, P, K, S, Zn and B nutrients were applied through urea, Triple super phosphate (TSP), Muriate of potash (MoP) Gypsum, $ZnSO_4$ and Boric acid, respectively. Nutrients was applied according to Krishi Projukti Hat Boi, BARI, 2016. Name and doses of nutrients were as follows:

Plant nutrients	Manure and fertilizer	Doses ha^{-1}
--	Cowdung	10 t
N	Urea	250 kg
P	TSP	170 kg
K	MoP	80 kg
S	Gypsum	150 kg
Zn	$ZnSO_4$	5 kg
B	Boric acid	10 kg

One third (1/3) of whole amount of urea and full amount of TSP, MoP, $ZnSO_4$ and Gypsum were applied at the time of final land preparation. The remaining

urea was top dressed in two equal installments- at 20 days after sowing (DAT) and 30 DAS respectively.

3.7 Sowing of seeds

Seeds were sown continuously @ 7 kg ha^{-1} on 17 November 2021 by hand as uniform as possible in the 30 cm apart lines. A strip of the same crop was established around the experimental field as border crop. After sowing the seeds were covered with soil and slightly pressed by laddering.

3.8 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of mustard.

3.8.1 Weeding and thinning

First weeding and thinning was done on 29 November 2021. Again, 2^{nd} weeding and thinning was done on 15 December 2021. Care was taken to maintain uniform plant population $plot^{-1}$.

3.8.2 Irrigation

Irrigation was done at three times. Three irrigations were given in the field on 28 November, 27 December 2021 and 24 January 2022 through irrigation channel.

3.8.3 Pest management

The crop was infested with aphids (*Lipaphis erysimi*) at the time of siliqua filling stage. The insects were controlled successfully by spraying Malathion 57 EC @ 2 ml L^{-1} water. The insecticide was sprayed on 6 January 2021. The crop was kept under constant observations from sowing to harvesting.

3.9 General observations of experimental field

The plots under experiment were frequently observed to notice any change in plant growth and other characters were noted down immediately to make necessary measures.

3.10 Harvesting and post harvest operation

The crop was harvested plot wise when 90% siliqua were matured. After collecting sample plants, harvesting was done from 3 February to 04 March 2022 according to varieties assigned. The variety, BARI sarisa 14 was harvested on 3 February 2022 whereas BARI sarisha-18 and BARI sarisha-16 were harvested on 27 February and 4 March 2022, respectively. The harvested plants were tied into bundles and carried to the threshing floor. The plants were sun dried by spreading the bundles on the threshing floor. The seeds were separated from the stover by beating the bundles with bamboo sticks. Seed and straw yield per plot were recorded after drying the plants in the sun followed by threshing and cleaning. At harvest, seed yield was recorded plot wise.

3.11 Data collection

Experimental data were recorded from 30 DAS and continued until harvest. The followings data were recorded during the experiment:

3.11.1 Morphological parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Shoot fresh weight plant^{-1} (g)
4. Shoot dry weight plant^{-1} (g)
5. SPAD value of leaf plant^{-1}

3.11.2 Yield contributing parameters

1. Siliqua length (cm)
2. Number of siliqua plant^{-1}
3. Number of seeds siliqua^{-1}
4. 1000-seed weight (g)

3.11.3 Yield parameters

1. Seed yield ha^{-1} (kg)
2. Stover yield ha^{-1} (kg)
3. Harvest index (%)

3.12 Measuring procedure of recording data

3.12.1 Morphological parameters

3.12.1.1 Plant height (cm)

Plant height was measured using a meter scale from the ground level to the apex of the plants in randomly selected 10 plants from specific rows of each plot at 30, 40 and 50 DAS and the mean plant height (cm) was recorded.

3.12.1.2 Number of leaves $plant^{-1}$

Ten plants were selected randomly from the inner rows of each plot. Leaves $plant^{-1}$ was counted from each plant sample at 30, 40 and 50 DAS and then averaged.

3.12.1.3 Shoot fresh weight $plant^{-1}$ (g)

Shoot fresh weight $plant^{-1}$ was measured from ten randomly selected plants. It was done by measuring of 10 plants from each plot at 30, 40 and 50 DAS then the average data were recorded.

3.12.1.4 Shoot dry weight $plant^{-1}$ (g)

Shoot dry weight $plant^{-1}$ was measured from ten randomly selected fresh plants of each plot. Sample plants were dried in an oven at 70°C for 72 hours. The sample plants was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample plants was taken and the average weight of 10 plants was termed as dry weight $plant^{-1}$ and was expressed in gram (g).

3.12.1.5 SPAD value of leaf $plant^{-1}$

Chlorophyll content was measured from leaves of each replication with the help of SPAD meter and it was measured at 30, 40 and 50 DAS.

3.12.2 Yield contributing parameters

3.12.2.1 Siliqua length (cm)

The length of the siliqua was measured from the base to the tip of the 10 randomly selected siliqua after harvest and then average data was recorded. It was done using meter scale and expressed in centimeter (cm).

3.12.2.2 Number of siliqua plant^{-1}

Number of total siliqua was counted from randomly pre-selected ten plants at harvest from each unit plot and the mean number was recorded. The number of siliqua plant^{-1} was recorded by the following formula.

$$\text{No. of siliqua plant}^{-1} = \frac{\text{Total number of siliqua}}{\text{Total number of plants for collected siliqua}}$$

3.12.2.3 Number of seeds siliqua^{-1}

The number of seeds was counted from randomly taking 10 siliqua per treatment. The average value is calculated as the number of seeds siliqua^{-1}.

3.12.2.4 Weight of 1000 seeds (g)

From the seed stock of each plot, 1000-seed were randomly collected and weighed by an electric balance. The 1000-seed weight was recorded in gram.

3.12.3 Yield parameters

3.12.3.1 Seed yield ha^{-1} (kg)

Seed yield was calculated from well dried grains (at 10% moisture level) collected from the central 1 m^2 area of inner rows of each plot (leaving boarder rows) and seed yield from 1 m^2 area was converted to kg ha^{-1}.

3.12.3.2 Stover yield ha^{-1} (kg)

Stover yield of central 1 m^2 area of inner rows of each plot (leaving boarder rows) was measured from well dried condition and recorded stover yield from 1 m^2 area was converted to kg ha^{-1}.

3.12.3.3 Harvest Index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula:

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

Here, biological yield = grain yield + stover yield

3.13 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Growth parameters

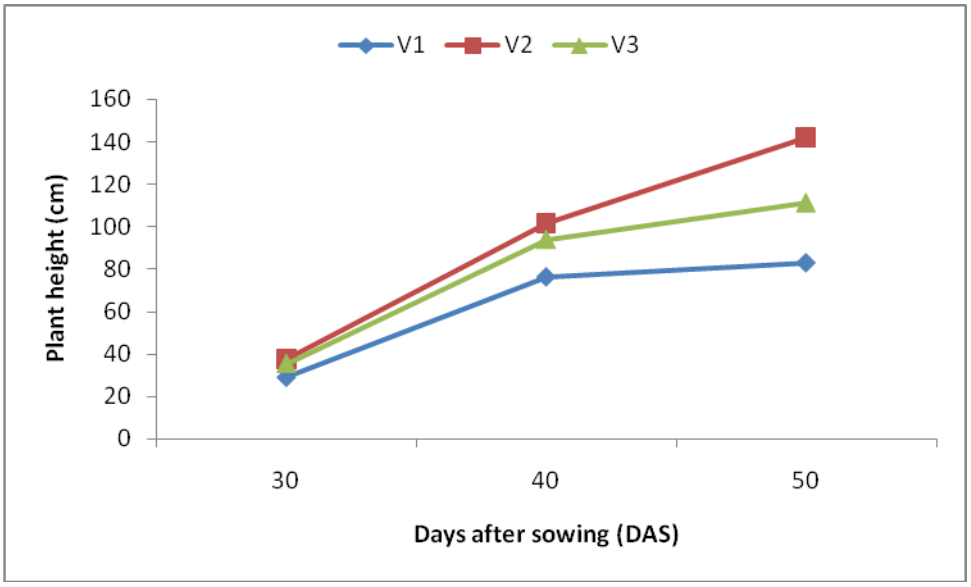
4.1.1 Plant height (cm)

Effect of variety

At various growth stages, the plant height of mustard varieties varied significantly (Figure 2). At 30, 40 and 50 DAS, the highest plant height (37.25, 101.30 and 141.93 cm, respectively) was achieved from the variety V_2 (BARI sarisha-16) which was followed by the variety V_2 (BARI sarisha-16) whereas the lowest plant height (28.90, 76.13 and 82.75 cm, respectively) was found from the variety V_1 (BARI sarisha-14). Sarker *et al*. (2021) and Lal *et al*. (2020) also found similar result with the present study and reported that plant height varied significantly due to varietal difference. The result obtained from the present study was similar with the findings of Kumar *et al*. (2018) and Thaneshwar *et al.* (2017).

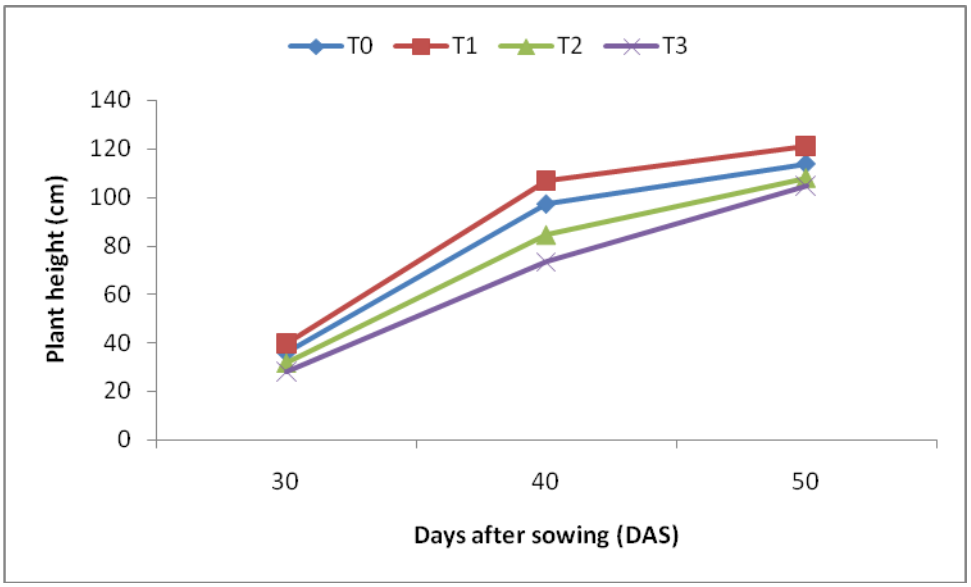
Effect of inorganic fertilizer with vermicompost

Different doses of inorganic fertilizer with vermicompost to mustard showed significant influence on plant height at different growth stages (Figure 3). At 30, 40 and 50 DAS, treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the highest plant height (39.68, 106.80 and 121.26 cm, respectively) followed by control treatment T_0 (RDF) whereas the lowest plant height (27.91, 73.34 and 104.94 cm, respectively) was found from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}).



V1 = BARI sarisha-14, V2 = BARI sarisha-16, V3 = BARI sarisha-18

Figure 2. Effect of different mustard varieties on plant height



T0 = Control [RDF (recommended doses of fertilizer)], T1 = RDF + VC (vermicompost 2.5 t ha-1), T2 = 75% RDF + VC (vermicompost 2.5 t ha-1), T3 = 50% RDF + VC (vermicompost 2.5 t ha-1)

Figure 3. Plant height mustard as influenced by vermicompost with inorganic fertilizers

Table 1. Plant height of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Plant height (cm)		
	30 DAS	40 DAS	50 DAS
V_1T_0	32.70 ef	83.23 f	85.34 i
V_1T_1	33.21 def	88.07 e	91.40 h
V_1T_2	25.40 h	68.37 h	77.97 j
V_1T_3	24.30 h	64.87 h	76.30 j
V_2T_0	38.97 b	106.00 bc	141.80 b
V_2T_1	43.40 a	123.10 a	152.60 a
V_2T_2	35.07 cd	92.93 d	137.50 c
V_2T_3	31.57 f	83.07 f	135.80 c
V_3T_0	36.50 c	103.00 c	114.80 e
V_3T_1	42.43 a	109.10 b	119.77 d
V_3T_2	34.72 cde	92.20 d	108.48 f
V_3T_3	27.87 g	72.10 g	102.72 g
$LSD_{0.05}$	2.270	3.659	4.371
CV(%)	8.36	10.24	13.47

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

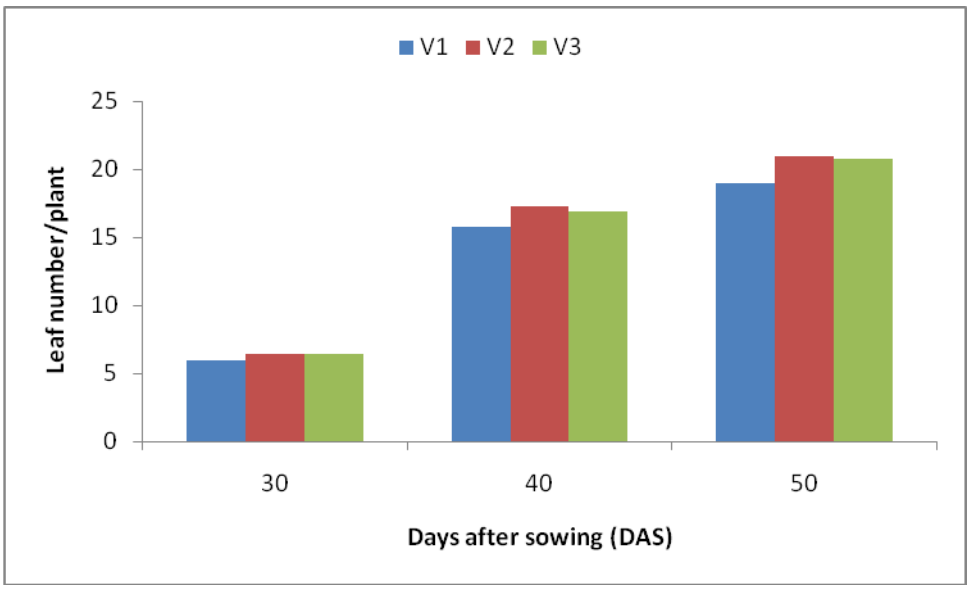
Combined effect of variety and inorganic fertilizer with vermicompost

Plant height of mustard at different growth stages varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 1 and Appendix IV). At 30, 40 and 50 DAS, the treatment combination of V_2T_1 showed the highest plant height (43.40, 123.10 and 152.60 cm, respectively) which was significantly different from other treatment combinations followed by V_1T_0 at all growth stages whereas V_1T_3 gave the lowest plant height (24.30, 64.87 and 76.30 cm, respectively) which was statistically same to V_1T_2 at 30, 40 and 50 DAS.

4.1.2 Leaf number plant^{-1}

Effect of variety

Results indicated that at 30, 40 and 50 DAS, the highest number of leaves plant^{-1} (6.42, 17.29 and 20.98, respectively) was achieved from the variety V_2 (BARI sarisha-16) which was significantly same to the variety V_3 (BARI sarisha-18) at 50 DAS whereas the lowest number of leaves plant^{-1} (5.92, 15.77 and 18.98, respectively) was found from the variety V_1 (BARI sarisha-14) (Figure 4). Similar result was also observed by Sarker *et al*. (2021).



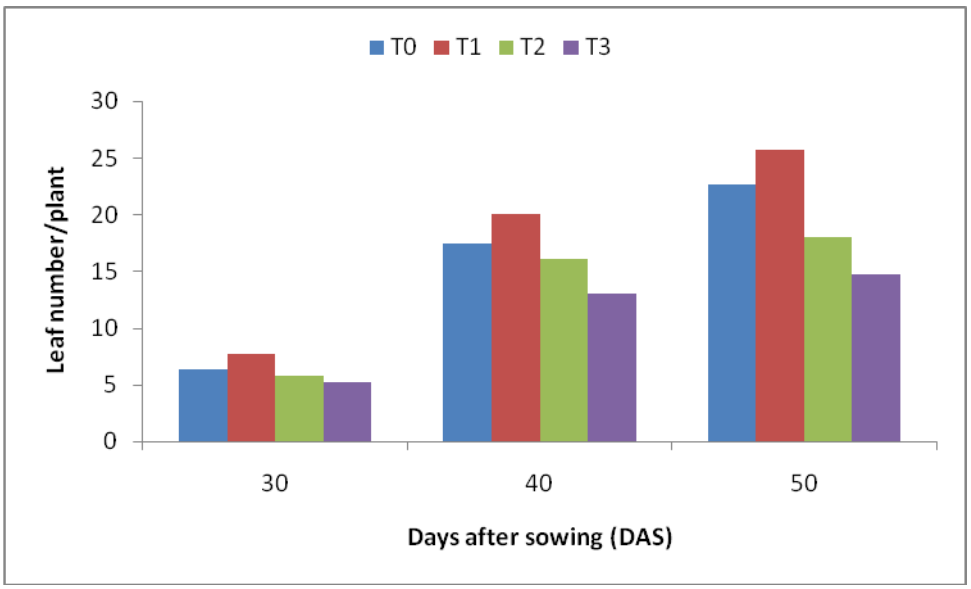
V1 = BARI sarisha-14, V2 = BARI sarisha-16, V3 = BARI sarisha-18

Figure 4. Effect of different mustard varieties on number of leaves plant^{-1}

Effect of inorganic fertilizer with vermicompost

Application of different doses of inorganic fertilizer in addition with vermicompost to mustard showed significant influence on number of leaves plant^{-1} at different growth stages except at 30 DAS (Figure 5 and Appendix V). However, at 30, 40 and 50 DAS, treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) showed the highest number of leaves plant^{-1} (7.67, 20.04 and 25.68,

respectively) followed by control treatment T_0 (RDF) whereas the lowest number of leaves plant^{-1} (5.22, 13.00 and 14.70, respectively) was found from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). Similar result was also observed by Kumar *et al*. (2018) who reported that inorganic fertilizer with vermicompost gave better yield compared to alone application for both.



T0 = Control [RDF (recommended doses of fertilizer)], T1 = RDF + VC (vermicompost 2.5 t ha-1), T2 = 75% RDF + VC (vermicompost 2.5 t ha-1), T3 = 50% RDF + VC (vermicompost 2.5 t ha-1)

Figure 5. Number of leaves plant^{-1} of mustard as influenced by vermicompost with inorganic fertilizers

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed significant variation on number of leaves plant^{-1} of mustard at different growth stages (Table 2 and Appendix V). At 30, 40 and 50 DAS, the treatment combination of V_2T_1 showed the highest number of leaves plant^{-1} (8.33, 21.27 and 26.03, respectively); at 50 DAS, it was significant similar to the treatment combination of V_1T_1 and V_3T_1 whereas V_1T_3 gave the lowest number of leaves plant^{-1} (5.00, 11.57 and 14.03, respectively) and it was significantly similar to V_2T_3 and V_3T_3 at 50 DAS.

Table 2. Number of leaves plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Leaf number plant^{-1}		
	30 DAS	40 DAS	50 DAS
V_1T_0	6.00 ef	17.23 de	21.10 d
V_1T_1	7.00 c	18.90 bc	25.03 ab
V_1T_2	5.67 fg	15.40 fg	15.77 f
V_1T_3	5.00 h	11.57 h	14.03 g
V_2T_0	6.33 de	17.40 de	23.00 c
V_2T_1	8.33 a	21.17 a	26.03 a
V_2T_2	5.67 fg	16.10 ef	18.60 e
V_2T_3	5.33 gh	14.50 g	15.33 fg
V_3T_0	6.67 cd	17.70 cd	23.67 bc
V_3T_1	7.67 b	20.07 ab	25.97 a
V_3T_2	6.00 ef	16.80 de	19.57 e
V_3T_3	5.33 gh	12.93 h	14.73 fg
$LSD_{0.05}$	0.6441	1.371	1.472
CV(%)	7.85	9.24	4.24

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

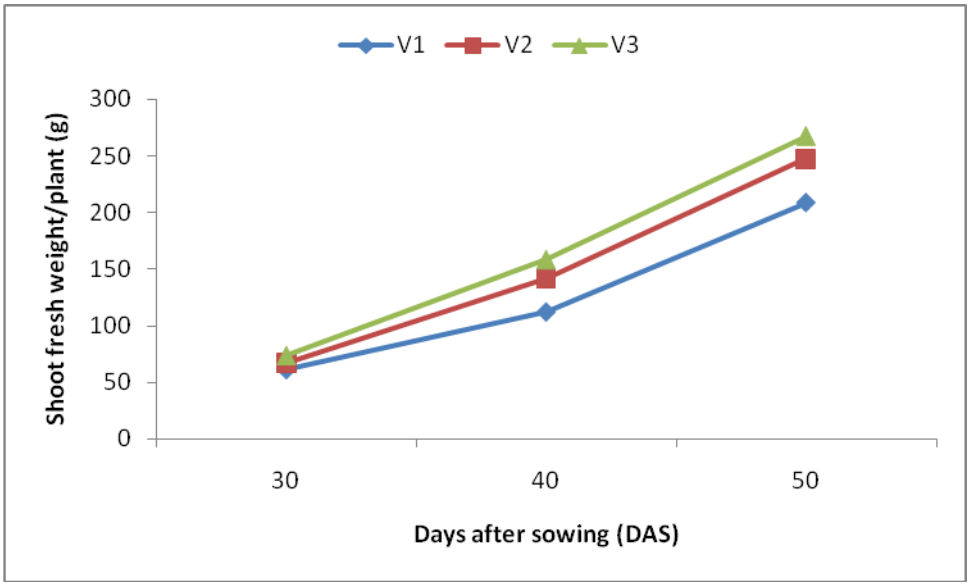
V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

4.1.3 Shoot fresh weight plant^{-1}

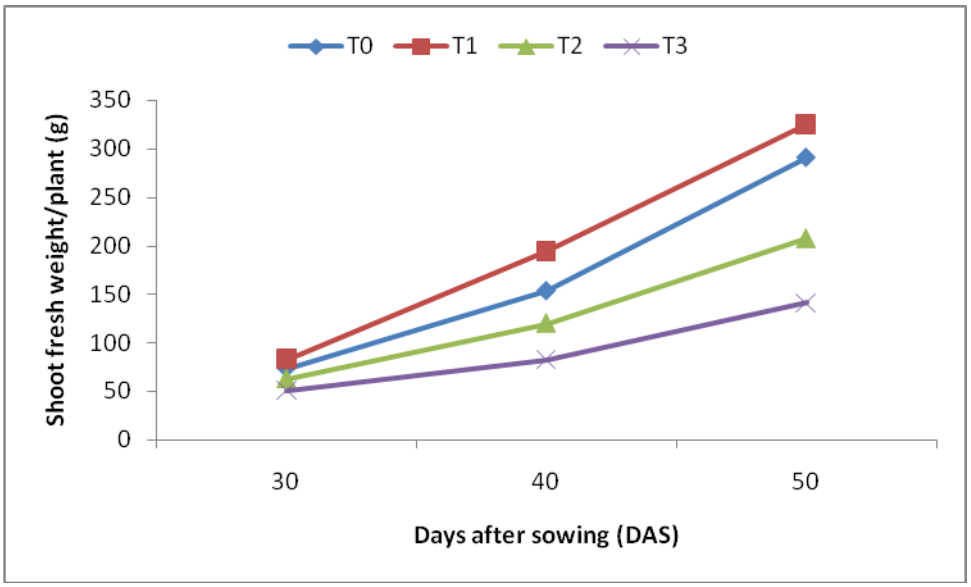
Effect of variety

Different mustard variety showed significant variation on shoot fresh weight plant^{-1} at different growth stages (Figure 6 and Appendix VI). The variety V_3 (BARI sarisha-18) showed maximum shoot fresh weight plant^{-1} at different growth stages whereas the minimum was found from V_1 (BARI sarisha-14). Results indicated that at 30, 40 and 50 DAS, the maximum shoot fresh weight plant^{-1} (73.33, 158.10 and 267.30 g, respectively) was achieved from the variety V_3 (BARI sarisha-18) which was followed by the variety V_2 (BARI sarisha-16) at all growth stages whereas the minimum shoot fresh weight plant^{-1} (61.50, 112.40 and 209.00 g, respectively) was found from the variety V_1 (BARI sarisha-14).



V1 = BARI sarisha-14, V2 = BARI sarisha-16, V3 = BARI sarisha-18

Figure 6. Effect of different mustard varieties on shoot fresh weight plant^{-1}



T0 = Control [RDF (recommended doses of fertilizer)], T1 = RDF + VC (vermicompost 2.5 t ha-1), T2 = 75% RDF + VC (vermicompost 2.5 t ha-1), T3 = 50% RDF + VC (vermicompost 2.5 t ha-1)

Figure 7. Shoot fresh weight plant^{-1} of mustard as influenced by vermicompost with inorganic fertilizers

Effect of inorganic fertilizer with vermicompost

Inorganic fertilizer with or without vermicompost applied to mustard showed significant variation on shoot fresh weight plant^{-1} at different growth stages (Figure 7 and Appendix VI). At all growth stages, treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) showed best performance in gaining shoot fresh weight whereas the least performance was from T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). Results revealed that at 30, 40 and 50 DAS, treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the maximum shoot fresh weight plant^{-1} (82.56, 194.10 and 325.30 g, respectively) followed by control treatment T_0 (RDF) whereas the minimum shoot fresh weight plant^{-1} (50.89, 82.67and 141.10 g, respectively) was recorded from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}).

Table 3. Shoot fresh weight plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Shoot fresh weight plant^{-1} (g)		
	30 DAS	40 DAS	50 DAS
V_1T_0	68.33 de	135.30 e	232.00 e
V_1T_1	71.67 cd	144.30 d	290.30 d
V_1T_2	58.33 f	98.33 f	197.70 f
V_1T_3	47.67 g	71.67 h	116.00 i
V_2T_0	73.67 cd	159.3 c	319.30 c
V_2T_1	83.00 b	197.00 b	331.30 b
V_2T_2	62.33 ef	130.30 e	205.00 f
V_2T_3	50.33 g	82.67 g	136.00 h
V_3T_0	78.00 bc	165.70 c	322.00 bc
V_3T_1	93.00 a	241.00 a	354.30 a
V_3T_2	67.67 de	132.00 e	221.30 e
V_3T_3	54.67 fg	93.67 f	171.30 g
$LSD_{0.05}$	7.837	8.311	11.33
CV(%)	8.53	8.07	5.51

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

Combined effect of variety and inorganic fertilizer with vermicompost

Shoot fresh weight plant^{-1} of mustard at different growth stages varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 3 and Appendix VI). At 30, 40 and 50 DAS, the treatment combination of V_3T_1 showed the maximum shoot fresh weight plant^{-1} (93.00, 241.00 and 354.30 g, respectively) which was significantly different from other treatment combinations at all growth stages followed by V_2T_1 whereas V_1T_3 gave the minimum shoot fresh weight plant^{-1} (47.67, 71.67 and 116.00 g, respectively) which was significantly different to other treatment combinations at all growth stages.

4.1.4 Shoot dry weight plant^{-1}

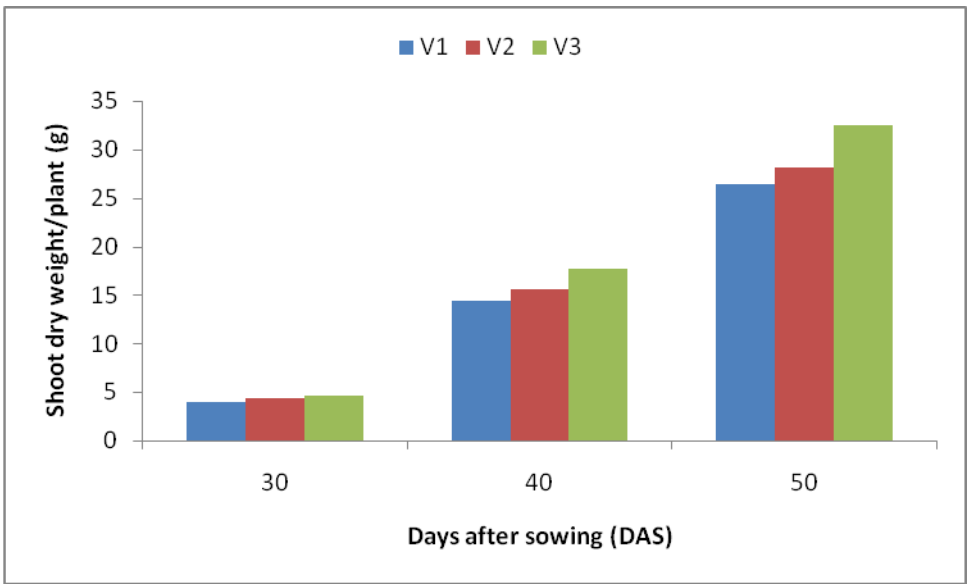
Effect of variety

Different mustard variety showed significant variation on shoot dry weight plant^{-1} at different growth stages (Table 4 and Appendix VII). Results indicated that at 30, 40 and 50 DAS, the maximum shoot dry weight plant^{-1} (4.58, 17.70 and 32.43 g, respectively) was achieved from the variety V_3 (BARI sarisha-18) which was followed by the variety V_2 (BARI sarisha-16) at all growth stages whereas the minimum shoot dry weight plant^{-1} (3.99, 14.40 and 26.42 g, respectively) was found from the variety V_1 (BARI sarisha-14). This result is in close conformity with the findings of Lal *et al*. (2020) and Ahamed *et al*. (2019).

Effect of inorganic fertilizer with vermicompost

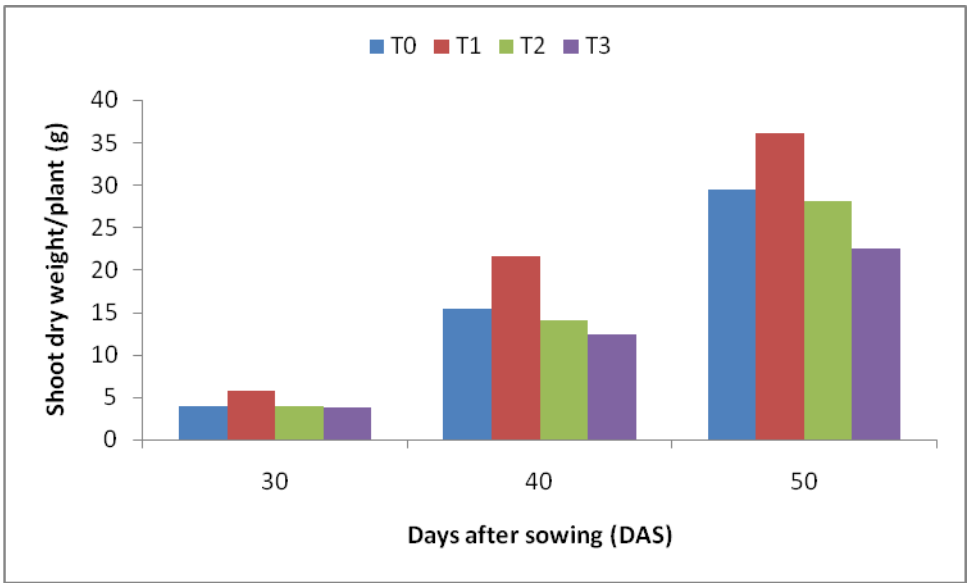
Inorganic fertilizer with or without vermicompost applied to mustard showed significant variation on shoot dry weight plant^{-1} at different growth stages (Table 4 and Appendix VII). Results revealed that at 30, 40 and 50 DAS, treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the maximum shoot dry weight plant^{-1} (5.73, 21.61 and 36.05 g, respectively) followed by control treatment T_0 (RDF) whereas the minimum shoot dry weight plant^{-1} (3.74, 12.45

and 22.43 g, respectively) was recorded from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). This result is in agreed with the findings of Kumar *et al*. (2018), Thaneshwar *et al.* (2017) and Singh *et al.* (2014).



V1 = BARI sarisha-14, V2 = BARI sarisha-16, V3 = BARI sarisha-18

Figure 8. Effect of different mustard varieties on shoot dry weight $plant^{-1}$



T0 = Control [RDF (recommended doses of fertilizer)], T1 = RDF + VC (vermicompost 2.5 t ha-1), T2 = 75% RDF + VC (vermicompost 2.5 t ha-1), T3 = 50% RDF + VC (vermicompost 2.5 t ha-1)

Figure 9. Shoot dry weight $plant^{-1}$ of mustard as influenced by vermicompost with inorganic fertilizers

Combined effect of variety and inorganic fertilizer with vermicompost

Shoot dry weight plant^{-1} of mustard at different growth stages varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 4 and Appendix VII). At 30, 40 and 50 DAS, the treatment combination of V_3T_1 showed the maximum shoot dry weight plant^{-1} (6.30, 23.58 and 39.61 g, respectively) which was significantly differed to other treatment combinations at all growth stages followed by V_2T_1 whereas V_1T_3 gave the minimum shoot dry weight plant^{-1} (3.60, 11.71 and 15.73 g, respectively) which was significantly different to other treatment combinations at all growth stages.

Table 4. Shoot dry weight plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Shoot dry weight plant^{-1} (g)		
	30 DAS	40 DAS	50 DAS
V_1T_0	3.87 cd	13.49 e	27.48 d
V_1T_1	4.64 b	19.74 bc	33.61 bc
V_1T_2	3.83 cd	12.65 e	26.59 de
V_1T_3	3.60 d	11.71 e	15.73 f
V_2T_0	3.91 cd	15.90 d	28.33 d
V_2T_1	6.25 a	21.50 ab	34.93 b
V_2T_2	3.84 cd	12.68 e	26.69 de
V_2T_3	3.68 d	12.16 e	24.91 e
V_3T_0	3.92 cd	16.83 d	32.44 c
V_3T_1	6.30 a	23.58 a	39.61 a
V_3T_2	4.39 bc	17.83 cd	32.69 c
V_3T_3	3.71 d	12.54 e	24.98 e
$LSD_{0.05}$	0.589	2.197	2.020
CV(%)	12.53	8.06	13.08

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

4.1.5 SPAD value

Effect of variety

SPAD value of mustard leaf varied significantly due to variation of mustard variety at different growth stages (Table 5 and Appendix VIII). At 30, 40 and 50 DAS, the highest SPAD value (51.68, 53.72 and 51.00, respectively) was achieved from the variety V_3 (BARI sarisha-18) which was followed by V_2 (BARI sarisha-16) whereas the lowest SPAD value (47.19, 51.08 and 48.89, respectively) was found from the variety V_1 (BARI sarisha-14).

Effect of inorganic fertilizer with vermicompost

Different doses of inorganic fertilizer with or without vermicompost application to mustard showed significant influence on SPAD value at different growth stages (Table 5 and Appendix VIII). At 30, 40 and 50 DAS, the highest SPAD value (55.89, 57.43 and 55.66, respectively) was recorded from the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) which was followed by control treatment T_0 (RDF) at all growth stages whereas the lowest SPAD value (44.40, 49.32 and 45.93, respectively) was found from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). Similar result was also observed by Mondal and Wahhab (2001).

Combined effect of variety and inorganic fertilizer with vermicompost

SPAD value of mustard at different growth stages varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 5 and Appendix VIII). At 30, 40 and 50 DAS, the highest SPAD value (57.87, 58.17 and 56.97, respectively) was achieved from the treatment combination of V_3T_1 and it was significantly same to V_1T_1 at 40 and 50 DAS whereas the lowest SPAD value (42.47, 46.23 and 44.99, respectively) was recorded from V_1T_3 which showed statistically similar result to V_3T_3 at 50 DAS.

Table 5. SPAD value of leaves of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	SPAD value		
	30 DAS	40 DAS	50 DAS
Effect of variety			
V_1	47.19 b	51.08 b	48.89 c
V_2	48.12 b	52.21 b	50.02 b
V_3	51.68 a	53.72 a	51.00 a
$LSD_{0.05}$	0.9376	1.234	0.9551
CV(%)	4.51	8.47	5.67
Effect of vermicompost with inorganic fertilizer			
T_0	48.21 b	52.19 b	47.64 c
T_1	55.89 a	57.43 a	55.66 a
T_2	47.48 b	50.40 c	50.66 b
T_3	44.40 c	49.32 c	45.93 d
$LSD_{0.05}$	1.681	1.270	1.155
CV(%)	4.51	8.47	5.67
Combined effect of variety and vermicompost with inorganic fertilizer			
V_1T_0	46.43 de	51.53 cde	47.02 cde
V_1T_1	54.58 b	56.63 a	56.13 a
V_1T_2	45.27 def	49.90 def	46.83 def
V_1T_3	42.47 f	46.23 g	44.99 f
V_2T_0	47.97 cd	52.10 bcd	47.63 cde
V_2T_1	55.23 ab	57.50 a	55.99 ab
V_2T_2	45.60 de	51.03 cde	46.95 cdef
V_2T_3	43.68 ef	48.20 fg	54.03 b
V_3T_0	50.23 c	52.93 bc	48.26 cd
V_3T_1	57.87 a	58.17 a	56.97 a
V_3T_2	54.38 b	53.93 b	48.90 c
V_3T_3	44.24 ef	49.87 ef	45.96 ef
$LSD_{0.05}$	2.913	2.200	2.001
CV(%)	4.51	8.47	5.67

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

4.2 Yield contributing parameters

4.2.1 Siliqua length (cm)

Effect of variety

Different mustard variety showed significant influence on siliqua length of mustard (Table 6 and Appendix IX). Results revealed that the highest siliqua length (6.78 cm) was achieved from the variety V_3 (BARI sarisha-18) whereas the lowest siliqua length (5.90 cm) was found from the variety V_1 (BARI sarisha-14) that was statistically same to V_2 (BARI sarisha-16). Ahamed *et al*. (2019) and Ahmed and Kashem (2017) also found similar result with the present study and reported variation on siliqua length due to varietal difference.

Effect of inorganic fertilizer with vermicompost

Siliqua length of mustard differed significantly due to different doses of inorganic fertilizer with or without vermicompost (Table 6 and Appendix IX). It was observed that the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the highest siliqua length (7.98 cm) followed by control treatment T_0 (RDF) and T_2 (75% RDF + vermicompost 2.5 t ha^{-1}) whereas the lowest siliqua length (5.16 cm) was given by the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). Kumar *et al*. (2018) also found similar result with the present study.

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed statistically significant variation on siliqua length of mustard (Table 6 and Appendix IX). Results indicated that the treatment combination of V_3T_1 showed the highest siliqua length (8.39 cm) which was statistically similar to the treatment combination V_2T_1 whereas V_1T_3 gave the lowest siliqua length (4.70 cm) which was statistically similar to V_1T_2 and V_3T_3.

4.2.2 Number of siliqua plant^{-1}

Effect of variety

The recorded data on number of siliqua plant^{-1} varied significantly due to varietal performance of mustard (Table 6 and Appendix IX). The maximum number of siliqua plant^{-1} (125.30) was registered from the variety V_3 (BARI sarisha-18) whereas the minimum number of siliqua plant^{-1} (93.87) was recorded from the variety V_1 (BARI sarisha-14) that was statistically same to V_2 (BARI sarisha-16). Similar result was also observed by Sarker *et al*. (2021) and Ahamed *et al*. (2019) which supported the present study.

Effect of inorganic fertilizer with vermicompost

Application of inorganic fertilizer and vermicompost treatment applied to mustard showed significant variation on number of siliqua plant^{-1} (Table 6 and Appendix IX). Treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the best performance in gaining number of siliqua plant^{-1} (141.60) followed by control treatment T_0 (RDF) whereas the minimum number of siliqua plant^{-1} (80.27) was performed by T_3 (50% RDF + vermicompost 2.5 t ha^{-1}) that was significantly different to other treatments. This result is in agreement with the findings of Kumar *et al*. (2018) and Thaneshwar *et al.* (2017).

Combined effect of variety and inorganic fertilizer with vermicompost

Number of siliqua plant^{-1} of mustard varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 6 and Appendix IX). Results indicated the treatment combination of V_3T_1 gave the maximum number of siliqua plant^{-1} (154.30) which was significantly different from other treatment combinations followed by V_2T_1 whereas V_1T_3 gave the minimum number of siliqua plant^{-1} (74.47) which was significantly different to other treatment combinations.

4.2.3 Number of seeds siliqua^{-1}

Effect of variety

Different mustard variety showed significant influence on number of seeds siliqua^{-1} (Table 6 and Appendix IX). Results revealed that the highest number of seeds siliqua^{-1} (27.23) was achieved from the variety V_1 (BARI sarisha-14) which was followed by V_3 (BARI sarisha-18) whereas the lowest number of seeds siliqua^{-1} (18.17) was found from the variety V_2 (BARI sarisha-16). This result is in agreement with the findings of Ahamed *et al*. (2019).

Effect of inorganic fertilizer with vermicompost

Number of seeds siliqua^{-1} of mustard differed significantly due to different doses of inorganic fertilizer with or without vermicompost (Table 6 and Appendix IX). It was observed that the highest number of seeds siliqua^{-1} (24.67) was given by the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) which was followed by control treatment T_0 (RDF) and T_2 (75% RDF + vermicompost 2.5 t ha^{-1}) whereas the lowest number of seeds siliqua^{-1} (21.67) was registered by the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). This result is in agreement with the findings of Kumar *et al*. (2018) and Rundala *et al*. (2013).

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed statistically significant variation on number of seeds siliqua^{-1} of mustard (Table 6 and Appendix IX). Results indicated that the treatment combination of V_1T_1 showed the highest number of seeds siliqua^{-1} (28.67) which was significantly differed to other treatment combinations followed by V_1T_0 whereas V_2T_3 gave the lowest number of seeds siliqua^{-1} (16.67) which was statistically similar to V_2T_0, V_2T_1 and V_2T_2.

Table 6. Yield contributing parameters of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Yield contributing parameters			
	Siliqua length (cm)	No. Siliqua plant^{-1}	No. seeds siliqua^{-1}	1000 seed weight (g)
Effect of variety				
V_1	5.90 b	93.87 c	27.23 a	3.27 b
V_2	6.21 b	125.30 a	18.17 c	4.03 a
V_3	6.78 a	107.48 b	24.67 b	4.11 a
$LSD_{0.05}$	0.324	5.077	0.344	0.124
CV(%)	7.91	14.05	8.92	5.40
Effect of vermicompost with inorganic fertilizer				
T_0	6.02 b	108.50 b	24.20 b	3.68 c
T_1	7.98 a	141.60 a	24.67 a	4.26 a
T_2	6.02 b	89.84 c	22.89 c	3.84 b
T_3	5.16 c	80.27 d	21.67 d	3.54 c
$LSD_{0.05}$	0.381	4.489	0.253	0.150
CV(%)	7.91	14.05	8.92	5.40
Combined effect of variety and vermicompost with inorganic fertilizer				
V_1T_0	5.98 c	103.60 e	27.92 b	3.05 d
V_1T_1	7.65 b	128.10 c	28.67 a	3.81 c
V_1T_2	5.25 de	93.27 f	26.33 c	3.17 d
V_1T_3	4.70 e	74.47 h	26.00 c	3.04 d
V_2T_0	6.04 c	103.90 e	18.67 g	3.98 c
V_2T_1	7.91 ab	142.40 b	19.33 f	4.41 a
V_2T_2	5.83 cd	93.40 f	18.00 h	4.00 bc
V_2T_3	5.06 e	84.20 g	16.67 i	3.89 c
V_3T_0	6.04 c	117.90 d	26.00 c	4.00 bc
V_3T_1	8.39 a	154.30 a	26.00 c	4.55 a
V_3T_2	7.54 b	125.70 cd	24.33 d	4.34 ab
V_3T_3	5.18 de	83.33 g	22.33 e	3.67 c
$LSD_{0.05}$	0.660	7.775	0.342	0.356
CV(%)	7.91	14.05	8.92	5.40

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

4.2.4 Weight of 1000 seeds

Effect of variety

The recorded data on 1000-seed weight varied significantly due to varietal performance of mustard (Table 6 and Appendix IX). The maximum 1000-seed weight (4.11 g) was registered from the variety V_3 (BARI sarisha-18) which was statistically same to the variety V_2 (BARI sarisha-16) whereas the minimum 1000-seed weight (3.27) was recorded from the variety V_1 (BARI sarisha-14). This result is in conformity with the findings of Sarker *et al*. (2021) and Helal *et al*. (2016).

Effect of inorganic fertilizer with vermicompost

Application of inorganic fertilizer and vermicompost treatment applied to mustard showed significant variation on 1000-seed weight (Table 6 and Appendix IX). Result revealed that the maximum 1000-seed weight (4.26 g) was given by the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) followed by T_2 (75% RDF + vermicompost 2.5 t ha^{-1}) whereas the minimum 1000-seed weight (3.54) was performed by T_3 (50% RDF + vermicompost 2.5 t ha^{-1}) that was significantly same to control treatment T_0 (RDF). Supported result was also observed by the findings of Tripathi *et al.* (2011) and Singh *et al*. (2006).

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed significant variation on 1000-seed weight of mustard (Table 6 and Appendix IX). Results indicated the treatment combination of V_2T_1 gave the maximum 1000-seed weight (4.55 g) which was statistically similar to the treatment combinations of V_3T_1 and V_3T_2 whereas V_1T_3 gave the minimum 1000-seed weight (3.04 g) which was significantly different to other treatment combinations.

4.3 Yield parameters

4.2.1 Seed yield ha^{-1}

Effect of variety

Different mustard variety showed significant influence on seed yield of mustard (Table 7 and Appendix X). Results revealed that the highest seed yield (1896.00 kg ha^{-1}) was achieved from the variety V_3 (BARI sarisha-18) which was followed by the variety V_2 (BARI sarisha-16) whereas the lowest seed yield (1494.00 kg ha^{-1}) was found from the variety V_1 (BARI sarisha-14). These results are in agreement with the findings of Sarker *et al*. (2021), Lal *et al*. (2020), Ahamed *et al*. (2019) and Ahmed and Kashem (2017).

Effect of inorganic fertilizer with vermicompost

Seed yield of mustard differed significantly due to different doses of inorganic fertilizer with or without vermicompost (Table 7 and Appendix X). It was observed that the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the highest seed yield (22.79) followed by control treatment T_0 (RDF) whereas the lowest seed yield (1327.00 kg ha^{-1}) was given by the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). The result obtained from the present study was similar with the findings of Kumar *et al*. (2018) and Thaneshwar *et al.* (2017).

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed statistically significant variation on seed yield of mustard (Table 7 and Appendix X). Results indicated that the treatment combination of V_3T_1 showed the highest seed yield (2480.00 kg ha^{-1}) which was significantly different to other treatment combinations followed by V_2T_1 whereas the lowest seed yield (946.70 kg ha^{-1}) was given by V_1T_3.

Table 7. Yield parameters of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Treatments	Yield parameters		
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Effect of variety			
V_1	1494.00 c	2222.00 c	39.64 b
V_2	1722.00 b	2413.00 b	41.25 a
V_3	1896.00 a	2548.00 a	42.14 a
$LSD_{0.05}$	14.82	22.79	1.100
CV(%)	11.27	7.85	8.32
Effect of vermicompost with inorganic fertilizer			
T_0	1710.00 b	2500.00 b	40.63 b
T_1	2279.00 a	2737.00 a	45.34 a
T_2	1500.00 c	2227.00 c	39.52 c
T_3	1327.00 d	2114.00 d	38.55 c
$LSD_{0.05}$	19.30	22.88	1.005
CV(%)	11.27	7.85	8.32
Combined effect of variety and vermicompost with inorganic fertilizer			
V_1T_0	1603.00 f	2351.00 e	40.63 d
V_1T_1	2033.00 c	2655.00 c	43.43 b
V_1T_2	1393.00 h	2196.00 g	38.74 de
V_1T_3	946.70 j	1686.00 j	35.76 f
V_2T_0	1740.00 e	2561.00 d	40.43 d
V_2T_1	2323.00 b	2743.00 b	45.80 a
V_2T_2	1533.00 g	2307.00 f	39.96 de
V_2T_3	1290.00 i	2040.00 i	38.82 de
V_3T_0	1787.00 d	2587.00 d	40.82 cd
V_3T_1	2480.00 a	2813.00 a	46.80 a
V_3T_2	2020.00 c	2689.00 c	42.84 bc
V_3T_3	1297.00 i	2105.00 h	38.10 e
$LSD_{0.05}$	33.42	39.62	2.190
CV(%)	11.27	7.85	8.32

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

V_1 = BARI sarisha-14, V_2 = BARI sarisha-16, V_3 = BARI sarisha-18

T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}), T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1})

4.2.2 Stover yield ha^{-1}

Effect of variety

The recorded data on stover yield varied significantly due to varietal performance of mustard (Table 7 and Appendix X). The maximum stover yield (2548.00 kg ha^{-1}) was registered from the variety V_3 (BARI sarisha-18) followed by V_2 (BARI sarisha-16) whereas the minimum stover yield (2222.00 kg ha^{-1}) was recorded from the variety V_1 (BARI sarisha-14). This result is in agreement with the findings of Sarker *et al*. (2021) and Lal *et al*. (2020).

Effect of inorganic fertilizer with vermicompost

Application of inorganic fertilizer and vermicompost treatment applied to mustard showed significant variation on stover yield (Table 7 and Appendix X). Treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the highest stover yield (2737.00 kg ha^{-1}) followed by control treatment T_0 (RDF) whereas the minimum stover yield (2114.00 kg ha^{-1}) was registered by T_3 (50% RDF + vermicompost 2.5 t ha^{-1}) that was significantly different to other treatments. Similar result was observed by Babar and Dongale (2013) and they reported that stover yield was increased with FYM and inorganic fertilizer compared to sole application.

Combined effect of variety and inorganic fertilizer with vermicompost

Stover yield of mustard varied significantly due to combined effect of variety and inorganic fertilizer with vermicompost (Table 7 and Appendix X). Results indicated the treatment combination of V_3T_1 gave the maximum stover yield (2813.00 kg ha^{-1}) which was significantly different from other treatment combinations followed by V_2T_1 whereas V_1T_3 gave the minimum stover yield (1686.00kg ha^{-1}) which was significantly different to other treatment combinations. Supported findings was also observed by Singh *et al.* (2018) and Kumar *et al*. (2018).

4.2.1 Harvest index

Effect of variety

Different mustard variety showed significant influence on harvest index of mustard (Table 7 and Appendix X). Results revealed that the highest harvest index (42.14%) was achieved from the variety V_3 (BARI sarisha-18) which was statistically same to V_2 (BARI sarisha-16) whereas the lowest harvest index (39.64% cm) was found from the variety V_1 (BARI sarisha-14). Similar result was also observed by Helal *et al*. (2016) and Salam *et al*. (2014).

Effect of inorganic fertilizer with vermicompost

Harvest index of mustard differed significantly due to different doses of inorganic fertilizer with or without vermicompost (Table 7 and Appendix X). It was observed that the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) gave the highest harvest index (45.34%) followed by control treatment T_0 (RDF) treatment whereas the lowest harvest index (38.55%) was given by the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}) that was significantly same to T_2 (75% RDF + vermicompost 2.5 t ha^{-1}). This result is agreed with the findings of Babar and Dongale (2013) they reported that inorganic fertilizer with FYM showed better harvest index compared to sole application of FYM or inorganic fertilizer.

Combined effect of variety and inorganic fertilizer with vermicompost

Treatment combination of variety and inorganic fertilizer with vermicompost showed statistically significant variation on harvest index of mustard (Table 7 and Appendix X). Results indicated that the treatment combination of V_3T_1 showed the highest harvest index (46.80%) which was statistically similar to the treatment combination V_2T_1 whereas V_1T_3 gave the lowest harvest index (35.76%) which was significantly different to other treatment combinations.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out during the period of November 2021 to March 2022 at the Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out the growth and yield of mustard as affected by vermicompost with different levels of fertilizer. Two factors experiment was laid out in Split Plot Design with three replications. Three mustard varieties *viz*. V_1 = BARI sarisha-14, V_2 = BARI sarisha-16 and V_3 = BARI sarisha-18 were combined with four treatments of inorganic fertilizers with or without vermicompost *viz*. T_0 = Control [RDF (recommended doses of fertilizer)], T_1 = RDF + VC (vermicompost 2.5 t ha^{-1}), T_2 = 75% RDF + VC (vermicompost 2.5 t ha^{-1}) and T_3 = 50% RDF + VC (vermicompost 2.5 t ha^{-1}) were considered for the present study.

Different varieties of mustard had significant effect on most of the parameters. At 30, 40 and 50 DAS, the variety V_2 (BARI sarisha-16) gave the highest plant height (37.25, 101.30 and 141.93 cm, respectively) and number of leaves $plant^{-1}$ (6.42, 17.29 and 20.98, respectively) whereas the lowest plant height (28.90, 76.13 and 82.75 cm, respectively) and number of leaves $plant^{-1}$ (5.92, 15.77 and 18.98, respectively) were found from the variety V_1 (BARI sarisha-14). Again, at 30, 40 and 50 DAS, the highest shoot fresh weight $plant^{-1}$ (73.33, 158.10 and 267.30 g, respectively), highest shoot dry weight $plant^{-1}$ (4.58, 17.70 and 32.43 g, respectively) and highest SPAD value (51.68, 53.72 and 51.00, respectively) were achieved from the variety V_3 (BARI sarisha-18) whereas the lowest shoot fresh weight $plant^{-1}$ (61.50, 112.40 and 209.00 g, respectively), shoot dry weight $plant^{-1}$ (3.99, 14.40 and 26.42 g, respectively) and lowest SPAD value (47.19, 51.08 and 48.89, respectively) were obtained from the variety V_1 (BARI sarisha-14). Similarly, the maximum siliqua length (6.78 cm), number siliqua $plant^{-1}$ (125.30), 1000-seed weight (4.11 g), seed yield (1896.00 kg ha^{-1}), stover yield (2548.00 kg ha^{-1}) and harvest index (42.14%) were found from V_3 (BARI

sarisha-18) while the maximum number of seeds siliqua^{-1} (27.23) was recorded from V_1 (BARI sarisha-14) whereas the minimum siliqua length (5.90 cm), number siliqua plant^{-1} (93.87), 1000 seed weight (3.27 g), seed yield (1494.00 kg ha^{-1}), stover yield (2222.00 kg ha^{-1}) and harvest index (39.64%) were found from V_1 (BARI sarisha-14) but the minimum number of seeds siliqua^{-1} (13.17) was recorded from V_2 (BARI sarisha-16).

Different treatments of inorganic fertilizer with vermicompost gave significant variation for most of the studied parameters. At 30, 40 and 50 DAS, the highest plant height (39.68, 106.80 and 121.26 cm, respectively), number of leaves plant^{-1} (7.67, 20.04 and 25.68, respectively), shoot fresh weight plant^{-1} (82.56, 194.10 and 325.30 g, respectively), shoot dry weight plant^{-1} (5.73, 21.61 and 36.05 g, respectively) and SPAD value (55.89, 57.43 and 55.66, respectively) were recorded from the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) whereas the lowest plant height (27.91, 73.34 and 104.94 cm, respectively), number of leaves plant^{-1} (5.22, 13.00 and 14.70, respectively), shoot fresh weight plant^{-1} (50.89, 82.67and 141.10 g, respectively), shoot dry weight plant^{-1} (3.74, 12.45 and 22.43 g, respectively) and SPAD value (44.40, 49.32 and 45.93, respectively) were found from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}). Similarly, the highest siliqua length (7.98 cm), number of siliqua plant^{-1} (141.60), number of seeds siliqua^{-1} (24.67), 1000-seed weight (4.26 g), seed yield (22.79), stover yield (2737.00 kg ha^{-1}) and harvest index (45.34%) were given by the treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) whereas the lowest siliqua length (5.16 cm), number of siliqua plant^{-1} (80.27), number of seeds siliqua^{-1} (21.67), 1000-seed weight (3.54), seed yield (1327.00 kg ha^{-1}), stover yield (2114.00kg ha^{-1}) and harvest index (38.55%) were recorded from the treatment T_3 (50% RDF + vermicompost 2.5 t ha^{-1}).

The treatment combination of variety and inorganic fertilizer with vermicompost showed statistically significant variation on all the studied parameters of the present study. Result revealed that at 30, 40 and 50 DAS, the

maximum plant height (43.40, 123.10 and 152.60 cm, respectively) and number of leaves plant^{-1} (8.33, 21.27 and 26.03, respectively) were achieved from the treatment combination of V_2T_1 whereas V_1T_3 gave the lowest plant height (24.30, 64.87 and 76.03 cm, respectively) but the lowest number of leaves plant^{-1} (5.00, 11.57 and 14.03, respectively) was recorded from V_1T_3. Again, at 30, 40 and 50 DAS, the highest shoot fresh weight plant^{-1} (93.00, 241.00 and 354.30 g, respectively), shoot dry weight plant^{-1} (6.30, 23.58 and 39.61 g, respectively) and SPAD value (57.87, 58.17 and 56.97, respectively) were achieved from the treatment combination of V_3T_1 whereas the lowest shoot fresh weight plant^{-1} (47.67, 71.67 and 116.00 g, respectively), shoot dry weight plant^{-1} (3.60, 11.71 and 15.73 g, respectively) and SPAD value (42.47, 46.23 and 44.99, respectively) were recorded from V_1T_3. Similarly, the highest siliqua length (8.39 cm), number of siliqua plant^{-1} (154.30), 1000-seed weight (4.55 g), seed yield (2480.00 kg ha^{-1}), stover yield (2813.00 kg ha^{-1}) and harvest index (46.80%) were obtained from the treatment combination of V_3T_1 whereas the lowest siliqua length (4.70 cm), number of siliqua plant^{-1} (74.47), 1000-seed weight (3.04 g), seed yield (946.70 kg ha^{-1}), stover yield (1686.00kg ha^{-1}) and harvest index (35.76%) were recorded from the treatment combination of V_1T_3 but the maximum number of seeds siliqua^{-1} (28.67) was recorded from V_1T_1 whereas the minimum number of seeds siliqua^{-1} (16.67) was recorded from V_2T_3.

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

1. The variety V_3 (BARI sarisha-18) can be considered as best regarding growth, yield contributing parameters and yield of mustered compared to the variety V_1 (BARI sarisha-14) and V_2 (BARI sarisha-16).
2. The treatment T_1 (RDF + vermicompost 2.5 t ha^{-1}) showed the better performance on growth, yield contributing parameters and yield of mustered compared to other treatments, so, this treatment can be considered as the best performer for mustard yield.

3. Among 12 treatment combinations of variety and inorganic fertilizer with vermicompost, V_3T_1 (BARI sarisha-18 × RDF with vermicompost 2.5 t ha^{-1}) was best regarding higher results on growth, yield contributing parameters and yield.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

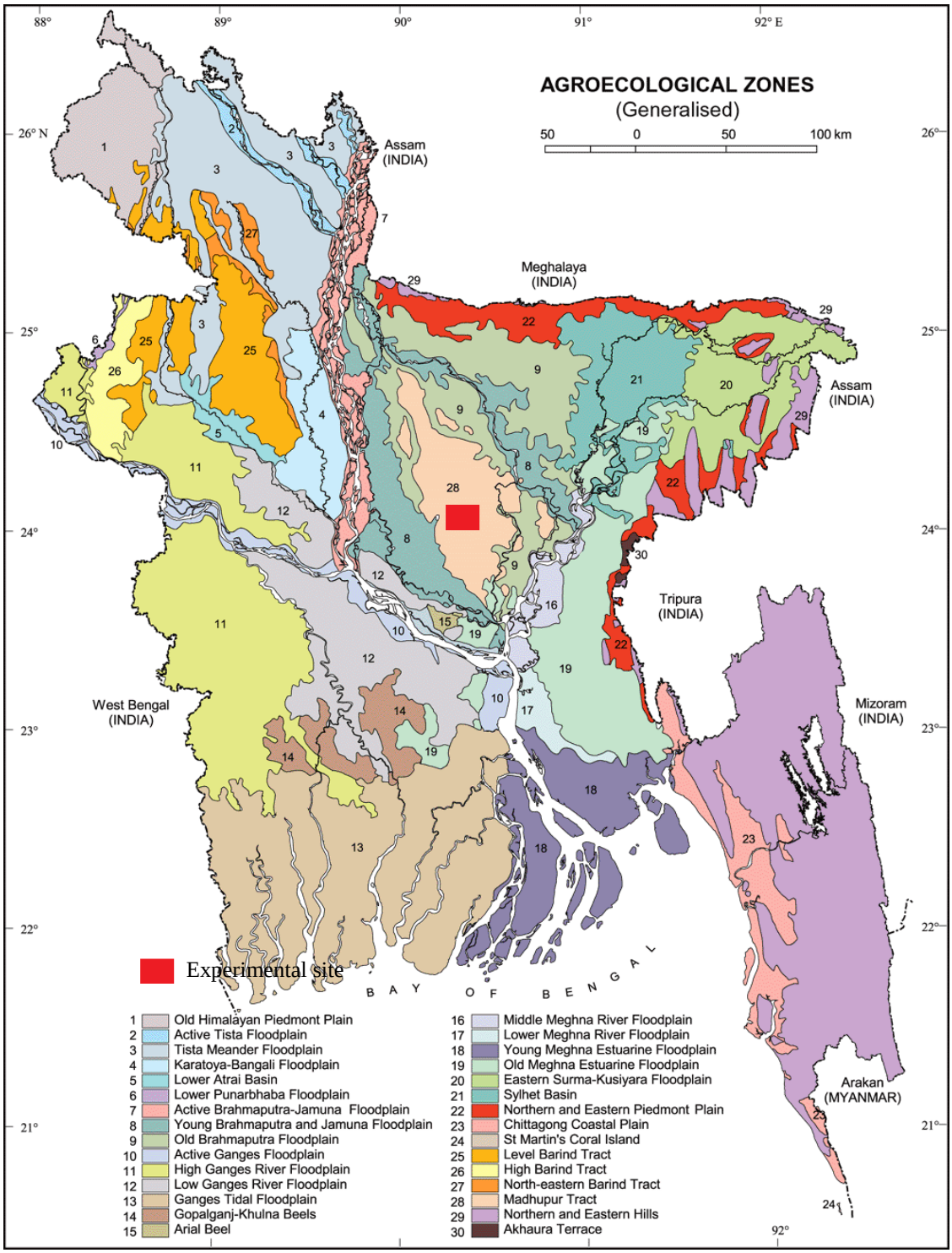

Figure 10. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2021 to March 2022.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2021	November	28.60	8.52	18.56	56.75	14.40
2021	December	25.50	6.70	16.10	54.80	0.0
2022	January	23.80	11.70	17.75	46.20	0.0
2022	February	22.75	14.26	18.51	37.90	0.0
2022	March	35.20	21.00	28.10	52.44	20.4

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Mean square of plant height of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of plant height		
		30 DAS	40 DAS	50 DAS
Replication	2	0.053	17.539	2.442
Factor A	2	230.45*	2012.05*	2471.05*
Error	4	1.757	5.209	12.509
Factor B	3	235.81*	1926.03*	2606.67*
AB	6	8.126**	72.594*	10.826**
Error	18	1.751	4.551	5.960

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Mean square of number of leaves plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of leaf number plant^{-1}		
		30 DAS	40 DAS	50 DAS
Replication	2	0.001	0.214	13.339
Factor A	2	1.000^{NS}	7.368*	14.300*
Error	4	0.250	0.186	0.176
Factor B	3	9.880^{NS}	77.335*	212.68*
AB	6	0.296**	1.529**	1.643**
Error	18	0.241	0.639	0.736

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Mean square of shoot fresh weight plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of shoot fresh weight plant^{-1}		
		30 DAS	40 DAS	50 DAS
Replication	2	93.361	11.778	175.861
Factor A	2	420.11*	6457.02*	10562.6*
Error	4	17.403	17.986	30.861
Factor B	3	1676.6*	20292.6*	62068.2*
AB	6	31.741*	927.102*	1084.28*
Error	18	20.870	23.472	43.639

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Mean square of shoot dry weight plant^{-1} of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of shoot dry weight plant^{-1}		
		30 DAS	40 DAS	50 DAS
Replication	2	0.793	4.161	14.12
Factor A	2	1.126**	33.60*	115.0*
Error	4	0.130	0.258	4.510
Factor B	3	7.947*	144.1*	281.5*
AB	6	0.683**	6.379**	29.65*
Error	18	0.118	1.640	1.386

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Mean square of SPAD value of leaves of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of SPAD value		
		30 DAS	40 DAS	50 DAS
Replication	2	9.653	10.46	15.72
Factor A	2	67.50*	21.21*	13.40*
Error	4	1.195	2.070	1.240
Factor B	3	214.9*	116.5*	163.9*
AB	6	22.96*	10.08**	22.39*
Error	18	2.882	1.645	1.361

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Mean square of yield contributing parameters of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters			
		Siliqua length (cm)	No. Siliqua plant^{-1}	No. seeds siliqua^{-1}	1000 seed weight (g)
Replication	2	0.295	268.423	9.083	0.005
Factor A	2	2.439**	1527.00*	1840.75*	2.820**
Error	4	0.143	395.032	1.833	0.021
Factor B	3	12.83*	8291.45*	30.76*	0.873**
AB	6	1.377**	1569.98*	6.491**	0.072**
Error	18	0.148	20.544	3.139	0.043

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix X. Mean square of yield parameters of different mustard varieties as influenced by vermicompost with inorganic fertilizers

Sources of variation	Degrees of freedom	Mean square of yield parameters		
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Replication	2	43352.778	45046.861	1.608
Factor A	2	486852.77*	322733.02*	19.24*
Error	4	16298.611	25705.903	8.646
Factor B	3	1543588.8*	705874.76*	81.53*
AB	6	190341.66*	177731.32*	9.441**
Error	18	379.630	533.556	1.630

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level