Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer-Reviewed International Journal

Article Code: 447/2024/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 11, No. 2, August 2024: 149-157.

INTEGRATED EFFECT OF BIO-SLURRY WITH CHEMICAL FERTILIZERS ON THE PERFORMANCE OF MUSTARD VARIETIES

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ARTICLE INFO

Received
20 March, 2024

Revised
20 May, 2024

Accepted
22 May, 2024

Online
September, 2024

Key words:
Mustard
Integrated plant nutrition
Branches plant^{-1}
Seed yield
Harvest index

ABSTRACT

To assess the importance of bio-slurry in combination with chemical fertilizers on the yield of mustard, a field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh. Four varieties of mustard (BARI sarisha-14, BARI sarisha-11, BARI sarisha-13, Tori-7) along with four fertilizers treatments i.e. control, recommended dose of inorganic fertilizer, bio-slurry @ 5 t ha^{-1} + inorganic fertilizer, farmers' practice (average of 15 farmers) was included in this study. The experiment was set up employing randomized complete block design with three replications. The result revealed significant varietal effects on all the yield and yield contributing characteristics. BARI sarisha-13 exhibited the highest seed yield (2.37 t ha^{-1}), which can be attributed to increased branches plant^{-1}, siliqua plant^{-1} and seeds siliqua^{-1}. Fertilizer treatments significantly affected different yield parameters and yield. Among them, bio-slurry @ 5 t ha^{-1} + inorganic fertilizer produced the highest seed yield (1.83 t ha^{-1}), while the control yielded the lowest (1.63 t ha^{-1}). The integrated effect of varieties and fertilizers showed promising results. BARI sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer produced the highest seed yield (2.56 t ha^{-1}). Therefore, it could be concluded that BARI sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer has the potential for maximizing mustard yield.

To cite this article: Pal C. R., S. K. Paul, M. T. Ahmed, M. R. Uddin and U. K. Sarker, 2024. Integrated effect of bio-slurry with chemical fertilizers on the performance of mustard varieties. Res. Agric. Livest. Fish. 11(2): 149-157.

DOI: https://doi.org/10.3329/ralf.v11i2.73505

INTRODUCTION

Bangladesh is a developing country where the population is increasing, and land is decreasing day by day, so we must produce more food on our limited land. The dependency on agriculture is skyrocketing. Moreover, many people all around Bangladesh are involved in land farming or crop production. However, farmers do not get the desired outcome due to lacking proper training and knowledge about cultivation and varieties (Hossain et al., 2018; Islam et al., 2017). They also use more and more chemical fertilizers for high yields. Unfortunately, they waste their money and create harmful environmental hazards. The excessive use of chemical fertilizers among Bangladeshi farmers has increased by 400% over the past 30 years (Rahman and Zhang, 2018). Reducing the use of synthetic chemicals is one of the most important factors for modern farming (Ali et al., 2023).

Mustard (*Brassica* spp.) is a vital oilseed crop that plays a crucial role in worldwide agriculture, contributing to oil yield and soil fertility improvement. Moreover, mustard oilcake is used as manure. The dry mustard stick is also used as fuel and feed for cattle and fish. For sustainable agricultural goals, researchers and farmers are searching for innovative approaches to maximize mustard crop production (Rahman et al., 2015). The selection of a good mustard variety is pivotal in determining successful cultivation. Adaptability to specific Agro-climatic conditions and yield potential are critical factors in varietal selection (Ahmed and Kashem, 2017). Applying bio-slurry further amplifies the potential for enhanced crop productivity with varietal diversity. Bio-slurry, a derivative of digested organic materials (animal manure, human excrement, or plant matter), is a nutrient-rich liquid fertilizer that is devoted to improving soil fertility and plant nutrition (Rewe et al., 2022, Anggraini et al., 2021; Chew et al., 2019). The organic material and inorganic fertilizers enhanced the growth and yield of crops (Islam et al., 2023). Its integration into mustard cultivation offers a sustainable alternative to conventional chemical fertilizers, promoting environmental stewardship and reducing the ecological footprint of agricultural practices. The synergy between mustard varieties and bio-slurry represented a novel and holistic approach to agricultural management (Vijayeswarudu and Singh, 2021). This integrated strategy aims to increase yield and address broader sustainability goals by minimizing reliance on synthetic inputs and mitigating environmental impacts (Lolamo et al., 2023). The growth and yield are widely affected by the integration of organic and inorganic chemicals (Nahar et al., 2021). As the agricultural sector grapples with resource depletion and climate change challenges, exploring such integrated approaches becomes imperative. This study seeks to investigate the effect of variety and the application of bio-slurry and chemical fertilizers on mustard crop performance. Examining the interplay between organic nutrient supplementation and chemical fertilizers aimed to provide insights that can apprise sustainable agricultural practices and contribute to developing resilient mustard cultivation systems.

MATERIALS AND METHODS

Experimental site and design

The experimental field was located at Agronomy Field Laboratory, BAU, Mymensingh, Bangladesh (latitude: 24°42'55", longitude: 90°25'47") at 18 above sea level in the Old Brahmaputra Floodplain Agro-Ecological Zone (UNDP and FAO, 1988). The soil was medium-high and sandy loam with a pH of 6.9. The four varieties of mustard (V_1- BARI Sarisha-14, V_2-BARI Sarisha-11, V_3-BARI Sarisha-13, V_4- Tori-7) and four dose of fertilizers T_1 - control (no manure and fertilizer), T_2 - recommended dose of inorganic fertilizer (N-P-K-S-Zn@140-60- 80-2-10 kg ha^{-1}), T_3 - bio-slurry @ 5 t ha^{-1} + inorganic fertilizer (N-P-K-S-Zn@ 127-53-74-2-10 kg ha^{-1}), T_4 - farmers' practice (average of 15 farmers) (N-P-K-S-Zn@120-40-60-2-8 kg ha^{-1}) were used in the study. To determine fertilizer management in farmers' practice, fifteen farmers were interviewed individually at Boira village adjacent to BAU, and then the average fertilizer was calculated. The experiment was set up following randomized complete block design with three replications. The total plots were 48 plots (4.0 m × 2.5 m). The distance between the individual unit plot was 0.5 m and between the replication was 1.0 m.

Cultivation practices and fertilizer management

The experimental land was prepared using a power tiller and country plow, achieving medium tilth. Field layouts and individual plots were created by spading. Weeds and stubbles were removed from each plot before sowing. Fertilizers were applied to the plot based on treatment specifications. The integrated plant nutrition system (IPNS) was followed when bio-slurry was applied. The sources of N-P-K-S-Zn were urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate respectively. Bio-slurry and all other fertilizers and half of urea were applied at the time of final land preparation and another half of urea was applied at 30 days after sowing. Weeding was done manually at 10 and 25 days after sowing.

Observation and data collection

Mustard plants (BARI sarisha-14, BARI sarisha-11, BARI sarisha-13, Tori-7) were harvested on different dates at full maturity (85 % brown siliqua). The harvested plants were kept for five days, brought to the threshing floor and dried for four consecutive days. The yield contributing parameters were recorded from five sample plants. One thousand clean dried seeds were counted randomly, taken from each plot and weighed by an electric balance for calculation of weight of 1000 seed. The total seed yield m^{-2} was converted into t ha^{-1}.

Statistical analysis

The recorded data were compiled and appropriately tabulated for statistical analysis using the analysis of variance (ANOVA) technique with the help of the computer package MSTAT. The mean differences were adjudged by Duncan's Multiple Range Test (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

In Table 1 significant plant height was noticed for the variety. The tallest plant height (115.44 cm) was found in BARI Sarisha-14 and the shortest plant height (62.79 cm) was observed in Tori-7. Because of the differences in their genetic makeup, this type of variation in plant height is recorded. Sana et al. (2003) reported that the variation in plant height of various varieties was found due to their genetic potential. So, the genetic makeup of the cultivar acted as a key component for the variation in plant height. The plant height was significant for the fertilizer dose (Table 2). The tallest plant height (88.46 cm) was observed in bio-slurry @ 5 t ha^{-1} + inorganic fertilizer and the lowest was found in control. Reza et al. (2022) reported that plant height varied during the application of organic fertilizers. Plant height was found to be significant for variety and fertilizer dose. The most extended plant (125.72 cm) was obtained by the interaction from BARI sarisha14 with bio-slurry @ 5 t ha^{-1}+ inorganic fertilizer.

Table 1. Effect of variety on yield components and yield of mustard varieties

Variety	Plant height cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Length of siliqua (cm)	Seeds siliqua^{-1} (no.)	Weight of 1000 seed (g)	Harvest Index (%)
V_1	115.44 a	4.73 b	60.02 c	4.53 b	11.20 b	3.58 a	48.23 a
V_2	80.77 b	4.80 b	66.55 b	4.74 b	23.98 a	2.98 b	47.40 ab
V_3	79.20 b	5.19 a	88.65 a	5.05 a	26.10 a	3.05 ab	49.08 a
V_4	62.79 c	2.30 c	52.75 d	4.17 c	12.80 b	2.96 b	46.34 b
LSD $_{(0.05)}$	2.80	0.29	0.75	0.23	2.68	0.54	1.67
Level of significance	**	**	**	**	**	**	**
CV (%)	3.98	8.18	1.36	6.10	7.41	2.87	4.22

In a column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT. **- Significant at 1% level of probability, V_1 - BARI sarisha-14, V_2 - BARI sarisha-11, V_3 - BARI sarisha-13, V_4 - Tori-7

Number of branches plant^{-1}

The maximum number of branches plant^{-1} produced by BARI sarisha-13 which was 5.19 followed by BARI sarissa-11 (4.80) and BARI sarisha-14 (4.73). However, the minimum number of branches plant^{-1} for Tori-7 was 2.30. The same kind of variety effect on the number of branches plant^{-1} was also shown by Ahmed and Kashem (2017). From the study, it was observed that fertilizer exerted a significant influence on the number of branches of plant^{-1} (Table 2). The maximum number of branches plant^{-1} (4.43) were found in bio-slurry @ 5 t ha^{-1} + inorganic fertilizer. The number of branches plant^{-1} increased with the increasing amount of organic and inorganic nutrient (Gupta et al., 2023). The number of branches of plant^{-1} was significantly affected by the interaction effect of fertilizer and variety (Table 3). The maximum number of branches plant^{-1} (5.40) was found from the interactions between BARI Sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer.

Table 2. Effect of fertilizer management on yield components and yield of mustard varieties

Treatment	Plant height (cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Length of siliqua (cm)	Seeds siliqua^{-1} (no.)	Weight of 1000 seed (g)	Harvest Index (%)
T_1	82.24 b	4.14 bc	65.81 c	4.48 b	17.49	3.13	46.13 b
T_2	84.26 b	4.38 ab	67.29 b	4.72 ab	18.88	2.95	47.79 ab
T_3	88.46 a	4.43 a	68.81 a	4.76 a	19.1	3.13	49.09 a
T_4	83.22 b	4.08 c	66.07 c	4.53 ab	18.6	3.36	48.08 a
$LSD_{(0.05)}$	2.80	0.29	0.75	0.23	2.68	0.54	1.67
Level of sig.	**	**	**	**	NS	NS	**
C V (%)	3.98	8.18	1.36	6.10	7.41	2.87	4.22

In a column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMR T. Here NS - Nonsignificant, ** - Significant at 1% level of probability, T_1 - Control (no manure and fertilizer), T_2 - Recommended dose of inorganic fertilizer T_3 - Bio-slurry @ 5 t ha^{-1} Inorganic fertilizer, T_4 - Farmers' practice (average of 15 farmers)

Number of siliqua plant^{-1}

The result revealed that BARI sarisha-13 produced the highest siliqua plant^{-1}(88.65), significantly higher than BARI sarisha-11 and BARI sarisha-14 (66.55 and 60.02 respectively) (Table 1). The lowest number of siliqua (52.75) plant^{-1} was observed for Tori-7. The effect of varieties on siliqua plant^{-1} was also observed by Chowhan et al. (2023), who found almost the same result for all other varieties except for BARI Sarisha -16. Fertilizer showed significant variation in producing siliqua plant^{-1} (Table 2). Applying fertilizer at different levels increased the production of siliqua plant^{-1}over control (no fertilizer). Bio-slurry @ 5 t/ha + inorganic fertilizer produced the highest siliqua plant^{-1} (68.81). The effect of inorganic and organic fertilizers on the growth of mustard was also observed by Saini et al. (2017). A significant difference for siliqua plant^{-1} was found due to the interaction of variety and fertilizer (Table 3). BARI Sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer produced the highest siliqua plant^{-1} (91.23).

Length of siliqua

The longest siliqua (5.05 cm) was produced by the variety BARI Sarisha-13, which was significantly higher than those of variety BARI sarisha-11 (4.74 cm), BARI Sarisha-14 (4.53 cm) and Tori-7 (4.17 cm). The highest length of siliqua (4.76 cm) was noted after applying bio-slurry @ 5 t/ha + inorganic fertilizer. The length of siliqua is related to seed yield. The integrated effect showed that BARI Sarisha-13 with bio-slurry @ 5 t ha-1+ inorganic fertilizer produced the highest siliqua length (5.40 cm). Siliqua length varied with variety and fertilizer application on mustard (Yadav et al., 2023).

Number of seeds siliqua^{-1}

The most significant number of seeds siliqua-1 (26.10) was counted for BARI sarisha-13, which was statistically identical to BARI sarisha-11 (23.98) (Table. 1). The effect of fertilizers was recorded in Table. 2, and it was non-significant, where the highest number of seeds siliqua^{-1} is listed at bio-slurry @ 5 t ha^{-1} + inorganic fertilizer. Fertilizer and variety interacted significantly in producing seeds siliqua^{-1} (Table 3). The highest number of seeds siliqua^{-1} (29.66) was found when BARI sarisha-13 was cultivated with bio-slurry @ 5 t ha^{-1}+ inorganic fertilizer. Kumar et al. (2022) stated that varieties and fertilizers affected the number of seeds siliqua^{-1} of mustard.

Table 3. Interaction effect of variety and fertilizer management on yield components and yield of mustard varieties

Inter action	Plant height (cm)	Branches plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Length of siliqua (cm)	Seeds siliqua^{-1} (no.)	Weight of 1000 seed (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1T_1	107.20 c	2.03 d	50.73 i	4.56 de	11.21 d	3.46 abc	0.64 i	0.68 j	41.74 d
V_1T_2	115.57 b	5.00 ab	60.17 h	4.79 bcd	11.46 d	3.00 bc	1.23 f	1.33 gh	48.21 ab
V_1T_3	125.72 a	5.10 ab	62.57 g	4.46 de	12.06 d	3.33 bc	1.40 e	1.63 f	46.19 bc
V_1T_4	113.27 b	4.26 c	58.96 hi	4.30 ef	11.23 d	4.53 a	1.14 f	1.19 hi	48.99 ab
V_2T_1	78.50 ef	4.53 bc	63.74 fg	4.56 de	20.73 c	2.70 bc	2.03 d	2.60 ab	44.10 cd
V_2T_2	80.33 def	4.90 ab	67.13 e	4.60 cde	23.46 bc	2.83 bc	2.10 cd	2.36 bcd	47.22 abc
V_2T_3	83.67 de	5.20 a	70.70 d	5.20 ab	23.00 bc	3.66 ab	2.18 c	2.30 cde	48.74 ab
V_2T_4	80.60 def	4.60 bc	64.64 f	4.60 cde	22.06 c	2.73 bc	2.05 d	2.09 e	49.55 a
V_3T_1	75.21 f	5.00 ab	85.74 c	4.44 def	25.56 abc	3.16 bc	2.15 cd	2.22 de	49.12 ab
V_3T_2	80.33 def	5.30 a	90.29 a	5.30 a	27.96 ab	3.43 bc	2.42 b	2.49 abc	49.30 ab
V_3T_3	85.56 d	5.40 a	91.23 a	5.40 a	29.66 a	2.40 c	2.56 a	2.68 a	48.91 ab
V_3T_4	75.73 f	5.06 ab	87.33 b	5.06 abc	27.86 ab	3.20 bc	2.34 b	2.44 bcd	48.99 ab
V_4T_1	68.08 g	2.46 d	55.36 j	4.38 def	13.60 d	3.20 bc	1.11 f	1.56 fg	41.74 d
V_4T_2	60.84 h	2.33 d	51.56 l	4.18 ef	12.63 d	2.53 c	0.85 h	0.97 i	46.43 abc
V_4T_3	58.90 h	2.03 d	50.73 l	3.97 f	11.70 d	3.13 bc	0.64 i	0.68 j	48.37 ab
V_4T_4	63.32 gh	4.56 bc	58.40 k	4.15 ef	11.75 d	3.00 bc	2.03 d	2.07 e	49.55 a
LSD (0.05)	5.61	0.58	1.51	0.47	5.37	1.09	0.12	0.25	3.35
Level of Sig.	**	**	**	**	**	**	**	**	**
CV (%)	3.98	8.18	1.36	6.10	7.41	2.87	4.22	8.23	4.22

In a column, figures with same letters or without letters do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT. Here, **-Significant at 1% level of probability, V_1 - BARI sarisha-14, V_2 - BARI sarisha-11, V_3 - BARI sarisha-13, V_4 - Tori-7, T_1 - Control (no manure & fertilizer), T_2 - Recommended dose of inorganic fertilizer, T_3 - Bio-slurry @ 5 t/ha + Inorganic fertilizer, T_4 - Farmers' practice (average of 15 farmers)

1000-seed weight

The weight of 1000 seeds for BARI sarisha-14 (3.58 gm) were closely aligned with BARI sarisha-13 (3.05). On the other hand, 1000 seeds for BARI sarisha-11 (2.98 gm) and Tori-7 (2.96 gm) were statistically identical. No significant change was observed in the fertilizer and manure application. Kumar et al. (2022) also observed the nonsignificant effect of fertilizers. The weight of 1000 seeds of the plant were significantly influenced by the interaction effect of variety and fertilizer management (Table 3). The interaction between BARI Sarisha-14 and farmer practices produced the highest seed weight (4.53gm).

Seed yield

The highest seed (2.37 t ha^{-1}) yield was recorded in BARI sarisha-13 followed by seed yield (2.09 t ha^{-1}) in BARI sarisha-11. The lowest number of seed yields (0.89 t ha^{-1}) was found in Tori-7 (Figure 1). Patel and Tiwari (2021) indicated the yield variation due to varietal differences. Different levels of fertilizer influenced the seed yield of mustard. Maximum seed yield (1.83 t ha-1) was found from bio-slurry @ 5 t ha^{-1} + inorganic fertilizer (Figure 3). Low seedling growth from a nutrient shortage might have drastically reduced the yield in control conditions. The interaction effect exerted significant variation concerning seed yield. Among the interaction treatments, BARI sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer produced the highest seed yield (2.56 t ha^{-1}) and the lowest seed yield (0.64 t ha^{-1}) obtained from the interaction between Tori-7 and control. Hossain et al. (2018) worked on boro rice and reported that the combined effect of Binadhan-8 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer produced the highest grain yield (6.10 t ha^{-1}) (Table 3).

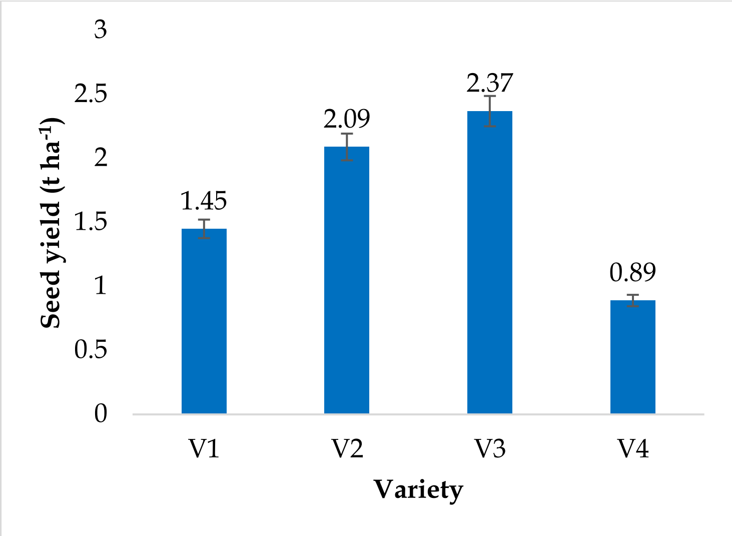

Figure 1. Effect of varieties on seed yield of mustard. Here, V_1 - BARI sarisha-14, V_2 - BARI Sarisha-11, V_3 - BARI sarish-13, V_4 -Tori-7

Straw yield

BARI sarisha-13 produced the higher straw yield (2.46 t ha^{-1}). The lowest straw yield was obtained by the Tori-7 (1.06 t ha^{-1}) (Figure 2). The straw yield was influenced by fertilizer management. The highest straw yield (2.11 t ha^{-1}) was found from bio-slurry @ 5 t ha^{-1} + inorganic fertilizer. The lowest straw yield (1.68 t ha^{-1}) was found in the control (Figure 4). Table 3 showed that the interaction of BARI sarisha-13 with bio-slurry @ 5 t ha^{-1}+ inorganic fertilizer produced the significantly highest straw yield (2.68 t ha^{-1}). In contrast, the interaction treatment Tori-7 with control produced the lowest straw yield (0.68 t ha^{-1}).

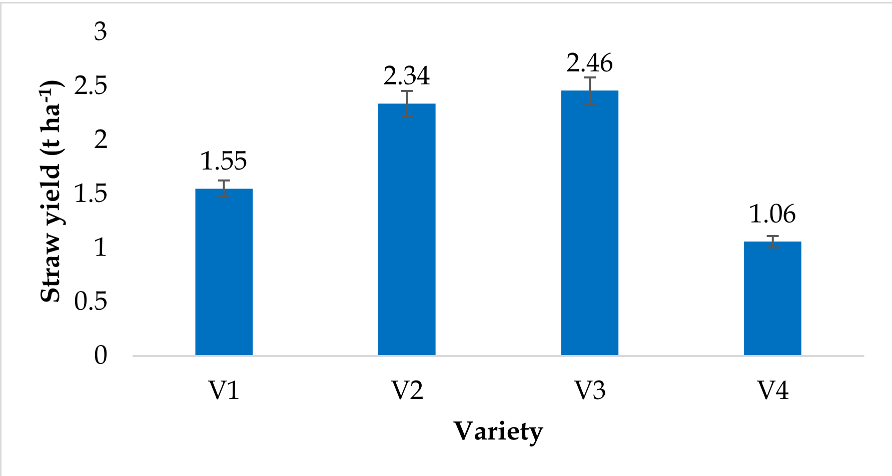

Figure 2. Effect of varieties on straw yield of mustard. Here, V_1 - BARI sarisha-14, V_2 - BARI Sarisha-11, V_3 - BARI sarish-13, V_4 -Tori-7

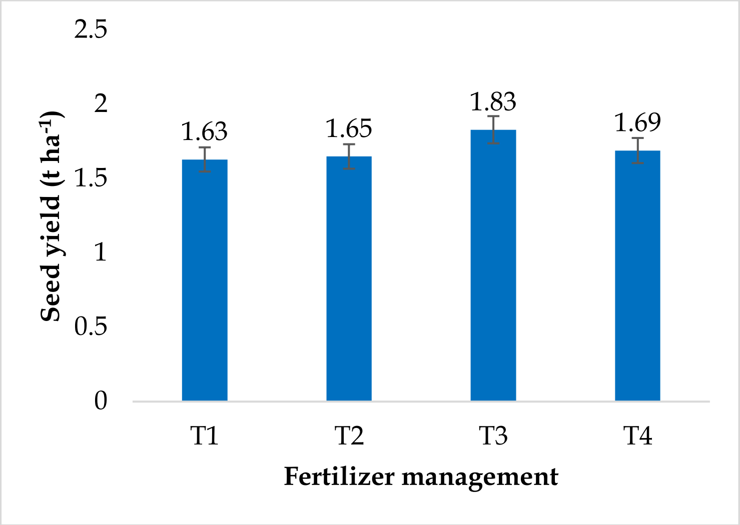

Figure 3. Effect of fertilizer management on seed yield of mustard. Here, T_1 - control (no manure and fertilizer), T_2 - recommended dose of inorganic fertilizer, T_3 - bio-slurry @ 5 t ha^{-1} + Inorganic fertilizer, T_4 - Farmers' practice (average of 15 farmers).

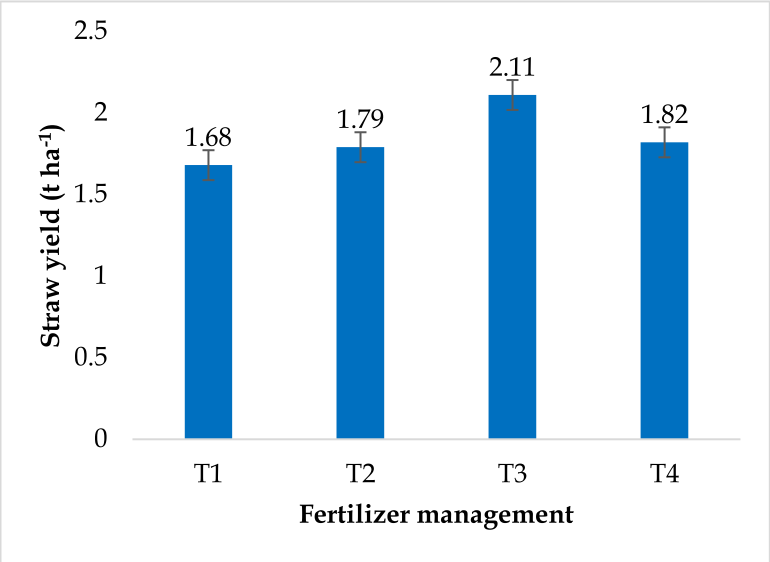

Figure 4. Effect of fertilizer management on straw yield in mustard. Here, T_1 - control (no manure and fertilizer), T_2 - recommended dose of inorganic fertilizer, T_3 - bio-slurry @ 5 t ha^{-1} + Inorganic fertilizer, T_4 - Farmers' practice (average of 15 farmers).

Harvest index

The data unveiled that notable differences were found due to variations in varieties (Table 1). The highest harvest index (49.08%) was found from BARI Sarisha-13 and the lowest (46.34%) was recorded in Tori-7. The application of different levels of fertilizer management exerted a significant influence on the harvest index (Table 2). The highest index (49.09%) was found at bio-slurry@ 5 t ha^{-1}+ inorganic fertilizer, and the lowest (46.13%) was found in control. Singh et al. (2018) reported that applying inorganic and organic fertilizers significantly improved the harvest index. The interaction between varieties and fertilizer treatments for harvest index was significant. The maximum harvest index was 49.55% for the interaction of BARI Sarisha-11 and farmers' practice.

CONCLUSION

The research findings revealed that variety significantly affected attributing yield parameters and yield. The most characteristic parameters supported BARI sarisha-13 at the top. This research also showed that fertilizer management influenced almost all the measured yield parameters and yield. The highest value of almost all the measured quantities was recorded with the implication of bio-slurry @ 5 t ha^{-1}+ inorganic fertilizer. The integrated effect of variety and fertilizers treatment also significantly affected measured parameters. The BARI sarisha-13 with bio-slurry @ 5 t ha^{-1} + Inorganic fertilizer had the highest seed and straw yield. The study concluded that the farmers could cultivate BARI sarisha-13 with bio-slurry @ 5 t ha^{-1} + inorganic fertilizer to obtain maximum seed yield.

ACKNOWLEDGEMENTS

The authors extend their appreciation to Ministry of Science and Technology, Government of the People's Republic of Bangladesh for funding.

CONFLICT OF INTEREST

The authors declared no conflict of interests concerning the publication of this paper.

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