J Bangladesh Agril Univ 22(2): ***185-192****, 2024* https://doi.org/10.3329/jbau.v22i2.74552

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Research Article

Effect of Different Fertilizer Combinations and Gibberellic Acid (GA3) on Yield Attributing Traits of Mustard

Suraia Habib Laboni[1], Abu Khayer Md. Muktadirul Bari Chowdhury[1]✉, Md. Maniruzzaman Bahadur[1], Md. Rabiul Islam[1], Md. Mahfuzul Hasan[2] and Nayan Chandra Howlader[2]

[1]Department of Crop Physiology and Ecology, Faculty of Agriculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh

[2]Department of Horticulture, Faculty of Agriculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ARTICLE INFO

Article history
Received:04 April 2024
Accepted: 25 June 2024
Published: 30 June 2024

Keywords
Boric acid,
Fertilizer combination,
GA3,
Mustard,
Yield

Correspondence
Abu Khayer Md. Muktadirul Bari Chowdhury
✉: minarbari07@gmail.com

Abstract

The combined use of organic and inorganic fertilizer combination and gibberellic acid (GA3) is a potential solution to increase yields. The motives of this investigation are to evaluate the yield and yield attributes of mustard varieties with different fertilizer combinations and gibberellic acid (GA3). The experiment was set at the Research Field of the Department Crop Physiology and Ecology of Hajee Mohammad Danesh Science and Technology University, Dinajpur, in accordance with randomized complete block design with three replications. Three mustard varieties viz., BARI mustard-14, BARI mustard-17 and BINA mustard-9 were evaluated against four combined fertilizations and GA3. The maximal yield and yield attributing traits were significantly subjugated by variant fertilization and varieties. The results expounded that BARI mustard-17 emanated the utmost values followed by varieties BARI mustard-14 and BINA mustard-9. In extent of fertilization, most of the growth parameters showed the highest values in Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10 % and the lowest values were recorded in Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}. In the majority of instances, the BARI mustard-17 and Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10 % exhibited the highest performance in the context of fertilization and variety interactions.

Introduction

In Bangladesh, mustard holds significant importance as a major oilseed crop, known locally as 'Sharisha'. Cultivated extensively during the winter season across the country, mustard seeds boast a composition of approximately 40-45% oil and 20-25% protein (Zhang *et al*., 2008). The oil derived from mustard seeds serve as a vital energy source in human nutrition, being devoid of cholesterol typically found in animal fats. Notably, mustard oil is rich in essential soluble vitamins such as A, D, E, and K (Sharif *et al*., 2017), making it a preferred choice for cooking and medicinal purposes. Additionally, the by-product of mustard oil extraction, known as mustard oilcake, finds utility as both animal feed and organic fertilizer.

Despite its nutritional significance, Bangladesh faces a shortfall in per capita oil and fat supply, amounting to merely 7.5 kg per year (FAO, 2010). Mustard cultivation, being a winter (Rabi) season crop, demands specific environmental conditions including cool temperatures, adequate soil moisture during growth, and dry harvesting conditions (Budzynski *et al*., 2019). Within the spectrum of oilseed crops, Brassica varieties contribute substantially to edible oil production in Bangladesh, accounting for a significant portion of total oilseed cultivation (AIS, 2010).

Efforts to enhance mustard yield have focused on employing high-yielding varieties and optimal agronomic practices, with fertilizer application emerging as a crucial determinant of productivity (Sezer *et al*., 2021). However, excessive use of chemical

Cite This Article
Laboni, S.H., Chowdhury, A.K.M.M.B., Bahadur, M.M., Islam, M.R., Hasan, M.M. and Howlader, N.C. 2024 Effect of Different Fertilizer Combinations and Gibberellic Acid (GA3) on Yield Attributing Traits of Mustard. *Journal of Bangladesh Agricultural University,* 22(2):185-192. https://doi.org/10.3329/jbau.v22i2.74552

fertilizers has raised environmental concerns, prompting exploration into eco-friendly organic alternatives. Organic manures/compost, derived from agricultural residues, play a pivotal role in improving soil fertility and nutrient availability, consequently augmenting crop growth and yield (Anee et al., 2022; Chowdhury *et al*., 2020).

In addition to agronomic factors, the role of plant growth regulators (PGRs) such as gibberellic acid in enhancing mustard yield has garnered attention (Keerthi *et al*., 2016). Gibberellic acid aids in seed germination, growth, flowering, and nutrient transport, thereby influencing overall crop performance (Dey *et al*., 2024). While the beneficial effects of essential nutrients like nitrogen, phosphorus, potassium, sulfur, zinc, and boric acid on mustard production are acknowledged, comprehensive insights into their impact on crop quality and nutrient interactions remain limited. Thus, further research is warranted to optimize nutrient management strategies for maximizing mustard yield and quality.

Oilseed crops, such as mustard, are crucial in Bangladesh's agriculture, along with cereals. Ensuring food security and agricultural prosperity requires understanding mustard cultivation, including its nutritional value, yield improvement techniques, and environmental sustainability. This study had three main objectives: analyzing the effects of specific inorganic fertilizer combinations on mustard growth and yield; examining the impact of plant growth regulators on mustard's growth and yield performance; and assessing the outcomes of using different fertilizer combinations and plant growth regulator doses. These goals aim to optimize agricultural practices for better mustard crop productivity.

Materials and Methods

Experimental site and design

The field experiment was conducted at the Research Field of the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science Technology University, Dinajpur, located at approximately 25°38' N latitude and 88°41' E longitude, with an elevation of 34.4 meters above sea level. This location has a subtropical climate that is characterized by various climatic conditions throughout the year.

The experiment followed a Randomized Complete Block Design (RCBD) with 36 plots, each measuring 1.5 × 1.5 meters, and three replications. Layout was completed on November 1, 2022, with 1.5-meter inter-plot spacing. Land preparation began on November 10, 2022, using a power tiller. The experiment had two factors: (A) three mustard varieties, (V1) = BARI mustard-14, (V2) = BARI mustard-17, (V3) = BINA mustard-9, and (B) four combined fertilizations and GA3 (recommended dose), T1 = (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Poultry litter-based compost 10 tons ha^{-1}), T2 = (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}), T3 = (Urea: 250 kg ha^{-1}, MoP: 70 kg ha-1, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, Boric acid: 10 kg ha^{-1}), and T4 = (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%). Seeds were treated with Provex-200 at 0.25% before sowing to safeguard against soil-borne diseases. Sowing occurred on November 18, 2022, at a rate of 7 kg ha^{-1}, with furrows spaced 30 cm apart. Seedlings emerged within 7 days.

Manuring and Fertilization

The calculated entire amount of all manures and Urea, TSP, MoP, Gypsum, Zinc sulphate, were applied during final plot preparation according to the design and treatment. The applied poultry litter composts, 120 days aged compost, were mixed properly with the soil in the plot using a spade. Boric acid and GA3 were applied just before the initiation of the flowering stage. In the case of the application of boron, 1–1.5 g of soluble boron powder (Solubor Boron 20%) was applied to one liter of water and sprayed the plants well. GA3 (Gibberellic Acid 10%) 10 gm tablet was soaked in a small volume of water for 1-2 hours before applying to plants. Later, after a specified time, the mixture (solution) was mixed with 50 liters of water and sprayed well on the plants.

Table 1. The recommended doses of application of organic and inorganic fertilizers

Fertilizers/manure	Dose ha^{-1}	Dose plot^{-1}
Urea	200 kg	45 g
Triple Supper Phosphate (TSP)	150 kg	33.75g
Muriate of Potash (MoP)	70 kg	15.75 g
Gypsum	120 kg	27 g
Boric acid	10 kg	2.25 g
Zinc Sulphate	4 kg	0.9 g
Poultry litter-based compost	10 tons	2 kg

Intercultural practices

Thinning was conducted on November 28, 2022, ensuring a 10 cm plant-to-plant distance. Pre-sowing irrigation in rows was administered to maximize germination. Three irrigations were provided at 10, 20, and 35 days after sowing. Drainage systems were established for excess water. Weeding was carried out as required, and disease and pest management measures were implemented.

Data collection

Number of siliqua plant^{-1} (no.)

Siliqua collected from ten randomly selected plants of each plot were counted at 75 days after planting (DAS) and at harvest and then the average numbers of siliqua for each plant was determined.

Number of seeds siliqua^{-1} (no.)

Total number of seed was counted from the selected 20 siliquae of ten randomly selected plants of each plot and averaged them to have number of seeds siliqua^{-1}.

Length of siliqua (cm)

Siliqua length was recorded from the base to the apex of siliquae from randomly selected 20 siliquas of ten randomly selected plants of each plot and then means value was calculated.

Weight of 1000-seeds (g)

One thousand clean sun-dried seeds were counted from the seed stock obtained from the sample plants, weighed by electronic balance and expressed in gram (g).

Greenness (SPAD value)

The SPAD meter (Model: MINOLTA, Chlorophyll meter, SPAD-502, JAPAN) was used for the rapid, accurate and non-destructive measurement of chlorophyll concentrations of mustard leaves.

Grain yield (kg ha^{-1})

Total mustard plants were collected from pre-selected area (2.25 m^2) of the middle of each plot. The plants were cut, threshed and dried. Final grain yield was adjusted at 14% moisture. The dried grains were weighed. The grain yield t ha^{-1} was measured by the following formula:

$$Grain\ Yield\,(kgha^{-1}) = \frac{Grainyieldperunitplot(kg) \times 1000}{Areaofunitplotinsquare \times 1000}$$

Stover yield (kg ha^{-1})

Stover obtained from each unit plot was sun-dried and weighed carefully. The dry weight of stover of central 4.0 m^2 area was used to record the final stover yield plot^{-1} which was finally converted to t ha^{-1}. The stover yield t ha^{-1} was measured by the following formula:

$$GrainYield\,(kgha^{-1}) = \frac{Stoveryieldperunitplot\,(kg) \times 1000}{Areaofunitplotinsquare \times 1000}$$

Biological yield (kg ha^{-1})

Grain and stover yields were altogether regarded as biological yield. The biological yield was calculated with the following formula:

Biological Yield (kg ha^{-1}) = Grain yield (kg ha^{-1}) + stover yield (kg ha^{-1})

Harvest index (%)

Harvest index (HI) is the ratio of economic yield to biological yield and was calculated with the following formula:

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

Statistical Analyses

The collected data were analyzed by the computer package program Statistix 10. Means were separated by Tukey's test (Gomez and Gomez, 1984).

Results

Effect of varieties on yield and yield attributing traits of mustard

The number of siliqua plant^{-1} was statistically similar with each other (Table 2). The highest value (89.867) was found in variety BARI mustard-14 (V1) followed by BARI mustard-17 (V2). In case of variety, significant variation of length of siliqua in pea plants were observed due to the application of different treatments. Plants were observed of getting highest siliqua length at V3 (7.008 cm) which was followed by BARI mustard-14, BARI mustard-17, having siliqua length 4.79 and 4.38 cm, respectively (Table 2). The number of seed per siliqua^{-1}, fertilization and GA3 were statistically varied with each other (Table 2). Plants got maximum number of seed siliqua^{-1} at in BARI mustard-14 (32.500) which was followed by BARI mustard-17 (31.925). The thousand seeds weight was varied significantly due to the influence of different varieties and treatment (Table 2). The highest quantity of thousand seeds weight was 11.833 g from BINA mustard-9 (V3), while the minimum was 6.333 g from BARI mustard-14. The highest stover weight plot^{-1} (360.00 g) was found in variety BARI mustard-14. At 30 DAS, plants were recorded having maximum SPAD value at in BINA mustard-9 (46), which was followed by BARI mustard-14, having SPAD value 43.883. At 45 DAS, the supreme SPAD value (44.383) was got from BINA mustard-9 (V3), that was followed by BARI mustard-14 (43.133). At 60 DAS, the SPAD value ranged 42.017 to 39.508 and varied significantly (Table 3). The highest grain yield ha^{-1} was found in BARI mustard-17 (1841.1 kg) in fresh weight basis and 1518.5

kg was found in dry weight basis (Table 3). It was noted that the highest amount of biological yield (3105.9 kg) and stover yield (1600.00 kg) was found in BARI mustard-14 (Table 4). It was noticed that highest percent of harvest index (49.852) was achieved from BARI mustard-17, whereas it was the lowest (44.44) from BINA mustard-9 (Table 4).

Table 2. Effect of variety and fertilization and GA3 on number of siliqua plant^{-1}, length of siliqua (cm), number of seed siliqua^{-1}, 1000 seed weight (g), stover weight plot^{-1} (g) of mustard

Treatment	Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seed siliqua^{-1}	1000-seed weight (g)	Stover weight plot^{-1} (g)
Variety					
V1	89.87a	4.7917b	32.500a	6.333c	360.00a
V2	85.27a	4.3833b	31.925a	8.875b	338.00a
V3	67.41a	7.0083a	21.125b	11.833a	341.25a
LS	ns	*	*	*	ns
Fertilization and GA3					
T1	84.98a	5.1111a	32.222a	8.3333b	326.00a
T2	76.97a	5.3222a	27.200b	8.4444ab	351.56a
T3	76.09a	5.8444a	27.522ab	9.3889ab	364.78a
T4	85.3a	5.3000a	27.122b	9.8889a	343.33a
LS	ns	ns	*	*	ns
CV %	22.52	20.11	16.48	19.35	21.59

Here, means having same letter within a column do not differ significantly at 5% level of probability *indicates 5% level of probability, ** indicates 1% level of probability and ^{ns} indicates non-significant

Table 3. Effect of variety and fertilization and GA3 on greenness (SPAD value), grain yield of mustard

Treatment	Greenness (SPAD value)			Grain yield (kg ha^{-1})	
	30 DAS	45 DAS	60 DAS	Fresh	Dry
Variety					
V1	43.88a	43.13a	39.658a	1733.3a	1505.9a
V2	46.00a	42.88a	39.508a	1841.1ab	1518.5a
V3	44.47a	44.38a	42.017a	1430.4b	1213.3b
LS	ns	ns	ns	*	*
Fertilization and GA3					
T1	43.97ab	43.13a	40.522a	1635.6a	1407.4a
T2	43.17b	42.63a	39.378a	1645.4a	1359.0a
T3	44.99ab	43.00a	41.356a	1661.2a	1438.0a
T4	47.01a	45.10a	40.322a	1730.9a	1445.9a
LS	ns	ns	ns	ns	ns
CV (%)	7.84	6.52	10.23	23.55	22.93

Here, means having same letter within a column do not differ significantly at 5% level of probability *indicates 5% level of probability, ** indicates 1% level of probability and ns indicates non-significant

Effect of fertilizer and GA3 on yield and yield attributing traits of mustard

In case of fertilization and GA3 application, statistically non-significant variation was observed with each other (Table 2). The utmost number of siliqua plant^{-1} (85.3) was noted in T4(Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%) and the minimal value (78.09) was in T3 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, Boric acid: 10 kg ha^{-1}). The highest length of siliqua (6.84 cm) was observed in T3 and the lowest value (5.11 cm) was in T1 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120kg ha^{-1}, Poultry litter-based compost: 10 tons ha^{-1}). T1had the peak number of seed siliqua^{-1} (32.22), whereas T4 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%) had the smallest number of seed siliqua^{-1} (27.12). The heaviest weight of thousand seeds (9.89 g) was acquired in T4 and the lowest value (8.33 g) was in T1 (Table 2). In extent of stover weight, non-significant variation was observed among the different treatment of fertilization and GA3 (Table 2). The top quantity of stover weight plot^{-1} (364.78 g) was observed in T2 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}) and the smallest value (326.00 g) was in T1 (Table 2). The highest SPAD value (47.011) was observed in T4 and the lowest value (4.167) was in T2. In extent of fertilization and GA3 application, The SPAD value (45.100) were highly non-significant from one another (Table 3). At 45 DAS, plants were observed getting highest SPAD value at T4 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%). The highest SPAD value (41.356) was attained from T3 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha-1, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, Boric acid: 10 kg ha^{-1}) at 60 DAS. T4 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%) was also revealed as the highest producer of grain yield ha^{-1} (1730.9 kg in fresh weight basis and 1445.9 kg in dry weight basis).

Table 4. Effect of variety and fertilization and GA3 on stover yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%)

Treatment	Stover yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)
Variety			
V1	1600.00a	3105.9a	49.006ab
V2	1502.22a	3020.72a	49.852a
V3	1516.66a	2729.96a	44.44b
LS	ns	ns	*
Fertilization and GA3			
T1	1448.88a	2856.28a	49.27a
T2	1562.48a	2921.48a	46.51a
T3	1621.24a	3059.24a	47.00a
T4	1525.91a	2971.81a	47.52a
LS	ns	ns	ns
CV %	21.07	19.12	13.82

Here, means having same letter within a column do not differ significantly at 5% level of probability, *indicates 5% level of probability, ** indicates 1% level of probability and ns indicates non-significant

T3 provided maximum biological yield (3059.24 kg ha^{-1}) and stover yield (1621.24 kg ha^{-1}). The highest harvest index (49.27 %) was acquired from T1 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120kg ha^{-1}, Poultry litter-based compost: 10 tons ha^{-1}) and the lowest (46.51 %) was in T2 (Table 4).

Interaction effect of variety fertilizer and GA3 on yield and yield attributing traits of mustard

The fertilization and varieties interaction of number siliqua plant^{-1} was statistically similar (Table 5). The maximum numbers of siliqua were executed in V2T4 (98.66) and the shortage value was in V3T1 (63.33) treatment combination followed by V3T2 (67.867). The longest length of siliqua was observed in V3T3 (8.33 cm) and the shortest value was in V2T2 (3.93 cm) treatment combination. The absolute number of seed siliqua^{-1} was audited in V1T1 (37.33) and the minimal value was in V3T2 (27.83) treatment combination. (Table 5).

Table 5. Interaction effect of variety and fertilization and GA3 on number of siliqua plant^{-1}, length of siliqua (cm), number of seed siliqua^{-1}, 1000 -seed weight (g), stover weight plot^{-1} (g) of mustard

Treatment		Number of siliqua plant^{-1}	Length of siliqua (cm)	Number of seed siliqua^{-1}	1000-seed weight (g)	Stover weight plot^{-1} (g)
V1	T1	97.80a	5.33cde	37.33a	6.00f	347.33a
	T2	87.33ab	4.53de	30.93ab	5.66f	390.00a
	T3	77.80ab	4.66de	31.23ab	6.50ef	350.00a
	T4	96.53a	4.63de	30.50abc	7.16def	352.67a
V2	T1	93.80ab	4.26de	34.00a	10.00bc	316.00a
	T2	75.66ab	3.93e	32.83ab	7.33def	321.33a
	T3	80.73ab	4.53de	29.16abc	8.66cde	332.67a
	T4	98.66ab	4.80cde	31.70ab	9.50cd	382.00a
V3	T1	63.33b	5.73cd	25.33bcd	9.00cde	314.67a
	T2	67.86ab	7.50ab	17.83d	12.33ab	343.33a
	T3	69.73ab	8.33a	22.16cd	13.02a	411.67a
	T4	68.70ab	6.46bc	19.16d	13.06a	295.33a
LS		ns	*	*	*	ns
CV %		22.52	20.11	16.48	19.35	21.59

Here, means having same letter within a column do not differ significantly at 5% level of probability, *indicates 5% level of probability, ** indicates 1% level of probability and ns indicates non-significant

The highest thousand seed weight was noted in V3T4 (13.06 g) and the lowest value was in V1T2 (5.66 g). Stover weight plot^{-1} was significantly diffused by interaction between different fertilization and varieties (Table 5). The highest amount of Stover weight plot^{-1} was recorded from V3T3 (411.67 g). Greenness (SPAD value) was significantly affected by interaction between different fertilization and varieties (Table 6). At 30 DAS, the highest SPAD value was observed in V2T4 (49.60) and the lowest value was in V1T2 (40.00) treatment combination. At 45 DAS, plants were observed getting highest SPAD value at V2T4 (45.90) treatment combination. At 60 DAS the highest SPAD value (41.35) was observed in treatment combination V3T3 (45.40).

Table 6. Interaction effect of variety and fertilization and GA3 on greenness (SPAD value), grain yield (kg ha^{-1}) of mustard

Treatment		Greenness (SPAD value)			Grain yield (kg ha^{-1})	
		30 DAS	45 DAS	60 DAS	Fresh	Dry
V1	T1	44.40abc	42.23a	40.13a	1751.1ab	1487.4ab
	T2	40.00c	42.33a	39.06a	1709.6ab	1502.2ab
	T3	44.96abc	43.10a	40.10a	1742.2ab	1517.0ab
	T4	46.16abc	44.86a	39.33a	1730.4ab	1517.0ab
V2	T1	42.93bc	41.83a	40.56a	1771.9ab	1487.4ab
	T2	46.36ab	43.40a	39.43a	1795.6ab	1437.0ab
	T3	45.10abc	41.66a	38.56a	1591.1ab	1315.6ab
	T4	49.60a	45.90a	39.46a	2205.9a	1834.1a
V3	T1	44.56abc	45.33a	40.86a	1383.7b	1247.4b
	T2	43.13bc	42.16a	39.63a	1431.1b	1137.8b
	T3	44.90abc	44.23a	45.40a	1650.4ab	1481.5ab
	T4	45.26abc	45.80a	42.16a	1256.3b	986.7b
LS		*	ns	ns	*	*
CV %		7.84	6.52	10.23	23.55	22.93

Here, means having same letter within a column do not differ significantly at 5% level of probability, *indicates 5% level of probability, ** indicates 1% level of probability and ns indicates non-significant

According to fresh weight basis the highest grain yield plot^{-1} was observed in V2T4 (496.33 g) and the lowest value was in V3T1 (311.33 g) treatment combination. The maximum fresh weight of yield ha^{-1} was observed in V3T4 (2205.9 kg) and the lowest value was in V3T4 (1256.3 kg) treatment combination. The utmost dry weight of yield ha^{-1} was observed in V2T4 (1834.1 kg) and the lowest value was in V3T2. V2T4 had the maximal amount of biological yield (3531.87 kg ha^{-1}) and V3T4 had the minimal quantity (2829.29 kg ha^{-1}) of biological yield. V3T3 treatment combination produced higher amount of stover yield (1829.64 kg ha^{-1}). Harvest index was significantly affected by the interaction between different fertilization and varieties. The highest harvest index (%) was noted in V2T4 (51.92) and the lowest value was in V3T4 (41.26) treatment combination (Table 7).

Table 7. Interaction effect of variety and fertilization and GA3 on stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index

Treatment		Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
V1	T1	1543.64a	3031.04ab	49.06a
	T2	1733.33a	3235.53ab	46.42a
	T3	1555.55a	3072.55ab	50.37a
	T4	1567.42a	3084.42ab	49.18a
V2	T1	1404.44a	2891.84ab	51.43a
	T2	1428.13a	2865.14ab	49.04a
	T3	1478.53a	2794.13ab	46.08a
	T4	1697.77a	3531.87a	51.92a
V3	T1	1398.53a	2645.93ab	46.53a
	T2	1529.91a	2663.71ab	42.65a
	T3	1829.64a	3311.14a	45.74a
	T4	1312.57a	2229.29b	41.26a
LS		ns	*	ns
CV		21.07	19.12	13.82

Here, means having same letter within a column do not differ significantly at 5% level of probability, *indicates 5% level of probability, ** indicates 1% level of probability and ns indicates non-significant

Discussion

The utilization of organic and inorganic fertilizers can govern the sustainable management of soil fertility, productivity, chemistry and also increases the plant growth, development and oil content of mustard. The application of organic fertilizer may increase the nitrogen availability in soil. (Ali M *et al*., 2018a; Chowdhury *et al*., 2013). different doses of S and Zn either alone or in combination of results revealed that in general, available N, P, K, S and Zn in soil decreased with an increase in the period of crop growth. Combined application of higher doses of S and Zn along with compost and recommended doses of N, P and K fertilizers increased N, P, K, S and Zn uptake by rapeseed (*Brassica napus*) crop. Number of seeds siliqua^{-1} and siliqua length were not influenced significantly due to various doses of N, P and K except number of siliquae plant^{-1} which was significantly higher with the application of 80 kg N ha^{-1} followed by 100 kg N ha^{-1} (Kumar *et al*., 2017). Number of siliqua plant^{-1}, thousand seeds weight, seed yield increased, whereas oil content decreased with increasing rates of nitrogen (Rimi *et al*., 2015; Keivanrad and Zandi, 2012). Zinc is required for the metabolism of plants, enzyme function and ion transport. Application of boron on *Brassica napus* significantly increased the amount of seeds siliqua^{-1}, grain weight and number of 1000-seed weight (Yadav *et al*., 2016). Hossain *et al*. (2012) also supported that uses of boron fertilizer provided higher weight of thousand seed over control. Boron is a micronutrient essential for cell wall formation, carbohydrate metabolism, and pollen tube elongation. Adequate boron availability improves flower development, pollen viability, and seed set, ultimately leading to increased biomass production and higher biological yield. GA3 is a plant growth regulator that stimulates cell elongation, flowering, and fruit development. Applied at appropriate concentrations, GA3 promotes grain filling, increases the number of grains per spike, improves grain weight, and enhances overall grain yield per hectare. By providing essential nutrients, micronutrients, and growth regulators, such as N, K_2O, P_2O_5, S, Zn, boric acid, and GA3 plants can optimize their growth, development, and yield potential, leading to increased grain yield per hectare. It's important to note that the effectiveness of these factors may vary depending on factors such as soil fertility, environmental conditions, crop variety, and management practices (Islam *et al*., 1992). GA3 promotes increased seed production per siliqua by stimulating flowering, improving pollination and fertilization, enhancing fruit set, extending the reproductive period, and improving seed viability. These effects contribute to higher seed yields and improved crop productivity in plants treated with GA3. GA3 may indirectly contribute to the production of more siliquae per plant by supporting overall plant health and vigor (Sharif *et al*., 2016 a). Combinations of BARI mustard-17 with poultry liter compost resulted in a higher length of siliqua. It may be concluded that poultry manure with T4 (Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4 kg ha^{-1}, Boric Acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, GA3: Gibberellic Acid 10%) provided maximum nutrient availability to the plants. Increase in available nitrogen content in soil helps to increase the greenness of leaf i.e. increase chlorophyll content. Result showed that highest chlorophyll SPAD value. It indicates that application of organic fertilizer may increase the nitrogen availability in soil. Ali M *et al*., (2018 b), found same result. SPAD values can be achieved through a combination of providing adequate nutrition, including essential macronutrients and micronutrients, and employing plant growth regulators like GA3 to stimulate chlorophyll synthesis and photosynthetic activity. Balancing these factors optimally can lead to improved plant health and vigor, as reflected in higher SPAD values (Sharif *et al*., 2016 b). 50 ppm GA3 was the optimum dose for producing the highest number of fertile siliqua plant^{-1} (Saha *et al*., 2021). The harvest index (HI) is a measure of the efficiency with which a plant allocates resources towards harvestable parts, typically grains or fruits, relative to total plant biomass. Increasing the harvest index is desirable in agriculture as it indicates a higher proportion of biomass being allocated to the harvestable portion of the plant, leading to greater yield efficiency. Factors such as N, K_2O, P_2O_5, S, Zn, boric acid, poultry litter and GA3 can contribute to an increase in harvest index through various mechanisms. Overall, by providing optimal nutrition and employing growth regulators like GA3, plants can allocate resources more efficiently towards the production of harvestable parts, resulting in an increased harvest index. Proper management of these factors is essential for maximizing crop yield and improving agricultural productivity (Mukharjee *et al*., 2013). Organic fertilizer, or organic matter, significantly increases the availability of soil nutrients, as well as the yield and production of fruit, siliqua, and seed (Howlader *et al*., 2023; Yesmin *et al*., 2023). Variety plays a vital part in achieving high output, and yield may vary due to the influences of genetics, climate, and management.

Conclusion

Mustard yield and yield-attributing traits can vary due to various fertilizer combinations, and GA3 application. BARI mustard-17 resulted in satisfactory yield and yield-attributing characteristics, as demonstrated by the findings of this investigation. The interaction between BARI Mustard-17 and Urea: 250 kg ha^{-1}, MoP: 70 kg ha^{-1}, TSP: 190 kg ha^{-1}, Gypsum: 120 kg ha^{-1}, Zinc Sulphate: 4

kg ha^{-1}, Boric Acid: 10 kg ha^{-1}, Poultry litter compost: 10 tons ha^{-1}, and GA3: Gibberellic Acid 10% significantly impacted several yield and yield attributing traits, including greenness (SPAD value), number of siliqua plant^{-1}, dry weight of yield ha^{-1}, biological yield, and harvest index.

Acknowledgements

The authors expressed their gratitude to the Ministry of Science and Technology (MOST), People's Republic of Bangladesh, for providing the research grant and support (Project ID: SRG-223486).

References

AIS (Agricultural Information Service)., 2010. Krishi diary (in Bangla). Agricultural Information Service, Dhaka, 13-14.

Ali, M., Khan, N., Khan, A., Rafeh Ullah, A.N., Khan, M.W., Khan, K., and Rauf, K., 2018 a, b. Organic manures effect on the bulb production of onion cultivars under semiarid condition. *Pure and Applied Biology*, 7(3): 1161-1170.

Anee, T. I., Islam, M.N.N., Hassan, M.M., Masud, A.A.C., Alam, M.M., and Hasanuzzaman, M., 2022. Organic amendments improve plant morpho-physiology and antioxidant metabolism in mitigating drought stress in bread wheat (Triticum aestivum L.). *Phyton-International Journal of Experimental Botany*, 91(9): 1959-1972.

BBS (Bangladesh Bureau of Statistics)., 2021. Statistical Year Book of Bangladesh. Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka.

Budzynski, W., and Jankowski, K., 2019. Effect of fertilization with sulphur, magnesium and nitrogen on the growth and yield of white and Indian mustard seeds. *Rosliny-Oleiste. Uniwersytet Mazurski*, 22(1): 45-58.

Chowdhury, A.K.M.M.B., Akratos, C.S., Vayenas, D.V., and Pavlou, S., 2013. Olive mill waste composting: a review. *International Biodeterioration & Biodegradation*, 85: 108-119. http://dx.doi.org/10.1016/j.ibiod.2013.06.019

Chowdhury, A.K.M.M.B., Hossain, M.A., Alam, J., Hasan, M.A., and Islam, M.Z., 2020. Amelioration of adverse effect of drought on BRRI dhan28 through poultry litter based compost. *The Agriculturists*, 18(1): 42-55.

Dey, B., Bhatt, P., Sharma, R.K., Sharma, D., and Mandal, S., 2024. optimization of chemical fertilizer through Integrated Nutrient Management (INM) approach and its effect on growth and yield of mustard (*Brassica juncea* L.). *Asian Journal of Soil Science and Plant Nutrition,* 10(1): 64-74.

FAO Quarterly Bulletin of Statics., 2010. Food and Agriculture Organization of the United Nations, 12(3/4): 62.

Gomez, K.A., and Gomez, A.A, 1984. Statistical Procedures for Agricultural Research. In: 2nd (Ed). John Wiley and Sons, New York pp 680.

Hossain, M. A., Jahiruddin, M., and Khatun, F., 2012. Response of mustard (*Brassica*) varieties to boron application. *Bangladesh Journal of Agricultural Research*, 2012, Vol. 37(1): 137-148.

Howlader, N.C., Hossain, M.M., Rabbani, M.G., Basunia, A.K., Hasan, M.M., and Saima, U., 2024. Effect of irrigation intervals on the growth, yield and fruit quality of lemon (*Citrus limon* L.). *Plant Physiology and Soil Chemistry*, 4(1): 20-25.

Islam, N., Rahman, L., Choudhury, M., and Miah, M.N.H., 1992. Optimization of nitrogen inputs of mustard (*Brassica juncea*) variety Sambal. *Bangladesh Journal of Agricultural Sciences*, 19(11): 79–84.

Keerthi, P., Pannu, R. K., Singh, R., and Dhaka, A. K., 2016. Thermal requirements, heat use efficiency and plant responses of Indian mustard (*Brassica Juncea*) for different levels of nitrogen under different environments. *Journal of Agrometeorology*, 18(2): 201-205.

Keivanrad, S., and Zandi, P., 2012. Effect of nitrogen levels on growth, yield and oil quality of Indian mustard grown under different plant densities. *Thai Journal of Agricultural Science*, 45(2): 105-113.

Kumar, M., Singh, P. K., Yadav, K. G., Chaurasiya, A., and Yadav, A., 2017. Effect of nitrogen and sulphur nutrition on growth and yield of Indian mustard (*Brassica juncea* L.) in western UP. *Journal of Pharmacognosy and Phytochemistry*, 6(6S): 445-448.

Mukherjee, D., 2013. Nutrient use efficiency for maximization of crop productivity. Advances in plant physiology-An international treatise series. Scientific Publishers, Jodhpur, India, 14: 173-209.

Rimi, T. A., Islam, M. M., Siddik, M. A., Islam, S., Shovon, S. C., and Parvin, S., 2015. Response of seed yield contributing characters and seed quality of rapeseed (Brassica campestris L.) to nitrogen and zinc. *International Journal of Scientific and Research Publications*, 5(11): 187-193.

Saha, D., Rahman, M. M., Hossain, M. A., Prodhan, A. K. M. A., Das, A. C., Saha, M., and Hasan, M. M 2021. Yield Performance of mustard using different concentrations of gibberellic acid (GA3). *American Journal of Agricultural Science, Engineering, and Technology*, 5(2): 488–495. https://doi.org/10.54536/ajaset.v5i2.159

Sezer, İ., Akay, H., Mut, Z., Arslan, H., Öztürk, E., Erbaş Köse, Ö. D., Kiremit, M. S. 2021. Effects of different water table depth and salinity levels on quality traits of bread wheat. *Agriculture*, 11(10): 969.

Sharif, M. A. R., Haque, M. Z., Howlader, M. H. K., Hossain, M. J., 2016 a, b. Effect of sowing time on growth and yield attributes of three mustard cultivars grown in Tidal Floodplain of Bangladesh. *Journal of the Bangladesh Agricultural University*, (2): 155–160.

Sharif, R.H., Paul, R.K.K., Bhattacharja, D.K., and Ahmed, K.U., 2017. Physicochemical chemistry of oil seeds from selected mustard genotypes. *Journal of Bangladesh Agricultural University*, 15(1): 27-40.

USDA., 2022. World Agriculture Production, Circular Series of Foreign Agriculture Service, USDA.

Yadav, S.N., Singh, S.K. Kumar, O. 2016. Effect of boron on yield attributes, seed yield andoil content of mustard (Brassica juncea L.) on an Inceptisol. *Journal of the Indian Society of Soil Science*, 64:291-296. https://doi.org/10.5958/0974-0228.2016.00041.4

Yesmin M.S., Sikder M.S.I., Hossain M.S., Hasan M.M., Howlader, N.C., 2023. Effect of organic seed priming on yield and yield attributing traits of chickpea (*Cicer arietinum* L.) in drought prone area. *Agriculture Extension in Developing Countries*, 1(1): 38-42. DOI: http://doi.org/10.26480/aedc.01.2023.38.42

Yuan, L., Chan, X., Jai, J., Chan, H., Shi, Y., Ma, j., and Lu, C., 2021. Stover mulching and inhibitor application maintain crop yield and decrease fertilizer N input and losses in no-till cropping systems in northeast China. *Agriculture, Ecosystem and Environment*, 312: 107360.

Zhang, Z., Wu, X., Tu, C., Huang, X., Zhang, J., Fang, H., and Lin, C., 2020. Relationships between soil properties and the accumulation of heavy metals in different *Brassica campestris* L. growth stages in a Karst mountainous area. *Ecotoxicology and Environmental Safety*, 206: 111150.