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Response of different mustard varieties to humic acid

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ABSTRACT

The experiment was conducted in the Research Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 from October 2017 to February 2018 to study effects of variety and humic acid on morpho-physiological parameters and yield of mustard. The experiment comprised of two factors; Factor A: Different mustard varieties (4 varieties)- i) V_1: BARI Sarisha 9, ii) V_2: BARI Sarisha 11, iii) V_3: BARI Sarisha 14, iv) V_4: BARI Sarisha 15; and Factors B: Different levels of humic acid (H) (4 levels)- i) H_0: 0 kg fertilizer (control condition), ii) H_1: Recommended dose of organic + inorganic fertilizer, iii) H_2: 12 kg HA ha^{-1}, iv) H_3: Recommended dose of organic + inorganic fertilizer + 12 kg HA ha^{-1}. Due to the interaction effect of varieties and humic acid, the tallest plants 55.64, 103.32, 122.42 and 139.39 cm were recorded V_2H_3, BARI Sarisha 11 and Recommended dose of organic + inorganic fertilizer + 12 kg HA ha^{-1}, while the shortest plant 27.40, 67.66, 68.56 and 77.81 cm from V_3H_0 treatment combination, BARI Sarisha 14 and 0 kg fertilizer (control condition) at 30, 40, 50 DAS and harvest, respectively. The highest number of siliqua $plant^{-1}$ (163.27) was recorded from V_2H_3, while the lowest (72.27) was from V_4H_0 treatment combination. The highest seed yield (2.85 t ha^{-1}) was recorded from V_2H_3 and the lowest (1.03 t ha^{-1}) from V_1H_0 treatment combination. BARI Sarisha 11 and recommended dose of organic + inorganic fertilizer + 12 kg HA ha^{-1} gave the highest yield by improving morpho-physiological traits and yield contributing characters of mustard under the climatic and edaphic condition of SAU.

***Key Words**: Organic compounds, Growth, Development and Production.*

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I. Introduction

Mustard belongs to the genus *Brassica* under the family Brassicaceae and is the most critical oilseed crop worldwide after soyabean and groundnut, including Bangladesh (FAO, 2004). In the past year,

824,000 tonnes were produced, this year, it was 11,52,000 tonnes. Production has increased by 40 percent in one year[1]. *Brassica napus, B. campestris* and *B. juncea* are the three species of mustard that produce edible oil. It is one of the most important oil crops in the world after soybean and groundnut (FAO, 2012). It is not only a high energy food but also a carrier of fat soluble vitamins like A, D, E and K. In Bangladesh context, mustard is a popular edible oil and is considered important for improving the taste of a number of food items (Aziz et al., 2011). It is used as a condiment, salad, fodder crop, and its leaf and stem are used as vegetable in various mustard growing countries. Mustard oil also serves as an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc. The villagers also use its oil for hair dressing and body massage before bath (Aziz et al., 2011). In Bangladesh, the total production of mustard was 0.534 million metric ton from 0.495 million hectares of land (AIS, 2017). Bangladesh has been facing an acute shortage of edible oil for the last several decades and needs to import a huge amount of oil and oilseeds. Our internal production can meet only about 21% of our consumption, and the remaining 79% is needed to import (Begum et al., 2012). A huge amount of foreign exchange involving over 160 million US$ is being spent every year for importing edible oils due to insufficient oil production in Bangladesh (Rahman, 2002). The major mustard growing districts are Comilla, Tangail, Jessore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur and Dhaka (BBS, 2016).

High yield potential of a variety is the prerequisite for increasing crop production. In recent years, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed several high yielding varieties of mustard with yield potential of up to 2.5 t ha^{-1} (Sharif et al., 2016). Yield contributing characters and yield of different varieties varied significantly for different BARI developed mustard varieties (BARI, 2001; Mamun et al., 2014) and the yield of mustard will be increased by cultivating high yielding varieties. Therefore, it is necessary to identify a suitable mustard variety to get a better seed yield under the climatic and edaphic conditions of Sher-e-Bangla Agricultural University (SAU).

The role of humic acid is well known for improving soil health and nutrient uptake by plants, mineral availability etc. (Mauromicale et al., 2011). Enhanced nutrient uptake by plants due to humic acid application is also well established (Day et al., 2000; Mackowiak et al., 2001; Sharif et al., 2004). Likewise, the increased yield attributes and yield is also observed in *brassica* due to the application of humic acid in different amount (Peng et al., 2001; Vetayasuporn, 2006). However, a minimal study has been conducted to examine the effects of humic acid on morpho-physiological parameters and yield of mustard. Now it is also necessary to find the interaction effect between variety and humic acid on morpho-physiological parameters and yield of mustard. With this background and situation, the present study was conducted to fulfill the following objectives: To investigate the interaction effects between variety and humic acid on changes in morpho-physiological parameters and yield of mustard under the climatic and edaphic conditions of SAU.

II. Materials and Methods

Study area

The present study was conducted in the Experimental Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28). Experimental area is situated in the sub-tropical climate zone, characterized by heavy rainfall from April to September and scanty rainfall during the rest of the year.

Treatment of the experiment

The experiment comprised of two factors, Factor A: Different mustard varieties (V): 4 varieties V_1: BARI Sarisha 9 under Brassica campestris, V_2: BARI Sarisha 11 under Brassica juncea, V_3: BARI Sarisha 14 under Brassica campestris, V_4: BARI Sarisha 15 under *Brassica campestris*; Factors B: Different levels of humic acid (HA): 4 levels, H_0: 0 kg fertilizer (control condition), H_1: Recommended dose of organic and inorganic fertilizer, H_2: 12 kg HA ha^{-1}. There were in total 16 (4×4) treatment combinations as V_1H_0, V_1H_1, V_1H_2, V_1H_3, V_2H_0, V_2H_1, V_2H_2, V_2H_3, V_3H_0, V_3H_1, V_3H_2, V_3H_3 V_4H_0, V_4H_1, V_4H_2 and V_4H_3.

[1] https://www.newagebd.net/article/200588/mustard-production-up-by-tk-3000-crore-worth-in-a-year-ministry

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Experimental design
The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three equal blocks. Each block contained 16 plots where 16 treatments combination were allotted at random. There were 48 unit plots altogether in the experiment.

Seed collection
BARI Sarisha 9, BARI Sarisha 11, BARI Sarisha 14 and BARI Sarisha 15 were used as planting materials in this experiment. Both are a high yielding mustard and developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The seeds were collected from the BARI, Joydebpur, Gazipur.

Collection and application of humic acid
Humic acid was collected from local market and applied as per treatments of the experiment and 50% as basal dose and 50% at 30 days after sowing (DAS) as broadcast.

Land preparation
The experimental plot was opened on 20 October 2017, with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed three times, followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. Finally land was prepared on 4 November 2017. Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses (BARI, 2014) and as per treatment of the experiment.

Seed sowing
The seeds of mustard variety were sown on 4 November, 2017 in rows in the furrows having a depth of 2-3 cm.

Intercultural operations Intercultural operations
Different intercultural operations such as thinning, irrigation and weeding, protection against insect and pest were done as needed.

Harvest and post-harvest operations
Harvesting was done when 90% of the siliqua became brown in color, which was estimated by eye observation**.** The matured plant was harvested manually.

Data collection and analysis
Five plants from each treatment and each replication were randomly selected and marked with sample card. The following data were recorded Plant height (cm), Number of branches plant^{-1}, Number of leaves plant^{-1}, SPAD value, Days to 1st flowering, Days to harvest, Number of siliqua plant^{-1}, Length of siliqua (cm), Number of seeds siliqua^{-1} ,Weight of 1000 seeds (g), Seed yield hectare^{-1} (t), Stover yield hectare^{-1} (t) and Biological yield hectare^{-1} (t). The data obtained for different parameters were statistically analyzed the morphology and yield of Mustard as influenced by varieties and humic acid. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

III. Results and Discussion

Plant height
Interaction effect of varieties and humic acid varied significantly on plant height of mustard at 30, 40, 50 DAS and harvest (Table 01). The tallest plant (55.64, 103.32, 122.42 and 139.39 cm, respectively) was recorded from the treatment combination of V_2H_3 (BARI Sarisha 11 and Recommended dose of organic + inorganic fertilizer + 12 kg HA ha^{-1}), while the shortest plant (27.40, 67.66, 68.56 and 77.81 cm, respectively) from V_3H_0 (BARI Sarisha 14 and 0 kg fertilizer i.e. control condition) at 30, 40, 50 DAS and at harvest. These results are reported by Mamun et al. (2014) and Rajpar et al. (2011).

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Altogether it suggests that interaction with variety and humic acid (HA) showed a positive effect on elongating the length of plant height of mustard from early to harvest.

Number of branches plant^{-1}

Number of branches plant^{-1} of mustard at 30, 40, 50 DAS and harvest showed significant differences due to the interaction effect of varieties and humic acid (Table 01). The maximum number of branches plant^{-1} (3.33, 5.47, 7.20 and 8.33, respectively) was found from the treatment combination of V_3H_3 and the minimum number (2.73, 3.73, 4.00 and 4.07, respectively) was observed from V_1H_0 at 30, 40, 50 DAS and at harvest. Barman et al. (2016) find out the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety significantly affected number of branches plant^{-1} and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

Table 01. Interaction effect of different varieties and humic acid on plant height and number of branches plant^{-1} at different days after sowing (DAS) and harvest of mustard

Treatments	Plant height (cm) at				Number of branches plant^{-1}			
	30 DAS	40 DAS	50 DAS	Harvest	30 DAS	40 DAS	50 DAS	Harvest
V_1H_0	30.34 f-i	65.11 g	72.26 ef	91.27 d	2.73 f	3.73 f	4.00 g	4.07 g
V_1H_1	33.63d-f	73.23d-f	81.96 cd	91.80 d	3.00 de	4.67 de	5.13 ef	5.40 ef
V_1H_2	32.41e-h	70.92d-g	82.00 cd	91.73 d	2.87 ef	4.60 de	4.93 f	5.13 f
V_1H_3	35.82 de	74.56c-e	89.25 bc	92.33 d	3.00 de	4.87 cd	5.20 ef	5.47 ef
V_2H_0	42.59 c	87.66 b	96.43 b	107.67 c	3.00 de	4.27 e	5.47 e	5.67 e
V_2H_1	53.72 ab	101.01 a	119.00 a	135.37ab	3.07 cd	4.87 cd	6.00 d	6.27 d
V_2H_2	50.81 b	98.59 a	114.77 a	130.35 b	3.00 de	4.87 cd	6.00 d	6.33 d
V_2H_3	55.64 a	103.32 a	122.42 a	139.39 a	3.13 b-d	4.93 b-d	6.13 cd	6.47 d
V_3H_0	27.40 i	67.66 fg	68.56 f	77.81 e	3.20 a-c	5.20 a-c	6.47 bc	7.20 c
V_3H_1	28.54ghi	67.41 fg	78.00 de	86.93 d	3.20 a-c	5.40 ab	7.07 a	8.33 a
V_3H_2	27.76 hi	66.84 fg	76.92 de	86.10 d	3.20 a-c	5.27 a-c	7.07 a	8.07 ab
V_3H_3	30.85 f-i	68.45e-g	78.85 de	88.64 d	3.33 a	5.47 a	7.20 a	8.33 a
V_4H_0	30.46 f-i	71.19d-g	80.92c-e	92.13 d	3.07 cd	5.27 a-c	6.80 ab	7.60 bc
V_4H_1	37.67 d	80.14 c	88.19 bc	100.71 c	3.33 a	5.53 a	7.07 a	8.00 ab
V_4H_2	32.60e-g	74.44c-e	81.27 cd	91.12 d	3.13 b-d	5.27 a-c	6.80 ab	7.60 bc
V_4H_3	34.97d-f	76.54 cd	87.92 bc	103.27 c	3.27 ab	5.33 a-c	7.07 a	8.20 a
$LSD_{(0.05)}$	4.206	5.732	5.732	7.674	0.149	0.435	0.412	0.463
Level of significance	*	*	*	**	*	*	*	*
CV (%)	6.90	4.41	4.41	4.58	4.85	5.24	4.01	4.10

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. V1: BARI Sarisha 9; V2: BARI Sarisha 11; V3: BARI Sarisha 14 and V4: BARI Sarisha 15 .H0: 0 kg fertilizer (control condition), H1: Recommended dose of organic and inorganic fertilizer, H2: 12 kg HA ha-1 and H3: Recommended dose of organic and inorganic fertilizer also used 12 kg HA ha-1. * = Significant at 5% level and ** = Significant at 1% level

Number of leaves plant^{-1}

Interaction effect of varieties and humic acid showed significant differences on number of leaves plant^{-1} of mustard at 30, 40, 50 DAS and at harvest (Table 02). The maximum number of leaves plant^{-1} (15.37, 28.20, 42.33 and 50.40, respectively) was recorded from the treatment combination of V_2H_3, while the minimum number (10.27, 18.73, 27.40 and 30.60, respectively) was found from V_1H_0 at 30, 40, 50 DAS and at harvest.Various studies have been conducted to evaluate HA effects on leaf chlorophyll content by the production of plant growth-promoting hormones such as auxin and cytokinin and metabolic enzymes (Rose et al., 2014; Olaetxea et al., 2020). The improved uptake of macro and micronutrients following HA application increases the leaf chlorophyll concentration, positively affecting shoot growth (Chen et al., 2004; Fan et al., 2014; Sible et al., 2021). As a result number of leaves per plant increases.

SPAD value

Interaction effect of varieties and humic acid varied significantly on SPAD value of mustard at 30, 40, 50 DAS and at harvest (Table 02). The highest SPAD value (34.21, 43.00, 52.55 and 47.77,

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respectively) was recorded from the treatment combination of V_2H_3, while the lowest (30.13, 34.37, 40.22 and 34.56, respectively) from V_1H_0 at 30, 40, 50 DAS and at harvest. Various studies have evaluated HA effects on leaf chlorophyll content by producing plant growth-promoting hormones such as auxin and cytokinin and metabolic enzymes (Rose et al., 2014; Olaetxea et al., 2020). The improved uptake of macro and micronutrients following HA application increases the leaf chlorophyll concentration, positively affecting shoot growth (Chen et al., 2004; Fan et al., 2014; Sible et al., 2021).

Table 02. Interaction effect of different varieties and humic acid on number of leaves plant^{-1} and SPAD value at different days after sowing (DAS) and harvest of mustard

Treatments	Number of leaves plant^{-1} at				SPAD value at			
	30 DAS	40 DAS	50 DAS	Harvest	30 DAS	40 DAS	50 DAS	Harvest
V_1H_0	10.27 i	18.73 e	27.40 e	30.60 g	30.13 h	34.37 h	40.22 e	34.56 j
V_1H_1	10.80 hi	21.07 d	32.93 d	37.00 f	30.96f-h	35.60 gh	43.59 d	37.43 i
V_1H_2	10.73 hi	20.80 d	33.27 d	37.40 f	30.77 gh	35.44 gh	43.48 d	37.76 i
V_1H_3	11.33 gh	21.67 cd	33.93 d	38.20 ef	31.56e-g	36.46 fg	44.26 d	38.31 hi
V_2H_0	12.60 ef	23.67 b	33.40 d	39.20 ef	31.78d-g	37.10 ef	45.09 cd	39.96f-h
V_2H_1	14.73 ab	27.67 a	41.40 a	50.00 a	34.50 a	42.08 ab	51.84 a	46.99 ab
V_2H_2	14.27 bc	27.27 a	41.47 a	48.00 ab	33.87 ab	41.61 b	51.07 a	45.56 bc
V_2H_3	15.37 a	28.20 a	42.33 a	50.40 a	34.21 a	43.00 a	52.55 a	47.77 a
V_3H_0	12.93d-f	22.40b-d	33.73 d	37.80 ef	32.27c-e	37.08 ef	45.10 cd	39.11 g-i
V_3H_1	13.13d-f	23.27 bc	37.80 bc	46.13 bc	32.55c-e	38.31c-e	48.52 b	44.64 cd
V_3H_2	13.00d-f	23.13 bc	37.27 bc	43.80 cd	32.46c-e	37.97c-e	48.31 b	43.44 cd
V_3H_3	13.67 cd	23.87 b	38.60 b	45.53 bc	33.46a-c	38.98 cd	48.95 b	44.65 cd
V_4H_0	12.20 fg	22.80 bc	35.33 cd	39.53 ef	31.54e-g	37.56d-f	46.81 bc	40.82 fg
V_4H_1	13.73 cd	24.13 b	37.93 b	43.40 cd	33.35a-c	39.38 c	48.49 b	43.13 de
V_4H_2	12.53 ef	23.07 bc	37.20 bc	41.00 de	32.02d-f	37.95c-e	47.04 bc	41.26 ef
V_4H_3	13.27 de	23.40 bc	38.00 b	45.41 bc	32.85b-d	38.38c-e	28.61 b	44.17 cd
$LSD_{(0.05)}$	0.881	1.565	2.325	2.942	1.104	1.294	1.912	1.957
Level of significance	*	*	*	*	*	**	**	**
CV (%)	4.13	4.00	3.83	4.19	5.34	4.26	4.23	5.37

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. V_1: BARI Sarisha 9; V_2: BARI Sarisha 11; V_3: BARI Sarisha 14 and V_4: BARI Sarisha 15. H_0: 0 kg fertilizer (control condition), H_1: Recommended dose of organic and inorganic fertilizer, H_2: 12 kg HA ha^{-1} and H_3: Recommended dose of organic and inorganic fertilizer also used 12 kg HA ha^{-1}. * = Significant at 5% level and ** = Significant at 1% level

Days to 1st flowering

Interaction effect of varieties and humic acid showed significant differences on days to 1st flowering (Table 03). The highest days to 1st flowering (39.00) was found from the treatment combination of V_2H_3, while the lowest days (26.00) was observed from V_3H_1. Karim et al. (2000) stated that mustard varieties showed significant influence in terms of days to flowering. Barman et al. (2016) find out the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety had significant effect on days to 1st flowering and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

Days to harvest

Interaction effect of varieties and humic acid showed significant differences on days to harvest (Table 03). The highest days to harvest (114.67) were recorded from the treatment combination of V_2H_2, while the lowest days (74.67) from V_4H_0.

Number of siliqua plant^{-1}

Interaction effect of varieties and humic acid showed significant differences in number of siliqua plant^{-1} (Table 03). The highest number of siliqua plant^{-1} (163.27) was recorded from the treatment combination of V_2H_3, while the lowest (72.27) was found from V_4H_0. Barman et al. (2016) determine the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety significantly affected number of siliqua plant^{-1} and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

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Length of siliqua

Interaction effect of varieties and humic acid showed significant differences in length of siliqua (Table 03). The highest length of siliqua (7.69 cm) was recorded from the treatment combination of V_2H_3, while the lowest length (4.11 cm) was found from V_3H_0. Barman et al. (2016) find out the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety significantly affected siliqua length (cm) and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

Table 03. Interaction effect of different varieties and humic acid on different yield contributing characteristics of mustard

Treatments	Days to 1st flowering	Days to harvest	Number of siliqua plant^{-1}	Length of siliqua (cm)
V_1H_0	35.00 a-c	89.00 c	79.53 ef	3.52 d
V_1H_1	30.67 c-e	82.67 c-e	98.13 d	5.47 b
V_1H_2	36.67 ab	89.33 c	96.13 d	5.23 b
V_1H_3	30.67 c-e	81.00 d-f	103.13 d	5.44 b
V_2H_0	36.67 ab	101.00 b	122.40 c	4.87 bc
V_2H_1	39.00 a	113.00 a	157.93 ab	7.48 a
V_2H_2	33.33 a-d	114.67 a	153.27 b	7.33 a
V_2H_3	39.00 a	106.00 b	163.27 a	7.69 a
V_3H_0	36.67 ab	81.67 d-f	100.00 d	4.11 cd
V_3H_1	26.00 e	75.67 ef	96.60 d	5.92 b
V_3H_2	34.33 a-c	80.67 d-f	94.67 d	5.57 b
V_3H_3	27.00 e	83.33 cd	98.87 d	5.56 b
V_4H_0	36.00 a-c	74.67 f	72.27 f	5.34 b
V_4H_1	31.33 b-e	101.33 b	84.00 e	5.29 b
V_4H_2	33.33 a-d	76.33 d-f	74.87 ef	4.95 bc
V_4H_3	28.33 de	83.33 cd	82.73 e	5.96 b
$LSD_{(0.05)}$	5.041	6.607	9.113	0.933
Level of significance	**	**	**	**
CV(%)	9.06	4.42	5.21	9.98

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. V_1: BARI Sarisha 9; V_2: BARI Sarisha 11; V_3: BARI Sarisha 14 and V_4: BARI Sarisha 15. H_0: 0 kg fertilizer (control condition), H_1: Recommended dose of organic and inorganic fertilizer, H_2: 12 kg HA ha^{-1} and H_3: Recommended dose of organic and inorganic fertilizer also used 12 kg HA ha^{-1}.* = Significant at 5% level and ** = Significant at 1% level

Number of seeds siliqua^{-1}

The interaction effect of varieties and humic acid showed significant differences in the number of seeds siliqua^{-1} (Figure 01). The highest number of seeds siliqua^{-1} (27.00) was recorded from the treatment combination of V_3H_3, while the lowest number (13.67) was found from V_2H_0. Barman et al. (2016) find out the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety had significant effect on number of seeds siliqua^{-1} and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

Weight of 1000 seeds

Interaction effect of varieties and humic acid showed significant differences on weight of 1000 seeds (Table 04). The highest weight of 1000 seeds (4.27 g) was recorded from the treatment combination of V_2H_1, while the lowest weight (2.61 g) was found from V_1H_0. Barman et al. (2016) find out the appropriate fertilizer dose and best variety on the yield and oil content of mustard. His results revealed that variety significantly affected 1000 seed weight(g) and the best result of the above characters was recorded in 100% recommended fertilizer dose in combination with best variety.

Seed yield hectare^{-1}

Interaction effect of varieties and humic acid showed significant differences on seed yield hectare^{-1} (Table 04). The highest seed yield (2.85 t ha^{-1}) was recorded from the treatment combination of V_2H_3 and the lowest seed yield (1.03 t ha^{-1}) was observed from V_1H_0. Lotfi et al. (2018) conducted an

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experiment to evaluate the effect of humic acid (HA) applications on the photosynthesis efficiency of rapeseed plants under different watering conditions. Results revealed that application of HA improved plants net photosynthesis under water stress via increasing the rate of gas exchange and electron transport flux in plants that, helps for attaining highest yield by producing better yield attributes. So humic acid application with the best variety was given the best result.

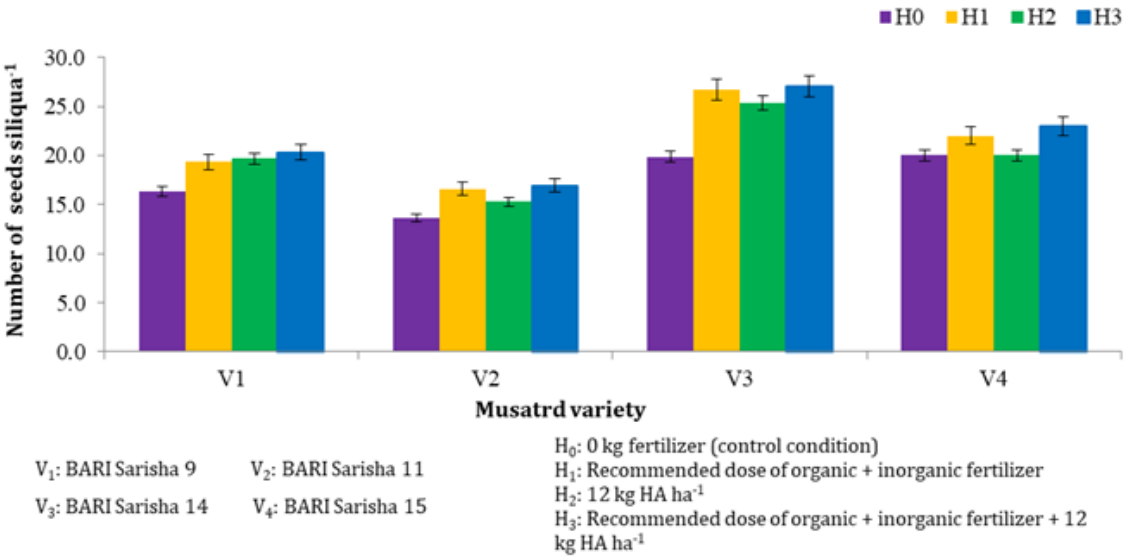

Figure 01. Interaction effect of different mustard variety and levels of humic acid on number of seeds siliqua^{-1} of mustard. (Vertical bars represent LSD value at 5% level of probability)

Stover yield hectare^{-1}

Interaction effect of varieties and humic acid showed significant differences in stover yield hectare^{-1} (Table 04). The highest stover yield (3.59 t ha^{-1}) was recorded from the treatment combination of V_2H_1, while the lowest stover yield (1.50 t ha^{-1}) was found from V_1H_0.

Table 04. Interaction effect of different varieties and humic acid on weight of 1000 seeds, seed and stover yield of mustard

Treatments	1000 seeds wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
V_1H_0	2.61 h	1.03 j	1.50 h
V_1H_1	3.04 fg	1.52 e-g	2.39 de
V_1H_2	2.92 g	1.27 hi	2.02 g
V_1H_3	3.28 ef	1.62 d-f	2.47 de
V_2H_0	3.44 e	1.62 d-f	2.38 de
V_2H_1	4.27 a	2.81 a	3.59 a
V_2H_2	4.04 a-c	2.52 b	3.16 b
V_2H_3	4.18 ab	2.85 a	3.58 a
V_3H_0	3.53 de	1.24 i	2.12 fg
V_3H_1	3.90 bc	1.73 d	2.85 c
V_3H_2	3.79 cd	1.44 f-h	2.48 de
V_3H_3	3.84 c	1.74 d	2.87 c
V_4H_0	3.32 ef	1.39 g-i	2.40 de
V_4H_1	3.52 de	1.68 de	2.60 d
V_4H_2	3.39 e	1.53 e-g	2.34 ef
V_4H_3	3.51 de	1.95 c	2.97 bc
$LSD_{(0.05)}$	0.279	0.175	0.224
Level of significance	*	**	**
CV(%)	4.76	6.07	5.15

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. V_1: BARI Sarisha 9; V_2: BARI Sarisha 11; V_3: BARI Sarisha 14 and V_4: BARI Sarisha 15. H_0: 0 kg fertilizer (control condition), H_1: Recommended dose of organic and inorganic fertilizer, H_2: 12 kg HA ha^{-1} and H_3: Recommended dose of organic and inorganic fertilizer also used 12 kg HA ha^{-1}.* = Significant at 5% level and ** = Significant at 1% level

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Biological yield hectare^{-1}

Interaction effect of varieties and humic acid showed significant differences on biological yield hectare^{-1} (Figure 02). The highest biological yield (6.43 t ha^{-1}) was recorded from the treatment combination of V_2H_3, while the lowest biological yield (2.53 t ha^{-1}) was found from V_1H_0.

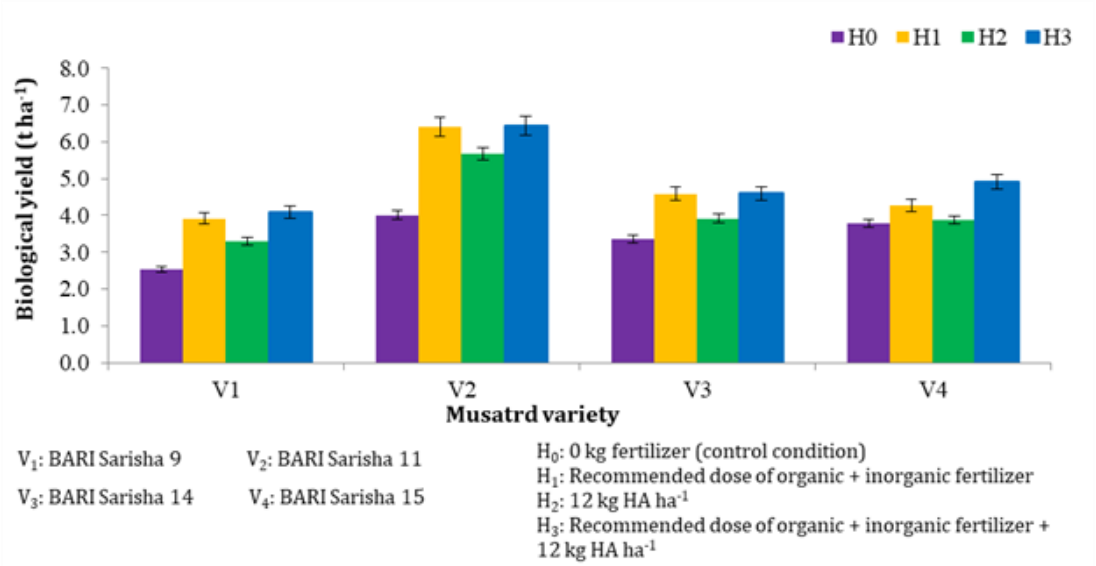

Figure 02. Interaction effect of different mustard variety and levels of humic acid on biological yield mustard (Vertical bars represent LSD value at 5% level of probability)

IV. Conclusion

Based on the aforementioned results, it can be inferred that the utilization of BARI Sarisha 11 in conjunction with the recommended dosage of organic and inorganic fertilizers, as well as 12 kg HA ha-1, led to a noteworthy enhancement in the growth and yield of mustard. The utilization of BARI Sarisha 11 and the application of a recommended dose of organic and inorganic fertilizer, along with 12 kg HA ha-1, resulted in the most rapid expansion and highest yield of mustard. Humic acids play a crucial role in facilitating the transfer of nutrients from the soil to the plant by effectively retaining ionized nutrients and preventing their leakage. Using cow dung as a fertilizer for plants is a beneficial practice due to its high-quality organic matter content, which aids in enhancing soil aeration and mitigating soil compaction.

V. References

[1]. AIS (Agricultural Information Service). (2017). Krishi Diary (In Bangla). Agril. Inform. Ser. Khamarbari, Farmgate, Dhaka, Bangladesh. p.16.

[2]. Aziz, M. A., Chakma, R., Ahmed, M., Rahman, A. K. M. M. and Roy, K. (2011). Effect of sowing dates on the growth, development and yield of mustard in the hilly areas. Journal of Experimental Biology, 2(1), 33-36.

[3]. BARI (Bangladesh Agricultural Research Institute). (2001). Annual Report 2000-2001. Oilseed Research Centre. Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. p. 115-118.

[4]. BARI (Bangladesh Agricultural Research Institute). (2014). Krishi Projucti, Handbook of Agro-technology. 3rd Edn. 2013-2014. Oilseed Research Centre. Bangladesh Agriculture Research Institute, Joydebpur, Gazipur.

[5]. Barman, K. K., Mahmud, S., Salim, M. and Chowdhury, B. L. D. (2016). Yield attributes and oil content of different mustard (*Brassica campestris* l.) varieties effected by different levels of fertilizers. Asian Journal of Medical and Biological Research, 2(1), 143-147. https://doi.org/10.3329/ajmbr.v2i1.27580

[6]. BBS (Bangladesh Bureau of Statistics). (2016). Monthly Statistical Bulletin. (August). Stat. Div., Minis. Planning, Govt. Peoples Repub. Bangladesh, Dhaka.

[7]. Begum F., Hossain F. and Mondal M. R. I. (2012). Influence of Sulphur on morpho-physiological and yield parameters of rapeseed. Bangladesh Journal of Agricultural Research, 37(4), 645-652. https://doi.org/10.3329/bjar.v37i4.14389

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[8]. Chen, Y., Magen, H. and Clapp, C. E. (2004). Mechanisms of plant growth stimulation by humic substances: The role of organo-iron complexes. Soil Science and Plant Nutrition, 50, 1089–1095. https://doi.org/10.1080/00380768.2004.10408579

[9]. Day, K. S., Thornton, R., Kreeft, H., Ghabbour, E. A. and Davies, G. (2000). Humic acid products for improved phosphorus fertilizer management. Humic substances, versatile components of plants, soil and water. Proceedings of the Fourth Humic Substances Seminar held at Northeastern University, Boston, Massachusetts, USA, on 22-24 March. pp. 321-325. https://doi.org/10.1016/B978-1-85573-807-2.50030-8

[10]. Fan, H., mei, Wang, X., wen, Sun, X., Li, Y., ying, Sun, X., zhi and Zheng, C., shu (2014). Effects of humic acid derived from sediments on growth, photosynthesis and chloroplast ultrastructure in chrysanthemum. Scientia Horticulturae, 177, 118–123. https://doi.org/10.1016/j.scienta.2014.05.010

[11]. FAO (Food and Agriculture Organization). (2004). FAO Production Year Book. Food and Agriculture Organization of the United Nations, Rome 00100, Italy. 56: 118.

[12]. FAO (Food and Agriculture Organization). (2012). Production Year Book. Food and Agriculture Organization of the United Nations, Rome. Italy.

[13]. Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. 2nd Ed. A. John Wiley Intersci. Pub. p. 130-240. https://www.newagebd.net/article/200588/mustard-production-up-by-tk-3000-crore-worth-in-a-year-ministry

[14]. Karim, M. R., Islam, F., Ahmed, F. and Islam, M. R. (2000). Performance of some *B. juncea* varieties under on-farm condition at Pabna. Bangladesh Journal of Extension Education, 27(1), 157-158.

[15]. Lotfi, R., Kalaji, H. M., Valizadeh, G. R., Khalilvand B. E., Hemati A., Gharavi-Kochebagh, P. and Ghassemi, A. (2018). Effects of humic acid on photosynthetic efficiency of rapeseed plants growing under different watering conditions. Photosynthetica, 56(3), 962-970. https://doi.org/10.1007/s11099-017-0745-9

[16]. Mackowiak, C., Grossl, P. and Bugbee, B. (2001). Beneficial effects of humic acid on micronutrient availability to wheat. Soil Science Society of America Journal, 65(6), 1744-1750. https://doi.org/10.2136/sssaj2001.1744

[17]. Mamun, F., Ali, M. H., Chowdhury, I. F., Hasanuzzaman, M. and Matin, M. A. (2014). Performance of Rapeseed and Mustard Varieties Grown Under Different Plant Density. Scientia Agriculturae, 8(2), 70-75.

[18]. Mauromicale, G., Angela, M.G.L. and Monaco, A.L. (2011). The effect of organic supplementation of solarized soil on the quality of tomato. Scientia Horticulturae Journal, 129(2), 189-196. https://doi.org/10.1016/j.scienta.2011.03.024

[19]. Olaetxea, M., Mora, V., Baigorri, R., Zamarreño, A. M. and García-Mina, J. M. (2020). The singular molecular conformation of humic acids in solution influences their ability to enhance root hydraulic conductivity and plant growth. Molecules, 26, 7–10. https://doi.org/10.3390/molecules26010003

[20]. Peng, Z. P., Shi-Chuan, X., Zhi-Mei, S., Ming-Xin, M. and Huixin, Z. (2001). A study of the effect of humic acid compound fertilizer on the quality and physiological index of Brassica. Journal of Agricultural University of Hebei, 24(1), 24-27.

[21]. Rahman, M. M. (2002). Status of oil seeds and future prospects in Bangladesh, Paper Presented in Review Workshop on the Impact of Technology Transfer on Oil Crops, held at BARI on 29 April 2002.

[22]. Rajpar, M. B., Bhatti, Z. H., Shah, A. N. and Tunio, S. D. (2011). Humic acid improves growth, yield and oil content of *Brassica compestris* L. Pakistan Journal of Agriculture, Agricultural Engineering & Veterinary Sciences, 27(2), 125-133.

[23]. Rose, M. T., Patti, A. F., Little, K. R., Brown, A. L., Jackson, W. R. and Cavagnaro, T. R. (2014). A meta-analysis and review of plant-growth response to humic substances: Practical implications for agriculture. Advance Agronomy, 124, 37–89. https://doi.org/10.1016/B978-0-12-800138-7.00002-4

[24]. Sharif, M. A., Ahmad, M. S. and Khattak. R. A. (2004). Effect of organic and inorganic fertilizers on the yield and yield components of maize. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences, 20(1), 11-16.

[25]. Sharif, M. A. R., Haque, M. Z., Howlader, M. H. K. and Hossain, M. J. (2016). Effect of sowing time on growth and yield attributes of three mustard cultivars grown in Tidal Floodplain of

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Bangladesh. Journal of the Bangladesh Agricultural University, 14(2), 155–160. https://doi.org/10.3329/jbau.v14i2.32689

[26]. Sible, C. N., Seebauer, J. R. and Below, F. E. (2021). Plant biostimulants: a categorical review, their implications for row crop production, and relation to soil health indicators. Agronomy, 11, 1297. https://doi.org/10.3390/agronomy11071297

[27]. Vetayasuporn, S. (2006). Effects of biological and chemical fertilizers on growth and yield of glutinous corn production. Agronomy Journal, 5(1), 1-4. https://doi.org/10.3923/ja.2006.1.4

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