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WEED MANAGEMENT THROUGH ALLELOPATHIC INTERACTION OF BANGLADESHI MUSTARD VARIETIES

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ABSTRACT

The effect of weed management through allelopathic interaction of Bangladeshi mustard varieties was studied through experiments conducted in the agronomy field and laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, in the Rabi season from October 2019 to February 2020. The experimental design in the laboratory bioassay was a completely randomized design (CRD) with three replications. The field experiment consisted of two factors which were factor A: mustard varieties (5) *viz,* Rai-5, BARI Sarisha-7, BARI Sarisha-8, BARI Sarisha-15, BARI Sarisha-18 (canola), and factor B: Weed management (3) *viz*, no weeding, one hand weeding at 15 DAS, and two hand weeding at 15 and 30 DAS. The field experiment was conducted utilizing a split-plot design with three replications, recording data on various parameters to evaluate its outcomes. The lab experiment revealed that among different mustard varieties, Rai-5, BARI Sarisha-7, BARI Sarisha-8, and BARI Sarisha-18 varieties performed well and showed potential allelopathic effects for reducing germination percentage and seedling growth of model plants (*Lactuca sativa* and *Raphanus sativus*) and weed (*Echinochloa colona*). *Cynodon dactylon*, *Cyperus rotundus*, and *E. colona* weed species were dominant in the mustard field. However, among different mustard varieties, BARI Sarisha-18 (canola) with 2 weeding recorded the maximum number of seeds siliqua^{-1} (26), and seed yield (1.85 t ha^{-1}). This suggests that varieties with both high allelopathic interaction and great competitive ability would be most useful to help farmers maximize yield and control weeds.

Keywords: Mustard, Bioassay, Allelopathy, Weed Management and Yield.

INTRODUCTION

Weed management is a critical component of agricultural practices, especially in regions like Bangladesh, where diverse cropping systems are prevalent. Weeds compete with crops for essential resources such as nutrients, water, and light, reducing crop yields and increasing economic losses (Kaur *et al*., 2018). Traditional weed management strategies often rely heavily on chemical herbicides, which, although practical, can lead to environmental pollution, development of herbicide-resistant weed species, and adverse effects on non-target organisms (Ofosu *et al*., 2023). Herbicides make up 47% and 25% of all pesticides used in the US and globally, respectively, and are vital to the management of weeds due to ease of use, effectiveness, and affordability (McErlich and Boydston, 2014). In this context, exploring alternative, sustainable weed management practices are vital. One promising approach is allelopathy, a biological phenomenon where plants release biochemicals (allelochemicals) into the environment that influence the growth and development of neighboring plants, including weeds (Masum *et al*., 2016).

Allelopathic interactions can potentially suppress weed growth, providing a natural, eco-friendly method of weed control. Many phytotoxic substances, suspected of causing germination and growth inhibition, have been identified in plant tissues and soils, which are termed allelochemicals

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(Saeedipour, 2010). It promotes sustainable agricultural practices by providing an environmentally friendly and sustainable substitute for chemical herbicides (Badesra *et al*., 2025).

Mustard (*Brassica* spp.) is a widely cultivated crop in Bangladesh. Bangladesh's mustard production increased by 3.35 lakh tonnes to 11.52 lakh tonnes, reaching Tk 3,000 crore if converted into oil, aiming to meet 40% of demand in three years (The Daily Star, 2023). Additionally, Alam (2020) stated that the demand for edible oil and oilseeds is rising due to population growth. Edible oils are essential for human nutrition, providing calories and aiding in fat-soluble vitamin digestion, with a recommended daily intake of 6g for a 2700 Kcal diet (Albahrani and Greaves, 2016; Miah and Mondal, 2017). Besides, mustard possesses allelopathic properties that can inhibit the growth and germination of various weed species. By harnessing these natural interactions, integrated weed management strategies that reduce reliance on synthetic herbicides and promote sustainable agriculture may be possible (Masum *et al*., 2019).

According to Singh *et al*. (2010), weeds in the mustard crop cause an approximate 20-30 percent yield reduction. Therefore, investigating the allelopathic potential of Bangladeshi mustard varieties contributes to the broader field of agricultural science. It enhances the understanding of plant-plant interactions and the role of allelochemicals in agroecosystems. The findings from this research can be applied to other crops and regions, potentially benefiting global agriculture. Consequently, the objective is to investigate how different mustard varieties interact with weeds through allelopathy and evaluate their effectiveness in reducing weed pressure. This research could contribute to developing environmentally friendly weed management practices that align with the goals of sustainable agriculture in Bangladesh.

MATERIALS AND METHODS

The experiment was conducted in the central laboratory and the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, located at 23° 77′ N latitude and 90° 33′ E longitude, at an altitude of 8.6 meters. In this experiment, a bioassay was done to screen out the allelopathic potential of 15 mustard varieties (donor crop), and *Lactuca sativa*, *Raphanus sativus,* as well as *Echinochloa colona* were used as receiver crops.

Donor-receiver bioassay

The screening method used a donor-receiver bioassay to select some possible allelopathic varieties. This experiment used a bioassay to screen out the allelopathic potential of 15 mustard varieties and how they influence weed biology, measured by standardized values of treated test crops over control treatment. Measuring parameters such as germination inhibition %, shoot inhibition %, root inhibition %, etc., were recorded to demonstrate the potential of mustard varieties. Mustard seeds were dried at 45-48°C for seven days to break the dormancy and then soaked in distilled water. After 24h of soaking, the seeds were sown on a sheet of moist filter paper at 25°C in the dark. After 48h, the seeds were transferred to a growth chamber with a 12h photoperiod. After another 48h, the uniformly germinated mustard seedlings were transferred (10 mustard seedlings per petri dish) to a 55mm petri dish, each containing a sheet of filter paper moistened with 2.5 mL, 1 mM phosphate (pH 7.0), and grown for a further 48h. Then, ten *E. colona*, *L. sativa*, and *R. sativus* seeds were sown on the filter paper in each petri dish and allowed to grow with the mustard seedlings under the above conditions. Each treatment was replicated three times, following CRD. After 48h, the germination percentage, germination speed rate, and relative germination percentage were calculated, and the length of the shoot and root of *L. sativa*, *R. sativus*, and *E. colona* were measured with a ruler. Control seedlings were incubated without mustard seedlings in the same way.

Field experiment

A field experiment was conducted after screening the potential allelopathic varieties from the lab experiment. The experiment utilized a split-plot design with three replications, with varieties in the main plot and weed management techniques in the subplot. There were 15 treatment combinations and 45-unit plots. The unit plot size was 5.4 m^{-2} (2.7 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively.

The collected data from both experiments were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of the computer package MSTATC. Duncan's Multiple Range Test (DMRT) adjusted the mean differences among the treatments at a 5% significance level.

RESULTS AND DISCUSSION

Laboratory Study (Donor-Receiver Bioassay)

Germination inhibition percentage

Experiment results showed that *L. sativa*, *R. sativus*, and *E. colona* recorded the maximum germination inhibition percentage (71.43, 57.14, and 100.00%, respectively) with the co-growth of the Rai-5 variety (Table 1).

Table 1. Effect of mustard varieties on the germination inhibition percentage of *L. sativa, R. sativus,* and *E. colona*

Treatments (Mustard varieties)	Germination inhibition (%)		
	L. sativa	***R. sativus***	***E. colona***
BARI Sarisha-7	42.86 ± 3.34 c	42.86 ± 3.56 b	66.67 ± 4.97 c
BARI Sarisha-8	28.57 ± 2.04 d	28.57 ± 2.04 c	50.00 ± 3.57 d
BARI Sarisha-13	14.29 ± 1.02 e	14.29 ± 1.02 d	33.33 ± 2.38 e
BARI Sarisha-18	57.14 ± 4.08 b	42.86 ± 3.06 b	83.33 ± 5.95 b
Tori-7	0.00 ± 00 f	0.00 ± 00 e	33.33 ± 2.38 e
Sonali (SS-75)	14.29 ± 1.02 e	0.00 ± 00 e	33.33 ± 2.38 e
Kallyani (TS-72)	28.57 ± 2.04 d	0.00 ± 00 e	16.67 ± 1.19 f
BARI Sarisha-6	28.57 ± 2.04 d	0.00 ± 00 e	16.67 ± 1.1 f
BARI Sarisha-9	28.57 ± 2.04 d	14.29 ± 1.02 d	16.67 ± 1.19 f
BARI Sarisha-12	0.00 ± 00 f	14.29 ± 1.02 d	16.67 ± 1.19 f
BARI Sarisha-14	14.29 ± 1.02 e	0.00 ± 00 e	33.33 ± 2.38 e
BARI Sarisha-15	0.00 ± 00 f	0.00 ± 00 e	0.00 ± 00 g
BARI Sarisha-17	14.29 ± 1.02 e	0.00 ± 00 e	33.33 ± 2.38 e
Rai-5	71.43 ± 5.10 a	57.14 ± 4.08 a	100.00 ± 7.14 a
BARI Sarisha-16	14.29 ± 1.02 e	0.00 ± 00 e	33.33 ± 2.38 e
LSD $_{(0.05)}$	0.94	0.47	0.76
CV (%)	4.85	4.04	2.46

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

With *R. sativus*, co-growth of BARI Sarisha-17 showed no germination inhibition properties, which was statistically similar to BARI Sarisha-14 and BARI Sarisha-17. *L. sativa* and *R. sativus* also recorded no germination inhibition with the co-growth of Tori-7. Besides, Sonali (SS-75), Kallyani (TS-72), BARI sarisha-6 varieties, and *R. sativus* recorded a germination inhibition of 0%. Rehman *et al*. (2019) reported that glucosinolates, allyl isothiocyanates, and brassinosteroids are among the strong allelochemicals produced by *Brassica* species that have a negative impact on the growth and development of their target species.

Shoot growth inhibition percentage

Our experiment results again showed that *L. sativa*, *R. sativus*, and *E. colona* recorded the greatest shoot growth inhibition percentage (62.26, 48.27, and 65.44%) with the co-growth of the Rai-5 variety, whereas *L. sativa* and *R. sativus* recorded the minimum shoot growth inhibition percentage (2.97 and 4.81%, sequentially) with the co-growth of the BARI Sarisha-15 variety (Table 2). Besides, *E. colona* showed the lowest shoot growth inhibition percentage (1.94%) with the Sonali (SS-75) co-growth, statistically similar to the BARI Sarisha-12 variety.

Table 2. Effect of mustard varieties on the shoot growth inhibition percentage and root growth inhibition percentage of *L. sativa, R. sativus,* and *E. colona*

Treatments (mustard varieties)	Shoot growth inhibition (%)			Root growth inhibition (%)		
	L. sativa	***R. sativus***	***E. colona***	***L. sativa***	***R. sativus***	***E. colona***
BARI Sarisha-7	59.84 ± 2.10 b	19.73 ± 0.66 g	57.77 ± 2.02 b	63.12 ± 1.85 b	58.21 ± 1.72 c	62.88 ± 1.87 b
BARI Sarisha-8	49.33 ± 1.69 c	20.93 ± 0.74 e	52.82 ± 1.88 c	49.80 ± 1.51 c	56.76 ± 1.71 d	56.20 ± 1.67 c
BARI Sarisha-13	45.01 ± 1.60 d	17.06 ± 0.61 h	20.39 ± 0.72 e	49.18 ± 1.49 c	41.03 ± 1.24 i	42.67 ± 1.29 e
BARI Sarisha-18	60.65 ± 2.16 b	40.26± 1.43 b	65.44 ± 2.34 a	63.93 ± 1.93 b	67.86 ± 2.05 b	63.91 ± 1.93 a
Tori-7	12.13 ± 0.43 j	12.93 ± 0.46 j	8.74 ± 0.31i	5.74 ± 0.17 k	18.21 ± 0.55 m	26.69 ± 0.81 h
Sonali (SS-75)	9.97 ± 0.35 l	17.33 ± 0.62 h	1.94 ±0.06 k	15.57 ± 0.47 j	8.97 ±0.27 n	20.11 ± 0.61 j
Kallyani (TS-72)	11.05 ± 0.39 k	10.81 ± 0.38 k	12.04 ± 0.42 g	31.76 ± 0.96 g	0.97 ±0.02 o	25.19 ± 0.77 i
BARI Sarisha-6	23.99 ± 0.85 h	26.79 ± 0.95 c	12.04 ± 0.42 g	34.02 ± 1.03 f	54.21 ± 1.64 f	30.45 ± 0.92 f
BARI Sarisha-9	37.20 ± 1.32 e	25.33 ± 0.91 d	19.81 ± 0.71 e	42.01 ± 1.27 e	52.75 ± 1.59 g	51.13 ± 1.54 d
BARI Sarisha-12	21.83 ± 0.77i	20.41 ± 0.73 f	2.33 ±0.08 k	46.72 ± 1.41 d	56.07 ± 1.69 e	24.81 ± 0.75 i
BARI Sarisha-14	31.81 ± 1.13 f	6.66 ±0.23 l	6.80 ±0.24 j	28.28 ± 0.85 i	20.06 ± 0.61 l	20.12 ± 0.61 j
BARI Sarisha-15	2.97 ± 0.11 m	4.81 ±0.17 m	24.27 ± 0.86 d	29.10 ± 0.88 i	31.52 ± 0.95 j	28.57 ± 0.86 g
BARI Sarisha-17	29.11 ± 1.03 g	15.21 ± 0.54 i	15.53 ± 0.55 f	30.33 ± 0.92 h	42.48 ± 1.28 h	15.04 ± 0.45 k
Rai-5	62.26 ± 2.22 a	48.27 ± 1.72 a	65.44 ± 2.33 a	69.67 ± 2.11 a	69.31 ± 2.11 a	64.27 ± 1.94 a
BARI Sarisha-16	36.66 ± 1.31 e	26.53 ± 0.94 c	11.07 ± 0.39 h	28.28 ± 0.85 i	30.55 ± 0.92 k	43.05 ± 1.31 e
LSD $_{(0.05)}$	0.51	0.21	0.29	0.42	0.33	0.36
CV (%)	1.92	1.24	1.46	1.32	1.01	1.17

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

Root growth inhibition

According to our results presented in Table 2, *L. sativa*, *R. sativus,* and *E. colona* recorded the highest root growth inhibition percentage with the co-growth of Rai-5 variety (69.67, 69.31, and 64.27% sequentially). Besides, it was statistically similar to the co-growth of BARI Sarisha-18 (Canola) variety with *E. colona,* with the percentage of 63.91%. On the other hand, *L. sativa, R. sativus,* and *E. colona* recorded the least root growth inhibition percentages with the co-growth of the Tori-7, Kallyani (TS-72), and BARI Sarisha-17 varieties (5.74%, 0.97%, and 15.04%) respectively. Nijsson and Halgren (1992) stated that *Brassica* spp. suppresses the weeds through their vigorous growth and release of allelochemicals.

Field experiment

Weed Flora

The experimental field showed eight weed species, including three grasses, one sedge, and four broadleaf weeds, with grass and broadleaf weeds dominating. Grass weeds were *Eleusine indica*, *Echinochloa colona*, *and Cynodon dactylon,* all belonging to the Poaceae family. The only sedge weed was *Cyperus rotundus,* which belongs to the Cyperaceae family. The broadleaf weeds include *Heliotropium indicum*, *Enydra fluctuans*, *Mimosa pudica*, and *Brassica kaber* (*Sinapis arvensis*), which belong to Boraginaceae, Asteraceae, Fabaceae, and Brassicaceae family, respectively. Our findings are similar to the work documented by Bhawana *et al*. (2019). Among them, C. *dactylon* (L.) Pers. and *C. album* L. were the predominant weeds in grass and broadleaf weeds, respectively.

Weed density

A significant effect was observed on weed density m^{-2} of different varieties and weed management techniques at 15 and 30 DAS (Figure 1). The maximum weed density m^{-2} was recorded in the BARI Sarisha-15 variety (V_4), and the values were 57 and 82 m^{-2} at 15 and 30 DAS, respectively. In contrast, the Rai-5 variety (V_1) recorded the minimum weed density m^{-2} of 39 and 55 at 15 and 30 DAS, respectively. The result also showed that no weeding (W_0) recorded the maximum weed density (51 and 94 m^{-2}), and two-hand weeding (W_2) recorded the minimum weed density (46 and 40 m^{-2}) at 15 and 30 DAS, respectively.

Weed dry matter weight

Mustard varieties and different weed management techniques played an important role in controlling weeds to some extent, ultimately affecting dry matter accumulation by various weeds in the field.

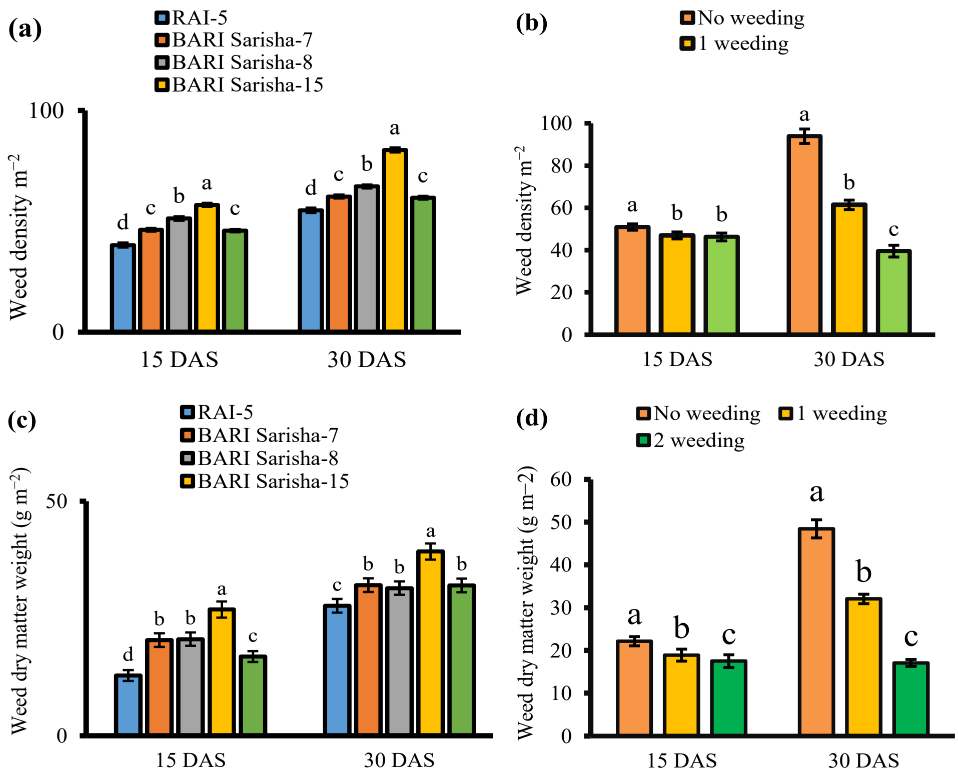

Fig. 1. Effect of varieties and weed management techniques on weed density (a and b) and weed dry matter weight (c and d) at different DAS.

According to our findings (Figure 1), among different mustard varieties, the BARI Sarisha-15 (V_4) variety recorded the highest weed dry weight (26.92 and 39.28 g m^{-2}) at 15 and 30 DAS. On the contrary, the Rai-5 variety (V_1) recorded the lowest weed dry weight (12.83 and 27.70 g m^{-2}) at 15 and

30 DAS. Additionally, no weeding (W_0) recorded the maximum weed dry weight at 15 and 30 DAS (22.15 and 48.45 g m^{-2}), whereas two weeding (W_2) recorded the minimum dry weight at 15 and 30 DAS (17.50 and 17.07 g m^{-2}, respectively). Dola *et al.* (2024) reported that the weed population and dry weight were greatly affected by the mustard aqueous extract.

Interaction effect of varieties and weed management techniques on weed density and weed dry weight

The interaction effect of variety and weed management significantly affected the weed density m^{-2} and weed dry weight (g m^{-2}) at both DAS (Table 3). The experiment showed that cultivation of BARI Sarisha-15 and no weeding (V_4W_0) recorded the maximum weed density (59 and 114 m^{-2}) at 15 and 30 DAS. In contrast, cultivation of Rai-5 along with two weeding (V_1W_2) recorded the minimum weed density (37 and 28 m^{-2}) at 15 and 30 DAS, which was statistically similar to V_1W_1 at 15 DAS. In addition, BARI Sarisha-7 and two weeding (V_2W_2) cultivations recorded the minimum weed density (32 m^{-2}) at 30 DAS.

According to our findings, BARI Sarisha-15, along with no weeding (V_4W_0), recorded the maximum weed dry weight at 15 and 30 DAS (28.11 and 60.79 g m^{-2}, respectively), which was statistically similar to V_4W_1 at 15 DAS. Meanwhile, cultivation of Rai-5 and two weeding (V_1W_2) resulted in the minimum dry weight (9.90 and 11.95 g m^{-2}) at 15 and 30 DAS.

Table 3. Interaction effect of varieties and weed management techniques on weed density and weed dry weight at 15 and 30 DAS

Treatment Combinations	Weed density m^{-2}		Weed dry weight (g m^{-2})	
	15 DAS	30 DAS	15 DAS	30 DAS
V_1W_0	43.33 ± 3.61 g	85.00 ± 1.17 c	16.44 ± 1.65 g	44.15 ± 5.57 c
V_1W_1	38.00 ± 0.95 h	52.00 ± 1.29 g	12.14 ± 0.71 h	27.01 ± 2.59 f
V_1W_2	36.67 ± 0.92 h	28.00 ± 0.70 i	9.90 ± 0.58 i	11.95 ± 0.71 j
V_2W_0	47.00± 1.17 de	84.67 ± 2.12 c	20.76 ± 1.22 cd	52.73 ± 3.11 b
V_2W_1	46.00 ± 1.15 ef	67.00 ± 1.67 e	20.13± 1.18 d-f	28.15 ± 1.65 f
V_2W_2	45.67 ± 1.14 ef	32.00 ± 0.80 i	20.28± 1.19 c-e	15.44 ± 0.91 i
V_3W_0	55.33 ± 1.38 b	100.33 ± 2.51 b	23.82 ± 1.40 b	41.69 ± 2.45 d
V_3W_1	50.00 ± 1.25 c	58.00 ± 1.45 f	19.13 ± 1.12 ef	34.34 ± 2.02 e
V_3W_2	48.67 ± 1.22 cd	39.00 ± 0.97 h	18.82 ± 1.11 f	18.39 ± 1.08 h
V_4W_0	59.00 ± 1.47 a	114.33 ± 2.85 a	28.11 ± 1.65 a	60.79 ± 3.57 a
V_4W_1	56.33 ± 1.41 b	74.67 ± 1.87 d	27.58 ± 1.62 a	36.26 ± 2.13 e
V_4W_2	57.00± 1.43 b	57.67 ± 1.44 f	25.08 ± 1.47 b	20.80 ± 1.22 g
V_5W_0	50.00± 1.25 c	85.33 ± 2.13 c	21.59 ± 1.27 c	42.89 ± 2.52 cd
V_5W_1	44.33 ± 0.12 fg	55.67 ± 1.39 fg	15.62 ± 0.92 g	34.51 ± 2.03 e
V_5W_2	43.33 ± 1.92 g	41.00 ± 0.02 h	13.44 ± 2.20 h	18.76 ± 0.11 h
LSD $_{(0.05)}$	0.84	2.09	0.67	0.94
CV (%)	2.15	3.94	4.18	3.55

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability. Here, NS: Non-Significant, V_1: Rai-5, V_2: BARI Sarisha-7, V_3: BARI Sarisha-8, V_4: BARI Sarisha-15, V_5: BARI Sarisha-18 (Canola), W_0: no weeding, W_1: 1 weeding at 15 days and W_2: 2 weeding at 15 and 30 days.

Crop Performance

Plant height

The research revealed notable variation in plant height due to the effects of various mustard varieties, indicating that plant height is a crucial morphological characteristic. Our experimental result showed that the Rai-5 (V_1) variety recorded the largest plants at all the time frames except 30 DAS, and the values were 16.70, 149.38, and 166.89 cm at 15 DAS, 45 DAS, and at harvest, respectively (Figure 2).

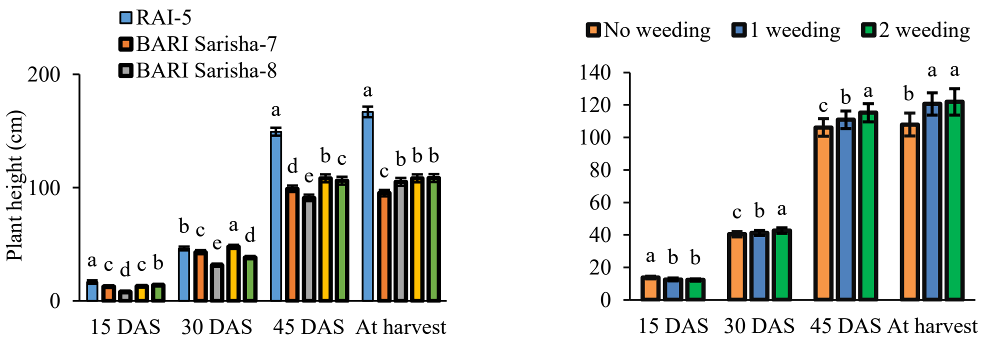

Fig. 2. Effect of varieties and weed management techniques on plant height at different DAS

Nonetheless, the BARI Sarisha-8 (V_3) variety recorded the most dwarf plants with heights of 7.90, 31.56, and 90.99 cm at 15, 30, and 45 DAS, accordingly. Plant height variation is influenced by genetic traits, with different varieties acquiring their height based on their genetic makeup in a specific environment (Das *et al.,* 2019). On the other hand, two weeding (W_2) recorded the maximum plant height at 30 DAS, 45 DAS, and at harvest (42.66, 115.26, and 121.93 cm, respectively), and it was statistically similar to one weeding recorded plant height at harvest (Figure 2). No weeding (W_0) produced the most miniature plants, 40.43, 106.16, and 107.96 cm at 30 DAS, 45 DAS, and at harvest, respectively. The result obtained from this study was similar to the findings of Raj *et al*. (2020), who reported that growth, yield attributes, and quality enhanced significantly under two hand weeding at 20 and 40 DAS.

Interaction effect of varieties and weed management techniques on plant height

Different mustard varieties and different methods of weed management significantly affected the plant height of mustard at different DAS.

Table 4. Interaction effect of varieties and weed management techniques on plant height of mustard at different DAS

Treatment Combinations	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	At harvest
V_1W_0	14.69 ± 0.87 c	46.38 ± 0.40 bc	143.23 ± 6.63 c	153.75 ± 2.64 b
V_1W_1	17.44 ± 1.48 a	45.53 ± 1.84 c	149.75 ± 1.88 b	171.43 ± 2.14 a
V_1W_2	17.95 ± 0.94 a	47.15 ± 1.87 b	155.16 ± 1.92 a	175.50 ± 2.19 a
V_2W_0	13.73 ± 1.08 c-e	41.93 ± 1.78 e	94.64 ± 1.75 jk	73.67 ± 0.92 e
V_2W_1	11.11 ± 0.74 g	43.10 ± 1.80 de	99.69 ± 1.74 hi	104.17 ± 1.30 cd
V_2W_2	13.53 ± 0.82 de	44.23 ± 1.82 d	102.71 ± 1.74 gh	107.82 ± 1.34 cd
V_3W_0	8.48 ± 0.87 h	29.77 ± 1.61 i	83.55 ± 1.79 l	97.09 ± 1.21 d
V_3W_1	7.32 ± 0.77 i	31.73 ± 1.64 h	91.94 ± 1.76 k	109.42 ± 1.37 cd
V_3W_2	7.90 ± 0.76 hi	33.17 ± 1.65 g	97.48 ± 1.75 ij	109.27 ± 1.37 cd
V_4W_0	12.93 ± 1.13 ef	46.26 ± 1.85 bc	106.52 ± 1.73 e-g	109.61 ± 1.37 cd
V_4W_1	14.53 ± 0.59 cd	47.51 ± 1.87 b	108.15 ± 1.73 d-f	109.41 ± 1.36 cd
V_4W_2	11.0 ± 1.34 g	49.71 ± 1.91 a	110.28 ± 1.73 de	105.91 ± 1.32 cd
V_5W_0	15.80 ± 0.58 b	37.79 ± 1.72 f	102.89 ± 1.74 gh	105.69 ± 1.32 cd
V_5W_1	12.25 ± 0.73 f	38.23 ± 1.73 f	104.95 ± 4.27 fg	108.83 ± 1.36 cd
V_5W_2	14.09 ± 0.67 cd	39.00 ± 3.46 f	110.67 ± 4.85 d	111.15 ± 28.61 c
LSD (0.05)	0.50	0.61	1.82	6.32
CV (%)	4.75	1.80	2.02	6.63

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability. Here, NS: Non-Significant, V_1: Rai-5, V_2: BARI Sarisha-7, V_3: BARI Sarisha-8, V_4: BARI Sarisha-15, V_5: BARI Sarisha-18 (Canola), W_0: no weeding, W_1: 1 weeding at 15 days and W_2: 2 weeding at 15 and 30 days.

According to Table 4, the Rai-5 variety and two weeding (V_1W_2) resulted in the tallest plants (17.95, 155.16, and 175.50 cm) throughout the period except 30 DAS. Though BARI Sarisha-8, along with no weeding (V_3W_0), recorded the minimum plant height at 30 and 45 DAS (29.77 and 83.55 cm), BARI Sarisha-7, along with no weeding (V_2W_0), recorded the minimum plant height at harvest (73.67 cm).

Above ground dry matter weight plant^{-1}

The cultivation of Rai-5 and BARI Sarisha-18 (Canola) both resulted in the maximum above-ground dry matter weight plant^{-1} at 30 and 45 DAS (Figure 3). Besides, BARI Sarisha-18 (Canola) (V_5) demonstrated the best result at harvest (17.70 g). BARI Sarisha-8 (V_3) recorded the least above-ground dry matter weight plant^{-1} (0.43, 1.31, and 5.38 g) at 15, 30, and 45 DAS, respectively. Rashid *et al.* (2010) similarly reported that dry matter accumulation varied among varieties. Furthermore, Figure 3 shows that two weeding (W_2) recorded the maximum above-ground dry matter weight plant^{-1} (0.57, 2.66, 9.93, and 15.28 g) at 15, 30, and 45 DAS and at harvest, respectively. Nevertheless, no weeding (W_0) performed the opposite, resulting in 0.44, 2.02, 6.88, and 11.8 g at 15, 30, 45 DAS, and at harvest, respectively.

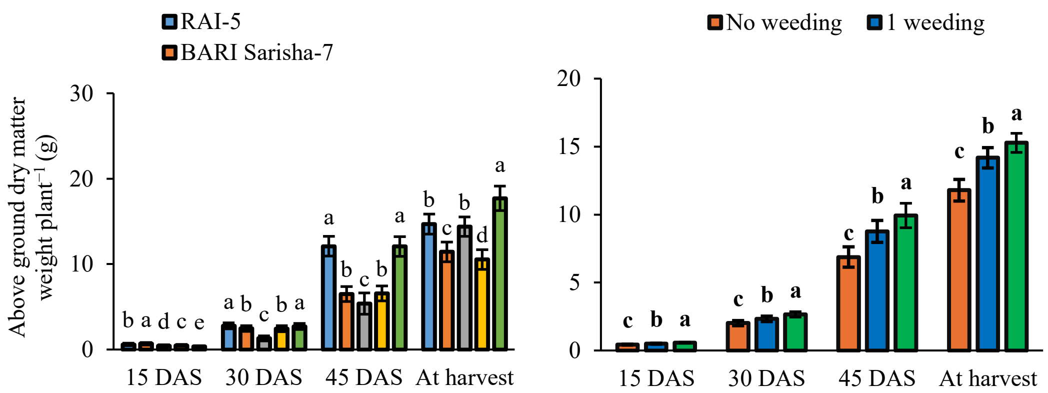

Fig. 3. Effect of varieties and weed management techniques on above ground dry matter weight plant^{-1} at different DAS

Interaction effect of varieties and weed management techniques on above-ground dry matter weight plant^{-1}

According to Table 5, the separate cultivation of BARI Sarisha-7 and Rai-5 and two weeding recorded the maximal above-ground dry matter weight plant^{-1} at 15 DAS and 30 DAS (0.74 and 3.24 g), respectively. Furthermore, BARI Sarisha-18 (Canola) with two weeding (V_5W_2) recorded the best in this regard at 45 DAS and at harvest (14.10 and 20.33 g), respectively. On the other hand, separate cultivation of BARI Sarisha-18 (Canola) and BARI Sarisha-8, and no weeding recorded the minimum above-ground dry matter weight plant^{-1} at 15 and 30 DAS (0.28 and 1.04 g), respectively. At 45 DAS and at harvest, cultivation of BARI Sarisha-15, along with no weeding (V_4W_0), recorded the minimum above-ground dry matter weight plant^{-1} (4.55 and 7.92 g), respectively.

Table 5. Interaction effect of varieties and weed management techniques on above-ground dry matter weight plant^{-1} of mustard at 15, 30, 45 DAS, and at harvest

Treatment Combinations	Above-ground dry matter weight plant^{-1} (g)			
	15 DAS	30 DAS	45 DAS	At harvest
V_1W_0	0.53 ± 0.01 d	2.39 ± 0.63 ef	10.78 ± 1.38 c	13.78 ± 2.10 de
V_1W_1	0.60 ± 0.02 bc	2.70 ± 0.67 cd	11.49 ± 1.43 c	14.49 ± 1.61 d
V_1W_2	0.65 ± 0.02 b	3.24 ± 0.81 a	14.00 ± 1.75 a	15.81 ± 1.75 c
V_2W_0	0.64 ± 0.02 b	2.30 ± 0.57 f	4.66 ± 0.58 h	9.06 ± 1.00 h
V_2W_1	0.65 ± 0.02 b	2.50 ± 0.62 d-f	7.15 ± 0.89 ef	12.30 ± 1.36 fg
V_2W_2	0.74 ± 0.02 a	2.59 ± 0.65 c-e	7.66 ± 0.95 ef	12.96 ± 1.44 ef
V_3W_0	0.41 ± 0.01 e	1.04 ± 0.26 h	5.0 ± 0.62g h	14.00 ± 1.55 de
V_3W_1	0.42 ± 0.01 e	1.22 ± 0.31 h	5.29 ± 0.66 gh	14.29 ± 1.58 d
V_3W_2	0.46 ± 0.01 e	1.67 ± 0.42 g	5.84 ± 0.72 g	14.84 ± 1.64 cd
V_4W_0	0.34 ± 0.01 f	1.82 ± 0.45 g	4.55 ± 0.56 h	7.92 ± 0.87 h
V_4W_1	0.54 ± 0.01 d	2.68 ± 0.67 cd	7.13 ± 0.89 f	11.27 ± 1.25 g
V_4W_2	0.56 ± 0.01 cd	2.81 ± 0.70 bc	8.03 ± 1.00 e	12.44 ± 1.38 f
V_5W_0	0.28 ± 0.01 g	2.54 ± 0.63 de	9.41 ± 1.17 d	14.23 ± 1.58 d
V_5W_1	0.34 ± 0.02 f	2.60 ± 0.65 c-e	12.71 ± 1.58 b	18.52 ± 2.05 b
V_5W_2	0.44 ± 0.11 e	2.98 ± 0.24 b	14.10 ± 0.23 a	20.33 ± 0.04 a
LSD $_{(0.05)}$	0.02	0.11	0.42	0.52
CV (%)	6.07	5.63	6.07	4.71

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability. Here, NS: Non-Significant, V_1: Rai-5, V_2: BARI Sarisha-7, V_3: BARI Sarisha-8, V_4: BARI Sarisha-15, V_5: BARI Sarisha-18 (Canola), W_0: no weeding, W_1: 1 weeding at 15 days and W_2: 2 weeding at 15 and 30 days.

Yield contributing characters

Number of siliquae plant^{-1}

Cultivation of different varieties with different weed management techniques significantly affected the number of siliquae plant^{-1} of mustard (Figure 4). The cultivation of the RAI-5 variety (V_1) recorded the most significant number of siliquae plant^{-1} (132), while cultivation of the BARI Sarisha-15 variety (V_4) recorded the lowest number (56), which was statistically similar to the cultivation of BARI Sarisha-18 (Canola). The study aligns with Alam *et al*. (2014), revealing that mustard varieties notably affect yield, with BJDH-05 having the maximal number of siliquae plant^{-1}. Additionally, the maximum number of siliquae plant^{-1} was produced when two hand weedings (W_2) were performed (98), while no weeding (W_0) recorded the minimum number of siliquae plant^{-1} (70). The result obtained from the present study was similar to the findings of Singh *et al*. (2020), who reported that the maximum number of siliquae plant^{-1} was recorded under two hand weedings at 20 and 40 DAS.

Number of seeds siliqua^{-1}

Though different varieties significantly affected the number of seeds siliqua^{-1} of mustard, various weed management techniques did not (Figure 4). The BARI Sarisha-18 (Canola) variety recorded the maximum number of seeds siliqua^{-1} (26). In contrast, the RAI-5 variety recorded the least number of seeds siliqua^{-1} (12). The differences in the number of seeds in siliqua^{-1} were due to the genetic makeup of the varieties (Patil *et al*., 2018). Additionally, the number of seeds siliqua^{-1} was 20 for all the weed management techniques.

Seed yield

We observed that varieties and weed management techniques greatly influenced the seed yield (t ha^{-1}) of different mustard varieties.

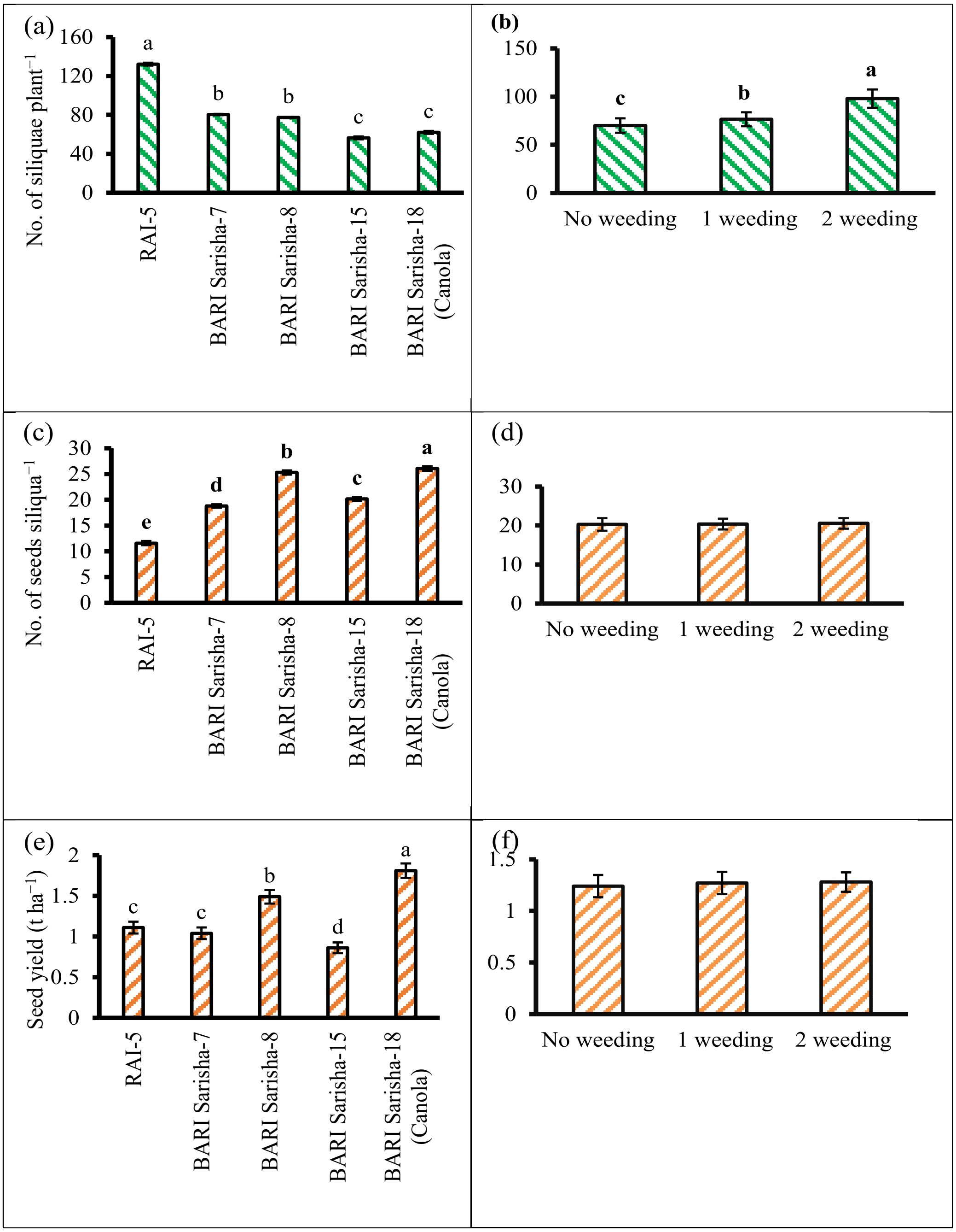

Fig. 4. Effect of varieties and weed management techniques on no. of siliquae plant^{-1} (a and b), no. of seeds siliqua^{-1} (c and d), and seed yield (e and f)

According to Figure 4, the BARI Sarisha-18 (Canola) variety recorded the highest seed yield (1.81 t ha^{-1}), while cultivation of the BARI Sarisha-15 variety recorded the lowest seed yield (0.86 t ha^{-1}). Biswas *et al.* (2020) also found similar results that supported the present finding and reported that seed yield differed among different varieties of mustard. On the other hand, we observed insignificant differences among the effects of different weed management practices on seed yield.

Interaction effect of varieties and weed management techniques on no. of siliquae plant^{-1}, no. of seeds siliqua^{-1}, and seed yield

Cultivation of different varieties and different weed management practices notably affected the number of siliquae plant^{-1} and the number of seeds siliqua^{-1} of mustard. According to our recorded data in Table 6, the cultivation of the RAI-5 variety, along with two weeding (V_1W_2), recorded the maximum number of siliquae plant^{-1} (151). In contrast, the cultivation of the BARI Mustard-8 variety and no weeding (V_3W_0) recorded the minimum (45).

Table 6. Interaction effect of varieties and weed management techniques on no. of siliquae plant^{-1}, no. of seeds siliqua^{-1}, and seed yield

Treatment Combinations	No. of siliquae plant^{-1}	No. of seeds siliqua^{-1}	Seed yield (t ha^{-1})
V_1W_0	117.07 ± 11.36 c	11.07 ± 1.01 f	1.12 ± 0.40 c-e
V_1W_1	128.13 ± 7.12 b	11.80 ± 1.07 f	1.05 ± 0.13 d
V_1W_2	151.02 ± 8.39 a	11.92 ± 1.08 f	1.15 ± 0.14 c
V_2W_0	85.13 ± 4.73 d	17.33 ± 1.57 e	0.99 ± 0.12 d-f
V_2W_1	74.05 ± 4.11 ef	19.45 ± 1.76 d	1.13 ± 0.14 cd
V_2W_2	81.40 ± 4.52 de	19.61 ± 1.78 d	1.01 ± 0.12 de
V_3W_0	45.16 ± 2.51 j	26.23 ± 2.38 ab	1.46 ± 0.18 b-d
V_3W_1	64.80 ± 3.60 fg	24.96 ± 2.26 c	1.55 ± 0.32 b
V_3W_2	121.20 ± 6.73 bc	24.69 ± 2.24 c	1.48 ± 0.18 bc
V_4W_0	48.20 ± 2.67 ij	20.29 ± 1.84 d	0.81 ± 0.11 e-h
V_4W_1	56.93 ± 3.16 g-i	20.17 ± 1.83 d	0.86 ± 0.11 e-g
V_4W_2	63.00 ± 3.50 gh	20.00 ± 1.81d	0.91 ± 0.11 ef
V_5W_0	54.27 ± 3.01 h-j	26.34 ± 2.39 ab	1.82 ± 0.22 ab
V_5W_1	58.33 ± 3.24 gh	25.47 ± 2.31 bc	1.78 ± 0.22 a-c
V_5W_2	73.13 ± 15.93 ef	26.41 ± 0.55 a	1.85 ± 0.23 a
LSD $_{(0.05)}$	4.47	0.43	0.08
CV (%)	6.72	2.57	7.62

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at a 0.05 level of probability.Here, NS: Non-Significant, V_1: Rai-5, V_2: BARI Sarisha-7, V_3: BARI Sarisha-8, V_4: BARI Sarisha-15, V_5: BARI Sarisha-18 (Canola), W_0: no weeding, W_1: 1 weeding at 15 days and W_2: 2 weeding at 15 and 30 days.

Moreover, the cultivation of the BARI Sarisha-18 (Canola) variety along with two weeding (V_5W_2) recorded the maximum number of seeds siliqua^{-1} (26). Meanwhile, the cultivation of the RAI-5 variety, along with all the weed management techniques, produced 11-12 seeds siliqua^{-1}. Cultivation of different varieties and different weed management significantly affected mustard's seed yield (t ha^{-1}) (Table 6). The experiment showed that cultivating the BARI Mustard-18 (Canola) variety and two weeding (V_5W_2) recorded the maximum seed yield (1.85 t ha^{-1}). Meanwhile, cultivation of the BARI Mustard-15 variety and no weeding (V_4W_0) recorded the minimum seed yield (0.81 t ha^{-1}). Kumar *et al.* (2017) revealed that the two-hand weeding also remains superior to seed yield.

CONCLUSION

As herbicide residues pose a significant threat to the environment, we conducted this research to ensure the allelopathic effects of some mustard varieties and their efficiency in weed management. According to our findings, RAI-5, BARI Sarisha-7, BARI Sarisha-8, BARI Sarisha-15, and BARI Sarisha-18 (Canola) mustard varieties exhibited notable allelopathic properties that can suppress the growth of various weed species. This natural ability can be harnessed to reduce reliance on chemical herbicides. Among different mustard varieties, the BARI Mustard-18 (Canola) variety (V_5) with 2 weeding recorded the maximal output in various parameters, including the number of seeds siliqua^{-1} (26), seed yield (1.85 t ha^{-1}). Like others, the cultivation of this variety can be promoted to lower the dependence on herbicides for controlling weeds after more trials are conducted in different parts of Bangladesh.

REFERENCES

Alam, A. K. M. F. 2020. Rising trend in consumption of oils and fats in Bangladesh. Retrieved from: https://thefinancialexpress.com.bd/views/analysis/rising-trend-in-consumption-of-oils-and-fats-in-bangladesh-1582381921. Accessed 29th August 2024.

Alam, M. M., Begum, F. and Roy, P. 2014. Yield and yield attributes of rapeseed mustard (*Brassica*) genotypes grown under late sown condition. *Bangladesh J. Agril. Res*. 39(2): 311-336.

Albahrani, A. A. and Greaves, R. F. 2016. Fat-soluble vitamins: clinical indications and current challenges for chromatographic measurement. *Clin. Biochem. Rev*. 37(1): 27-47.

Badesra, S., Manuja, S., Sharma, G. D., Shivalika, Mali, S. and Kumari, S. 2025. Allelopathy based weed management: advances and challenges. *Vigyan Varta*. 6(4): 231-233.

Bhawana, Singh, S., Sarita, Mehla, U., Kumari, S. 2019. Studies on weed dynamics in mustard (*Brassica junceae* L.) crop under Doon valley conditions of Uttarakhand. *Int. J. Chem. Stud*. 7(5):3169-3171.

Biswas, P. K., Ferdous, L. J., Roy, T. S. and Masum, S. M. 2020. Performance of rapeseed and mustard with different planting techniques. *Bangladesh Agron. J*. 22(1): 79–88.

Boydston, R. A. and Al-Khatib, K. 2008. Exudation of mesotrione from potato roots injures neighboring plants. *Weed Sci*. 56(6): 852–855.

Das, A., Ray, M. and Murmu, K. 2019. Yield and yield attributes of hybrid mustard as affected by crop geometry and varieties. *Int. J. Curr. Microbiol. App. Sci*. 8(4): 2160-2166.

Dola, N. A., Sarker, U. K., Ahmed, M. T., Upama, S. A., Rashid, M. H. O. and Uddin, M. R. 2024. Comparative advantages of aqueous extract of mustard crop residues with herbicide to weed control and crop performance of wheat. *Arch. Agric. Environ. Sci*. 9(2): 294-301.

Kaur, S., Kaur, R., and Chauhan, B. S. 2018. Understanding crop-weed-fertilizer-water interactions and their implications for weed management in agricultural systems. *Crop Prot*. 103: 65-72.

Kumar, R., Yadav, S. S., Dudwal, B. L., Verma, H. P., Balwan and Yadav, N. 2017. Effect of weed management and sulphur fertilization on weed dynamics, nutrient depletion of weed and productivity of mustard in semi-arid eastern plain zone of Rajasthan. *Chem. Sci. Rev. Let.* 6(22): 1205-1212.

Masum, S. M., Hossain, M. A., Akamine, H., Sakagami, J. I. and Bhowmik, P. C. 2016. Allelopathic potential of indigenous Bangladeshi rice varieties. *Weed Biol. Manag*. 16(3): 119-131.

Masum, S. M., Hossain, M. A., Akamine, H., Sakagami, J. I., Ishii, T., Nakamura, I., Asaduzzaman, M. and Bhowmik, P. C. 2019. Performance of Bangladesh indigenous rice in a weed infested field and separation of allelopathy from resource competition. *Weed Biol. Manag*. 19(2): 39-50.

McErlich, A. F. and Boydston, R. A. 2014. Current state of weed management in organic and conventional cropping systems. In: Young, S., Pierce, F. (eds) Automation: the future of weed control in cropping systems. *Springer, Dordrecht*. https://doi.org/10.1007/978-94-007-7512-1_2

Miah, M. A. M. and Mondal, M. R. I. 2017. Oilseeds sector of Bangladesh: challenges and opportunities. *SAARC J. Agric*. 15(1): 161-172.

Nijsson, H. and Halgren, E. 1992. White mustard meal for control of *Galium apaine, Matricaria indora* and *Chenopodium album*: A greenhouse experiment. 33rd Swedish crop protection conference weeds and weed control reports. pp. 269-276.

Ofosu, R., Agyemang, E. D., Márton, A., Pásztor, G., Taller, J., Kazinczi, G. 2023. Herbicide resistance: managing weeds in a changing world. *Agron*. 13(6): 1595.

Patil, S., Kalamkar, V., Deotale, R. D., Kamdi, S. R., Kuchanwar, O. and Chopde, N. 2018. Genetic analysis of siliqua per plant and seed yield per plant in mustard (*Brassica juncea*). *Int. J. Curr. Microbiol. Appl. Sci*. 6: 1355–1360.

Raj, P., Singh, R. P., Pal, R. K., Rajput, P. and Rana, S. S. 2020. Integrated weed management in Indian mustard (*Brassica juncea* L.). *Int. J. Cur. Micro. App. Sci*. 10: 271-276.

Rashid, M. M., Moniruzzaman, M., Masud, M. M., Biswas, P. K., and Hossain, M. A. 2010. Growth parameters of different mustard (*Brassica campestris* L.) varieties as effected by different levels of fertilizers. *Bull. Inst. Trop. Agr., Kyushu Univ*. 33(1): 73-81.

Rehman, S., Shahzad, B., Bajwa, A. A., Hussain, S., Rehman, A., Cheema, S. A., Abbas T., Ali, A., Shah, L., Adkins, S., and Li, P. (2019). Utilizing the allelopathic potential of *Brassica* species for sustainable crop production: a review. *J. Plant Growth Regul*. 38(1): 343–356.

Saeedipour, S. 2010. Allelopathic effect of white mustard (*Sinapis alba*) on germination and growth of wheat (*Triticum aestivum* L.). *Int. J. App. Agric. Res*. 5(1): 47–53.

Sarmah, M. K., Narwal, S. S. and Yadava, J. S. 1992. Smothering effect of *Brassica* species on weeds. Proceeding first national symposium allelopathy in agroecosystems agriculture and forestry held at CCS Haryana Agricultural University. *Ind. Soc. Allelop*. pp. 51–55.

Singh, A., Yadav, R. S., Anshuman, K., Kumar, A., Patel, V. K., Singh, A. P. and Singh, R. P. 2020. Effect of weed management practices on yield and economics in Indian mustard. *Int. J. Chem. Stud*. 8(2): 1364-1367.

Singh, C., Singh, P. and Singh, R. 2010. Modern techniques of raising field crops. New Delhi: Oxford & IBH publishing company Pvt. Ltd.

The Daily Star. 2023. Mustard output worth Tk 3,000 crore in Bangladesh. https://www.thedailystar.net/business/news/mustard-output-worth-tk-3000-crore-bangladesh-3309126. Accessed on August 25, 2004.