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YIELD PERFORMANCE OF MUSTARD USING DIFFERENT CONCENTRATIONS OF GIBBERELIC ACID (GA₃)

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ABSTRACT

An experiment was conducted at the Crop Botany Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during November 2007 to March 2008 to evaluate the effects of Gibberellic acid (GA₃) on yield performance and silique shattering of mustard (var. BINA shorisha-6). Four concentrations of GA₃ viz. 0, 25, 50 and 75 ppm were sprayed on canopy at 30 days after sowing. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The results showed that different levels of GA₃ significantly influenced the number of silique/plant, number of seeds/silique, percentage of shattered silique/plant, number of flowers/plant, setting of silique/plant (%), seed weight/plant and harvest index. The GA₃ at 50 ppm significantly increased the number of fertile silique/plant, number of flowers/plant, setting of silique/plant (%), number of seeds/silique, seed weight/plant and harvest index. The highest seed yield/plant was recorded from 50 ppm GA₃ application at optimum harvest date. The variety incurred 47.29% yield loss due to shattering of silique when harvested 10 days after optimum date without application of hormone but loss was reduced to 15.34% with the application of 50 ppm of GA₃.

Keywords: Yield performance, silique shattering, mustard, GA₃.

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INTRODUCTION

Mustard belongs to genus *Brassica* under the family Cruciferae. Out of 100 species of *Brassica*, the *Brassica napus* L. is a high yielding one. Next to soybean, mustard is one of the important oil seed crops in the world (FAO, 2001). In Bangladesh, seed oil of mustard is the number one edible oil crop, covering about 80% of the total oil crops area and contributing more than 71% of the total production (BBS, 2007). Bangladesh is facing a huge deficit of edible oil. In view of the importance of this crop, attention has to be given to increase its production in order to meet the huge shortage of cooking oil in the country. According to the National Nutrition Council (NCC) of Bangladesh, the recommended dietary allowance (RDA) is estimated to be 6 gm oil per capita per day for a diet with 2700 Kcal (NNC, 1984). On this RDA basis, Bangladesh requires 0.29 million tons of oil equivalent to 0.8 million tons of oil seeds for nourishing her people. At present, the indigenous oil seed production is about 0.25 million tons,

which covers only 40% of the domestic need (FAO, 2001). Mustard oil not only plays a great role as a fat substitute in our daily diet but also nourish the economy of the nation. The ordinary people of Bangladesh also use it as medicine against cold. It is widely used as cooking ingredient and condiment. Oil cake produced from mustard is an important food for livestock and also used as organic manure for crop production. The climatic and edaphic conditions of Bangladesh are quite favorable for mustard cultivation (Haque *et al.*, 1987). However, the average seed yield is low (0.74 t/ha), which is unfortunately much lower than the average yield of many countries of the world (FAO, 2001). The poor yield of mustard under Bangladesh condition might be attributed to inefficient and inappropriate uses of production inputs and improved technologies of crop production.

Gibberellic acid (GA₃), a phytohormone, can alter the plant growth and development with low concentration. GA₃ enhances plant growth activities, stimulates stem elongation (Deotale *et al.*, 1998; Abd, 1997; Lee, 1990), and increases dry weight and yield (Deotale *et al.*, 1998 and Maske *et al.*, 1998). The research findings admitted that the yield of mustard seed can be increased significantly by the application of phytohormones (Bruns *et al.*, 1990). At present, many research works have been conducted in many parts of the world to increase oil seed production by using Gibberellic acids. Therefore, the research work was undertaken to study the effects of various concentrations of GA₃ on yield performance of mustard and to estimate the yield losses due to shattering of siliqua at delayed harvest.

MATERIALS AND METHODS

The experiment was conducted in plots in the Crop Botany Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during November 2007 to March 2008. The experimental site is located at 27.75°N latitudes and 90.5°E longitudes. The planting material used in this experiment was the seeds of the mustard variety BINA shorisha-6. The experiment was laid out in a randomized complete block design with three replications. Well-decomposed cowdung was applied as a source of organic matter. Inorganic fertilizers viz. urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc oxide and borax were used as sources of nitrogen, phosphorus, potassium, sulphur, zinc, and boron, respectively (Table 1).

Table 1. Doses of manures and fertilizers used in the experiment

Manures and fertilizers	Doses (kg/ha)	Quantity/plot (g)
Cowdung	10,000	583.33
Urea	250	1.8
TSP	150	1.3
MP	60	0.5
Gypsum	125	1.1
Zinc oxide	4	0.04
Borax	10	0.1

Total amount of well decomposed cowdung, TSP, MoP, gypsum, zinc oxide and borax were applied as basal dose during final plot preparation. Urea was applied in two splits, half of the

amount was applied during final plot preparation and the remaining amount was applied 30 days after sowing as top dressing. Seeds were sown in each plot uniformly by broadcasting. After one week extra seedlings were removed from the plots keeping only two in each plot. The experiment consisted of four levels of GA₃ viz. 0, 25, 25 and 75 ppm. Gibberellic acid was prepared for spraying in the flowering stage and it was sprayed on leaves in the afternoon at 30 days after sowing and by using a hand sprayer. Data of yield attributes were recorded as per following standard procedure. Setting of siliqua/plant was calculated by dividing number of siliqua/plant by number of flower/plant and expressed in percentage. Harvest index (HI) was calculated at the final harvest by the following formula proposed by Donald and Humbling (1976).

$$HI (\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100. \dots\dots\dots(1)$$

The collected data on different parameters were statistically analyzed to obtain the level of significance using MSTAT-C package program (Russell, 1986). The mean differences were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Number of flowers/plant: The application of different concentrations of GA₃ had significantly influenced the number of flowers/plant. The highest number of flowers/plant (337.61) was noted for the application of 75 ppm GA₃, which was statistically similar to 50 ppm GA₃ (Table 2) and the lowest number (219.52) was recorded for the untreated control.

Number of fertile siliqua/plant: The application of different concentrations of GA₃ had influenced the number of fertile siliqua/plant significantly (Table 2). The highest number of fertile siliqua/plant (247.38) was obtained from 50 ppm GA₃, which was statistically similar to 75 ppm GA₃ and the lowest number (200.34) was recorded in the control treatment. The results indicated that 50 ppm GA₃ was the optimum dose for producing the highest number of fertile siliqua/plant. The results also showed that the number of fertile siliqua/plant was increased with the increasing concentrations of GA₃ until its application at the rate of 50 ppm; however, it was reduced when 75 ppm GA₃ was applied. This indicated that GA₃ had direct effects on pod formation; however, excessive application of GA₃ had detrimental effects on the growth of the crop. The results of the present study is similar to the findings of Khan et al. (1998), who observed that the application of GA₃ at 80 days after sowing on *Brassica juncea* (var. varuna) had increased the number of siliqua/plant. The translocation of assimilates to the reproductive organ might be increased up to certain levels of GA₃ application resulted in the maximum number of fertile siliqua/plant (Uddin et al., 1986; Kandil, 1983).

Number of unfertile siliqua/plant: The number of unfertile siliqua/plant was significantly influenced by different concentrations of GA₃ (Table 2). The results showed that the highest number of unfertile siliqua/plant (19.36) was observed in the untreated control, while the lowest number (9.57) was noted for 50 ppm GA₃ application.

Table 2: Effects of GA₃ on yield attributes of mustard

Treatment	No. of flowers plant ⁻¹	No. of fertile siliqua plant ⁻¹	No. of unfertile siliqua plant ⁻¹	% siliqua setting plant ⁻¹	Length (cm) of siliqua	No. of seeds siliqua ⁻¹	1000-seed weight (g)	Harvest index (%)
0 (Control)	219.5c	200.34c	19.36a	57.33c	5.82	25.81c	2.08d	36.85b
25 ppm	271.6b	220.55b	16.51b	65.75b	6.76	27.79b	3.05c	37.85b
50 ppm	325.4a	247.38a	9.57c	76.54a	6.22	29.82a	3.85b	32.27c
75 ppm	337.6a	240.50a	10.33c	68.52b	6.19	29.26ab	6.53a	40.36a
Sig. level	**	**	**	**	NS	**	**	**

In a column, figures having same letter (s) do not differ significantly at $p \leq 0.05$ by DMRT, NS =Not significant.

Setting of siliqua/plant (%): The application of different levels of GA₃ influenced the setting of siliqua/plant. The highest setting of siliqua/plant (76.54%) was observed with the application of 50 ppm GA₃ and the lowest (57.33%) was found under control treatment (Table 2). The percentage of setting of siliqua was increased with the increased level of GA₃ upto 50 ppm; however, a higher level of GA₃ decreased the percentage of setting of siliqua/plant.

Length of siliqua: The application of different concentrations of GA₃ on the length of siliqua was insignificant (Table 2), however, the length of siliqua varied from 4.82 to 6.76 cm. The results of the present study is similar to the findings of Bouttier and Morgan (1992) who reported that GA₃ at various levels sprayed on mustard showed no positive influence on length of siliqua. But, Sayed *et al.* (1997) reported that the application of GA₃ had increased the pod length. Ancha and Morgan (1996) stated that spraying of GA₃ at flowering stage resulted in an enlarged pod structure in mustard.

Number of seeds/siliqua: The number of seeds/siliqua significantly influenced by different levels of GA₃. The highest number of seeds/siliqua (29.82) was obtained from 50 ppm GA₃, which was statistically similar with 75 ppm and the lowest number (25.81) was recorded from the untreated control (Table 2). The results showed that the number of seeds/plant was increased over the control with the increasing levels of GA₃. This indicated that GA₃ had direct effects on seed formation. The plant growth regulators like GA₃ is involved in the formation of seeds in the pods and their optimum nourishments resulted in less number of aborted seeds and thus it maximized the survival of fertile seeds/pod in rapeseed and mustard (Inaga and Kumura, 1987; Holmberg and German, 1991; Boultior and Morgan, 1992). Gibberellic acids might increase translocation of assimilates to the seed which increased the number of seeds/plant with the application of different levels of GA₃.

Thousand seed weight: The application of different concentrations of GA₃ had influenced 1000-seed weight (Table 2). However, 1000-seed weight varied from 3.08-3.53 g in different

treatments of GA₃. Saran et al. (1992) stated that *Brassica juncea* seeds soaked in 0, 25, 50, 75 or 100 ppm GA₃ for 12h before sowing resulted in increased shoot length, internodes length and 1000 seed weight.

Harvest index (HI): The results showed that different concentration of GA₃ had significant influence on the harvest index (Table 2). The highest harvest index (40.36%) was observed from 75 ppm GA₃, which was statistically similar with 50 ppm and the lowest (32.27%) was obtained in the control treatment. The higher harvest index indicated that GA₃ application accelerated assimilate supply to sink, which is in agreement with the results of Goupping and Etmal (1992). GA₃ at 0-75 mg/L applied at 600 liters/ha at the pre-flowering stage on Indian mustard (*Brassica juncea*) was reported to increase the harvest index (Khan, 1997).

Table 3: Effects of GA₃ on siliqua shattering and seed yield of mustard

Treatment	Percentage of shattered siliqua at different harvesting dates				Seed yield/plant (g)at different harvesting dates				
	Optimu m date	4 days later	7 days later	10 days later	optimu m date	4 days later	7 days later	10 days later	% yield loss (harvest at 10 days later)
0 (Control)	0.00	0.77a	1.55a	5.70a	9.20d	8.19c	7.10d	5.65b	47.29a
25 ppm	0.00	0.63a b	1.23a b	4.11a	11.05c	10.26 b	9.18c	6.44b	44.79b
50 ppm	0.00	0.36b	0.83b	2.95b	13.13a	12.63 a	12.15 a	11.20a	15.34d
75 ppm	0.00	0.43b	0.94b	3.23a	12.90b	12.63 a	11.73 b	9.78ab	25.87c
Sig. level	NS	**	**	**	**	**	**	**	**

In a column, figures having same letter (s) do not differ significantly at $p \leq 0.05$ by DMRT, NS =Not significant.

Percentage of shattered siliqua/plant: The percentage of shattered siliqua/plant was greatly influenced by the application of different levels of GA₃ (Table 3). The highest percentage of shattered siliqua (5.70) was recorded in the control treatment at 10 days after the optimum harvesting date, which was statistically identical with the application of 75 ppm and 25 ppm concentration of GA₃, respectively, and the lowest percentage of siliqua shattering (2.95) was observed with 50 ppm of GA₃. The results revealed that the percentage of shattered siliqua decreased with the increasing levels of GA₃ up to 50 ppm; however, further increase in the levels of GA₃ was also effective against siliqua shattering with different harvesting dates. The yield losses due to siliqua shattering were reduced by the application of 50 ppm of GA₃ and it would be a recommended dose of GA₃ to reduce yield losses due to siliqua shattering. It was also observed that the percentage of shattered siliqua/plant was higher with the delayed harvest. At optimum time, shattering was zero, and at 10 days later it was higher for each levels of GA₃ application. However, the shattering was lower at higher concentrations of GA₃, specially at

the rate of 50 ppm.

Seed yield at optimum harvest date: Different levels of GA₃ had significant effects on seed yield/plant (Table 3). The application of 50 ppm GA₃ produced the highest seed yield/plant (13.13g), while the control plant produced the lowest seed yield (9.20 g). The results showed that the seed yield/plant was also increased with the increasing levels of GA₃ up to 50 ppm concentration. The concentration beyond 50 ppm had resulted in decreased seed yield/plant. This might be due to the application of 50 ppm GA₃ resulted more plant height, fertile siliqua/plant, number of seeds/siliqua, and the highest 1000-seed weight than other treatments resulting higher seed yield/plant. This indicated that GA₃ had direct effects on seed yield. The results of the present study are similar to the findings of Jagadeeswari et al. (1998), who stated that the foliar application of GA₃ increased seed yield/plant significantly. It was also supported by Hossain (1974), who applied 50, 100 and 200 ppm of GA₃ on tomato plant, which increased seed yield/plant with higher concentration. The application of 50 ppm of GA₃ was more effective to reduce yield loss due to siliqua shattering. Khan et al. (2002) observed an increased yield of *Brassica juncea* in a field trial when applied GA₃ at the concentration of 0, 10-4, and 10-5 M. GA₃ at 75 mg/L applied at the pre-flowering stage on Indian mustard provided the greatest total seed yield (Khan et al., 2002). Hayat et al. (2001) conducted an experiment with GA₃ at the concentration of 10-6 M on 30 day old plants in mustard and observed that GA₃ increased vegetative growth and seed yield at harvest. Khan et al. (1998) observed in a field experiment of *Brassica juncea* with 10-5 M GA₃ at 40, 60 or 80 days after sowing and found that the application of GA₃ at 40 or 60 days sowing significantly increased seed yield.

Seed yield at 4 days later of optimum harvest date: The results of the experiment showed that the influence of different treatments on seed yield/plant was statistically significant (Table 3). The highest seed yield/plant (12.63 g) was recorded with the application of 50 ppm of GA₃ which was identical of the application of 75 ppm GA₃ and the lowest (8.19 g) was obtained from the control treatment. The application of 25 or 50 ppm of GA₃ increased seed yield/plant in okra, cabbage and groundnut (Jagadesewari et al., 1998; Gundaria et al., 1990).

Seed yield at 7 days later of optimum harvest date: The results of the experiment showed that the influence of different treatments on seed yield/plant was statistically significant (Table 3). The highest seed yield/plant (12.15 g) was recorded with the application of 50 ppm of GA₃, which was similar to the application of 75 ppm GA₃ and the lowest was obtained (7.10g) from the control treatment.

Seed yield at 10 days later of optimum harvest date: The results of the experiment showed that the influence of different treatments on seed yield/plant was statistically significant (Table 3). The highest seed yield/plant (11.20 g) was recorded with the application of 50 ppm of GA₃ and the lowest (5.65 g) from the control treatment.

Yield loss at final harvest: Percent yield loss at final harvest (10 days later) was statistically significant (Table 3). It was observed from the analysis of variance that different levels of GA₃ had significant influence on percent yield loss. The highest yield loss (47.2%) was obtained from the untreated control treatment and the lowest (15.34%) was recorded for 50 ppm GA₃.

The results clearly indicated that the yield loss due to delayed harvesting was significantly reduced with the application of GA₃ and the loss decreased with increased level of GA₃ application up to 50 ppm.

CONCLUSIONS

The experimental result indicated that the application of 50 ppm GA₃ had positive impacts on yield and siliqua shattering of the mustard variety BINA shorisha-6. Mustard incurred more or less 47.29% yield loss due to shattering of siliqua, when harvested 10 days after optimum date. However, the loss had been reduced to 15.34% by the application of 50 ppm GA₃. Therefore, the application of 50 ppm GA₃ seems to have the possibility to increase the yield of mustard. However, the finding is obtained from the research station-based experiment, which needs further trials in fields to come to a concrete conclusion on the usefulness of GA₃ for large-scale mustard production. The results of the study suggest that the application of GA₃ would be recommended for increasing mustard yield and thus it would also reduce the import dependency of oil seeds from other countries.

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