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Effect of foliar application of GABA and Miyodo growth regulators on yield and yield attributes in wheat

M. M. Islam, M. A. Mondal[1], M. M. Ali[2], Q. Y. Akther[3], M. Z. F. A. Begum[1] and A.K.M.A. Prodhan
Department of Crop Botany, [1]Department of Biotechnology, [2]Department of Entomology, [3]Department of Plant Pathology, Bangladesh Agricultural University Mymensing-2202

Abstract: An experiment was carried out in the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to investigate the effect of foliar application of two plant growth regulators (GABA and Miyodo) on growth, yield and yield attributes of wheat. The high yielding variety of whear (Kanchan) was used in this experiment and the concentrations of PGRs were 2mg L^{-1}, 3mg L^{-1} and 4mg L^{-1} with a control. Among PGRs, GABA was performing better result for enhancing those characters compared to Miyodo. The GABA produced the tallest plant, highest number of leaf, tiller number, leaf area, total dry matter, yield and yield attributes. Different concentrations of PGRs enhanced all those parameters significantly over control. Lower concentration of GABA and higher concentration of Miyodo enhanced grain yield over control and shoud the best result compared to all other concentrations of PGRs. The present study clearly indicates that GABA with 2mg L^{-1} and Miyodo at 4 mg L^{-1} could be used for growth and yield of wheat.
Key words: GABA, Miyodo, concentrations, yield in wheat

Introduction

Wheat (*Triticum aestivum* L.), an important cereal crop, belongs to the grass family Gramineae (Poaceae) and is cultivated throughout the world. It ranks first in acreage and production among cereal crops of the world. Wheat is the most important cereal crop next to rice. In Bangladesh, wheat is cultivated throughout the country during Rabi season with or without irrigation. The major wheat producing districts are Rajshahi, Dinajpur, Pabna, Faridpur, Kushtia and Cumilla. The yield of wheat in Bangladesh has been increased obviously with the introduction of high yielding varieties. But the yield is still not satisfactory rather it is low compared to that of the leading wheat growing countries. Use of plant growth regulators (PGRs) might be a useful tool in increasing wheat production. Recently, there has been global realization of the increasingly important role of PGRs in crop production, better growth of crop and yield (Prasad and Paudel, 1994). Many developed countries like Japan, China, Russia, Poland, Korea etc. have been using PGRs to increase crop production. Therefore, information regarding their structure and biochemical properties are unknown to all except few provided by the company. Plant growth regulators (PGRs) are being used as an aid to enhance yield (Nickel, 1982). Miyodo and GABA are synthetic plant growth regulators which can manipulate a variety of growth and yield in various crops. Literature regarding the effect of Miyodo on wheat is very scanty therefore; the present work was designed to study the effect of various concentrations of PGRs (GABA and Miyodo) on morphological, growth, yield and yield attributing characters of wheat in Bangladesh.

Materials and Methods

The experiment was conducted at the experimental field of Bangladesh Agricultural University, Mymensingh, during the period from November, 2006 to March, 2007 in Rabi season using wheat. Geographically the experimental field is located at $24^0 50'$ N Latitude and $90^0 50'$ E longitude at the elevation of 18 m above the sea level (Khan, 1997). The soil of the experimental site contained organic carbon 0.55 %, soluble P 8.88 ppm, exchangeable K 0.09 meq/100g soil, available S 0.5 ppm and available Zn 1.5 ppm. The p^H of the soil was 6.9 (Alom, 2001). Then the field was thoroughly prepared by ploughing, cross ploughing and laddering to get a good tilth with power tiller. The fertilizers were applied @ of 220 kg Urea ha^{-1},180 kg triple super phosphate (TSP) ha^{-1},150 kg muriate of potash (MP) ha^{-1},100 kg gypsum ha^{-1} and 8 ton cowdung ha^{-1} and the fertilizer war applied according to the standard way. For preparation of GABA and Miyodo working solution 2.0 mg, 3.0 mg and 4.0 mg of original powder were added separately to 1 litre of water contained in volumetric flax and spraying was done on wheat plants at afternoon by using a hand sprayer at 35 DAS. Data of growth and morphological characters *viz.* leave numbers, numbers of tillers $hill^{-1}$, leave area, dry weight of root and shoot, length of spike, number of filled grain $spike^{-1}$, number of effective tiller and thousand grain weights were collected. The collected data were statistically analyzed to obtain the level of significance using the MSTAT-C computer package programme developed by Russel (1986). The differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Plant height: The plant growth regulators (PGRs) used in the present study had stimulatory effect on plant height throughout the growth period (Table 1). Data revealed that GABA produced higher plant height than Miyodo at all growth stages. At final harvest, the plant height was 100.86 cm in GABA and 97.88 cm in Miyodo. The result indicates that GABA was more effective than Miyodo in enhancing plant height in wheat. Plant height was influenced significantly by the concentrations of PGRs at all growth stages, except at 45 DAS (Table 1). The PGRs concentrations maintained higher plant height over control. Results

revealed that statistically similar plant height was recorded up to 75 DAS. The tallest plant was obtained at 2mg L^{-1} (100.8 cm) followed by4 mg L^{-1} (99.87cm) at 110 DAS where as control always maintained the shortest plant height. The interaction effect of PGRs on plant height was significantly different at different DAS, except 45 DAS (Table 1). It was revealed that the GABA at 2mg L^{-1} produced the tallest plant (104.65cm) at final harvest. The plant height decreased gradually with the increase of concentration of GABA. Incase of Miyodo at 4mg L^{-1} showed the highest plant height (101.78cm) at final harvest and gradually increased with the increased concentration of Miyodo. Further, plant height increased rapidly until 75 DAS and thereafter increased slowly reaching a peak at physiological maturity at 90 DAS. The plant height of wheat became higher at lower concentration of GABA and higher concentration of Miyodo. The plant height was consistent with the result of Rahman (2006) who reported that the Miyodo treated plants showed increased plant height with higher concentration compared to control and this may be due to increase number of internodes or length of internodes because of increased cell number. Plant height increment is the result of cell expansion, cell elongation and cell division. The application of PGRs might have activated the hormonal activities which ultimately led to stem elongation in wheat plant.

Table 1. Effect of GABA and Miyodo on the plant height and number of tillers hill^{-1} in wheat

Treatments	Plant height (cm)					No. of tillers hill^{-1}				
	45DAS	60 DAS	75 DAS	90 DAS	110 DAS	45 DAS	60 DAS	75 DAS	90 DAS	110 DAS
Hormone										
GABA	40.43	74.33	94.23	99.87	100.86	3.39	3.77	6.48	7.77	7.77
Miyodo	41.00	73.21	92.00	97.35	97.88	3.04	3.44	6.38	7.03	7.03
Concentration										
Control	40.70	68.13b	78.73c	84.04c	86.35c	2.71c	2.92c	4.00c	4.37d	4.38d
2 mg L^{-1}	41.63	74.70a	97.37a	99.95a	100.8a	3.38a	3.88a	7.46a	7.93a	7.94a
3 mg L^{-1}	42.29	75.79a	96.58a	98.30b	99.97b	3.54a	3.87a	6.88b	7.73ab	7.74ab
4 mg L^{-1}	38.25	76.46a	95.46b	97.93b	99.87b	3.25b	3.75b	6.82b	7.43b	7.44b
Interaction										
GABA x Control	37.33	67.17c	74.50d	81.75d	86.08e	2.58de	3.00de	3.75e	3.91c	3.92e
GABA x 2 mgL^{-1}	43.33	76.75a	100.25a	104.45a	104.65a	4.25a	4.50a	8.42a	9.00a	9.00a
GABA x 3 mgL^{-1}	40.92	76.75a	95.58b	97.03d	99.98c	3.50bc	4.00b	6.83cd	7.99c	7.99c
GABA x 4 mgL^{-1}	40.17	76.67a	91.25c	94.23f	97.96de	3.25bcd	3.58c	6.50d	7.01de	7.02de
Miyodo x Control	39.17	69.08c	83.17d	86.32g	86.62g	2.83cde	2.83e	4.25e	4.50g	4.51g
Miyodo x 2 mgL^{-1}	38.08	72.66ab	94.50b	95.46de	96.85f	2.50e	3.25cd	6.50d	6.86f	6.87f
Miyodo x 3 mgL^{-1}	43.08	74.83a	97.58a	99.58c	99.96e	3.00cde	3.50c	6.88ef	7.25bc	7.26ef
Miyodo x 4 mgL^{-1}	43.67	76.25a	99.67a	101.62bc	101.78bc	3.83ab	4.16ab	7.91ab	8.46bc	8.47bc

In a column, figures with common letter(s) do not differ significantly at 5% level as per DMRT.

Crop growth rate (CGR): CGR changes with its growth (Tanaka, 1983) and reaches maximum at panic emergence and decrease soon after panicle emergence (Wilson and Ellis, 1981). The CGR increased gradually up to 45-75 DAS and decreased thereafter. The higher crop growth rate was obtained with GABA (66.24g m^{-2} day^{-1}) compared to Miyodo (59.16gm^{-2} day^{-1}) at 60-75 DAS. Crop growth rate was promoted differently with different concentrations of PGRs (GABA and Miyodo) at different days after sowing (Table 2). All concentrations of PGRs enhanced CGR significantly over control. The highest (70.83g m^{-1} day^{-1}) crop growth rate was obtained with 2mg L^{-1} concentration followed by 4mg L^{-1} (69.58g m^{-2} day^{-1}) which was statistically similar to 3mg L^{-1} (69.56g m^{-2} day^{-1}) at 60-75 DAS. In contrast, control produced the lowest (40.80g m^{-2} day^{-1}) CGR at all growth stages due to production of less amount of TDM. The interaction effect of application of different concentrations of PGRs significantly enhanced the crop growth rate at different DAS (Table 2). At 60-75 DAS, the highest crop growth rate was attained with GABA at 2mg L^{-1} (80.83 g m^{-2} day^{-1}) followed by GABA at 3mg L^{-1} (75.83g m^{-2} day^{-1}). In Miyodo, 4mg L^{-1} proved the best (74.16 g m^{-2} day^{-1}) compared to its other concentrations. These results are consistent with the results of Rahman (2006) who reported that the plant of 5.0mg L^{-1} of Miyodo application maintained the highest CGR value in most of the growth stages in mungbean. The lower value of CGR at initial stages of growth was the result of lower LAI. This result is an agreement with the findings of Prasad *et al.* (1978).

Length of spike: Length of spike was not influenced statistically by different PGRs (Table 3). The plant treated with GABA produced the longer spike (9.10cm) compared to Miyodo (8.97cm). The effect of different concentrations of PGRs on spike length is shown in Table 3. The highest (9.33cm) spike length was obtained with 2mg L^{-1} concentration which was statistically similar to 3mg L^{-1} (9.29cm) followed by 4mg L^{-1} (9.25cm) concentrations. The lowest (8.32cm) spike length was obtained at control plants. The interaction effect of different concentrations of PGRs (GABA and Miyodo) on spike length was statistically significant (Table 3). The highest spike length (9.60cm) was found at 2mgL^{-1} of GABA which was identical to all other concentrations of GABA and

Miyodo. The PGRs concentrations were better for spike length compared to that of control. Hoque (2002) reported that the length of spike in GABA treated plant was significantly higher than that of other PGRs treatments in wheat.

Number of spikelet spike^{-1}: The effect of different PGRs on number of spikelet spike^{-1} is presented in Table 3. The GABA produced the higher (17.93) spikelet spike^{-1} compared to Miyodo (17.31). The highest (18.01) spikelet spike^{-1} was obtained with 2mg L^{-1} concentration which was statistically identical to 3mg L^{-1} (17.80) and 4mg L^{-1} (17.89). The lowest spikelet spike^{-1} was found at control (16.45). The interaction effect of different concentrations of GABA and Miyodo on number of spikelet spike^{-1} was statistically significant (Table 3). The result revealed that 2mg L^{-1} of GABA produced the highest number of spikele spike^{-1} (19.70) followed by 4mg L^{-1} of Miyodo (18.50) which was similar to that of 3mg L^{-1} of GABA (18.11) and 3mg L^{-1} of Miyodo (17.50). GABA produced the higher spikelet spike^{-1} (average of 18.37) over that of Miyodo (average 17.44). Thus GABA is superior to Miyodo in enhancing the number of spikelet spike^{-1}. Hoque (2002) reported that application of GABA at 0.33ml L^{-1} produced the highest spikelet number over other concentrations of PGRs in wheat. Application of GA_3 (10^{-5} M) or IAA (10^{-5} M) in wheat plant enhanced the spikelet per spike compared to untreated control (Gurdev and Saxena, 1991). The present study agrees with those reports.

Number of effective tillers hill^{-1}: The application of GABA and Miyodo had stimulatory effect on number of effective tillers hill^{-1} (Table 3). The higher number of effective tillers hill^{-1} was observed in GABA (4.27) compared to Miyodo (3.58). The number of effective tillers hill^{-1} was varied significantly among the concentrations of PGRs (GABA and Miyodo) (Table 3). The interaction effect of different concentrations of PGRs (GABA and Miyodo) showed statistically significant variations in the number of effective tillers hill^{-1} (Table 3). The maximum number of effective tillers hill^{-1} (5.50) was recorded at 2mg L^{-1} GABA followed by 3mg L^{-1} GABA (4.30) which was statistically identical to 4mg L^{-1} of GABA (4.26), 4mg L^{-1} of Miyodo (4.20), 3mg L^{-1} Miyodo (4.0) and 2mg L^{-1} of Miyodo (3.46). The GABA was better (average of 4.69) than Miyodo (average of 3.89) in increasing the number of effective tillers hill^{-1}. This finding was supported by Pathan (2006) in aman rice, who reported that application of 1.00mg L^{-1} GABA produced the highest number of effective tillers hill^{-1} (11.73) while the lowest number of effective tiller hill^{-1} (9.00) was recorded in the control treatment.

Number of filled grains spike^{-1}: Variations in the number of filled grains spike^{-1} were found in different treatments of GABA and Miyodo (Table 3). The result revealed that filled grain spike^{-1} was increased over control due to application of PGRs. The higher number of filled grains spike^{-1} was observed with GABA (27.70) compared to Miyodo (25.60). The result revealed that the filled grains spike^{-1} increased over control due to application of PGRs. The highest (33.42) filled grains spike^{-1} was obtained with 2mg L^{-1} concentration followed by 3mg L^{-1} (30.99) and 4mg L^{-1} (29.86) concentrations and the lowest was found at control (18.84). Incase of interaction effect the highest number of filled grains spike^{-1} was obtained from 2mg L^{-1} GABA (38.36) followed by 4mg L^{-1} Miyodo (33.43) which was identical to 3mg L^{-1} GABA (32.31). The lowest filled grain spike^{-1} was observed in control. It was revealed from the result that GABA (average of 32.32) was superior to Miyodo (average of 30.53) in enhancing the number of filled grains spike^{-1}. The present result is consistent with the result of Zhang *et al.,* (1989) who reported that application of GA_3 at 20, 100 ppm in wheat increased the number of filled grains per ear.

Number of unfilled grain spike^{-1}: The higher number of unfilled grain spike^{-1} was observed with Miyodo (3.16) as compared to that of GABA (2.88). The maximum number of unfilled grains spike^{-1} was obtained at control plants (3.83) compared to that of PGRs treated plants. The lowest number of unfilled grains spike^{-1} was found at 4mg L^{-1} concentration (2.55) which was statistically similar to 2mg L^{-1} (2.62) and 3mg L^{-1} (3.08) concentrations. The interaction effect shooed that the highest number of unfilled grains spike^{-1} was recorded at control (4.16) with Miyodo and the lowest number of unfilled grains spike^{-1} was obtained with 2mg L^{-1} GABA (2.26) which was statistically identical to Miyodo at 4mg L^{-1}. It was revealed from the result that PGRs were effective in reducing the number of unfilled grains spike^{-1} (average of 2.76) compared to control (average of 3.83). Between the PGRs, GABA (average of 2.68) was more effective than Miyodo (average of 2.83) in reducing the number of unfilled grain spike^{-1}. Similar result was reported by Pathan (2006) in aman rice.

Grain yield: Variation in grain yield was found between the PGRs (Table 3). The higher grain yield was recorded at GABA (3.63) compared to Miyodo (2.95). The highest grain yield was recorded at 4mg L^{-1} concentration (3.23 t ha^{-1}) which was statistically identical to 2mg L^{-1} (3.19 ton ha^{-1}) and 3mg L^{-1} (3.12 ton ha^{-1}). The lowest grain yield was obtained with control (2.50 ton ha^{-1}). The interaction effect of grain yield was significantly different at different concentrations of PGRs (GABA and Miyodo) (Table 3). The highest grain yield was found at 2mg L^{-1} GABA (3.63 ton ha^{-1}) which was similar to that of 4mg L^{-1} Miyodo (3.45 ton ha^{-1}). The lowest grain yield was obtained at controlled treatment (2.50 ton ha^{-1}) followed by 2mg L^{-1} Miyodo (2.76 ton ha^{-1}). Both the PGRs were effective in increasing grain yield in wheat. But GABA was more effective (average of 3.25 ton ha^{-1}) than Miyodo (average of 3.11 ton ha^{-1}) as compared to control (2.50 t/ha^{-1}). The result is consistent by Afroz (2005), he reported that application of GABA at 2mg L^{-1} produced maximum grain yield in rice (8.06 ton ha^{-1}) than others. Hoque (2002) reported that application of GABA at 0.33ml L^{-1} in wheat plant produced the highest grain yield (4.0 ton ha^{1}).

Treatment of sorghum seeds with 50, 100 or 200 ppm of GA_3 (Shinde *et al.*, 1989) and wheat seeds with 15 ppm of GA_3 (Singh *et al.*, 1987) resulted in higher grain yield over untreated control.

Table 2. Effect of GABA and Miyodo on total dry matter and crop growth rate in wheat

Treatments	Total dry matter (TDM) (g)				Crop growth rate (CGR) (g m^{-2} day^{-1})		
	45 DAS	60 DAS	75 DAS	90 DAS	45-60 DAS	60-75 DAS	75-90 DAS
Hormone							
GABA	2.055	4.343	15.43	17.70	12.915	66.24	14.70
Miyodo	1.974	3.600	15.18	17.68	9.691	59.16	11.45
Concentration							
Control	1.88	2.82 c	10.06 b	12.24 c	6.66	40.80 c	14.16 ab
2 mg L^{-1}	2.03	4.81 a	17.37 a	20.48 a	12.08	70.83 a	16.50 a
3 mg L^{-1}	2.02	4.20 b	17.05 a	18.92 b	11.47	69.56 b	9.58 c
4 mg L^{-1}	2.13	4.04 b	16.74 a	19.13 b	15.00	69.58 b	12.08 b
Interaction							
GABA x Control	1.80	2.65 e	10.25 c	12.13 d	6.66 e	40.82 g	14.16 b
GABA x 2 mg L^{-1}	2.24	5.65 a	18.56 a	22.32 a	20.00 a	80.83 a	19.66 a
GABA x 3 mg L^{-1}	2.12	4.44 b	16.17 b	18.58 bc	12.50 b	75.83 b	14.16 b
GABA x 4 mg L^{-1}	2.10	4.29 bc	15.65 b	17.78 c	12.50 b	67.50 d	10.83 bcd
Miyodo x Control	1.83	2.68 e	9.78 c	12.34 d	6.66 e	40.80 g	14.16 b
Miyodo x 2 mg L^{-1}	1.91	3.78 d	16.18 b	18.63 bc	10.00 d	58.33 f	8.320 d
Miyodo x 3 mg L^{-1}	1.99	3.96 cd	17.31 ab	19.69 bc	10.44 d	63.33 e	10.00 cd
Miyodo x 4 mg L^{-1}	2.17	3.97 cd	18.44 a	20.06 b	11.66 c	74.16 c	13.33 bc

In a column, figures with common letter(s) do not differ significantly at 5% level as per DMRT.

Table 3. Effect of GABA and Miyodo on the yield and yield contributing characters in wheat

Treatments	Length of spike (cm)	No. of spikelets $spike^{-1}$	No. of effective tillers $hill^{-1}$	No. of Filled grains $Spike^{-1}$	No. of unfilled grains $spike^{-1}$	1000- grain weight (g)	Grain yield (t ha^{-1})	Harvest index (%)
Hormone								
GABA	9.10	17.93	4.27	27.70	2.88	40.29	3.63	44.46
Miyodo	8.97	17.31	3.58	25.60	3.16	40.03	2.95	42.00
Concentration								
Control	8.32b	16.45b	2.83c	18.84c	3.83a	36.16c	2.50b	37.00d
2 mg L^{-1}	9.33a	18.01a	4.48a	33.42a	2.62b	41.52a	3.19a	45.00a
3 mg L^{-1}	9.29a	17.89a	4.15b	30.99b	3.08b	40.45b	3.12a	44.00b
4 mg L^{-1}	9.25a	17.80a	4.23b	29.86b	2.55b	40.30b	3.23a	43.50c
Interaction								
GABA x Control	8.33b	16.97d	3.00c	18.44e	3.50a	36.13b	2.50d	37.00f
GABA x 2 mg L^{-1}	9.60a	19.70a	5.50a	38.36a	2.26c	43.63a	3.63a	49.00a
GABA x 3 mg L^{-1}	9.43a	18.11bc	4.30b	32.31b	3.01b	41.91a	3.12b	44.00d
GABA x 4 mg L^{-1}	9.16a	17.29c	4.26b	26.29d	2.77b	38.43b	3.00b	42.00c
Miyodo x Control	8.32b	15.94d	2.66c	19.25e	4.16a	36.13b	2.50d	37.00f
Miyodo x 2 mgL^{-1}	9.06a	16.32cd	3.46bc	28.48cd	2.98b	36.97b	2.76c	41.00e
Miyodo x 3 mgL^{-1}	9.07a	17.50bc	4.00b	29.67c	3.16b	41.13a	3.12b	44.00c
Miyodo x 4 mgL^{-1}	9.43a	18.50b	4.20b	33.43b	2.34bc	42.47a	3.45a	45.00b

In a column, figures with common letter (s) do not differ significantly at 5% level as per DMRT.

Harvest index (HI): Data on HI of present experiment are presented in Table 3. Data revealed that GABA produced the higher harvest index (44.46 %) than that of Miyodo (42.00 %). The highest harvest index (45.00 %) was found at 2mg L^{-1} concentration followed by 3mg L^{-1} (44.00 %) and 4mg L^{-1} (43.50 %). The lowest harvest index was found at control (37.00 %). The interaction effect of different concentrations of PGRs (GABA and Miyodo) had significantly influenced on harvest index in wheat (Table 3). The highest harvest index (49%) was found at 2mg L^{-1} GABA followed by 4mg L^{1} Miyodo (46%) and 3mg L^{-1} Miyodo (44%). The lowest harvest index was obtained at control (37%) followed by 2mg L^{-1} Miyodo (41%) and 4mg L^{-1} GABA (42%). Both the PGRs increased harvest index (average of 44.34%) over control (37%) being 7.34% over untreated plants. However, GABA (average of 45%) was more effective than Miyodo (average of 43.67%) in increasing harvest index in wheat. Hoque (2002) soaked wheat seeds in 0.16, 0.33 and 0.66ml L^{-1} solutions of GABA, TNZ-303 and CI-IAA respectively and observed that 0.33ml L^{-1} of GABA enhanced the highest harvest index (47.19%) which was statistically identical to that of

0.66ml L^{-1} (46.41%) of same PGR. Wheat cultivar Sonalika was treated with 10 ppm GA_3 or 10 ppm IAA + $ZnSO_4$. The GA_3 treating plants showed the highest harvest index compared to 10 ppm IAA+ $ZnSO_4$ (Baruah, 1990). The present result agrees with this report

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