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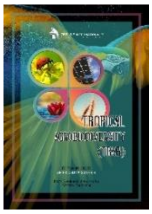

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RESEARCH ARTICLE

PLANT GROWTH REGULATORS (PGR): THEIR EFFECT ON GROWTH AND YIELD TRAITS IN RAPESEED

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ABSTRACT

A field experiment was conducted at Farmers field Fulbaria, Mymensingh and Tarail, Kishoreganj during the Rabi season 2021-22 and 2022-23. The objective of the study was to find out the effect of plant growth regulators (PGR) on growth, yield and yield contributing characters of rapeseed. There the four common plant growth regulators namely Flora (Nitrobenzene 3g/L), Power (Gibberellic acid 20%, 1g/20L), Bioferty (Auxin + Amino acid 3g/L), Bumper folon (Chlorophenoxy acidic acid 3g/L) were used with the popular BINA released rapeseed variety Binasarisha-9 and Binsarisha-11. The plant growth regulators were sprayed over the rapeseed field at the vegetative growth stage at 30 days after sowing. The experiment was conducted through randomized complete block design (RCBD) with three replications. The unit plot size was 5m×4m. Data on yield and yield components were recorded at harvest and analyzed statistically following the experimental design and means were compared with LSD. The result of the experiment showed that Bumper folon (Chlorophenoxy acidic acid 3g/L) produced statistically higher seed yield (1.8 tha^{-1}) among the plant growth regulators followed by Bioferty (Auxin +Amino acid 3g/L) and Flora (Nitrobenzene 3g/L) (1.7 t ha^{-1}). The plant height (92.4 cm) and 1000 seed weight (4.1 g) also highest for Bumper folon (Chlorophenoxy acidic acid 3g/L) but maturity duration was lowest (78.2 days).

KEYWORDS

PGR; Yield; Rapeseed

1. INTRODUCTION

Brassica napus and Brassica campestris are types of rapeseed, which belong to the Brassicaceae family and are valuable oilseed crops worldwide. In Bangladesh, two types of oilseeds are grown in the Brassicaceae family: mustard and rapeseed, contributing to around 3-5% of the national oil production (Miah et al., 2015). Rapeseed plants are a good source of oil and a valuable source of vegetables. Consuming these vegetables provides people with different soluble fibers, anti-cancer properties, and vitamins such as C and E (Zhang et al., 2022). According to the report of the Bangladesh Bureau of Statistics, mustard and rapeseed cover almost 80% of the total oilseed crop area in Bangladesh (Miah et al., 2015). The total cultivated area of rapeseed and mustard is 0.234 million hectares, with over 0.203 million ton of oil produced per year in Bangladesh (BARI, 2011). Data collected from the National Board of Revenue shows that around 25.7 lakh tons of soybean and palm oil were imported in 2023 to mitigate a large oil deficit; proper attention needs to be taken (The Daily Star, April 21, 2024). There are four common growth regulators, namely Flora (Nitrobenzene), Power (Gibberellic acid 20%), Bioferty (Auxin + Amino acid), and Bumper folon (Chlorophenoxy acetic acid), which are used for the growth and development of rapeseed plants. These growth regulators increase seed germination, cell division, cell elongation, pollen development, pollen tube growth, and fruit growth of rapeseed plants. Nitrobenzene can help promote vigorous growth and development in plants, increasing vegetative growth, and resulting in foliage and overall plant health (Haque et al., 2024). Gibberellic acid (GA_3) is a plant growth regulator that requires small quantities at low concentrations to be involved in plant cell elongation and other physiological activities (Suresh et al., 2018). Auxin is the first identified growth hormone derived from the amino acid tryptophan. It promotes cell division, cell differentiation, cell expansion, and stem and root growth in plants (Gomes and Scortecci, 2021). Chlorophenoxy acetic acid is a growth hormone that can be used to control fruit and root growth. It is also helpful in preventing flower and fruit drop. Chlorophenoxy acetic acid is absorbed into the plant body through leaves, stems, flowers, and root (Zhang et al., 2022). Auxins are known to stimulate cell elongation and root development. As demonstrated that auxin application increased plant height and leaf area, resulting in higher biomass accumulation (Khan et al., 2023). Plant growth regulators (PGRs) can potentially play a fundamental role in regulating plant responses to various abiotic stresses and hence, contribute to plant adaptation under adverse environments. The major effects of abiotic stresses are growth and yield disturbance, and both these effects are directly overseen by the PGRs (Sabagh et al., 2021). Auxin treatment improved pod formation and seed set, contributing to enhanced yields (Shahid et al., 2021). Gibberellins promote stem elongation and flowering. Gibberellin application led to a significant increase in the number of pods per plant and seeds per pod, thereby increasing overall seed yield according to (Hussain et al., 2019). Gibberellins enhanced the seed weight and oil content in rapeseed, making it a promising regulator for oilseed production (Ali et al., 2022). Cytokinins play a crucial role in cell division and delay leaf senescence. As found that cytokinin application improved chlorophyll content and photosynthetic efficiency, resulting in increased biomass and yield (Zhang et al., 2020). Furthermore, Cytokinin treatment led to a higher number of branches and pods, enhancing yield potential. Ethylene, often associated with stress responses, has been shown to influence flowering and fruit set. Ethylene application improved stress tolerance in rapeseed, resulting in better yield under adverse conditions (Rahman et al., 2020). The combined application of PGRs has also been explored. A combination of gibberellins and cytokinins resulted

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in synergistic effects, significantly improving growth parameters and seed yield compared to single applications (Mansoor, 2022). The effectiveness of PGRs is highly dependent on the timing and concentration of application. Proper timing during critical growth stages (e.g., flowering, pod development) can maximize their benefits. PGRs can help plants cope with environmental stresses (e.g., drought, salinity) by improving root development and water uptake, ultimately supporting better yield under stress conditions. Cytokinin treatments have resulted in higher chlorophyll content, contributing to improved photosynthetic efficiency. The present research aims to identify effective growth regulators for the growth and yield of rapeseed.

2. Materials and Methods

The experiment was conducted at farmer's field Fulbaria, Mymensingh during the rabi season 2021-22 and Tarail, Kishoreganj during the rabi season 2022-23. The soil texture of the field was sandy loam having pH-6.0-6.6. At first, the field was ploughed 3 to 4 times with the help of tractor. Then the field was leveled by laddering and clean properly. Following the recommendations of the Bangladesh Institute of Nuclear Agriculture (BINA), the following amounts of fertilizer were applied per hectare: Urea 90 kg, murate of potash (MOP) 55 kg, gypsum 60 kg, Zinc Sulfate 4 kg, and Boric Acid 3 kg. The required amount of fertilizer for each plot area was calculated according to varietal fertilizer requirement. In the experiment, the distance between blocks was 1 m, the distance between plots was 0.5 m, and the plant spacing was 25 cm into 5 cm. The gypsum, MOP, and Triple super phosphate (TSP) were applied during the final land preparation. For Urea, half of the portion was applied before sowing the seeds, and the other half was used after the first irrigation. After completing land preparation, sowing was done. The density of the rapeseed sowing was 75 to 80 plants/m^2 and seed used for sowing was 8kg/ha. After 25 days, hand weeding was performed. Then, plant growth regulators (PGR) were sprayed over the rapeseed plot during the vegetative growth stage, 30 days after sowing of Binasharisa-9 and Binasarisha-11. Ten plants were randomly selected and tagged from each plot to analyze yield and yield-contributing characteristics such as plant height, length of the siliqua, primary branch, and thousand seed weight. Plant height and siliqua length were measured, and the primary branch was counted five times before the rapeseed harvest. All collected data were analyzed using analysis of variance (ANOVA) and the LSD technique at a 5% level of significance (Gomez and Gomez, 1984).

3. Results and Discussions

3.1 Plant height

Different concentrations of plant growth regulators (PGRs) showed significant variation in the height of rapeseed plants. By applying these growth regulators at 30 DAS, we observed a notable increase in the mature height of the rapeseed plants. In Mymensingh, the tallest plant measured 97 cm, recorded with the Power (Gibberellic acid 20%, 1g/20L) treatment, while the shortest plants, at 87.3 cm, were found in the control treatment. Among these growth regulators, Power (Gibberellic acid 20%, 1g/20L) recorded the maximum plant height at the mature stage, followed by Bumper folon (Chlorophenoxy acidic acid 3g/L). On the other location, In Kishoreganj, the maximum plant height was obtained from same Power (Gibberellic acid 20%, 1g/20L) treatment (100.25 cm). Gibberellic acid (GA_3) is a vital plant growth hormone that promotes stem elongation, cell division, and various physiological processes in plants. In rapeseed, GA_3 primarily increases plant height by enhancing cell division and elongation. This occurs through the activation of genes responsible for growth and division, including those that encode enzymes that loosen the cell wall, allowing cells to expand (Sasaki et al., 2002). Additionally, GA_3 may help counteract the effects of environmental stress, promoting normal growth patterns, especially in stems, which ultimately leads to taller plants.

3.2 Number of branches

Following the foliar application at 30 days, the plant growth regulators significantly impacted the total number of branches. In Mymensingh, Bioferty (Auxin acid at 3 g/L) resulted in the highest number of branches (2.63), which was statistically similar to Bumper folon (Chlorophenoxy acidic acid at 3 g/L). The control treatment recorded the lowest number of branches. In Kishoreganj, Bumper folon (Chlorophenoxy acidic acid 3g/L) showed the highest number of branches statistically similar to Bioferty (Auxin + Amino acid 3g/L). The control treatment had the lowest number of branches. In both locations, all treatments showed a significantly higher number of branches compared to the control group.

3.3 Number of Siliqua

In Kishoreganj, All the treatment significantly increased number of siliqua per plant except Flora (Nitrobenzene 3g/L) and Power (Gibberellic acid 20%,1g/20L) over control. The maximum number of siliqua per plant was recorded in Bumper folon (Chlorophenoxy acidic acid 3g/L) followed by Bioferty (Auxin +Amino acid 3g/L) and the lowest data was found in Flora (Nitrobenzene 3g/L) over control. In Mymensingh, all the treatment showed positive impact on the number of siliqua per plant. The highest number of siliqua per plant was recorded in Bumper (Chlorophenoxy acidic acid 3g/L) and lowest data was recorded in Flora (Nitrobenzene 3g/L).

3.4 Siliqua length

In Mymensingh, the longest length of siliqua (7.34 cm) was produced by Power (Gibberellic acid 20%, 1g/20L) treatment, whereas Bioferty (Auxin acid at 3 g/L) produced shortest length of siliqua (6.73cm). In Kishoreganj, the longest siliqua was found in Power (Gibberellic acid 20%, 1g/20L treatment plot and Bumper folon (Chlorophenoxy acidic acid 3g/L) treatment plot showed shortest length of siliqua (6.52cm). After foliar application of the four plant growth regulators on rapeseed, Power (Gibberellic acid 20%,1g/20L) showed highest siliqua length in both location because GA_3 is a key regulator of cell elongation by promoting the loosening of cell walls, which allows siliqua cells to expand and development, that elongation contributes to increased pod length. This finding is supported by (Ahmad et al., 2018; Ye and Li, 2021).

3.5 Number of seeds siliqua^{-1}

The highest number of seeds siliqua^{-1} was achieved with GA_3 treatment and the lowest number of seeds siliqua^{-1}was found with Flora (Nitrobenzene 3g/L) treatment at both locations. Gibberellic acid might increase cell division and elongation, translocation of assimilates to the seed influences the reproductive phase by boosting flower and fruit set which could lead to an increased number of seeds per siliqua. In Mymensingh, the maximum number of seeds siliqua^{-1} (25.6) was produced in Power (Gibberellic acid 20%, 1g/20L) and minimum number of seeds siliqua^{-1} (22.40) was obtained by Flora (Nitrobenzene 3g/L) which is statistically similar to the control. In Kishoreganj, the maximum number of seeds siliqua^{-1} (24.63) was obtained by applying Power (Gibberellic acid 20%,1g/20L) treatment and minimum number of seeds siliqua^{-1} (22.73) was produced by Flora (Nitrobenzene 3g/L).

3.6 Thousand seed weight

The average thousand seeds weight varied significantly with the application of the four growth regulators (Table 1 and Table 2). In Mymensingh, the average thousand seed weight ranged from 3.98 gm to 4.09 gm. The maximum thousand seeds weight was found at Bumper folon (Chlorophenoxy acidic acid 3g/L) (4.09 gm) which was similar to Bioferty (Auxin acid at 3 g/L) (4.06 gm) and Flora (Nitrobenzene 3g/L) (3.99 gm). In Kishoreganj, the range of thousand seeds weight was 4.07 gm to 4.28 gm. The maximum thousand seeds weight was obtained Bumper (Chlorophenoxy acidic acid 3g/L) (4.29 gm) which was statistically similar to Bioferty (Auxin acid at 3 g/L) (4.22 gm) and Flora (Nitrobenzene 3g/L) (4.20 gm). This result might be due to Chlorophenoxy Acidic acid promotes cellular elongation and growth which enhance flower development and pod formation, indirectly improving seed weight due to improved hormonal balance (Kaur et al., 2016). Nitrobenzene improves flower retention, nutrient uptake, chlorophyll content, and photosynthesis. This leads to greater dry matter allocation to seeds, ultimately increasing seed weight.

3.7 Seed yield

In Mymensingh, the highest yield was recorded with the application of Bumper folon (Chlorophenoxy acidic acid 3g/L) (1.84 t/ha) which was statistically similar with Bioferty (Auxin acid at 3 g/L) (1.81 t/ha) and Flora (Nitrobenzene 3g/L) (1.77 t/ha) (Table 1). On the other hand in Kishoreganj the maximum yield was obtained by the application of Bumper folon (Chlorophenoxy acidic acid 3g/L) (1.89 t/ha) which was statistically similar with Bioferty (Auxin acid at 3 g/L)(1.86 t/ha) Power (Gibberellic acid 20%,1g/20L(1.84 t/ha) and Flora (Nitrobenzene 3g/L) (1.83 t/ha)(Table 2).The least data was recorded in control treatment (1.7 t/ha). Bumper folon (Chlorophenoxy acidic acid 3g/L) produced the best results in both locations by mitigating environmental stress, improving flowering, branching, and fruit set, which contribute to better biomass and higher yields under various growing conditions. These results are closely similar with the findings (Baliyan et al., 2013).

Mymensingh:

The application of Bumper folon (Chlorophenoxy acidic acid 3g/L) produced statistically higher seed yield (1.8 tha^{-1}) among the plant growth regulators followed by Bioferty (Auxin +Amino acid 3g/L) and Flora (Nitrobenzene 3g/L) (1.7 t ha^{-1})

Table 1: Effect of plant growth regulators on growth, yield and yield contributing characters of rapeseed.

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Siliqua length (cm)	Seeds siliqua^{-1} (no.)	1000 seed wt. (g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Crop duration (days)
Varieties									
Binasarisha-9 (V_1)	86.03	2.36	38.75	6.89	24.07	3.98	1.71	3.52	86
Binasarisha-11 (V_2)	100.94	2.63	36.86	7.17	24.07	4.08	1.77	3.91	77
Level of significance	**	**	*	NS	NS	**	NS	*	
Plant growth regulators									
Control (T_0)	87.73	2.1	35.56	7.0	22.46	4.02	1.50	3.39	
Flora (Nitrobenzene 3g/L) (T_1)	93.73	2.51	36.66	7.28	22.4	3.99	1.77	3.55	
Power (Gibberellic acid 20%, 1g/20L) (T_2)	97	2.53	38.23	7.34	25.6	3.98	1.76	3.71	
Bioferty (Auxin +Amino acid 3g/L) (T_3)	94.35	2.71	39	6.73	25.13	4.06	1.81	3.92	
Bumper folon (Chlorophenoxy acidic acid 3g/L) (T_4)	94.61	2.63	39.56	6.81	24.76	4.09	1.84	4.01	
$LSD_{0.05}$	3.77	0.20	3.0	0.48	1.63	0.17	0.05	0.28	
Varieties× Plant growth regulators									
$V_1 \times T_0$	82.97	1.8	35.9	6.67	22.46	4.03	1.46	3.28	
$V_1 \times T_1$	86.07	2.33	38.93	7.19	22.4	3.9	1.68	3.42	
$V_1 \times T_2$	89	2.43	40	7.37	25.6	3.9	1.76	3.64	
$V_1 \times T_3$	81.5	2.63	38.86	6.5	25.13	4.05	1.82	3.62	
$V_1 \times T_4$	90.63	2.6	40.06	6.7	24.76	4.03	1.81	3.64	
$V_2 \times T_2$	92.5	2.4	35.23	7.34	22.46	4.02	1.55	3.51	
$V_2 \times T_0$	101.4	2.68	34.4	7.37	22.4	4.08	1.86	3.67	
$V_2 \times T_1$	105	2.63	36.46	7.3	25.6	4.06	1.76	3.77	
$V_2 \times T_3$	107.2	2.8	39.13	6.92	25.13	4.08	1.81	4.22	
$V_2 \times T_4$	98.6	2.66	39.06	6.92	24.76	4.14	1.87	4.38	
$LSD_{0.05}$	5.33	0.29	4.32	0.67	2.31	0.25	0.08	0.40	
CV (%)	3.33	6.84	6.67	5.63	5.6	3.64	2.81	6.38	

Kishoreganj:

The application of Bumper folon (Chloro-phenoxy acetic acid 3 g/L) resulted in the highest statistically significant seed yield of 1.89 t ha^{-1}, followed by Bioferty (Auxin + Amino acid 3 g/L). The Bumper treatment also produced the highest number of branches per plant 2.92 and siliqua per plant 52. These findings suggest that the use of specific plant growth regulators can significantly enhance the growth and yield of rapeseed (Table 2).

Table 2: Effect of plant growth regulators on growth, yield and yield contributing characters of rapeseed

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Siliqua plant^{-1} (no.)	Siliqua length (cm)	Seeds siliqua^{-1} (no.)	1000 seed wt. (g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Crop duration (days)
Varieties									
Binasarisha-9 (V_1)	92.65	2.62	51.16	6.53	23.27	4.17	1.76	3.94	
Binasarisha-11 (V_2)	100.94	2.84	51.35	6.76	23.47	4.23	1.85	4.33	
$LSD_{0.05}$	**	**	NS	NS	NS	NS	NS	*	
Plant growth regulators									
Control (T_0)	92.25	2.33	50.93	6.58	23.03	4.22	1.70	3.88	81.42
Flora (Nitrobenzene 3g/L) (T_1)	96.92	2.71	51.07	6.75	22.73	4.20	1.83	4.09	80.83
Power (Gibberellic acid 20%, 1g/20L) (T_2)	100.25	2.78	50.25	6.82	24.63	4.07	1.84	4.28	82.00

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Table 2 (cont): Effect of plant growth regulators on growth, yield and yield contributing characters of rapeseed

Bioferty (Auxin +Amino acid 3g/L) (T_3)	98.32	2.90	51.90	6.57	24.07	4.22	1.86	4.23	81.35
Bumper flon (Chlorophenoxy acidic acid 3g/L) (T_4)	96.25	2.92	52.12	6.52	23.37	4.28	1.89	4.21	82.17
LSD $_{0.05}$	2.94	0.26	3.43	0.36	1.30	0.13	0.04	0.19	
Varieties× Plant growth regulators									
$V_1 \times T_0$	92.00	2.03	52.83	6.30	23.47	4.20	1.70	3.64	
$V_1 \times T_1$	92.50	2.63	49.03	6.87	22.60	4.23	1.70	4.11	
$V_1 \times T_2$	92.43	2.53	53.43	6.70	22.13	4.23	1.76	3.87	
$V_1 \times T_3$	101.40	2.89	48.70	6.80	23.33	4.17	1.89	4.31	
$V_1 \times T_4$	95.50	2.70	50.13	6.93	23.07	4.03	1.84	4.06	
$V_2 \times T_2$	105.00	2.87	50.37	6.70	24.20	4.11	1.85	4.49	
$V_2 \times T_0$	89.43	2.83	49.90	6.33	24.53	4.17	1.86	4.07	
$V_2 \times T_1$	107.20	2.97	53.90	6.80	23.60	4.27	1.86	4.39	
$V_2 \times T_3$	93.90	3.00	49.50	6.40	23.13	4.20	1.85	4.06	
$V_2 \times T_4$	98.60	2.83	54.73	6.63	23.60	4.37	1.92	4.35	
LSD $_{0.05}$	4.16	0.37	4.85	0.51	1.85	0.18	0.06	0.28	
CV (%)	2.51	7.82	5.52	4.48	4.60	2.50	1.95	3.88	

4. Conclusion

Plant growth regulators PGRs positively influence plant height, leaf area, and overall biomass. the number of pods per plant, seeds per pod, and seed weight, which are critical yield-contributing factors. PGRs enhance photosynthetic efficiency and stress tolerance, allowing rapeseed to better adapt to environmental challenges. PGRs improved water use efficiency and nutrient uptake, which are essential for optimal growth and yield under varying conditions. The effectiveness of PGRs is influenced by the type, concentration, and timing of application. Research highlights the importance of optimizing these parameters to maximize the benefits for rapeseed cultivation and improving the productivity and resilience of rapeseed crops. Bumper folon (Chlorophenoxy acidic acid 3g/L) showed the highest number of thousand seeds weight, seeds siliqua^{-1} and ultimately the seed yield. Further research is needed to explore the specific mechanisms of action of various PGRs and their interactions with environmental factors, ensuring tailored applications for different agro-climatic conditions.

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