Effect of Foliar Applied of Barassinosteroid and Gibberellic Acid on Vegetative Growth, Flowering and Chemical Constituents of *Petunia hybrida* plants

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ABSTRACT

This study was carried out at the Nursery of Department of Floriculture, Ornamental Horticullture and Landscape Gardening, Faculty of Agriculture, Alexandria University, Alexandria, Egypt, during the growing seasons 2022 and 2023. The aim of this study was to determine the vegetative growth, flowers and characteristic components through pen test for the pen effect of barssinostroids (Brs) and gebbrellic acid (GA_3) of *Petunia hybrida* plants. Petunia plants were sprayed with either gebbrellic acid (GA_3) at three doses (zero, 100, and 200 mg/l) or barssinostroids (Brs) at four concentrations (zero, 1, 2, and 4 mg/l) each alone or with all possible combination, between them (12 treatments). BRs at 1 mg/l gave the best results for bud height, diameter, fresh and dry weight reproductive leaves flower diameter, and number of flowers, while 4 mg/l of brassinostroid gave the highest chlorophyll content A, B, and total carbohydrate of petunia plants, stem diameter, flower number, flowering period, root length, and root number. The flower diameter, chlorophyll A, chlorophyll B, flowering duration, total carbohydrates, leaf area, and stem diameter were measured when gibberellic acid alone was applied at 200 mg/l. The best results were obtained when we used both barassinostroids and gibberellic acid at 1 mg/l of barassinostroids and at 100 mg/l of gibberellic acid, shoot high and flower diameter while using 4 mg/l of brasssinostroid with 100 mg/l of gibberllic acid for non–buds and flower diameter while 4 mg/l of brasssinostroid with 100 mg/l of gibberellic acid gave total carbohydrates, fresh weight and limited area, compared with other treatments.

Keywords: *Petunia hybrida*, brassinostroides (BRs), gibberellic acid (GA_3), growth regulators, chlorophyll, Total carbohydrates.

INTRODUCTION

The *Solanaceae* family of flowering plants includes the genus petunia, which is indigenous to South America. Petunia flowers are the ideal option for adding a burst of color and beauty to your garden or containers with their profusion of showy, trumpet-shaped blooms in a wide range of colors. Petunias are a popular choice for gardeners and are widely used in landscaping because they add color and texture to gardens and outdoor spaces (Farooq *et al*., 2021 and Sravya *et al.*, 2024).

Since petunias develop to maturity in just one growing season, they are usually planted as annual flowers. Usually planted in the spring after the risk of frost has gone, they bloom for a few months before going dormant when the winter weather. Brightly colored trumpet-shaped flowers in a variety of hues, such as pink, purple, red, white, and yellow, are the reason petunias are highly valued (Farooq *et al*., 2021).

Petunias are typically grown as annual flowers, meaning they complete their life cycle in one growing season. They are typically planted in the spring after the danger of frost has passed, bloom for several months, and then die off with the onset of cold weather.

Petunias come in a wide variety of forms, such as grandiflora, multiflora, and trailing variants. Gardeners love petunias because they are low care and simple to cultivate, however each variety has its own distinct traits and development patterns. They may be cultivated in hanging baskets, pots, and garden beds, among other places. Because of their vivid colors and long-lasting blooms, petunias are frequently used as cut flowers and in floral arrangements (Lashaki *et al.*, 2018).

Brassinosteroids (BRs) are endogenous plant hormones essential for the proper regulation of multiple physiological processes required for normal plant growth and development. BRs regulate the expression of numerous genes, impact the activity of complex metabolic pathways, contribute to the regulation of cell division and differentiation, and help control overall developmental programs leading to morphogenesis hey are also involved in regulating processes more specific to plant growth including flowering and cell expansion in the presence of a potentially growth-limiting cell wall (Lashaki *et al*., 2018).

Brassinosteroids are steroidal plant hormones that play a significant role in the growth and development of plants. Much has been learned about the production of BRs and sterols, as well as the signaling cascade they cause in plants (Steven, 2011).

DOI: 10.21608/asejaiqjsae.2025.419270
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Received February 10, 2025, Accepted March 26, 2025.

For almost eight decades, the significance of steroidal hormones in mammalian development has been established. The discovery of Brassinolide (BL), a steroid with potent growth-promoting properties for plants, led scientists to hypothesize that plant steroids also carry out hormonal tasks (Clough *et al.,* 2011).

The plant hormone gibberellic acid (GA_3) controls a number of vital growth and developmental processes, such as the germination of seeds (Faraj and Buhedma, 2016), the expansion of leaves, the stimulation of flowering, and the elongation of stems. Unwanted height growth is a typical issue in the cultivation of attractive potted plants, which is why GA_3 biosynthesis inhibitors are employed to regulate plant height: 2, 3 to offer a different approach to controlling plant architecture and avoiding "stretching" after harvest (Singh *et al*., 1993; Liang *et al.*, 2014 and Sravya *et al.,* 2024).

The aim of the research is to study the effect of some concentrations of gibberellic acid and brassinosteroids on vegetative growth, flowering and chemical constituents of a local cultivar of *Petunia hybrida* plant.

MATERIAL AND METHODS

Experimental location and plantation:

During two consecutive seasons, from January to June in 2022 and 2023, *Petunia hybrida* plants were planted at nursery of Floriculture and Ornamental Horticulture Department, Faculty of Agriculture, Alexandria University.

Certified petunia 'local cultivar''light purple seeds were acquired from Horticulture Department, Faculty of Agriculture Alexandria University. In both seasons, seeds planting were in December 3, 2021 and 2022. In the first season, the resulting seedlings were transplanted on January 4, 2022, and in the second season on January 10, 2023. Petunia seedlings (10–15 cm tall, with four leaves per plant) were transplanted in clay pots (30 cm in diameter) that were filled with a blend of equal parts of clay and sand according to Jackson (1958). The physical and chemical characteristics of the utilized soil are displayed in Table (1). The plants were exposed to direct sunlight.

Table 1. The physical and chemical characteristics of the used mixture soil for the two seasons

pH		**EC ds/m**		
8.15		**2.57**		
Soil particles	Clay	Silt	Sand	Soil texture
%	50.90	19.65	29.45	Clay sandy

Preparing and addition of hormones:

Four concentrations of brassinostroid (BRs) were zero, 1, 2, and 4 mg/l. and, three concentrations of gibberellic acid (GA_3) zero, 100, and 200 mg/l were prepared. Brassinostroid and gibberellic acid were added alone or in combinations in April for the first season and May for the second season this is done over four periods.

Experimental design and Statistical analysis:

Randomized complete block design (RCBD) was used for the experiment's layout, and a factorial experiment with 12 treatments was used to evaluate the results. There were four plants in each treatment, each with three duplicates.

Investigated parameter:

1 -Vegetative growth characteristics:

Shoot height (cm), diameter of stem (mm), number of leave per plant, number of branches, leaf area (cm^2), fresh weight and dry weight of leaves (g).

2- Flowering traits:

Number of flowers, diameter of flowers (mm) and flowering period (day).

3-Root growth:

Root length/plant (cm), number of roots/plant.

Analysis of chemicals:

1-Chlorophyll contents (chlorophyll A, chlorophyll B and total chlorophyll) were determined using spectrophotometer (T80-UV/LTD) in the fresh leaf samples of plants for the different treatments at the end of each season before harvest according to the method described by Wellburn (1994).

2-The method outlined by Dubios *et al.* (1956) was used to determine the leaves' carbohydrate content before harvest.

3-Nitrogen content (%): of the leaves were determined before harvest according to the methods described by Evenhuis and Dewaard (1980).

4-Phosophorus content (%): in the leaves was determined before harvest according to the methods described by Murphy and Riley (1962).

5-Potassium content (%): in the leaves was determined before harvest according to the methods described by Page *et al.* (1982).

Statistical analysis:

The SAS software was used to analysis the variance (ANOVA) of the data (SAS Institute, 2002). The means of the individual factors and their interactions were compared by L.S.D test at 5% level of probability according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

RESULTS

Vegetative growth characteristics:

1-Shoot height (SH) (cm):

Upon the statistical analysis, it has been found that there is a non-significant impact of the application of barassinostroids alone on the shoot height of petunia plants except 4 mg/l in the first season, also the application of gebberellic acid (alone) has non-significant impact on shoot height, compared with the other treatments (Table 2).

Considering the effect of the interaction between both hormone, the application of barassinostroids and gebberellic acid at 2 mg/l and 100 mg/l have induced the plant length in first season, while the application of barassinostroids and gebberellic acid at 1 mg/l and 100 mg/l have induced the plant length in second season (Table 2), compared with the other treatments.

2-Leaf number (LN/plant):

Observing Table (2), in both seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone.

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 2 mg/l of barassinostroids and 100 mg/l of gebberellic acid, have displayed the highest LN in the first season, with non-significant differences among each other in second season, it was found that the petunia plants treated with zero mg/l of barassinostroids and 200 mg/l combined with gebberellic acid, have displayed the highest LN, in second season (Table 2), compared with the other treatments.

3-Branch Number (BN):

As it has been obtained in case of branch number, non-significant impact of the application of both hormones (barassinostroids and gebberellic acid) each alone at all used concentrations, in second seasons, while in first season there were same significant impacts of branch number of the application of both hormones (Table 2), compared with the other treatments.

Table 2. Means of vegetative growth characteristics of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) and their interactions in the two seasons of 2022 and 2023

Treatment (mg/l)	Shoot height (cm)		Leaf number/plant (LN)		Branch number/plant (BN)		Stem diameter (SD) (mm)	
	2022	2023	2022	2023	2022	2023	2022	2023
BR0	44.50a	39.60a	49.16a	49.80a	6.26a	6.50a	1.10a	1.17a
BR1	47.20a	47.36a	43.76a	48.95a	6.22a	5.90a	0.51a	0.50a
BR2	40.20ab	40.47a	45.42a	48.60a	5.20ab	6.34a	0.49a	0.59a
BR4	29.50b	٤٦,٣٦a	37.98a	46.50a	4.01b	5.45a	1.26a	0.63a
$LSD_{0.05}$ (BR)	14.83	12.26	18.50	13.66	1.75	1.55	1.50	0.78
GA0	39.10a	44.67a	41.65a	50.26a	4.89b	6.81a	0.45a	0.56a
GA100	46.90a	42.85a	52.50a	46.25a	6.50a	5.69a	0.94a	0.62a
GA200	35.00a	42.88a	38.00a	48.95a	4,80b	5.64a	1.12a	0.98a
$LSD_{0.05}$ (GA_3)	12.84	10.62	16.04	11.83	1.52	1.34	1.30	0.68
Control	53.76a	45.93a	52.6٠b	52.13b	5.00ab	5.8ab	0.60ab	0.60ab
BR0+GA100	36.76ab	30.43b	46.10b	37.40ab	7.43a	6.60b	2.06a	0.67ab
BR0+GA200	43.10a	42.60ab	48.60b	60.00a	6.36b	7.00a	0.63b	2.23a
BR1+GA0	57.20a	47.50a	43.0ab	42.30ab	5.80ab	5.70ab	0.53b	0.50ab
BR1+GA100	48.16a	50.83a	44.90ab	51.10b	6.40b	5.50ab	0.58b	0.58ab
BR1+GA200	36.23ab	43.76ab	43.30ab	53.40b	6.30b	6.43b	0.42b	0.43b
BR2+GA0	34.86ab	38.87ab	50.60b	53.16b	6.00b	5.60b	0.48b	0.66ab
BR2+GA100	59.76a	47.10a	59.80a	46.40ab	6.23b	5.30b	0.50b	0.48b
BR2+GA200	26.00b	35.43a	25.70ab	46.30ab	3.30ab	8.00a	0.51b	0.62ab
BR4+GA0	10.86c	46.43a	20.20c	53.40b	2.60ab	5.30ab	0.18b	0.48b
BR4+GA100	43.04a	43.00a	59.40a	50.00b	5.80ab	5.20ab	0.64b	0.75a
BR4+GA200	34.66ab	49.66a	34.30ab	36.03	3.50ab	5.80ab	2.95a	0.65ab
$LSD_{0.05}$(BR*GA_3)	18.13	14.9	4.78	4.11	1.47	1.38	1.83	0.96

Based on the significant interaction of the impact of barassinostroids and gebberellic acid, it has been found that it is clear that the plants treated had displayed the lowest BN, except for those applied with zero mg/l of barassinostroids and 100 mg/l of gebberellic acid in first season, compared with the other treatments, while in second season the highest BN (8 branch) was found at using 2 mg/l of barassinostroids and 200 mg/l of gebberellic acid (Table 2).

4-Stem diameter (SD) (mm):

Observing Table (2), in both seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone.

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and 200 mg/l of gebberellic acid, have displayed the highest SD in the first season, compared with the other treatments, while in second season the highest SD was found at zero mg/l of barassinostroids and 200 mg/l of gebberellic acid (Table 2), compared with the other treatments.

5-Plant fresh weight (FW) (g):

Observing Table (3), in both seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone.

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and 100 mg/l of gebberellic acid, have displayed the highest FW in the first season, while it was found that the petunia plants treated with 2 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the highest FW in second season (Table 3), compared with the other treatments.

6- Plant dry weight (DW) (g):

Observing Table (3), in both seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone.

Table 3. Means of vegetative growth characteristics of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) and their interactions in the two seasons of 2022 and 2023

Treatment (mg/l)	Plant fresh weight (FW)(g)		Plant dry weight (DW)(g)		Leaf area/plant (LA)(cm^2)	
	2022	2023	2022	2023	2022	2023
BR0	4.76a	5.19a	0.95a	1.08a	12.20a	10.44a
BR1	5.49a	6.12a	1.02a	1.46a	11.0a	11.60a
BR2	4.45a	6.35a	0.91a	2.08a	9.1ab	11.65a
BR4	4.45a	6.20a	0.75a	1.29a	7.30b	10.20a
$LSD_{0.05}$ (BR)	2.46	1.89	0.45	1.08	3.31	3.03
GA0	5.00a	6.10a	0.93a	1.44a	9.85a	10.89a
GA100	5.52a	6.29a	1.09a	1.66a	10.50a	10.89a
GA200	3.80a	5.56a	0.70a	1.34a	9.41a	11.34a
$LSD_{0.05}$ (GA_3)	2.14	1.63	0.39	0.94	2.81	2.60
Control	5.60a	5.86ab	1.03a	1.33ab	12.7a	8.86b
BR0+GA100	5.30a	4.77b	1.20a	0.94b	11.90a	10.06a
BR0+GA200	3.40b	4.93b	0.63b	0.96b	12.13a	11.80ab
BR1+GA0	4.80a	5.71ab	0.86ab	1.00b	12.20a	11.60ab
BR1+GA100	6.35a	6.60ab	1.20a	1.30b	9.40ab	12.80a
BR1+GA200	5.33a	6.00ab	1.01a	2.10ab	11.40a	10.40ab
BR2+GA0	6.70a	7.40a	1.25a	2.60a	10.33ab	11.40ab
BR2+GA100	3.60b	6.90ab	0.77ab	2.50a	9.80ab	10.80ab
BR2+GA200	2.90b	4.7b	0.70b	1.10b	7.30b	12.70a
BR4+GA0	2.96b	5.4ab	0.60b	0.84b	4.20b	11.70ab
BR4+GA100	6.80a	6.80ab	1.20a	1.86ab	11.00a	8.50b
BR4+GA200	3.50b	6.6ab	0.45b	1.18b	6.80b	10.40ab
$LSD_{0.05}$(BR*GA_3)	3.03	2.31	0.55	1.32	4.05	3.70

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and 200 mg/l of gebberellic acid, have displayed the lowest DW in the first season, while it was found that the petunia plants treated with 4 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the lowest DW in second season (Table 3), compared with the other treatments.

7-Leaf area/plant (LA) (cm^2):

Observing Table (3), in second seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone, while it was some significant impacts of barassinostroids was obtained in first season on leaf area.

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the lowest LA in the first season, while it was found that the petunia plants treated with 4 mg/l of barassinostroids and 100 mg/l of gebberellic acid, have displayed the lowest LA in second season (Table3), compared with the other treatments.

Flowering characteristics:

1-Number of flower/Plant (NF):

Observing Table (4), in first season, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone, while in second season, some significant impacts of barassinostroids and gebberellic acid were obtained on flower number per plant. Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 2 mg/l of barassinostroids and 100 mg/l of gebberellic acid and BR4 and GA0 have displayed the lowest NF in the first season, while it was found that the petunia plants treated with 1 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the highest NF in second season (Table 4), compared with the other treatments.

2- Flowering period (FP) (Days):

In Table (4), in first season, significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone, while in second season, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations on FP.

Data in Table (4) indicate the significant effect interaction of using barassinostroids and gebberellic acid together it was found that the petunia plants treated with 4 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the lowest FP in the first season, while in second season was found that all concentrations treated have displayed FP convergent value of flowering period in the petunia plants.

3-Flower diameter (FD) (cm):

In Table (4), in first season, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone on FD, while in second season, significant impact of barassinostroids and non-significant impact of gebberellic acid was obtained.

Data in Table (4) indicate the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the lowest FD in the first season, while in second season the lowest FD was found when the petunia plants treated with 1 mg/l of barassinostroids and 100 mg/l of gebberellic acid, compared with the other treatments.

4-Fruits Number/Plant (FN):

Data in Table (4), in first season, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone on FN, while in second season, non-significant impacts of barassinostroids and some significant impacts of gebberellic acid was obtained on fruits number /plant.

In Table (4) indicate the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and 100 mg/l of gebberellic acid, have displayed the highest fruit number per plant in the first season, while in second season the lowest fruit number was found that the petunia plants treated with 1 mg/l of barassinostroids and 100 mg/l of gebberellic acid, compared with the other combinations.

Root growth characteristics:

1-Root number/plant (RN):

In Table (5), in first season, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone on RN, while in second season, significant impact of barassinostroids and non-significant impacts of gebberellic acid was obtained using all concentrations on root number.

In Table (5) indicate the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 4 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the lowest root number in the first season, while the highest root number was in second season.

Table 4. Means of flowering characteristics of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) and their interactions in the two seasons of 2022 and 2023

Treatment (mg/l)	Number of flowers/plant (NI)		Flowering period (FP) (Days)		Flower diameter (ID) (cm)		Fruits number/plant (FN)	
	2022	2023	2022	2023	2022	2023	2022	2023
BR0	16.20a	17.70a	66.50ab	69.00a	3.11a	3.88a	13.33a	11.04a
BR1	16.00a	21.60a	69.00ab	67.44a	3.33a	2.77b	13.22a	12.50
BR2	17.66a	13.50a	74.10a	71.50a	3.00a	3.30ab	11.00a	10.33b
BR4	18.40a	14.30a	59.40b	73.10a	2.88a	3.66a	13.10a	11.00b
$LSD_{0.05}$ (BR)	6.94	7.3	12.89	6.69	0.83	0.77	7.9	7.05
GA0	14.83a	22.25a	57.26b	67.70a	2.83a	3.41a	11.91a	22.25a
GA100	16.58a	14.75b	69.40a	69.75a	3.16a	3.25a	16.50a	14.75b
GA200	14.30a	13.50b	75.16a	73.30a	3.25a	3.50a	14.30a	13.50b
$LSD_{0.05}(GA_3)$	6.84	6.10	11.16	5.79	0.72	0.67	6.12	6.00
Control	16.30ab	19.00a	54.60b	66.30b	3.00ab	4.00a	12.60b	17.00b
BR0+GA100	14.83ab	21.60ab	70.00ab	65.00b	3.00ab	3.60ab	11.91b	12.60b
BR0+GA200	22.30ab	12.60ab	75.00a	75.60a	3.33b	4.00a	12.60a	5.30b
BR1+GA0	12.00ab	30.00a	69.30b	71.30ab	4.00a	3.00a	10.60b	17.60a
BR1+GA100	22.63ab	14.60c	62.60b	66.00b	3.33b	2.33b	12.60a	4.60ab
BR1+GA200	16.60ab	20.30b	75.00a	65.00b	2.60ab	3.00a	3.30b	15.63b
BR2+GA0	21.60b	19.30ab	78.30a	63.30b	3.00ab	3.00a	11.30b	14.30b
BR2+GA100	11.60b	11.30b	70.00ab	75.60a	2.33ab	3.60a	11.30b	10.60c
BR2+GA200	21.00b	10.60c	74.00ab	75.60a	3.66b	3.33a	10.00b	5.30c
BR4+GA0	11.60ab	20.60b	26.60b	70.00ab	1.33b	3.66a	10.60b	10.30b
BR4+GA100	32.30a	12.00b	75.00a	72.30b	4.00a	3.33a	18.00b	9.00ab
BR4+GA200	12.30ab	13.60ab	76.00a	77.00a	3.33b	4.00a	11.60b	10.30c
$LSD_{0.05}(BR*GA_3)$	2.92	3.00	4.07	2.87	1.02	0.94	3.12	2.95

2- Root length (RL) (cm):

Observing Table (5), in both seasons, non-significant impact of barassinostroids and gebberellic acid was obtained using all concentrations alone on RL.

Upon the significant interaction of barassinostroids and gebberellic acid it was found that the petunia plants treated with 2 mg/l of barassinostroids and zero mg/l of gebberellic acid, have displayed the highest root length in both seasons (Table 5).

Analysis of chemical contents:

1-N, P, K content (%)

In both seasons, non-significant impact of brassinostroids, while significant impact of gibberellic acid in both seasons on leaf nitrogen content (N) (Table 6). As for phosphorus content (P), in both seasons, a non-significant impact of brassinostroids and gibberellic acid (Table 6). A significant impact of brassinostroids in first season and non-significant impact in second season on potassium content (K), while in both seasons, non-significant impact of gibberellic on leaf K content (Table 6).

2-Total carbohydrate (TC) (%):

Determining TC, a non-significant impact of brassinostroids or gibberellic acid in both seasons was detected on leaf TC content (Table 6).

3-Chlorophyll content (CC) (mg/g):

Observing Table (7), in both seasons, a non-significant impact of brassinostroids or gibberellic acid in both seasons was detected on chlorophyll A and B contents.

As for chlorophyll B, in both seasons, the all plants applied brassinostroids at 4 mg/l or gibberellic acid at 100 mg/l with had displayed content higher than that of the control, non-significant differences among each other were found. Also, non-significant differences between applied and non-applied with in both seasons (Table 7).

Regarding total chlorophyll, a significant impact of brassinostroids in the first season and a non-significant impact of brassinostroids in second seasons, while, gibberellic acid and in both seasons a non-significant impact was detected on chlorophyll content of petunia leaves (Table 7).

Table 5. Means of root number and root lenght of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) and their interactions in the two seasons of 2022 and 2023

Treatment (mg/l)	Root number/plant (RN)		Root length (RL) (cm)	
	2022	2023	2022	2023
BR0	5.33a	4.33b	6.22a	6.88a
BR1	5.88a	4.77ab	6.33a	7.66a
BR2	5.00a	5.88ab	9.80a	8.33a
BR4	4.00a	6.44a	7.66a	9.44a
$LSD_{0.05}$ (BR)	2.38	1.96	4.24	3.56
GA0	4.25a	5.70a	7.25a	8.66a
GA100	5.66a	5.30a	8.00a	7.41a
GA200	5.20a	5.00a	7.33a	8.16a
$LSD_{0.05}$ (GA)	2.06	1.70	3.67	3.08
Control	4.00a	3.60b	4.66ab	4.30c
BR0+GA100	6.60a	4.30ab	5.30ab	7.90ab
BR0+GA200	5.33a	5.00ab	8.60b	8.60b
BR1+GA0	5.00a	4.60b	5.60ab	7.60ab
BR1+GA100	6.00a	5.00ab	8.00ab	7.60ab
BR1+GA200	6.60a	4.60ab	5.30ab	7.60ab
BR2+GA0	5.00a	6.30ab	14.30a	13.30a
BR2+GA100	6.00a	6.60b	10.00a	6.33ab
BR2+GA200	4.00a	4.60ab	5.30ab	5.33ab
BR4+GA0	3.00a	8.30a	4.30c	9.33b
BR4+GA100	4.00a	5.30ab	8.60b	8.00ab
BR4+GA200	5.00a	5.60ab	10.00a	11.00b
$LSD_{0.05}$ (BR * GA)	1.71	2.09	5.18	4.30

Table 6. Means of nitrogen, phosphorus, potassium and carbohydrate content of leaves of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) in the two seasons of 2022 and 2023

Treatment (mg/l)	Nitrogen content N (%)		Phosphorus content P (%)		Potassium content K (%)		Total carbohydrate (TC) (%)	
	2022	2023	2022	2023	2022	2023	2022	2023
BR0	2.79a	2.70a	0.250a	0.198	2.90a	2.60a	15.00a	14.60a
BR1	2.67a	2.64a	0.274a	0.302a	2.30b	2.40a	9.20a	10.26a
BR2	2.67a	2.70a	0.295a	0.317a	2.50ab	2.50a	12.73a	13.36a
BR4	2.68a	2.66a	0.291a	0.308a	2.40ab	2.20a	11.10a	11.36a
$LSD_{0.05}$ (BR)	0.83	0.64	3.78	3.71	4.88	4.35	14.26	13.27
GA0	2.79a	2.75a	0.223a	0.313a	2.50a	2.60a	9.15a	10.15a
GA100	2.75ab	2.71a	0.233a	0.336a	2.30a	2.40a	8.32a	9.00a
GA200	2.61ab	2.56b	0.167a	0.240a	2.60a	2.30a	18.55a	18.05a
$LSD_{0.05}$ (GA_3)	0.72	0.55	3.27	3.21	4.23	3.76	12.35	11.88

Table 7. Means of chlorophyll content of leaves of *Petunia hybrida* plants as influenced by brassinostroids (Brs) and gibberellic acid (GA_3) in the two seasons of 2022 and 2023

Treatment (mg/l)	Chlorophyll (A) mg/l (F.W.)		Chlorophyll (B) mg/l (F.W.)		Total chlorophyll mg/l (F.W.)	
	2022	2023	2022	2023	2022	2023
BR0	19.00a	35.0a	32.56a	33.50a	68.25b	75.90a
BR1	28.00a	52.0a	29.85a	31.71a	68.45b	78.00a
BR2	35.00a	28.0a	31.87a	30.71a	72.80b	70.30a
BR4	27.00a	43.0a	35.28a	35.05a	91.85a	77.92a
$LSD_{0.05}$ (BR)	0.56	0.67	8.46	9.28	17.59	26.00a
GA0	53.00a	22.0a	30.70a	31.70a	79.49a	67.00a
GA100	39.00a	34.0a	33.89a	32.70a	76.67a	74.70a
GA200	24.00a	62.0a	32.50a	33.69a	69.85a	84.96a
$LSD_{0.05}$ (GA_3)	0.488	0.58	7.33	8.04	15.23	22.52

DISCUSSION

After analyzing the data, it was clear that the highest concentration of brassinosteroids, (4 mg/l) produced the best results for total chlorophyll, root length, number of roots for both seasons, number of flowers in the first season, stem diameter, and flowering period in the second season combared with control treatment. In contrast, the lowest concentration of brassinosteroids (1 mg/l) produced the best results for shoot height, stem diameter, fresh and dry weight, number of root and flower diameter in the first season, and flower diameter in the second season, chlorophyll A and number of flowers compared with control treatment.

Pacholczak *et al.* (2021) found that brassinosteroids positively affected the degree of rooting and root length. Their application led to an increase in chlorophyll content, and Kshitij *et al.* (2011) observed the effect of the plant growth regulator brassinolide, which showed a significant increase in seed germination, root and bud length, relative root elongation, fresh and dry weight, seedling growth and vigor index, and the highest germination percentage was observed at a concentration of 0.4 ppm. Bansidharrao (2016) found that brassinosteroids (BR) at concentrations of 1 and 10 tM produced fewer flowers, but the degree of flowering inhibition was dependent on the concentration and method of BR application as well as the length of the inductive dark period of brassinstroide-treated plants. The importance of these substances in controlling typical plant growth and development has been highlighted by brassinosteroids. A family of polyhydroxylated steroidal plant hormones called brassinosteroids (BRs) resemble animal steroid hormones in structure. Khripach *et al*. (2000) proposed that brassinosteroids provide plants resilience to biotic and abiotic stressors, potentially improving physiological processes ranging from flower opening to fertilization.

For the first season, the best results were obtained by applying gibberellic acid alone at a high concentration of 200 mg/l in terms of flower diameter, chlorophyll b, flowering period, and total carbohydrates, compened with other treatments. For the second season, the best results were obtained in terms of leaf area, chlorophyll A & B, total chlorophyll, and total carbohydrates compened with other treatments. Shoot height showed the greatest response to gibberellic acid at 100 mg/l. When gibberellic acid (GA_3) was added Sardoei *et al.* (2023) found that while the plants' height and number of new shoots increased, the length and quantity of their roots decreased for both "Prism Rose" and "Prism White." cultivars. Krupa-Małkiewicz *et al.* (2019) also reported similar results. The stem height, lateral stem length, stem number, fruit number, root length, root wet weight, stem wet weight, pigment function, chlorophyll index, and reducing sugars were all shown to be significantly impacted by the experimental parameters. Fresh weight, number of branches, area of leaves, diameter of flower, pace of blooming, amount of nitrogen, amount of phosphorus, and number of inflorescences in the first season. These findings supported the theory that gibberellic acid is critical to the growth and development of plants (Liang *et al.*, 2014).

For the majority of the parameters examined, including shoot height and flower diameter, we get the best results when we use both barassinostroid and gibberellin together. In the second season, this results in 1 mg/l of barsassinostroid and 100 mg/l of gibberllic acid, while in the first season, 4 mg/l of brasssinostroid with 100 mg/l of gibberllic acid gave rise to the greatest flower number, fresh weight and leaf area.

The greatest results were fresh weight and flower number in the first season and leaf area in the second season when employing high concentrations of brassinostroid at 4 mg/l with 100 mg/l of gibberllic acid whereas at 4 mg/l of (Br) with 200 mg/l of (GA_3) the results show that the largest outcomes pertain to stem diameter and dry weight in the first season. Padashetti *et al.* (2010) also observed that applying 50 ppm GA_3 + 1 ppm BRs at fruit set in Arka Neelamani and Thompson seedless resulted in enhanced sugar content.

At used brassinostroid (Brs) at 2 mg/l with 100 mg/l of gibberllic acid (GA_3) the highest result are showed shoot high and leaf number in first season. The increased growth with GA_3 application was probably due to increased auxin content due to rapid metabolic conversion of soluble compounds (Singh *et al.,* 1993). BRs are involved in increasing ABA content which activates the metabolic pathway (Simmons *et al.,* 2006).

According to Yokota (1997) and Engin *et al*. (2015), gibberellic acid and antioxidants seem to promote cell elongation and division. This might be the case. Furthermore, exogenous administration of gibberellic acid and antioxidants has been shown to function synergistically and enhance length and diameter of stems (Gregory & Mandava, 1982 and Steber & McCourt, 2001). Furthermore, enhanced RNA and DNA polymerase activity as well as protein synthesis have been linked to brassinosteroid-induced growth (Kalinich *et al.,* 1985).

CONCLUSION

In general, the results of the two seasons showed that the use of parsinosteroids at concentrations of 2-4 mg/l and gibberellic acids at concentrations of 100-200 mg/l of the mixture gave the best results for all treatment methods on the local petunia variety 'Light purple' compared to the use of each substance alone.

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الملخص العربي

تأثير الرش الورقى بالبراسينوستروويد وحامض الجيبريللن على النمو الخضري والزهري والتحليل الكيماوي لنباتات البيتونيا

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أجريت هذه الدراسة في مشتل قسم الزهور ونباتات الزينة وتنسيق الحدائق بكلية الزراعة (الشاطبي) جامعة الإسكندرية، الإسكندرية، مصر، خلال موسمي النمو ٢٠٢٢ و٢٠٢٣. وكان الهدف من هذه الدراسة تحديد النمو الخضري والزهري الأمثل من خلال اختبار تأثير الرش الورقي بمنظم النمو البارسينوستيرويد (BRs) وحامض الجيبريللن (GA_3) على نباتات البيتونيا الهجين. حيث تم رش نباتات البيتونيا إما بحامض الجيبريلين (GA_3) بثلاث جرعات (صفر، ١٠٠، ٢٠٠ مجم/لتر) أو البارسينوستيرويد (BRs) بأربعة تركيزات (صفر،١، و٢، و٤ مجم/لتر) كلٌ على حدة أو مع جميع التركيزات الممكنة (١٢ معاملة) وذلك خلال أربع فترات. وقد أظهرت البارسينوستروويد بتركيز ١ ملجم/لتر أفضل النتائج لأرتفاع النبات وقطر الساق والوزن الطازج والجاف للأوراق وقطر الزهرة وعدد الأزهار، في حين أظهرت الباسينوستروويد بتركيز ٤ ملجم/لتر أعلى محتوى من الكلوروفيل أ، ب، وكذلك الكلوروفيل الكلي والكربوهيدرات الكلية لنباتات البيتونيا وقطر الساق وعدد الأزهار وفترة الإزهار وطول الجذر وعدد الجذور. تم قياس قطر الزهرة والكلوروفيل أ والكلوروفيل ب والكلوروفيل الكلي ومدة الإزهار والكربوهيدرات الكلية والمساحة الورقية وقطر الساق وذلك عند إضافة حامض الجبيريلين منفردا بتركيز عالٍ٢٠٠ ملجم/لتر. تم الحصول على أفضل النتائج عند استخدام كل من الباراسينوستروويد بتركيز ١ ملجم/لتر وحمض الجيبريلين بتركيز ١٠٠ ملجم/لتر لأرتفاع النبات وقطر الأزهار، بينما أدى استخدام ٤ ملجم/لتر من الباراسينوستروويد مع ١٠٠ ملجم/لتر من حمض الجيبريلين إلى أعلى نمو النبات وقطر الأزهار وزيادة في الكربوهيدرات الكلية والوزن الطازج ومساحة الورقة، مقارنةً بالمعاملات الأخرى.

الكلمات المفتاحية: نباتات البيتونيا الهجين، البارسينوستيرويد (BRs)، حامض الجيبريللن (GA_3)، منظمات النمو، الكلوروفيل، الكربوهيدرات الكلية.