DOI: 10.21608/alexja.2023.249820.1051

Interactive Effects of Benzyladenine and Gibberellic Acid on Vegetative, Flower Growth and Chemical Constituents of *Tropaeolum majus* Plant

Nader A. El-Shanhorey*, Amira A. yousef

Botanical Gardens Research Department, Horticultural Research Institute, ARC, Alexandria, Egypt.

* Correspondence: dr_shanhorey@yahoo.com

ARTICLE INFO

Article History

Receiveed: 29/11/2023

Revised: 22/12/2023

Accepted: 27/12/2023

Key words:

Tropaeolum majus; gibberellic acid**;** benzyladenine.

ABSTRACT

During the 2021 and 2022 growing seasons, this study was conducted at the nursery of the Department of Flowers, Ornamental Plants, and Landscape Gardens, Faculty of Agriculture (El-Shatby), Alexandria University, Alexandria, Egypt. This study, aimed to test the effect of applying foliar sprays of gibberellic acid and benzyladenine in increasing the quality and performance of *Tropaeolum majus* L. plants. The *Tropaeolum* seedlings were planted individually in plastic pots 30 cm diameter. The plants were sprayed with gibberellic acid at the concentrations of 500, 1000 and 1500 mg/l and benzyladenine at the concentrations of 200, 250 and 300 mg/l and the interaction between them. The obtained results showed that spraying with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l together significantly increased plant height, number of leaves per plant, leaves dry weight, leaves area, stem diameter, stem dry weight, number of branches per plant, root length and root dry weight. While, the obtained results showed that spraying with gibberellic acid at 1000 mg/l and benzyladenine at 250 mg/l together resulted in the highest chlorophyll content, carbohydrates content, nitrogen percentage in the leaves, phosphorus percentage in the leaves and potassium percentage in the leaves.

INTRODUCTION

The South American Andes, which stretch from Bolivia to Columbia, are the natural habitat of the genus (*Tropaeolum majus L.*), sometimes known as Indian Cress or Monks Cress. Both as an ornamental and a therapeutic plant, it is widely cultivated. In annual beds and borders, this herbaceous annual produces rainbows of cheery colour. On low fences or trellises, on a gravelly or sandy slope, or in a hanging container, its trailing varieties are employed. Nasturtiums are planted not just for their blossoms but also for their edible leaves and flowers, which may be used in salads and have a somewhat peppery flavour. According to Ferreira *et al.* (2004) and Ferro (2006), its leaves have been used in traditional medicine to treat constipation, asthma, urinary tract infections, and cardiovascular diseases.

Cytokinins are significant plant hormones that control a variety of processes involved in plant growth and development. According to Skoog and Armstrong (1970) and Hall (1973), cytokinins appear to be particularly important in the control of cell division, differentiation, and organogenesis in developing plants, as well as in the promotion of leaf expansion, nutrient mobilisation, and delayed senescence. According to Shudok (1994), two groups of adenine cytokinins and urea cytokinins with similar physiological effects have been identified. These two groups have a strong influence on cotyledon growth and expansion as well as other activities. As indicated by Mazrou (1992) on Datura plants, Mazrou *et al.* (1994) on sweet basil plants, Mansour *et al.* (1994) on soybean plants, Vijayakumari (2003) on *Andrographis panculata* and Eraki *et al.* (1993) on Saliva plants, the effect of cytokinins, particularly benzyladenine, on the plant growth and chemical components of many plants has been well documented. Could be related to its distinct functions in plant growth and development, which several researchers have reported. According to Leopold and Kriedmann (1975), GA3 has the power to alter the growth pattern of treated plants by influencing DNA and RNA levels, cell division and growth, and the manufacture of enzymes, proteins, carbohydrates, and pigments involved in photosynthetic processes. Shedeed *et al.* (1991) on the croton plant, Abou-Leila *et al.* (1994) on the Ocimum basillicum and, Eraki (1994) on Queen Elizabeth rose plants, and Ibrahim (2005) on the jojoba plant recorded the beneficial effects of gibberellic acid on various plants. They came to the conclusion that gibberellic acid is used to regulate plant growth by increasing cell division and cell elongation.

The purpose of this study is to examine several significant characteristics of unpinched *Tropaeolum majus* L. plants treated with benzyladenine and gibberellic acid as foliar applications, as well as the impact of these treatments on maintaining landscape plants of marketable quality.

MATERIALS AND METHODS

This study was carried out at the nursery of the Department of Flowers, Ornamental Plants, and Landscape Gardens, Faculty of Agriculture (El-Shatby), Alexandria University, Alexandria, Egypt, during the growth seasons of 2021 and 2022. The purpose of the study is to find out how gibberellic acid and benzyladenine foliar sprays affect the quality and productivity of *Tropaeolum majus* L. plants.

T. majus homogeneous seedlings (20–25 cm tall, with an average of four leaves per plant) were planted separately on March 10th, 2021 and 2022 (during the first and second seasons, respectively), in plastic pots (30 cm in diameter), each containing 10 kg of sandy soil. As stated by Jackson (1958), the chemical components of the soil were measured and are shown in Table 1.

The plants were sprayed with gibberellic acid at concentrations of 500, 1000, and 1500 mg/l, benzyladenine at concentrations of 200, 250, and 300 mg/l, and the interaction between them, starting on April 10 (in both seasons) and continuing every 15 days until May 25 (in both seasons). Tap water was sprinkled on the control plants. In both seasons, the plants were harvested on July 10.

All plants were given 2.0 g of Milagro Aminoleaf 20-20-20 fertilizer per pot over both seasons to provide NPK chemical fertilization. The growing season, which ran from the 20th of March to the 20th of June, involved 15-day intervals between fertilization applications. In addition, as soon as the weeds appeared, they were manually pulled out.

Data were recorded as follows

(1)Vegetative growth parameters:

Plant height (cm), leaves number per plant, dry weight of leaves (g), leaves area (cm^2) as calculated by Koller (1972), stem diameter (cm), dry weight of stem (g), branches number per plant, root length (cm) and dry weight of root (g).

(2)Chemical analysis determination:

- Total chlorophylls content (mg/l) Total chlorophyll was determined in leaf samples (mg/g fresh matter) according to Nornai (1982).
- Total carbohydrates contents (%) of the leaves were determined according to Dubios *et al.*(1956).
- Nitrogen (%) was determined in the digested solution by the modified micro Kjeldahl method as described by Pregl (1945).
- Phosphorus in the leaves (%) was determined according to the methods described by Murphy and Riley, (1962).
- Potassium in the leaves (%)was determined according to the methods described by Page *et al.,* (1982).

Complete randomised block design (RCBD) was used for the experimental layout, which included 16 treatments divided into three replicates, each containing three plants. Using the SAS programme from the SAS Institute (Snedecor and Cochran, 1989), data were subjected to analysis of variance (ANOVA), and the mean values were compared using the LSD test at the 5% level (SAS Institute, 2002).

RESULTS

Vegetative growth

- **Plant height (cm)**

Table(2) presents results indicating a substantial influence of benzyladenine and gibberellic acid treatments on plant height. When compared to the control plants, the plants sprayed with a combination of 300 mg/l of benzyladenine and 1000 mg/l of gibberellic acid showed the highest plant height in both seasons. Similar to other vegetative characteristic data, the highest stem length was 65.83 and 67.66 cm in the first and second seasons, respectively, when the plants were sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l combined. Comparable growth in plant height following treatments with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l combined.

- **Number of leaves per plant**

T. majus plants' leaf count was significantly impacted by the various gibberellic acid and benzyladenine treatments, as indicated by the data in Table (2). The plants sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l together significantly generated more leaves with a mean leaves number of 47.66 and 47.16 in the first and second seasons, respectively. Conversely, in the first and second seasons, the control plants produced the fewest leaves per plant 32.83 and 27.00, respectively. The stimulatory impact of benzyladenine on the growth of more leaves per plant could be the cause of these findings. The increase in plant leaves treated with 1000 mg/l of gibberellic acid and 300 mg/l of benzyladenine.

Table 1. Some chemical analysis of the used sandy soil for the two successive seasons 2021 and 2022.

Season	pH	EC (dsm^{-1})	Soluble cations (mg/l)				Soluble anions (mg/l)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_2^{--}
2021	7.87	1.51	3.1	4.2	6.4	1.1	3.5	6.5	2.4
2022	7.92	1.43	3.4	2.9	6.2	0.9	3.2	6.3	2.1

Table 2: Means values of plant height, number of leaves, dry weight and area of leaves *Tropaeolum majus* L. plants as influenced by gibberellic acid (GA_3) and benzyladenine (BA) in the two seasons of 2021 and 2022.

Treatments	Plant height (cm)		Number of leaves per plant		Dry weight of leaves (g)		Leaves area (cm²)	
	2021	2022	2021	2022	2021	2022	2021	2022
Control	55.50	54.66	32.83	27.00	7.02	6.97	38.00	37.67
GA500	60.83	59.00	41.16	41.16	10.09	11.16	50.54	49.08
GA1000	61.16	59.33	41.66	41.66	11.57	11.96	50.25	49.58
GA1500	62.33	60.33	41.83	42.33	11.97	12.11	51.00	51.00
BA200	56.66	54.66	34.00	32.83	7.47	9.05	42.87	41.42
BA250	55.83	57.16	38.00	35.66	7.80	9.38	42.62	41.87
BA300	55.83	56.50	39.00	36.66	8.26	9.90	44.88	44.17
GA500 + BA200	58.00	58.33	39.33	37.00	8.95	10.02	46.54	45.33
GA500 + BA250	59.00	58.50	39.33	38.66	9.18	10.14	46.96	45.37
GA500 + BA300	59.33	58.50	40.66	39.00	9.65	10.19	48.08	47.59
GA1000 + BA200	62.83	61.16	46.50	44.83	14.22	13.03	53.66	53.25
GA1000 + BA250	64.33	62.83	47.50	45.16	14.55	13.73	53.50	53.50
GA1000 + BA300	65.83	67.66	47.66	47.16	14.95	16.62	54.00	53.75
GA1500 + BA200	60.00	60.66	43.00	43.16	12.05	12.12	51.67	51.00
GA1500 + BA250	61.16	60.83	45.33	43.66	12.65	12.33	52.50	52.50
GA1500 + BA300	62.33	62.83	45.66	44.16	13.09	12.51	53.25	52.58
L.S.D. at 0.05	6.59	5.47	7.84	9.42	5.33	4.69	4.17	4.37

- **Leaves dry weight (g) per plant**

In addition, Table (2) data demonstrate that spraying 1000 mg/l of gibberellic acid and 300 mg/l of benzyladenine together greatly increased the dry weight of leaves on *T. majus* plants, yielding values of 14.95 and 16.62 g per plant in the first and second seasons, respectively, in comparison to the control (7.02 and 6.97 g per plant in the first and second seasons, respectively). The data in Table (2) thus show that, in comparison to plants sprayed with any other concentration, *T. majus* plants treated with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l together greatly enhanced their leaves' dry weight. Gibberellic acid's stimulatory action on increasing the dry weight of leaves is linked to these outcomes. In this.

- **Leaves area (cm²)**

T. majus plants' leaf area was significantly impacted by the various gibberellic acid and benzyladenine treatments, as indicated by the results in Table (2). Similar increases in leaf area were observed as a result of the gibberellic acid and benzyladenine treatments. Plants sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l together formed significantly larger leaves (with a mean area of 54.00 and 53.75 cm^2 in the first and second seasons, respectively) than those formed by control plants (38.00 and 37.67 cm^2).

- **Stem diameter (cm)**

According to Table (3)'s data, spraying 1000 mg/l of gibberellic acid and 300 mg/l of benzyladenine together on *T. majus* plants resulted in the largest stem diameters, measuring 0.35 and 0.34 cm, respectively, compared to the control treatment's 0.26 and 00.27 cm in the first and second seasons. The increase in stem diameter brought about by the combined application of 300 mg/l of benzyladenine and 1000 mg/l of gibberellic acid together.

- **Dry weight of stem (g)**

According to the findings in Table (3), the heaviest values of stem dry weight were 3.25 and 3.12 g in the first and second seasons, respectively, when *T. majus* plants were sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 300 mg/l combined. In contrast, it was discovered that in the first and second seasons, spraying with tap water (control) reduced the stem dry weight to 2.03 and 2.17 g, respectively, when compared to other treatments. The increase in stem dry weight brought on by the combined spraying of 300 ppm of benzyladenine and 1000 ppm of gibberellic acid supports

- **Number branches per plant**

Table (3) displays the data indicating that plants sprayed with a combination of 1000 mg/l of gibberellic acid and 300 mg/l of benzyladenine produced the greatest number of branches per plant, yielding 5.00 and 5.33 branches in the first and second seasons, respectively. In contrast, control plants produced the fewest branches per plant—two branches per plant over both seasons. Spraying benzyladenine at 300 mg/l and gibberellic acid at 1000 mg/l simultaneously resulted in an increase in the number of branches per plant, which supports.

Table 3. Means values of diameter, dry weight of stem and number of branches of *Tropaeolum majus* L. plants as influenced by gibberellic acid (GA3) and benzyladenine (BA) in the two seasons of 2021 and 2022.

Treatments	Stem diameter (cm)		Dry weight of stem (g)		Number of branches per plant	
	2021	2022	2021	2022	2021	2022
Control	0.26	0.27	2.03	2.17	2.00	2.00
GA 500	0.30	0.31	2.61	2.71	2.00	2.33
GA 1000	0.30	0.31	2.67	2.74	2.00	2.33
GA 1500	0.30	0.31	2.70	2.77	2.00	2.33
BA 200	0.27	0.29	2.28	2.49	2.66	3.00
BA 250	0.28	0.29	2.41	2.55	3.33	3.66
BA 300	0.28	0.30	2.40	2.65	3.33	3.66
GA500 + BA200	0.29	0.31	2.45	2.67	2.66	3.00
GA500 + BA250	0.29	0.31	2.55	2.68	3.00	3.33
GA500 + BA300	0.30	0.31	2.56	2.69	3.33	3.66
GA1000 + BA200	0.33	0.32	3.03	2.87	3.33	3.66
GA1000 + BA250	0.34	0.34	3.08	3.10	4.00	4.66
GA1000 + BA300	0.35	0.34	3.25	3.12	5.00	5.33
GA1500 + BA200	0.33	0.32	2.93	2.80	2.66	3.00
GA1500 + BA250	0.32	0.32	2.95	2.84	3.00	3.33
GA1500 + BA300	0.33	0.32	2.98	2.86	3.66	4.00
L.S.D. at 0.05	0.03	0.04	0.42	0.49	1.01	1.07

1- Root length (cm)

According to Table (4)'s data, spraying 1000 mg/l of gibberellic acid and 300 mg/l of benzyladenine together on *Tropaeolum majus* plants resulted in the tallest root lengths, measuring 86.66 and 84.00 cm, respectively, compared to the control treatment's results of 70.16 and 63.50 cm in the first and second seasons. When gibberellic acid (1000 mg/l) and benzyladenine (300 mg/l) are sprayed simultaneously, the resultant increase in root length supports.

2- Dry weight of root (g)

The data in Table (4) demonstrated that the heaviest root dry weights were obtained by spraying benzyladenine at 300 mg/l and gibberellic acid at 1000 mg/l simultaneously on *Tropaeolum majus* plants.

Table 4. Means values of root length and root dry weight of *Tropaeolum majus* L. plants as influenced by gibberellic acid (GA3) and benzyladenine (BA) in the two seasons of 2021 and 2022.

Treatments	Root length (cm)		Dry weight of root (g)	
	2021	**2022**	**2021**	**2022**
Control	70.16	63.50	2.84	2.97
GA 500	78.66	70.83	3.92	3.79
GA 1000	79.16	71.33	4.24	3.95
GA 1500	81.00	72.83	4.28	4.10
BA 200	72.00	64.50	3.17	3.42
BA 250	70.66	68.00	3.43	3.45
BA 300	70.66	67.00	3.44	3.51
GA500 + BA200	74.16	70.00	3.53	3.62
GA500 + BA250	75.83	70.16	3.59	3.74
GA500 + BA300	76.16	70.16	3.67	3.75
GA1000 + BA200	81.83	74.16	4.97	4.62
GA1000 + BA250	84.33	76.50	5.11	4.69
GA1000 + BA300	86.66	84.00	5.54	5.07
GA1500 + BA200	77.16	73.33	4.42	4.23
GA1500 + BA250	79.16	73.50	4.46	4.38
GA1500 + BA300	81,00	76.50	4.79	4.45
L.S.D. at 0.05	10.54	8.17	1.96	1.75

These weights were 5.54 and 5.07 g in the first and second seasons, respectively. In contrast, it was discovered that in the first and second seasons, spraying with tap water (control) reduced the root dry weight to 2.84 and 2.97 g, respectively, when compared to other treatments. The results are corroborated by the increase in root dry weight that follows from spraying with benzyladenine at 300 mg/l and gibberellic acid at 1000 mg/l combined.

3-Chemical constituents

1-Total chlorophyll contents (mg/g F.W)

The total chlorophyll concentrations were clearly impacted by the gibberellic acid and benzyladenine treatments, as indicated by the findings of the leaf chemical analysis in Table (5). In the first and second seasons, the highest mean readings were 5.15 and 5.52 mg/g, respectively. The values were observed during the first and second seasons, respectively, at the treatment of 1000 mg/l gibberellic acid and 250 mg/l benzyladenine. In plants sprayed with tap water (control), the lowest mean values were 4.63 and 4.95 mg/g in the first and second seasons, respectively.

2-Total carbohydrates content (%)

The findings in Table (5) further demonstrate that, in comparison to the control, the majority of the tested concentrations of benzyladenine and gibberellic acid raised the mean total carbohydrates in the leaves of *Tropaeolum majus* plants. The plants that were sprayed with a combination of 1000 mg/l of gibberellic acid and 250 mg/l of benzyladenine had the highest levels of total carbohydrates in their leaves in the first and second seasons, respectively, out of all the plants that received the various treatments.

3- Nitrogen percentage in leaves (%)

The results in Table (5) also demonstrate that, in comparison to the control, the plants that were sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 250 mg/l had slightly increased mean nitrogen content in their leaves. This resulted in nitrogen contents of 2.54% and 2.55% in the first and second seasons, respectively. Plants sprayed with tap water (control) had the lowest results (2.39 and 2.15 % in the first and second seasons, respectively).

4- Phosphorus percentage in leaves (%)

The results in Table (5) also demonstrate that, in comparison to the control, the plants that were sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 250 mg/l had a slightly increased mean phosphorus content in their leaves. This resulted in phosphorus contents of 0.273 and 0.244 percent in the first and second seasons, respectively. In plants sprayed with tap water (control), the lowest values (0.228 and 0.204 percent in the first and second seasons, respectively) were noted.

Table 5: Means of chemical constituents of *Tropaeolum majus* L. plants as influenced by gibberellic acid (GA3) and benzyladenine (BA) in the two seasons of 2021 and 2022.

Treatments	Chlorophyll content (mg/g F.W)		Carbohydrates Content in leaves (%) D.W		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Control	4.63	4.95	12.81	12.91	2.39	2.15	0.228	0.204	2.406	2.166
GA 500	4.74	5.06	13.45	13.55	2.47	2.24	0.236	0.213	2.486	2.253
GA 1000	4.83	5.15	14.11	14.10	2.55	2.29	0.244	0.219	2.569	2.309
GA 1500	4.77	5.10	13.73	13.79	2.50	2.26	0.240	0.215	2.519	2.273
BA 200	4.73	5.03	13.41	13.35	2.46	2.21	0.235	0.210	2.476	2.229
BA 250	4.83	5.13	14.09	14.01	2.55	2.29	0.244	0.218	2.566	2.306
BA 300	4.79	5.07	13.86	13.63	2.52	2.24	0.241	0.215	2.536	2.256
GA500 + BA200	4.88	5.18	14.43	14.25	2.60	2.32	0.250	0.222	2.616	2.333
GA500 + BA250	5.13	5.53	16.09	16.27	2.82	2.56	0.271	0.245	2.836	2.576
GA500 + BA300	5.02	5.42	15.38	15.67	2.72	2.48	0.261	0.237	2.736	2.496
GA1000 + BA200	4.87	5.22	14.38	14.47	2.60	2.34	0.249	0.223	2.613	2.356
GA1000 + BA250	5.15	5.52	16.24	16.32	2.84	2.55	0.273	0.244	2.853	2.566
GA1000 + BA300	4.92	5.32	14.75	15.10	2.64	2.41	0.253	0.230	2.656	2.429
GA1500 + BA200	4.91	5.27	14.64	14.82	2.63	2.38	0.252	0.227	2.646	2.399
GA1500 + BA250	5.06	5.37	15.62	15.38	2.76	2.45	0.265	0.234	2.776	2.463
GA1500 + BA300	4.98	5.33	15.09	15.16	2.69	2.42	0.258	0.231	2.703	2.433
L.S.D. at 0.05	0.06	0.08	0.44	0.52	0.06	0.05	0.006	0.005	0.061	0.058

5- Potassium percentage in leaves(%)

The results in Table (5) also demonstrate that, in comparison to the control, the plants that were sprayed with gibberellic acid at 1000 mg/l and benzyladenine at 250 mg/l had slightly higher mean potassium contents in their leaves. This resulted in potassium contents of 2.566% in the second season and 2.853% in the first. Plants sprayed with tap water (control) had the lowest values (2.406% and 2.16% in the first and second seasons, respectively).

DISCUSSION

Effect of Benzyl Adenine:

One of the best growth regulators is benzoyl adenine, which has been used to affect a variety of plant developmental processes, including branching. The results reported by Ibrahim *et al.* (2010) on croton plants. Spraying to solution of Zantedeschia aethiopica caused an increase in number of leaves (Majidian *et al.,* 2012), Majidian et al. (2012) on Zantedeschia aethiopica. Our results showed the effective role of benzyladenine on preventing of chloroplast and chlorophyll degradation. Which result to decreasing in leaves senescence and increasing in total chlorophyll content, according to Vasudevan and Kannan (2015), rose plants treated with 200 ppm concentration of BA showed improvements in plant spread, shoot length and diameter, and the quantity of cut stems per square metre. The flower's vase life also increased. In reported that cytokinins, increase chlorophyll development. Chlorophyll has primary basic role from view of absorption and use of light energy in photosynthesis. Effect of growth regulators of plant growth are effective on biosynthesis and decomposition of chlorophyll on photosynthesis, directly, In their 2017 study, Mondal and Sarkar [34] investigated the effects of benzyl adenine on the growth, blooming, yield, and quality parameters of the hybrid tea rose cultivar "Bugatti." Plants treated with 100 mg/l of BA showed highest numbers of flowers per plant, maximum spread, and maximum floral diameter (at cup stage). The highest number of secondary shoots, stalk diameter, leaf area, and longer blossom duration were produced by BA at 200 mg/l. As a result, they concluded that, in comparison to other treatments, BA 200 mg/l generated the highest-quality blooms. Chrysanthemum was subjected to foliar application of a variety of PGRs, as observed by Bala and Singh (2018) [35]. The biggest floral diameter and longest bloom life were observed by BA 200 mg/l, according to the data. The impacts of GA3 and BA on lily flowering and post-harvest characteristics were studied by Kapri, (2018) [36]. Different concentrations of GA3 and BA (100, 150, and 200 mg/l) were applied to the plants. The results demonstrated that a single 100 mg/l dose of BA produced the highest diameter, least number of days required for buds to colour develop, and maximum vase life. GA3 200 mg/l, however, displayed early blossoming. Sijo *et al.* (2020) evaluated the effects of GA3 and BA on rose morphology and floral characteristics. GA3 treatments (200 mg/l and 250 mg/l) and BA treatments (200 mg/l and 250 mg/l) were applied topically. The plants that received a foliar application of BA 200 mg/l displayed the greatest number of leaves per branch, plant spread, and total number of branches per plant. An experiment was conducted by Jayshree *et al.* (2020) to investigate the effects of gibberellic acid and benzyl adenine on the morphological behaviour of Asiatic lilies. In this investigation, different doses of BA (50, 100, and 150 mg/l) and gibberellic acid (100, 150, and 200 mg/l) were given to a total of 16 treatments.

Effect of Gibberellic acid:

One of the most useful growth regulators is gibberellic acid (GA3), which has been used to affect a variety of plant developmental processes, including seed germination, growing plants to greater heights, producing more flowers, triggering sex expression and flowering, and ending hibernation. Gibberellic acid causes to increase plasticity of cellular wall, too. This problem can be due to acidification of cellular wall or as a result of absorption of calcium ion inside cytoplasm (Baninasab and Rahemi., 1994). It has been proved that gibberellic acid increases activity of oxigenase carboxilase non phosphate ribolose (Rabisco) enzyme that is a main photosynthesis enzyme in plants. The effect of gibberellic acid on increasing rate of dry material of plant can be attributed to its effect on increasing photosynthesis rate through increasing leaf surface (Lester *et al,* 2002). The effect of gibberellic acid on increasing rate of dry material of plant can be attributed to its effect on increasing photosynthesis rate through increasing leaf surface (Lester *et al,* 2002). However, gibberellic acid is used to regulating plant growth through increased meristimatic activity due to enhance cell division and elongation Bhattuchajee *et al.,* (2002) on *Corchourus olitorius*. In this respect Halter *et al.* (2005) mentioned that the leaf area was higher in artichokes plants treated with gibberellic acid. Was recorded by Ibrahim *et al.* (2010) on croton plants. However, gibberellic acid is used to regulating plant growth through increased meristimatic activity due to enhance cell division and elongation. The effects of different GA3 concentrations (50, 100, 150, 200, and 150 mg/l) on the vegetative and floral properties of the gladiolus cv. "Red Candyman" were investigated by Aier *et al.* (2015). The highest plant height, leaf area, number of leaves per plant, and shortest days for flower emergence were all seen at a concentration of 200 mg/l of GA3. El-Shanhorey and Sorour (2015) on Dracaena marginata plant and Sorour and El-Shanhorey (2016) on Dracaena marginata plants gibberellic acid effected cellular processes such as cellular division stimulation, lengthening cells caused to increase vegetative growth. The effects of various plant growth regulators on the growth, flowering, and yield characteristics of African marigold were examined by Palei *et al.* (2016). Comparing GA3 100 mg/l to all other PGRs, they found that there was an increase in plant height, the number of branches and leaves per plant, early flower bud initiation, first flower opening, flower weight per plant, and flower count per plant. A study was conducted by Sumalatha (2017) to evaluate the effects of gibberellic acid on the vegetative, floral, and bulb properties of the Asiatic lilium variety "Menorca" (Lilium longifolium). The plants were sprayed with four different levels of GA3 (50, 100, 150, and 200 mg/l) thirty days after they were planted. GA3 100 mg/l demonstrated the most encouraging outcomes when compared to other therapies. In comparison to the control, there were significant increases in plant height, flower buds per plant, spike length, bulb weight, bulblet weight, and bulblet number. Research on the effects of BA and GA3 on gladiolus cv. "Summer Shine's" was conducted by Holkar *et al.* (2018) . BA (100, 200, and 300 mg/l) and GA3 (150, 200, and 250 mg/l) were used in different combinations as well as in isolation. The results showed that the maximum spike girth, floret diameter, floret length, 50% flowering days, minimum spike initiation days, and first floret opening days were all present in gibberellic acid**.** According to Alshakhaly and Qrunfleh (2019), Cyclamen persicum flowers grow faster when GA3 is applied in comparison to development controls. Also, they simultaneously open more flowers. The treatment of GA3 on Amaryllis belladonna has a significant impact on the plant's development and yield characteristics, according to Mishra *et al.* (2019). The plants given GA3 treatment had the largest height, the longest flower stalk, and the fewest days needed for bud initiation. Jayshree *et al.* (2020) carried out an investigation on the effects of various concentrations of gibberellic acid (50, 100, and 150 mg/l) on the morphological behavior of Asiatic lilies. Application of GA3 at 200 mg/l resulted in maximum plant height of 83.13 cm, maximum leaf number 67.25, leaf length of 10.27 cm, 2.52 cm in breadth, and early sprouting (6.00 days). The effects of foliar application plant growth regulators on the development and flowering of potted hibiscus plants were evaluated by Patel, (2020). The treatment of gibberellic acid, benzyl adenine, and salicylic acid at varying quantities (control) had a substantial impact on the vegetative growth, flowering characteristics, and plant pigments of Hibiscus rosa-sinensis plants. At 30, 60, and 90 days, plants treated with 100 ppm gibberellic acid attained their maximum height, spread, shoot length, and leaf area. More flowers per plant, more flowers per branch, larger-diameter blooms, and longer vase lifetimes were also noted. The plants' levels of anthocyanins and chlorophyll in their flowers had increased. Different GA3 concentrations were found to have a significant impact on calendula's capacity to generate high-quality flowers (Shrestha *et al.*, 2020) . They saw the first bud form early on and the blossoming **.** A study by Yogendra (2021) found that the application of GA3 significantly increased plant spread, flower counts, branch and leaf counts, early flowering, and seed production. Furthermore, it was found that GA3 accelerates blooming more effectively for commercial application.

CONCLUSIONS

By extending the lifetime of the source and so maintaining the right balance of source and sink, plant growth regulators (growth promoters and growth retardants) are known to regulate metabolism in plants. The level of perfect physiological relationships impacts plants indirectly without leading to deformity. In this regard, the use of growth regulators can alter plant growth, development, and yield—both quantitatively and qualitatively—to optimise plant production.

These arguments fully support the need for growth regulators in marketing in order to increase quality. gibberellic acid 1000 mg/l and benzyladenine 300 mg/l showed the best results among the treatments, and while their means did not differ significantly from one another, they differed from other treatments. gibberellic acid 1000 mg/l with benzyladenine 300 mg/l had the most significant differences from other treatments in plant height, number of leaves per plant, dry weight of leaves, area of leaves, stem diameter, dry weight of stem, number of branches per plant, and length and dry weight of roots. The combination of 1000 mg/l gibberellic acid and 250 mg/l benziladenine was the most successful treatment for total chlorophyll, carbohydrate, and nitrogen levels, phosphorus levels and potassium levels. This therapy differed significantly from the control.

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الملخص العربي

التأثيرات التفاعلية للبنزيل أدنين وحمض الجبريليك على النمو الخضري والزهري والمكونات الكيميائية فى نبات أبو خنجر

نادر أحمد الشنهورى, أميرة عبد الحميد يوسف

فرع بحوث الحدائق النباتية بأنطونيادس – الإسكندرية– معهد بحوث البساتين – مركز البحوث الزراعية

تمت هذه الدراسة خلال موسمى2021 و2202 فى مشتل قسم الزهور ونباتات الزينة– كلية الزراعة (الشاطبى)– جامعة الإسكندرية، الإسكندرية. كان الهدف من هذه الدراسة هو معرفة تأثير الرش بحمض الجبرللين والبنزيل أدنين على تحسين جودة نباتات أبو خنجر. تم زراعة شتلات أبو خنجر فى أوانى بلاستيكية ذات قطر 30 سم. رشت النباتات بحمض الجبرللين بتركيزات (500, 1000,1500 ملجم/ لتر) كذلك بالبنزيل أدنين بتركيزات (200,250,300 ملجم/ لتر).

وكانت النتائج المتحصل عليها أظهرت أن رش نباتات أبو خنجر بحمض الجبرللين 1000 ملجم/ لتربالإضافة إلى البنزيل أدنين 300 ملجم/ لتر أعطى نتائج معنوية فى كل من أرتفاع النبات, عدد الأوراق, الوزن الجاف للأوراق, المساحة الورقية, قطر الساق, الوزن الجاف للساق, عدد الأفرع على النبات, طول الجذور, الوزن الجاف للجذور. بينما أظهرت نتائج رش النباتات بحمض الجبرلين 1000 ملجم/ لتر بالإضافة إلى البنزيل ادنين 250 ملجم/ لتر أعطى نتائج معنوية فى كل من محتوى الكلوروفيل الكلى ومحتوى الكربوهيدرات الكلية, نسبة النيتروجين فى الأوراق ونسبة الفوسفور فى الأوراق ونسبة البوتاسيم فى الأوراق.