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Effect of Different Levels of Zn and Concentrations of BA by Spraying on Vegetative Growth of Two Cultivars of Zinnia Plant (*Zinnia elegans*)

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ABSTRACT: This study was carried out in the Lath of Horticulture Department Nursery, College of Agriculture Engineering Sciences, Duhok University. Kurdistan region, Iraq, for the period from 5th 2024 to study the effect of different levels of Zn (0, 0.50, and 0.75) and different concentrations of BA (0.50, and 100) mg l⁻¹ on some vegetative parameters of two cultivars of Zinnia plant. The results were as follows: The mean values showed that the largest plants (90.556 cm) were recorded in the Zinnia Lavonda cultivar. Also, the same cultivar shows the maximum number of branches, aerial fresh and dry weight, and total carotin reached (8.160, 213.194 g, 11.534 g, and 12.398), respectively. While another parameter such as number of leaves, number of internodes, leaf area, and total chlorophyll were observed in the Zinnia rosso scarlatta cultivar and gave the maximum results reached (23.284, 10.790, 19.206, and 30.561), respectively. Also, data reported in the same table reveal that number of leaves, number of branches, number of internodes, plant fresh and dry weight, leaf area (cm²), and finally total carotin increased significantly with a 50 mg l⁻¹ concentration of BA for the Zinnia Lavanda cultivar (26.741, 9.296, 12.556, 259.054, 13.829, 24.489, and 14.798), respectively, compared to the control. Furthermore, the highest value of the number of leaves. About the three factors, the maximum plant height for two cultivars of Zinnia Lavanda and Zinnia rosso scarlatta), the higher values reached 101.411 cm when spraying the plant by 50 mg l⁻¹ + 0.50% Zn and 96.622 cm at 0.50% Zn alone, respectively, than the control plants (77.856 and 77.356 cm), respectively, were obtained in two cultivars. While the number of leaves, number of branches, number of internodes, and leaf area (cm²) increased significantly compared to control and other treatments, the main value reached (30.889, 9.778, 15.222, and 33.230 cm²) respectively, when the Zinnia Lavanda cultivar was spraying with 100 mg l⁻¹ BA + 0.50% Zn. Also, the plant fresh weight, plant dry weight, total chlorophyll, and total carotin give the height value reached (333.080, 15.680, 42.714, and 17.90), respectively, when the Zinnia Lavanda cultivar was spraying with 100 mg l⁻¹ BA + 0.75% Zn.

Keyword: Levels of Zn, BA Concentrations, Spraying, Vegetative Growth and Two Cultivars.

INTRODUCTION

Zinnia elegans is native to Mexico and Central America and is a member of the Asteraceae family. Due to its ability to tolerate hot, dry weather, it is widely planted for commercial purposes as a cut flower and bedding plant (Dole and Wilkins, 1999). *Zinnia* is a crop with economic value as well. *Zinnia* may be studied to determine its potential as a dry condition cut flower crop because of its natural ability to survive in both dry and humid conditions. Due to the variety of colors and long flowering period, *Zinnia elegans* is a beautiful ornamental plant that may be utilized in landscape design. (Rouhi, et al., 2014). It grows after the frost season ends and is susceptible to low temperatures. *Z. elegans* are very easy to propagate by seeds, and it is used as a cut flower (Shiravand, 2011). It's one of those plants that's frequently utilized to create flower arrangements in urban landscaping. *Zinnias* look great when planted alone or in combination with other ornamental annuals (Ziobro and Usova, 2016; Konstantinova, 2017). This plant fits perfectly into the modern trend of the natural garden with a minimum of maintenance. Furthermore, *Zinnia* graceful is appropriate for growing in containers and pots, as well as for cutting to create bouquet arrangements (Javid et al., 2005; Loyola et al., 2019).

Zinnia graceful is a heliophyte and is resistant to high soil temperatures and low air humidity. *Zinnia* is a typical long-day plant (Kim et al., 2009; Safdar et al., 2016; Toscano and Romano, 2021; Marković et al., 2022). *Zinnia* is the two most promising between 20-30 species (Javid et al., 2005), having many types and numerous cultivars, which are widely grown for their attractive flowers, but greatly of ornamental cultivars are derived from *Zinnia elegans*. It can be easily grown in beds, window boxes, and rock gardens (Yassin & Ismail, 1994). One of the most important features in cut flower production is the appropriate supply of nutrition during the growing period (Abbasi et al., 2004). Many plant growth regulators have known effect to increase the vase life of flowers, and they can be efficiently used to enhance the vase life of flowering crops (Peng et al., 2007).

Plant growth regulators in small amounts can adjust plant physiological processes and play a vital role in plant growth and development, such as elongation and flower development (Yamaguchi and Kamiya, 2000). When using plant growth regulators, controlling blooming is one of the most crucial practical issues. Plant growth regulators as cytokinin play a vital role from seed germination to the senescence stage, which enables prolonging the vase life and postponing the onset of senescence (Chatsudthipong and Muanprasat, 2009). Cytokinin can be used in a different of applications, from the treatment of seeds (Riedell et al., 1985) to applications during flowering (Dyer et al., 1986). Synthetic cytokinin like benzyl adenine (BA) can improve plant growth by increasing cell division, breaking bud dormancy, and enhancing the growth of the lateral buds (Hossain et al., 2006). Application of synthetic cytokinin to leaves increased chlorophyll formation and protein synthesis within tissues (George et al., 2008). However, available literature has no reports so far regarding the effect of cytokinin on the growth and flowering of *Gaillardia*.

Zinc (Zn) is an essential micronutrient for higher plants, where it is required for activity of various types of enzymes (dehydrogenases, RNA and DNA polymerases), gene expression, structural and functional integrity of bio-membranes, photosynthetic carbon metabolism, carbohydrate metabolism, and protein synthesis. Zn also plays an greater role in the production of biomass; Zn deficiency may affect the photochemical processes in thylakoids, thus inhibiting the biophysical processes of photosynthesis (Cakmak 2000). In the case of excess Zn, one of the ways to limit damage is to stop the uncontrolled oxidation caused by antioxidant enzymes, which require Fe, Mn, Cu, and Zn as metal cofactors. With the introduction of micronutrients that are necessary for plant growth, it became possible to get the greatest growth of plants (Khan et al., 2018). Micronutrients greatly impacted plant growth and development, including zinc nutrients. Zinc plays a key role in plant physiology, where it activates certain enzymes related to carbohydrate metabolism and has a useful effect of zinc in many ornamental plants (Mirshekari, 2012). Foliar spray of zinc increased by 0.5% and was the most effective influencing the vegetative growth and the size of the rise (Katiyar et al., 2012). The aim of an experiment was to enhance the growth of two cultivars of *Zinnia*. To evaluate the effect of synthetic cytokinin (BA) concentrations and Zinc levels alone and their interactions with BA on the growth performance of the two cultivars of the *Zinnia* plant.

MATERIALS AND METHOD

The study was carried out in the lath house of the Department of Horticulture, College of Agriculture Engineering Sciences, University of Duhok, Kurdistan region, Iraq, for the period from April 2024. The study was arranged in a factorial test with a complete randomized design (RCBD) with three factors and three replicates, each replicate consisting of four plants. The different materials used include BA (0, 50, and 100 mg l⁻¹) with ZnSO₄ (0, 0.50, and 0.75%), % used alone, and their interaction on the growth of two cultivars of the Zinnia plant (Lavanda and rosso scarlatta). So, the experiment includes (3×3×2×3×4= 216) plants. The seeds of Zinnia were imported (Zinnia elegans) from the Pagano Costantino company in Italy through Kurdistan offices, which is one of the agricultural offices in Duhok. The seeds were sowing in peatmoss for the first time. After germination, the seedlings were transferred to a growing medium containing river soil and peatmoss at 2:1 v/v in 24 cm pots. The pots were placed in a lather with an average day/night temperature of 25°C/18°C. The plants at the four-leaf stage were sprayed individually with different concentrations of this BA and Zn, which are used in foliar application, by spraying the plant three times and 15 days between the sprays. Study parameters: The study assessed various growth parameters, including plant height (cm), stem diameter (cm), number of leaves per plant, number of branches, number of internodes per plant, plant fresh weight, plant dry weight, and leaf area (cm²).

STATISTICAL ANALYSIS

The experiment was carried out using a completely randomized design. Each treatment comprised three replicates and four plants for each replication. Collected data were subjected to analysis of variance (ANOVA) and the mean values were assessed by Duncan Test at $P \leq 0.05$ using program (SAS).

RESULTS

Effect of cultivars

The results in Table 1 regarding many vegetative parameters such as plant height (cm), number of leaves. Plant⁻¹, number of branches. Plant⁻¹, number of internodes. Plant⁻¹, aerial fresh and dry weight, leaf area (cm²), and finally total chlorophyll, total carotin showed that the effect of zinnia cultivars was non-significant in all parameters except the number of branches; it was significant between the cultivars. The mean values showed that the largest plants (90.556 cm) were recorded in the Zinnia Lavonda cultivar. Also, the same cultivar shows the maximum number of branches, aerial fresh and dry weight, and total carotin reached (8.160, 213.194 g, 11.534 g, and 12.398), respectively. While another parameter such as number of leaves, number of internodes, leaf area, and total chlorophyll were observed in the Zinnia rosso scarlatta cultivar and gave the maximum results reached (23.284, 10.790, 19.206, and 30.561), respectively.

Cultivar	plant height (cm)	number of leaves. Plant ⁻¹	number of branches	number of internodes. Plant ⁻¹	aerial fresh weight	aerial dry weight	leaf area (cm ²)	total chlorophyll	total carotin
Zinnia Lavonda	90.556 ^a	22.469 ^a	8.160 ^a	10.691 ^a	213.194 ^a	11.534 ^a	19.177 ^a	25.754 ^b	12.398 ^a
Zinnia rosso scarlatta	90.464 ^a	23.284 ^a	7.185 ^b	10.790 ^a	181.890 ^a	10.075 ^a	19.206 ^a	30.561 ^a	12.093 ^a

Effect of BA concentration on different characteristics of two cultivars of zinnia plants

The data illustrated in Table 2 show that increasing the BA concentrations significantly increased zinnia parameters such as plant height (cm) and number of leaves. Plant⁻¹, number of branches. Plant⁻¹, number of internodes. Plant⁻¹, plant fresh and dry weight, leaf area (cm²), and finally total chlorophyll, total carotin compared to untreated plants. The tallest plants obtained from the treatment of 50 mg⁻¹ BA reached 96.556 cm for the Zinnia Lavanda, followed by Zinnia rosso-scarlatta cultivars, whose maximum length reached 25.778 cm at 100 mg⁻¹ BA. About the other characters, data reported in the same table reveal that number of leave, number of branches, number of internodes, plant fresh and dry weight, leaf area (cm²), finally total carotin increased significantly with a 50 mg⁻¹ concentration of BA for the Zinnia Lavanda cultivar (26.741, 9.296, 12.556, 259.054, 13.829, 24.489, and 14.798), respectively, compared to the control. Furthermore, the highest value of number of leaves. Plant⁻¹, number of branches. Plant⁻¹, number of internodes. Plant⁻¹, plant fresh and dry weight, leaf area (cm²), finally total carotin was recorded for the Zinnia rosso scarlatta cultivar at 100 mg⁻¹BA with a significant increase compared to the control (25.778, 7.852, 12.370, 203.083, 12.833, 22.930, and 13.863), respectively, compared to the control. Also, 50 mg⁻¹ BA spraying in the Zinnia rosso scarlatta cultivar gave the highest value of total chlorophyll with significant differences compared to the other treatment, and the control reached 34.789.

Effect of Zinc level on different characteristics of two cultivars of zinnia plants

The data regarding some growth parameters are shown in Table 2. The results showed that such as plant height (cm) and number of leaves. Plant⁻¹, number of branches. Plant⁻¹, number of internodes. Plant⁻¹, plant fresh and dry weight, leaf area (cm²), and finally total chlorophyll and total carotin were significantly affected by zinc application. The results indicated that Zn levels significantly varied the whole parameter of two Zinnia cultivars compared to the control. The main values of the data showed greater plant height and number of leaves. Plant⁻¹, number of branches., number of internodes, plant fresh and dry weight, leaf area (cm²), and finally total chlorophyll, total carotin (94.837, 26.444, 8.333, 12.481, 262.440, 12.149, 24.817, 32.20, and 14.562), respectively, were recorded for Zinnia Lavanda cultivar with application of Zn at the rate 50% and (94.156, 26.889, 7.741, 12.593, 244.617, 11.908, 26.134, 39.749, and 14.145) respectively, were recorded for Zinnia rosso scarlatta cultivar with application of Zn at the rate 100%.

Table (2): Effect of foliar application of BA concentration on different characteristics of two cultivars of zinnia plants

Cultivar	BA mg ⁻¹	plant height (cm)	number of leaves. Plant ⁻¹	number of branches	number of internode s. Plant ⁻¹	aerial fresh weight	aerial dry weight	leaf area (cm ²)	total chlorophyll	total carotin
Zinnia Lavanda	0	85.126 ^c	17.185 ^b	6.704 ^c	8.074 ^c	130.661 ^b	7.342 ^b	10.151 ^c	11.901 ^c	8.650 ^b
	50	96.556 ^a	23.481 ^a	8.481 ^{ab}	11.444 ^{ab}	249.868 ^a	13.432 ^a	22.892 ^a	32.374 ^a	13.746 ^a
	100	89.985 ^{abc}	26.741 ^a	9.296 ^a	12.556 ^a	259.054 ^a	13.829 ^a	24.489 ^a	32.987 ^a	14.798 ^a
Zinnia rosso scarlatta	0	88.141 ^{bc}	21.926 ^{ab}	6.444 ^c	9.222 ^{bc}	127.933 ^b	6.689 ^b	16.144 ^b	26.342 ^b	9.564 ^b
	50	89.481 ^{bc}	22.148 ^{ab}	7.259 ^{bc}	10.778 ^{abc}	214.654 ^a	10.702 ^{ab}	18.543 ^b	34.789 ^a	12.851 ^a
	100	93.769 ^{ab}	25.778 ^a	7.852 ^{abc}	12.370 ^a	203.083 ^{ab}	12.833 ^a	22.930 ^a	30.551 ^{ab}	13.863 ^a

Cultivar	Zn%	plant height (cm)	number of leaves. Plant ⁻¹	number of branches	number of internodes. Plant ⁻¹	aerial fresh weight	aerial dry weight	leaf area (cm ²)	total chlorophyll	total carotin
Zinnia Lavanda	0.00	84.470 ^c	16.296 ^b	7.519 ^{ab}	7.926 ^b	143.869 ^c	9.372 ^{ab}	8.491 ^b	13.147 ^c	8.527 ^b
	0.50	94.837 ^a	26.444 ^a	8.333 ^a	12.481 ^a	262.440 ^a	12.149 ^a	24.817 ^a	32.208 ^b	14.562 ^a
	0.75	92.359 ^{ab}	24.667 ^a	8.630 ^a	11.667 ^a	233.274 ^{ab}	13.082 ^a	24.224 ^a	31.907 ^b	14.105 ^a
Zinnia rosso scarlatta	0.00	86.177 ^{bc}	16.741 ^b	6.630 ^a	8.296 ^b	141.797 ^c	6.876 ^b	9.214 ^b	14.812 ^c	9.652 ^b
	0.50	91.059 ^{abc}	26.222 ^a	7.185 ^{ab}	11.481 ^a	159.258 ^{bc}	11.441 ^{ab}	22.269 ^a	37.122 ^a	12.482 ^a
	0.75	94.156 ^a	26.889 ^a	7.741 ^{ab}	12.593 ^a	244.617 ^a	11.908 ^a	26.134 ^a	39.749 ^a	14.145 ^a

Effect of BA concentration and Zn% on different characteristics of two cultivars of zinnia plants

The variability of growth parameters of zinnia cultivars in response to BA concentrations and Zn % foliar application is shown in table 4. In terms of the maximum plant height for two cultivars of (Zinnia Lavanda and Zinnia rosso scarlatta), the higher values reached 101.411 cm when spraying the plant by 50 mg l⁻¹ + 0.50 % Zn and 96.622 cm at 0.50 % Zn alone respectively than the control plants (77.856 and 77.356 cm) respectively were obtained in two cultivars.

Cultivar	BA mg l ⁻¹	Zn %	plant height (cm)	number of leaves. Plant ⁻¹	number of branches	number of internodes. Plant ⁻¹	aerial fresh weight	aerial dry weight	leaf area (cm ²)	total chlorophyll	total carotin
Zinnia Lavanda	0	0.00	77.856 ^{de}	12.667 ^e	5.333 ^f	6.111 ^d	113.620 ^c	6.253 ^{ab}	8.735 ^e	8.689 ^d	7.486
		0.50	90.311 ^{a-d}	19.333 ^{cde}	6.889 ^{b-f}	9.667 ^{a-d}	137.233 ^c	7.793 ^{ab}	9.555 ^e	13.506 ^d	9.539
		0.75	87.211 ^{b-e}	19.556 ^{b-e}	7.889 ^{a-f}	8.44 ^{cd}	141.130 ^c	7.980 ^{ab}	12.163 ^{de}	13.508 ^d	8.926
	50	0.00	89.711 ^{a-e}	17.111 ^{de}	8.667 ^{a-d}	8.889 ^{bcd}	176.653 ^{bc}	10.430 ^{ab}	8.930 ^e	15.736 ^d	9.441
		0.50	101.411 ^a	29.111 ^{abc}	8.333 ^{a-e}	12.556 ^{abc}	347.337 ^a	14.280 ^{ab}	31.667 ^a	41.886 ^{ab}	16.317 ^{ab}
		0.75	98.544 ^{ab}	24.222 ^{a-d}	8.444 ^{a-e}	12.889 ^{abc}	225.613 ^{abc}	15.587 ^a	28.080 ^{ab}	39.499 ^{abc}	15.482 ^{ab}
	100	0.00	85.844 ^{b-e}	19.111 ^{cde}	8.556 ^{a-d}	8.778 ^{bcd}	141.333 ^c	11.433 ^{ab}	7.808 ^e	15.015 ^d	8.654 ^c
		0.50	92.789 ^{abc}	30.889 ^a	9.778 ^a	15.222 ^a	302.750 ^{ab}	14.373 ^a	33.230 ^a	41.231 ^{abc}	17.831 ^a
		0.75	91.322 ^{abc}	30.222 ^a	9.556 ^{ab}	13.667 ^{abc}	333.080 ^a	15.680 ^a	32.429 ^a	42.714 ^{ab}	17.907 ^a
Zinnia rosso scarlatta	0	0.00	77.356 ^e	17.111 ^{de}	5.667	7.778 ^{bcd}	112.053 ^c	4.853 ^b	8.433 ^e	10.221 ^d	9.457 ^c
		0.50	96.622 ^{abc}	22.889 ^{a-d}	7.000 ^{a-f}	8.889 ^{bcd}	122.463 ^c	7.233 ^{ab}	18.023 ^{cd}	34.497 ^{bc}	9.289 ^c
		0.75	90.444 ^{a-d}	25.778 ^{a-d}	6.667 ^{c-f}	11.000 ^{a-d}	149.283 ^{bc}	7.980 ^{ab}	21.975 ^{bc}	34.309 ^{bc}	9.947 ^c
	50	0.00	85.256 ^{cde}	16.000 ^{de}	7.889 ^{a-f}	8.111 ^a	177.400 ^{bc}	7.117 ^{ab}	9.574 ^e	16.415 ^d	9.668 ^c
		0.50	87.167 ^{b-e}	25.111 ^{a-d}	6.778 ^{a-f}	12.000 ^{a-d}	224.503 ^{abc}	12.087 ^{ab}	19.319 ^c	44.715 ^a	13.507 ^b
		0.75	96.022 ^{abc}	25.333 ^{a-d}	7.111 ^{a-f}	12.222 ^{abc}	242.060 ^{abc}	12.903 ^{ab}	26.737 ^{ab}	43.239 ^{ab}	15.377 ^{ab}
	100	0.00	95.920 ^{abc}	17.111 ^{de}	6.333 ^{def}	9.000 ^{bcd}	135.937 ^c	8.657 ^{ab}	9.635 ^e	17.800 ^d	9.830 ^c
		0.50	89.389 ^{a-e}	30.667 ^a	7.778 ^{a-f}	13.556 ^{abc}	130.807 ^c	15.003 ^a	29.464 ^a	32.155 ^c	14.648 ^{ab}
		0.75	96.000 ^{abc}	29.556 ^{ab}	9.444 ^{abc}	14.556 ^{ab}	342.507 ^a	14.840 ^a	29.690 ^a	41.698 ^{ab}	17.112 ^{ab}

While number of leaves, number of branches, number of internodes and leaf area (cm²) increased significantly compared to control and other treatment, the main value reached (30.889, 9.778, 15.222 and 33.230 cm²) respectively when the Zinnia Lavanda cultivar spraying with 100 mg l⁻¹BA+ 0.50% Zn. Also, the plant fresh weight, Plant dry weight, total chlorophyll and total carotin give the height value reached (333.080, 15.680, 42.714 and 17.90) respectively, when the Zinnia Lavanda cultivar spraying with 100 mg l⁻¹BA+ 0.75% Zn.

Concerning the combination of the three factors BA concentration and Zn% on different characteristics of Zinnia rosso scarlatta it was demonstrated that the Zinnia rosso scarlatta cultivar under spraying in 100 mg l⁻¹BA and 0.75 % Zn, which recorded the maximum value for number of branches, number of internodes, plant fresh weight, leaf area (cm²) and total carotin reached (9.444, 14.556, 342.507, 29.690 and 17.112) respectively. However, the maximum number of leaves and Plant dry weight (30.667 and 15.003) was noticed at 100 mg l⁻¹BA and 0.50 % Zn application, The total chlorophyll generally increased, but 50 mg l⁻¹BA and 0.50 % Zn concentrations in different concentrations had no statistically significant effect on the total carotin.

DISCUSSION

The increased in various growth parameters of zinnia seedlings after the treatments of different concentration of BA and different levels ZnSO₄. Concerning the main effect of different rates of synthetic cytokinin (BA) on plant growth parameters, data in Table (2, 3 and 4) indicated that spraying zinnia plants with BA in general significantly increased vegetative growth parameters compared to control treatment. Spraying plants with BA at 100 mg l⁻¹ gave the highest mean values of plant height, number of branches per plant, leaf area, aerial fresh and dry weights per plant during the study for two cultivars compared to the control treatments. However, there was no significant difference between the two concentrations of BA (50, and 100 mg l⁻¹) in number of branches per plant and leaf area. Generally, the superior influence of BA treatments on stimulating vegetative growth parameters may be due to the role of BAP in stimulating cell division and elongation (Mazher et al. 2011, and Sadak et al., 2013), which leads to stimulation of primordial production and partially intermodal elongation on the apex (Kumari, 2017), which reflected in the increase of plant height. Cytokinins play an important role in counteracting or eliminating the apical dominance and stimulating the release of axillary buds from apical dominance (Tamas, 1995; Arteca, 1996 and Menaka et al., 2018) which lead to an increase in number of branches per plant.

The results obtained are comparable with those obtained by Mazher et al., (2011) on *Codiaeum variegatum* L. cytokinin is considered growth control hormones, which promote protein synthesis, cell division, enlargement, cell number and nutrient mobilization (Bairwa and Mishra, 2017). When exogenous applications of Cytokinin are made, they promote cell expansion (Miller, 1956) which leads to increasing the leaf area. The general increase in leaf area because of BA treatments agrees with the findings of Henschke et al., (2015) on *Helleborus Oriental*, Mansour et al., (2016) on *Conocarpus erectus* L. Plants, Mara (2017) on *Echinacea Hybrids* and Mohamed (2017) on aster plant

The positive effect of BA on fresh and dry weights could be interpreted by the findings of Sorokin and Thimann (1964) who claimed that the increment in the fresh weight of *Pisum sativum* could be explained through the role of BA in stimulating xylem differentiation and vascular strand development, consequently more absorption of water and nutrients from the soil, which was reflected in more growth. It could also be attributed to the increment in plant height and number of branches because of overcoming the apical dominance of the plant leading to the formation of more leaves. The effect on fresh and dry weights was authenticated by some authors. El-Sayed et al. (1989) on *Polianthus tuberosa* and Menesi et al. (1991) on *Calandula officinalis* concluded that BA application increased the fresh and dry weights of roots. Menesi et al. (1994) reported that the greatest values of fresh and dry weights of some ornamental plants resulted from BA at 25 mg/L. These results are in harmony with those obtained by Eid and Abou-Leila (2006) on Coroton plant, and Neetu and Singh (2016) on gladiolus.

On the other hand, the main effect of different rates of spraying at different levels of Zn on plant growth parameters, data in Table (2, 3 and 4) indicated that spraying zinnia plants with Zn in general significantly increased vegetative growth parameters compared to control treatment. Spraying plants with Zn at 0.75 % gave the highest mean values of plant height, number of branches per plant, leaf area, aerial fresh and dry weights per plant during

the study for two cultivars compared to the control treatments. However, there was no significant difference between the two concentrations of Zn (0.50, and 0.75) % in number of branches per plant and leaf area. One of the reasons for increasing height of plants compared to untreated plants is because the positive effect of zinc on auxin hormone biosynthesis, can increase cell division and elongation and Price (1970) reported that the beneficial effect of Zn on plant growth may be due to its roles in auxin biosynthesis through the amino acid tryptophan. Moreover, EI-Bagoury et al. (1984) and Osman et al. (2000) suggested that the increase in shoot height resulted from zinc application might be mainly due to the increment in internodes length because of the increment of protoplasm in cell wall material proportion and consequently the increment in cell size that manifested in internode elongation.

Also, improving the CCI, leaf area, and another parameter by applying zinc sulfate can improve photosynthesis and increase dry matter accumulation and lead to increased aerial dry weights, which will result in increasing the vegetative. Foliar zinc has significantly affected the leaf area which might be due the fact that zinc activated different types of enzymes which ultimately increased leaf area of zinnia plant and additionally zinc also increased vegetative growth. These results are in line with (Tariq et al., 2007). The foliar application of zinc was significantly increasing vegetative growth and size of spike of gladiolus plant (Katiyar et al., 2012). Foliar zinc application significantly affected the number of leaves. Zinc might be activated by different types of enzymes which increase the number of leaves and leaf area. Zinc activated different types of enzymes which increased plant height of zinnia flower. These results are line with (Ambreen et al., 2013) who reported that zinc application significantly increased plant height of gladiolus flower. Zinc plays an important role in biosynthesis of plant auxin which promotes the plant in growth (Calmak 2008).

CONCLUSION

In conclusion, the present study indicated that the growth parameters of two cultivars of zinnia plants were highly enhanced by spraying different concentrations of BA and varied levels of zinc. 100 mg^l⁻¹ is considered the best treatment to produce admirable vegetative parameters of zinnia plants under the environmental conditions of this study. As well as the zinc application levels increasing growth, based on the experimental results, the following conclusions were obtained: number of leaves, number of branches, number of internodes, leaf area (cm²) and plant height performed better with foliar Zn application of 0.50 and 0.75 percent combined with 100 mg^l⁻¹

REFERENCE

- Abbasi, N. A., Zahoor, S., & Nazir, K.** (2004). Effects of preharvest phosphorus and potassium fertilizers and postharvest AgNO₃ pulsing on the postharvest quality and shelf life of zinnia (*Zinnia elegans* cv. Blue point) cut flowers. *Int. J. Agri. Biol.*, 129-131.
- Memon, S. A., Baloch, A. R., Muhammad Ayubbaloch, M. A., & Mahmooda Buriro, M. B.** (2013). Effect of zinc sulphate and iron sulphate on the growth and flower production of gladiolus (*Gladiolus hortulanus*). *J. of Agric.* 9(6):1621-1630.
- Arteca, R. N.** (1996). *Plant growth substances: principles and applications*. Springer Science & Business Media. Chapman & Hall, New York. 133: 67- 69.
- Bairwa, S., & Mishra, J. S.** (2017). Effect of NAA, BA and kinetin on yield of African marigold (*Tagetes erecta* Linn.). *International Journal of Current Microbiology and Applied Sciences*, 6(6), 1236-1241.
- Cakmak, I.** (2000). Tansley Review No. 111 Possible roles of zinc in protecting plant cells from damage by reactive oxygen species. *The New Phytologist*, 146(2), 185-205.
- Cakmak, I.** (2008). Enrichment of cereal grains with zinc: agronomic or genetic biofortification. *Plant and soil*, 302, 1-17.
- Chatsudthipong, V., & Muanprasat, C.** (2009). Stevioside and related compounds: therapeutic benefits beyond sweetness. *Pharmacology & therapeutics*, 121(1), 41-54.
- Dole, J. M., & Wilkins, H. F.** (1999). *Floriculture: Principles and species* Hall, Upper Saddle River, N.J., USA,

1048 p.

- Dyer, D. J., Carlson, D. R., Cotterman, C. D., Sikorski, J. A., & Ditson, S. L.** (1987). Soybean pod set enhancement with synthetic cytokinin analogs. *Plant Physiology*, 84(2), 240-243.
- Eid, R. A., & Abou-Leila, B. H.** (2006). Response of croton plants to Gibberellic acid, benzyl adenine and ascorbic acid application. *World J. Agric. Sci* 2.2: 174-179.
- El Bagoury, O. H., Mohamed, F. A., Sharabash, M. T. M., El Kholy, A. F., & Hashim, M. M. F.** (1984). Response of soybean plant to zinc-chelate and soil moisture content [Egypt]. *Agric. Res. Rev.*, 26(413): 447-457.
- El-Sayed, A. A., Salem, M. A., & El-Maadawy, E. I.** (1989). Effect of Gibberellic acid (GA3) and benzyladenine (BA) on *Polianthes tuberosa* L. *Journal of Agricultural Research, Tanta Univ. (Egypt)*, 15(2):301-311.
- George, E. F., Hall, M. A., & De Klerk, G. J.** (2008). Plant propagation by tissue culture 3rd Edition. *The Netherland, The Background Springer*, 65-175.
- Henschke, M., Czuchaj, P. K., & Szczepaniak, S. J.** (2015). The effect of benzyladenine and gibberellic acid on growth and flowering of *Helleborus Orientalis* Lam. *Bulgarian Journal of Agricultural Science*, 21(6), 1198-1203.
- Hossain, M. S, Rahman, M. M., Rashid, M. R., Farid, A. T. M., Kaium, M. A., Ahmed, M., Alam, M. S. and Uddin, K. M. S.** (2006). In "Handbook on Agro technology". 4th ed., Bangladesh Agricultural Res. Inst., Gazipur 1701, Bangladesh, 356-358
- Javid, Q. A., Abbasi, N. A., Hafiz, I. A., & Mughal, A. L.** (2005). Performance of *Zinnia (Zinnia elegans)* "Dahlia Flowered" Crimson Shade by application of NPK fertilizer. *International Journal of Agriculture and Biology*, v.7, n.3, p.474-476.
- Katiyar P., P. K., Chaturvedi, O. P., & Dheerendra Katiyar, D. K.** (2012). Effect of foliar spray of zinc, calcium and boron on spike production of *gladiolus* cv. eurovision. 1(4): 334-338.
- Khan, A., Ullah, F., Khan, M., Zeb, A., Khan, M., Ahmad, K., & Zainub, B.** (2018). Response of *Zinnia* to foliar application of boron and zinc. *Science International*, 30, 133-139.
- Kim, D. H., Doyle, M. R., Sung, S., & Amasino, R. M.** (2009). Vernalization: winter and the timing of flowering in plants. *Annual Review of Cell and Developmental*, 25(1), 277-299.
»<https://doi.org/10.1146/annurev.cellbio.042308.113411>
- Konstantinova, A.A.** (2017) Characteristics of Flower Decoration In The City Of Onega. *International Student Scientific Bulletin*, v.5, p.92.
- Kumari, S.** (2017). Effect of Kinetin (6-FAP) and Cycocel (CCC) on growth, metabolism and cellular organelles in Pearl Millet (*Pennisetum glaucum*) under water stress. *Int. J. Curr. Microbiol. App. Sci*, 6(8), 2711-2719.
- Loyola, C. E., Dole, J. M., & Dunning, R.** (2019). North American specialty cut flower production and postharvest survey. *HortTechnology*, 29(3), 338-359.<https://doi.org/10.21273/HORTTECH04270-19>
- Mara, C. G.** (2017). *Controlling growth in Echinacea Hybrids* (Doctoral dissertation, Ph. D. Thesis, Virginia Polytechnic Institute and state University).
- Marković, M., Šoštarić, J., Kojić, A., Popović, B., Bubalo, A., Bošnjak, D., & Stanisavljević, A.** (2022). *Zinnia (Zinnia elegans L.) and periwinkle (Catharanthus roseus (L.) G. Don)* responses to salinity stress. *Water*, 14(7), 1066. » <https://doi.org/10.3390/w14071066>
- Mazher, A. A., Zaghloul, S. M., Mahmoud, S. A., & Siam, H. S.** (2011). Stimulatory effect of kinetin, ascorbic acid and glutamic acid on growth and chemical constituents of *Codiaeum variegatum* L. plants. *American Eurasian J. Agric. & Environ. Sci.*, 10 (3): 318- 323.
- Mazrouh, M. M.** (1992). The growth and tropane alkaloids distribution in the different organs of *Datura innoxia* Mill. plants in relation to benzyladenine (BA) application. *Menofiya Journal of Agricultural Research*, 17(4).
- Menaka, P., Rani, Y. A., Rao, K. N., Babu, P. H., & Ahamed, M. L** (2018). Response of chickpea (*Cicer arietinum* L.) to foliar application of ethrel, kinetin and boron. *Int. J. Curr. Microbiol. App. Sci*, 7(11), 1653-1660.
- Menesi, F. A., Khalafalla, M. M., & Kandeel, Y.** (1994). Effect of some growth regulators and calcium chloride on *Tagetes erecta*. The 1st Conf. Ornamental Hor. Fac. Agric. Kafr El-Sheikh, Tanta Univ., Egypt, 2:408-425.

- Menesi, F. A., Nofal, E. M. S., & El-Mahrouk, E. M.** (1991). Effect of some growth regulators on *Calendula officinalis* L. *Egypt. J. Appl. Sci*, 6, 1-15.
- Miller, C. O.** (1956). Similarity of Some Kinetin and Red-Light Effects. *Plant Physiology*, 31(4), 318.
- Mirshekari, B.** (2012). Seed priming with iron and boron enhances germination and yield of dill (*Anethum graveolens*). *Turkish Journal of Agriculture and Forestry*, 36(1), 27-33.
- Mohamed, Y. F. Y.** (2017). Effect of some growth stimulants on growth, flowering and postharvest quality of aster (*Symphotrichum novi-belgii* L.) cv. Purple Monarch. *Middle East J. Agric. Res*, 6(2), 264-273.
- Neetu, R. K., & Singh, A. K.** (2016). Effect of different kinetin concentration on growth and flowering attributes in gladiolus cultivars. *Agricultural Science Digest-A Research Journal*, 36(4), 319-322.
- Osman, A. S., Abido, Y. M. Y., & Allam, S. M. M.** (2000). Response of soybean to phosphorus and zinc fertilization under irrigation regime. *Annals Agric. Sci., Ain Shams Univ., Cairo*, 45(1): 229-238.
- Peng XiaoLi, P. X., Rao JingPing, R. J., & Zhang YanLong, Z. Y.** (2007). Effect of exogenous salicylic acid on vase life of cut flowers of Prato lily and related physiological influence. *Acta Hort. Sinica*, 34(1): 189-192.
- Price, C. A.** (1970). *Molecular approaches to plant physiology*. New York: McGraw-Hill. pp: 398.
- Riedell, W. E., Khoo, U., & Inglett, G. E.** (1985). Effects of bioregulators on soybean leaf structure and chlorophyll retention. In: *Plant Growth Regulation*, Lake Alfred, Florida, Proceedings. Lake Alfred. 204-212
- Rouhi, V., Shiran, B., & Mohamadkhani, A.** (2014). Effects of calcium chloride, gibberellin and benzyladenine on qualitative and quantitative characteristics and flower longevity of Zinnia (*Zinnia elegans* J.). *Journal of Horticultural Science*, 27(4), 444-452.
- Sadak, M. S., Dawood, M. G., Bakry, B. A., & El-Karamany, M. F.** (2013). Synergistic effect of indole acetic acid and kinetin on performance, some biochemical constituents and yield of faba bean plant grown under newly reclaimed sandy soil. *World Journal of Agricultural Sciences*, 9(4), 335-344.
- Safdar, A.W.; Tanveer, F.M.; Noor, U.N.M.; Niaz, A.W.** (2016). Photoperiodic Effect on Vegetative Growth and Flower Quality of Zinnia (*Zinnia elegans* Jacq.). *Sarhad Journal of Agriculture*, 32(4). p.258-423. [»http://dx.doi.org/10.17582/journal.sja/2016.32.4.316.324](http://dx.doi.org/10.17582/journal.sja/2016.32.4.316.324)
- Shiravand, D.** (2011). *Design of green spaces with ornamental trees and shrubs*. Iran: Agriculture Training and Education Press.
- Sorokin, H. P., & Thimann, K. V.** (1964). The histological basis for inhibition of axillary buds in *Pisum sativum* and the effects of auxins and kinetin on xylem development. *Protoplasma*, 59(2), 326-350.
- Tamas, I. A.** (1995). Hormonal regulation of apical dominance. In *Plant hormones: physiology, biochemistry and molecular biology* (pp. 572-597). Dordrecht: Springer Netherlands. 572- 597.
- Tariq, M., Hameed, S., Malik, K. A., & Hafeez, F. Y.** (2007). Plant root associated bacteria for zinc mobilization in rice. *Pakistan Journal of Botany*, 39(1), 245.
- Toscano, S., & Romano, D.** (2021). Morphological, physiological, and biochemical responses of zinnia to drought stress. *Horticulturae*, 7(10), 362. [»https://doi.org/10.3390/horticulturae7100362](https://doi.org/10.3390/horticulturae7100362)
- Yamaguchi, S., & Kamiya, Y.** (2000). Gibberellin biosynthesis: its regulation by endogenous and environmental signals. *Plant and cell physiology*, 41(3), 251-257.
- Yassin, M. Y., & Ismail, A. E.** (1995). Effect of Zinnia elegans as a mix-crop along with tomato against Meloidogyne incognita and Rotylenchulus reniformis. *Der TROPENLANDWIRT-JOURNAL OF AGRICULTURE IN THE TROPICS AND SUBTROPICS*, 96(2), 221-225.
- Ziobro, K.S., Usova, K.A.** (2016) The Use of Growth Regulators In The Cultivation Of Graceful Zinnia. *New science: experience, tradition, innovation*, v.591, n.2, p.4-8.