Effect Of Benzyl Adenine And Gibberellic Acid On The Vegetative Growth And Flowering Of Chrysanthemum Plant

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BSTRACT

The present study was carried out during two successive seasons of 2016 and 2017 in nursery of Department of Floriculture, Ornamental Horticulture and Garden Design Faculty of Agriculture University of Alexandria at Shatby to investigate the effect of foliar spraying three times of four concentrations (0, 50, 100 and 200 ppm) of each of benzyl adenine and gibberellic acid singly or in combinations (16 treatments) on the vegetative growth, flowering characteristics and some chemical analysis of *Chrysanthemum morifolium* cv. "Zambla White".

Results indicated that using benzyl adenine alone at 100 – 200 ppm led to significant increases of some studied parameters (branch dry weight, period from showing color to full opening stage, flowering duration on plant, inflorescence dry weight and total carotenoids content). Besides, using gibberellic acid alone at 200 ppm gave significant increases of all the studied parameters of *Chrysanthemum* plant.

While using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the maximum increases of all the studied parameters, compared with the other treatments.

From the previous results generally it can be recommended to spray *Chrysanthemum morifolium* cv. "Zambla White" three times during the vegetative growth period with benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm to activate the vegetative growth of the plants and produced early flowering with a high quality.

Key words: Benzyl Adenine, Gibberellic Acid, Chrysanthemum,

INTRODUCTION

Chrysanthemum morifolium, is a perennial plant, which occupies a prominent place in ornamental horticulture. Commercially, it is known as florist's C*hrysanthemum* or autumn of queen flower and predominantly sold as cut flowers in many countries of the world (Erler and Siegmund, 1986). It is globally the most important floricultural crop (Visser *et al.* 2007). The wide spectrum of colors and shapes, excellent vase life, and their ability to produce desired grades and types at any time during the year promoted their economic importance. In some countries, it ranks next to rose in value of the crop produced. The plant grows erect and tall making it suitable for border planting, loose flower, or as cut flowers. It is also grown in pots for flower shows.

The plant growth regulators are compounds that in minor amounts modify the physiological processes of plants and ultimately alter the yield and quality. Numerous plant growth regulators have been widely used in many flowering plants and their efficacy have been demonstrated for nursery production, foliage plants and many other ornamental plants (Sanap *et al.* 2000). Among the major groups are cytokinins and gibberellins (Salisbury and Ross, 1992).

Cytokinins are a large group of plant hormones, and benzyl adenine is one of the most active cytokinins (Buban, 2000). It has been identified as a natural cytokinin in number of plants (Van Staden and Crouch, 1996). Benzyl adenine has recently been used as one of other sources that can maintain or increase the quality of various ornamental plants (Han, 2001).

Application of benzyl adenine have been shown to have effects on many other physiological and developmental processes, including leaf senescence, leaf chlorosis, increase the vase life, delaying senescence of cut carnation by inhibiting ethylene biosynthesis (Cook *et al.* 1985), nutrient mobilization, apical dominance, the formation and activity of shoot apical meristems, floral development, combating drought stress in plants (Waterland *et al.* 2010).

Gibberellin was first recognized in 1926 by a Japanese scientist, Eiichi Kurosawa who was studying bakanae or "foolish seedling" disease in rice (Salisbury and Ross, 1992).

Gibberellins function as plant growth regulators influencing a range of developmental processes in plants life like stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction and leaf and fruit senescence. Spraying of GA_3 recorded maximum plant height,

plant spread and more number of leaves and branches in chrysanthemum and other flowering plants, chlorophyll content, yield and quality in different flowering crops and increased in vase life (Emami *et al.* (2011) and Sure *et al*. (2012).

The main objective of this research is to study the effect of different concentrations of benzyl adenine and gibberellic acid on the vegetative growth, flowering parameters and some chemical composition of *Chrysanthemum morifolium,* plant.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2016 and 2017 at the nursery of Department of Floriculture, Ornamental Horticulture and Landscape Gardening, Faculty of Agriculture, Alexandria University, Egypt, to investigate the effects of different concentrations of benzyl adenine (BA) and gibberellic acid (GA_3) on the vegetative growth, flowering parameters and chemical composition as well as their effect on vase life of the cut flowers of *Chrysanthemum morifolium*, plants. The used plant for this investigation was *Chrysanthemum morifolium,* Ram. cultivar "Zambla White". This cultivar has a large white decorative flower (inflorescences). It was chosen for its popularity in Egypt flower-trade and for year-round production.

The terminal cuttings of the used cultivar of the two experimental seasons were obtained from a commercial nursery in Menoufia Governorate which had a length of 8-10 cm and contained 4-6 leaves and they were planted on 14th May in plastic trays to form roots.

The planted cuttings were placed in a partial shade place and watered thoroughly. After one month (15th June) the rooted cuttings were first transplanting in small plastic pots of 10 cm diameter for each rooted cutting. The final transplanting of the rooted cuttings took place on July 15th in final plastic pots of 25 cm diameter filled by the used medium, using one plant per pot. The growing terminal of each plant was pinched to stimulate the growing of axillary buds to give more side branches. Another pinch was practiced two weeks later (on August 1st) to accelerate more basal branching. Three well distributed branches for each plant were chosen on 15th August, for the experimental purpose. These branches were disbudded to allow only one terminal flower bud to develop per each branch. Each branch was loosely held to a short cane inserted in the pot soil. The normal culture practices of growing C*hrysanthemum* plant were applied as usual manner (Deotale *et al.* 1994).

The used medium for planting the rooted cuttings and for the final transplanting was a mixture of sand and peat moss at the ratio of 1:1 by volume (Sajid *et al.* 2016).

The physical and chemical analysis of the used growing media were done at the Unit of Analysis and Scientific Services Soil and Water Activity, Faculty of Agriculture, University of Alexandria and the results of the analysis presented in Tables (A, B and C).

Table A: The physical analysis of the used medium.

Particle size distribution (%)			Texture
Clay	Silt	Sand	Sandy soil
4	3	93	

After one month of transplanting on 15th August, the spraying program with the growth regulators was started, and repeated three times at 21 days' interval (Sajid *et al.* 2016).

Two growth regulators were used for this study *i.e.* benzyl adenine (BA) ($C_{12}H_{11}N_5$) and gibberellic acid (GA_3) ($C_{19}H_{22}O_6$). Each growth regulator was used with four concentrations (Zero, 50, 100 and 200 ppm). The amounts of the growth regulators were dissolved in tap water and the proper concentration was applied to each plant. Each growth regulator was sprayed singly and with all possible combinations with the other growth regulator to produce 16 treatments.

The foliar application was done with a hand sprayer. The sprayer nozzle was set to the finest point to give an even mist. The plants under treatment were sprayed until the run-off point with applying the growth regulator solution to both upper and lower surface of the leaves with using "Tween 20" at 1 ml/l as a surfactant substance for enhancing the efficiency of the used materials. The spraying was done always at 8 O'clock mornings. The control treatment was sprayed at same time with tap water containing "Tween 20" at 1 ml/1.

To supply the plants with their requirements of nitrogen, phosphorus and potassium, supplementary nitrogen as ammonium nitrate (33.5 % N) at 1 g /1 plant $^{-1}$, mono-calcium superphosphate (15.5% P_2O_5) at 1 g/1 plant $^{-1}$, and potassium sulphate (48 % K_2 O) at 0.25 g /l plant $^{-1}$ were applied dissolved in tap water twice weekly started two weeks after the final transplanting until the flower buds reached a diameter of 1 to 1.5 cm (Kofranek and Lunt, 1980). To avoid salt accumulation around the root zone, every two weeks the substrate was leached by using tap water to get out the excessive salts (Kofranek and Lunt, 1980). Plant requirement of magnesium (Mg) and iron (Fe) was added as $MgSO_4$ $7H_2O$ at 150 ppm and Fe-EDTA (8.5% Fe) at 75 ppm.

The collected data:

Vegetative growth characteristics:

Plant height (cm), number of removed auxiliary buds per plant, number of leaves per branch, leaf area (cm^2/plant), and branch dry weight (g),.

Table B: The chemical analysis of the used medium.

pH	EC(ds/m)	Cations (meq/l)				Anions (meq/l)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
7.10	0.93	2.31	0.31	1.76	0.23	-	0.35	1.06	3.20

Table C: The available macro-and micro-nutrients in the used medium.

Macronutrients (meq/l)			Micronutrient (ppm)			
N	P	K	Cu	Fe	Mn	Zn
0.139	0.109	0.002	0.36	1.52	2.67	5.50

Flower characteristics:

Time taken from final transplanting date to flower buds showing color (day), time taken to full opening stage (day), inflorescences diameter (cm) at full opening stage, flowering duration on the plants (day) from showing color to fading stage, inflorescence dry weight (g), and vase life of the cut inflorescence at full opening stage till the fading stage (day).

Chemical analysis:

Total chlorophyll content (mg/ 100g fresh leaves) and total carotenoids content (mg/ 100g fresh leaves).

The experiment layout was designed to provide as complete randomized blocks in factorial experiment containing three replicates, each replicate contained (16) different treatments. (Four GA_3 concentrations X four BA concentrations = 16). Six pots were used as a plot for each treatment in each replicate (three pots for the experiment purpose and the three other pots for the vase life determination). The means of the individual factors and their interactions were compared by L.S.D. test at 5% Level of probability (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Vegetative growth

Plant height (cm):

Generally, data of the two experimental seasons presented in Table (1) showed that using gibberellic acid or benzyl adenine alone at the highest concentration (200 ppm) gave the maximum plant height of *Chrysanthemum morifolium* cv. "Zambla White" compared with their other concentrations. While, using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the highest plant height, compared with the other treatments.

These results may be due to the role of each material alone, or there was a synergistic effect between them at suitable concentration on increasing cell division and/ or elongation or both of them. Accordingly, the plant height could be increased. Similar trend of results was found by Sajid *et al.* (2016) on *Chrysanthemum* plant.

Numbers of removed axillary buds per plant

Data of the two seasons in Table (1) indicated that using gibberellic acid alone at any concentration led to significant increase the number of removed axillary buds per plant, compared with the control treatment. Also, using gibberellic acid at 200 ppm gave the maximum number of removed axillary buds per *Chrysanthemum* plant, compared with its other concentrations in the two seasons.

These results might be due to that using gibberellic acid at a suitable concentration led to increase leaves number and leaf area per plant, then the production and the accumulation of the biosynthesis materials could be increased and activated the lateral buds to grow, consequently the number of removed buds could be increased.

Besides, data in Table (1) showed that using benzyl adenine at 100 ppm combined with gibberellic at 200 ppm gave the highest number of the removed axillary buds per plant, compared with the other treatments.

These results may be due to that there was a synergistic effect between the two used materials when each one was used at a suitable concentration on increasing leaf number or leaf area or both of them, consequently more biosynthesis materials could be produced and accumulated within the plant which encourage the lateral buds to grow, then their number could be increased.

Similar trend of results was reported by Alhajhof (2017) on *Chrysanthemum* and Vinutha *et al.* (2017) on China aster.

Number of leaves per plant:

Generally, data of the two experimental seasons presented in Table (1) indicated that using gibberellic acid at any concentration led to significant increase the number of leaves per *Chrysanthemum* plant compared with the control treatment. Also, using the highest concentration of gibberellic acid alone gave the maximum leaf number per plant, compared with its other concentrations.

Table 1:Effect of benzyl adenine and gibberellic acid concentrations and their combinations on means of plant height (cm), number of removed axillary buds /plant and number of leaves /plant of *Chrysanthemum morifolium* cv".Zambla White" during the two seasons of 2016 and 2017.

BA	GA_3	Plant height(cm)		Mean	Number of removed buds /plant		Mean	Number of leaves/plant		Mean
(ppm)	(ppm)	Season			Season			season		
		2016	2017		2016	2017		2016	2017	
0	0	56.79	45.72	51.25	39.70	38.22	38.96	49.77	48.29	49.03
	50	70.31	67.51	68.91	54.15	48.26	51.20	64.22	58.33	61.27
	100	77.16	67.66	72.41	61.37	49.03	55.20	71.44	57.10	64.27
	200	77.84	67.67	72.75	61.48	49.15	55.31	71.55	59.22	65.38
Mean		70.52	62.14	66.33	54.17	46.16	50.16	64.24	56.23	60.23
50	0	62.97	46.79	54.88	46.38	41.88	44.13	56.55	51.95	54.25
	50	72.66.	67.18	67.18	65.31	48.53	56.92	66.78	58.60	62.69
	100	80.07	67.99	74.03	63.92	49.48	56.70	73.99	59.55	66.77
	200	81.01	68.23	74.62	65.07	50.14	57.605	75.10	60.21	67.655
Mean		74.18	62.55	68.36	57.92	47.50	52.71	68.01	57.58	62.79
100	0	65.33	51.40	58.36	48.7	47.92	48.31	58.77	57.99	58.38
	50	72.46	67.64	70.05	57.26	48.65	52.95	67.33	58.72	63.02
	100	82.81	68.09	75.45	66.37	49.76	58.06	76.44	59.83	68.13
	200	86.09	69.30	77.69	68.81	51.01	59.91	78.88	61.05	69.96
Mean		76.67	64.10	70.38	60.28	49.33	54.80	70.35	59.40	64.87
200	0	69.34	57.08	63.21	53.15	48.09	50.62	63.22	58.16	60.69
	50	75.70	67.75	71.72	59.81	49.03	54.42	69.88	59.10	64.49
	100	84.49	67.16	75.82	68.01	48.37	58.19	78.05	58.44	68.24
	200	83.21	67.77	75.49	66.87	49.20	58.035	76.94	59.27	68.10
Mean		78.19	64.94	71.56	61.96	48.67	55.31	72.02	58.74	65.38
LSD at 0.05	BA	0.20	NS		0.10	NS		0.10	NS	
	GA_3	0.20	3.08		0.10	2.88		0.10	2.89	
	BA X GA_3	0.40	NS		0.21	NS		0.21	NS	

These results might be attributed to that using gibberellic acid at a proper concentration led to increase the differentiation of leaf primordial in the apical growing region (Moond and Rakesh,2006), consequently the leaf number per plant could be increased.

While, using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the highest leaf number per plant, compared with the other treatments.

These results may be due to the role of each material or there was a synergistic effect between the two used materials when each one was used at a proper concentration on activation more leaf primordial in the growing apex to form, thus the leaf number per plant could be increased.

Similar trend of results was reported by Aier *et al.* (2015) and Sajid *et al.* (2016) on *Chrysanthemum* plant.

Leaf area (cm^2/plant):

*D*ata of the two seasons in Table (2) showed that increasing the used concentration of gibberellic acid led to significant increase the leaf area per plant compared with the control treatment. Also, using gibberellic acid alone at the highest concentration (200 ppm) gave the maximum leaf area per plant in the two seasons, compared with its other concentrations.

These results might be attributed to the role of gibberellic acid at a proper concentration on stimulation of cell division and cell elongation of the leaves or on increasing the number of leaves per plant, or all of them, consequently the leaf area per *Chrysanthemum* plant could be increased.

Also, data of the two seasons in Table (2) indicated that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the largest leaf area per plant, compared with the other treatments.

These results may be due to the role of each material alone, or there was a synergistic effect between them at a specific concentration on increasing leaf number or size or both of them, consequently the leaf area per plant could be increased. Similar trend of results was reported by Shisaenla *et al.* (2015) on *Gladiolus* cv. Red Candyman.

Branch dry weight (g):

Generally, data of the two experimental seasons presented in Table (2) showed that using each of benzyl adenine alone at concentration more than 50 ppm or gibberellic acid at any concentration led to significant increase the branch dry weight of *Chrysanthemum* plant, compared with control treatment. Besides, using the two growth regulators combined at any concentration for each one gave significant increase of the branch dry weight of *Chrysanthemum* plant more than that of using each material alone. Also, data of the two seasons in Table (2) indicted that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the maximum value of branch dry weight of *Chrysanthemum* plant, compared with the other combinations.

These results were probably due to that using the two growth regulators combined each at a proper concentration led to encourage plant growth and increase the activity of photosynthesis process in *Chrysanthemum* plant or both of them, consequently the branch dry weight could be increased.

These results are in accordance with those of Sardoei *et al.* (2014) on other plant.

Flowering characteristics

Generally, data of the two seasons presented in Table (3) showed that using gibberellic acid at any concentration led to decrease the time taken to flower buds showing their color, compared with control treatment. Besides, using gibberellic acid alone at 200 ppm gave the shortest period for flower buds to show their color. The previous treatment led to decrease the time taken to flower buds showing color with 8.55 and 7.45 days, in the first and second seasons, respectively.

These results were probably due to that using gibberellic acid at a suitable concentration led to accelerate the iniation and development phases of the inflorescence of *Chrysanthemum* plant, accordingly the inflorescence could be reached its show color stage early.

Similar trend of results was reported by Patel *et al.* 2010) and Sharifuzzaman *et al.* (2011) on *Chrysanthemum* plant.

Time taken to full opening stage (day)

Generally, data of the two seasons presented in Table(3) indicated that using benzyl adenine alone at concentration more than 50 ppm led to significant decrease the period taken from showing color stage of the inflorescence to reach its full opening stage, compared with control treatment. Besides, data of means of the two seasons in Table (3) showed that using benzyl adenine at concentration of 200 ppm gave the shortest period to full opening stage of the inflorescence compared with its other concentrations.

These results were probably due to that using benzyl adenine at a suitable concentration led to accelerate the development phases of the inflorescence; accordingly, the inflorescence could be reached to full opening stage early.

Similar trend of results was found by Nambiar *et al.* (2012) and Soumen and Nilimesh (2014) on other plants.

Furthermore, data of the two seasons presented in Table (3) showed that using gibberellic acid alone at any concentration led to significant decrease the time taken from showing color stage of the inflorescence to reach its full opening stage, compared with control treatment. Also, using gibberellic acid at 200 ppm gave the shortest period from showing color stage of the inflorescence to reach its full opening stage, compared with its other concentrations.

These results were probably due to that using gibberellic acid at a proper concentration led to accelerate the development phases of the inflorescence of *Chrysanthemum* plant, consequently the needed period from showing color stage to full opening stage of the flower buds could be decreased.

Similar trend of results was reported by Dutta *et al.* (1993) Saker (1995), Patel *et al.* (2010) and Aier *et al.* (2015) on *Chrysanthemum* and other plants.

Besides, data of the two seasons in Table (3) revealed that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the shortest period needed to full opening stage of the inflorescence, compared with the other treatments.

Table 2:Effect of benzyl adenine and gibberellic acid concentrations and their combinations on means of leaf area (cm^2)/plant and branch dry weight (g) of *Chrysanthemum morifolium* cv."Zambla White" during the two seasons of 2016 and 2017.

BA (ppm)	GA_3 (ppm)	Leaf area/plant (cm^2)		Mean	Branch dry weight (g)		Mean
		Season			Season		
		2016	2017		2016	2017	
0	0	945.76	917.50	931.63	10.96	10.28	10.62
	50	1220.20	1108.20	1164.2	13.26	11.75	12.50
	100	1357.36	1122.90	1240.13	14.13	13.56	13.84
	200	1359.20	1125.10	1242.15	14.27	13.62	13.94
Mean		1220.65	1065.47	1143.06	13.155	12.3025	12.72
50	0	1074.46	987.10	1030.78	11.84	10.51	11.17
	50	1261.23	1113.40	1187.315	13.46	12.41	12.93
	100	1405.96	1131.50	1268.73	14.70	13.73	12.21
	200	1426.76	1144.00	1285.38	14.85	13.39	14.12
Mean		1292.13	1094.04	1193.08	13.71	12.51	13.11
100	0	1120.96	1101.70	1111.33	12.31	10.97	11.64
	50	1279.30	1115.60	1197.45	13.43	12.8	13.11
	100	1452.43	1136.70	1294.56	10.02	13.46	14.24
	200	1498.86	1159.90	1329.38	15.96	13.95	14.95
Mean		1337.89	1128.52	1233.20	14.18	12.79	13.48
200	0	1201.10	1105.00	1153.05	13.00	11.01	12.00
	50	1327.83	1122.90	1225.36	13.78	13.78	13.78
	100	1482.96	1110.40	1296.68	15.50	13.51	14.50
	200	1461.83	1126.10	1293.96	15.28	13.62	14.45
Mean		1368.43	1116.15	1242.29	14.39	12.98	13.68
LSD at 0.05	BA	2.64	NS		0.07	0.467	
	GA_3	2.64	55.03		0.07	0.467	
	BA X GA_3	5.29	NS		1.39	0.934	

These results may be due to the synergistic effect between the two materials at a specific concentration for each one on acceleration the inflorescence to reach its full opening stage early.

Inflorescence diameter (cm)

Generally, data of the two seasons in Table (3) showed that using gibberellic acid at concentration more than 50 ppm led to significant increase the inflorescence diameter of *Chrysanthemum* plant, compared with the control treatment. Besides, using gibberellic acid alone at 200 ppm gave the maximum inflorescence diameter, compared with its other concentrations.

These results were probably due to that using gibberellic acid at a proper concentration led to extend the length of ray florets, or promote more initiated florets per capitulum or both of them, accordingly the diameter of the inflorescence of *Chrysanthemum* plant would be increased.

Similar findings were reported by Sainath and Meena (2012) and Sajid *et al.* (2016) on *Chrysanthemum* plant.

Besides, data in Table (3) revealed that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the largest inflorescence diameter of *Chrysanthemum* plant, compared with the other treatments.

These results may be due to the synergistic effect between the two used materials at a specific concentration for each one on activation the vegetative growth of *Chrysanthemum* plant, thus the flower quality could be increased.

Table 3: Effect of benzyl adenine and gibberellic acid concentrations and their combinations on means of time of showing color (day), required time to full opening stage (day) and inflorescence diameter (cm) of *Chrysanthemum morifolium* cv. "Zambla White" during the two seasons of 2016 and 2017.

BA	GA_3	Time to showing color (day)		Mean	Time to full opening stage (day)		Mean	Inflorescence diameter (cm)		Mean
(ppm)	(ppm)	Season			Season			season		
		2016	2017		2016	2017		2016	2017	
0	0	138.33	137.70	138.01	19.33	17.66	18.49	8.22	7.24	7.73
	50	134.10	134.86	134.48	17.33	14.33	15.83	8.57	7.57	8.07
	100	132.10	132.70	132.40	16.66	13.33	14.99	8.75	8.16	8.45
	200	128.90	130.03	129.46	16.33	12.00	14.16	8.89	8.46	8.67
Mean		133.35	133.82	133.58	17.41	14.33	15.87	8.60	7.86	8.23
50	0	137.06	138.36	137.71	17.66	16.33	16.99	8.55	7.26	7.90
	50	134.46	134.56	134.51	18.00	14.33	16.16	8.42	7.66	8.04
	100	132.93	132.83	132.88	14.33	12.33	13.33	9.33	8.04	8.68
	200	128.66	130.30	129.48	13.00	11.33	12.16	9.64	8.50	9.07
Mean		133.28	134.01	133.64	15.75	13.58	14.66	8.98	7.87	8.42
100	0	138.23	137.63	137.93	15.66	16.33	15.99	8.98	7.36	8.17
	50	134.30	134.70	134.50	13.66	13.66	13.66	9.37	7.67	8.52
	100	132.83	133.23	133.03	9.00	12.33	10.66	10.13	8.23	9.18
	200	129.33	130.86	130.09	8.00	10.66	9.33	10.51	8.81	9.66
Mean		133.67	134.10	133.88	11.58	13.25	12.41	9.75	8.02	8.88
200	0	137.50	137.96	137.73	15.33	15.33	15.33	9.04	7.56	8.30
	50	134.93	134.66	134.79	12.00	11.66	11.83	9.70	7.69	8.69
	100	133.23	133.76	133.49	10.00	10.66	10.33	10.10	8.36	9.23
	200	130.03	130.66	130.34	11.00	10.00	10.50	10.06	8.35	9.20
Mean		133.92	134.26	134.09	12.08	11.91	11.99	9.72	7.99	8.85
LSD at 0.05	BA	NS	NS		0.52	0.91		0.16	NS	
	GA3	0.85	0.94		0.52	0.91		0.16	0.72	
	BA X GA_3	NS	NS		1.04	NS		0.32	NS	

Flowering duration on the plants (day)

Generally, results of the two seasons presented in Table (4) showed that using benzyl adenine alone at 100 ppm gave the longest flowering duration of *Chrysanthemum* plant, compared with its other concentrations.

These results were probably due to that using benzyl adenine at a proper concentration led to increase the inflorescence life or delaying the senescence of the flower or both of them as a result the flowering period (duration) could be increased.

These results were a good agreement with these concluded by Guo *et al.* (2003) on *Chrysanthemum,* and Baghele *et al.* (2012) on rose.

Besides, data of the two seasons in Table (4) revealed that using gibberellic acid alone at a concentration ranged between 50 to 100 ppm gave the maximum flowering period of *Chrysanthemum* plant, compared with its other gibberellic acid concentrations.

These results might be due to that using gibberellic acid at a suitable concentration led to delay flower senescence by reducing ethylene production and chlorophyll breakdown, consequently the flowering period could be increased.

Similar trend of results was reported by Kjonboon and Kanlayanarat (2005) and Mayak *et al.* (2006) on other plants.

Furthermore, data of the two seasons presented in Table (4) indicated that using benzyl adenine at 50 ppm combined with gibberellic acid at 200 ppm led to significant increase the flowering period of *Chrysanthemum* plant, compared with the other combinations.

These results were probably due to the role of each material when it used at a suitable concentration, or there was a synergetic effect between them on delaying flower senescence and inhibition chlorophyll and protein degradation, consequently the flowering period could be increased.

Similar trend of results was reported by Mondal and Sarkar (2017) on other plants.

Inflorescence dry weight (g)

Generally, data of the two experimental seasons presented in Table (4) indicated that using benzyl adenine at concentration more than 50 ppm and/or gibberellic acid with any concentration alone or in combination together led to significant increase the inflorescence dry weight of *Chrysanthemum morifolium* plant, compared with the control treatment. Besides, using benzyl adenine at 100 ppm combined with gibberellic acid at 100 or 200 ppm gave the maximum inflorescence dry weight, compared with the other concentrations in the two seasons.

These results were probably due to that using benzyl adenine and gibberellic acid combined each one at a suitable concentration led to increase the florets number per head or size or both of them, consequently the dry weight of the inflorescence of *Chrysanthemum* plant would be increased.

Similar findings were reported by Sainath and Meena (2012) and Sajid *et al.* (2016) on *Chrysanthemum* plant.

Vase life of the cut inflorescences (day)

Generally, data of the two seasons in Table (4) indicated that using gibberellic acid at any concentration led to significant increase the period of the vase life of the cut inflorescence of *Chrysanthemum* plant, compared with the control treatment. Besides, using gibberellic acid at 200 ppm gave the maximum value of the vase life of the cut inflorescence compared with its other concentrations in the two experimental seasons.

These results were probably due to that using gibberellic acid at a suitable concentration led to delay the florescence's senescence and reduce ethylene production in the cut inflorescence, consequently the inflorescence duration in the vase could be increased.

Similar trend of results was reported by Kjonboon and Kanlayanarat (2005) and El-Bably (2016) on other plants.

Besides, data of the two seasons in Table (4) showed that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the longest vase life of the cut inflorescence, compared. with the other treatments.

These results may be due to the synergistic effect between the two used materials at a suitable concentration for each one on delaying the inflorescence's senescence through reducing its ethylene production, consequently the vase life of the cut inflorescence could be more prolonged.

Chemical analysis

Total chlorophyll content (mg/100g leaves fresh weight)

Generally, data of the two seasons presented in Table (5) showed that using gibberellic acid at any concentration led to significant increase the total chlorophyll content of *Chrysanthemum* leaves, compared with the control treatment. Besides, using gibberellic acid at 200 ppm gave the maximum value of total chlorophyll content of the leaves of *Chrysanthemum* plant, compared with its other concentrations.

These results might be attributed to that using gibberellic acid at a proper concentration led to active the enzymes needed for chlorophyll formation and/or it reduced the degradation of chlorophyll as reported by Janowska and Jerzy (2003), or both of them, accordingly the total chlorophyll content of *Chrysanthemum* leaves could be increased. Similar trend of results was reported by Hussein (2009), Mohamed (2011) and Roni and Singh (2013) on other plants.

Besides, data of the two seasons in Table (5) revealed that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the highest chlorophyll content in *Chrysanthemum* leaves, compared with the other treatments.

These results may be due to the role of each material or there was a synergistic effect at a suitable concentration of each material on increasing the synthesis and decreasing the degradation of chlorophyll or both of them, consequently the total chlorophyll content in *Chrysanthemum* leaves could be increased.

Total carotenoids content (mg/100g fresh leaves)

Generally, data of the two experimental seasons presented in Table (5) showed that using benzyl adenine at concentration more than 50 ppm led to significant increase the total carotenoids content of *Chrysanthemum* leaves, compared with the control treatment.

Table 4: Effect of benzyl adenine and gibberellic acid concentrations and their combinations on means of flowering duration (da), inflorescence dry weight (g) and vase life of the cut inflorescence of *Chrysanthemum morifolium* cv". Zambla White" during the two seasons of 2016 and 2017.

BA	GA_3	Flowering duration (day)		Mean	Inflorescence dry weight (g)		Mean	Vase-life (day)		Mean
(ppm)	(ppm)	Season			Season			season		
		2016	2017		2016	2017		2016	2017	
0	0	50.43	48.62	49.52	1.380	1.280	1.330	11.88	20.44	16.16
	50	51.04	50.06	50.55	2.562	2.450	2.506	15.44	22.66	19.05
	100	51.48	49.32	50.40	2.660	2.571	2.615	14.66	23.10	18.88
	200	51.93	46.03	48.98	2.661	2.530	2.595	19.11	23.77	21.44
Mean		51.22	48.51	89.86	2.315	2.207	2.261	15.27	22.49	18.88
50	0	50.39	49.84	50.11	1.626	1.522	1.574	12.44	21.18	16.81
	50	49.71	49.45	49.58	2.443	2.309	2.376	13.22	22.88	18.05
	100	52.10	49.14	50.62	2.673	2.560	2.617	23.88	23.55	23.71
	200	52.04	49.73	50.88	2.618	2.551	2.584	26.44	23.44	24.94
Mean		51.06	49.54	50.30	2.340	2.235	2.290	18.99	22.76	20.88
100	0	52.15	51.23	51.69	1.860	1.731	1.795	21.88	21.88	21.88
	50	52.26	49.08	50.67	2.481	2.312	2.396	25.22	23.66	24.44
	100	52.21	49.19	50.70	2.750	2.630	2.690	29.22	23.66	26.44
	200	51.71	49.23	50.47	2.760	2.601	2.680	30.10	23.99	27.04
Mean		52.08	49.68	50.88	2.462	2.318	2.390	26.60	23.05	24.95
200	0	52.60	49.95	51.27	2.106	1.990	2.048	23.88	21.99	22.93
	50	52.16	47.56	49.86	2.511	2.416	2.463	27.22	22.88	25.05
	100	51.77	47.79	49.77	2.731	2.664	2.697	28.55	23.66	26.10
	200	52.38	48.18	50.28	2.770	2.630	2.700	27.55	23.66	25.60
Mean		52.23	48.37	50.29	2.529	2.425	2.477	26.80	23.30	24.92
LSD at 0.05	BA	0.35	0.47		0.132	0.129		0.56	NS	
	GA_3	0.35	0.47		0.132	0.129		0.65	1.64	
	BAx GA_3	0.70	0.95		0.264	0.258		1.12	NS	

These results may be attributed to that using benzyl adenine at a proper concentration led to accelerate the synthesis of carotenoids, besides, it protects the degradation of photosynthetic pigments, consequently the total carotenoids in the leaves of *Chrysanthemum* plant could be increased. Similar trend of results was reported by Talaat and Youssef (1998) on *Hibiscus sabdariffa* plant.

Besides, data of the two experimental seasons in Table (5) indicated that using gibberellic acid at any concentration led to significant increase the total carotenoids content in *Chrysanthemum* leaves, compared with the control treatment. Also, using gibberellic acid at 200 ppm gave the maximum value of total carotenoids in the leaves, compared with its other concentrations.

These results may be due to that using gibberellic acid at a proper concentration led to activate the formation of carotenoids in the leaves of *Chrysanthemum* plant, consequently the total carotenoids in the leaves could be increased.

Similar trend of results was reported by Eid and Abou-leila (2006), and Mohamed (2011) on other plants.

Furthermore, data of the two seasons in Table (5) indicated that using benzyl adenine at 100 ppm combined with gibberellic acid at 200 ppm gave the highest carotenoids content in *Chrysanthemum* leaves, compared with the other treatments.

These results were probably due to the role of each material or there was a synergistic effect between the two materials when each one was used at a specific concentration on activation the synthesis and protection the carotenoids from degradation, thus their content in the leaves could be increased.

Table 5: Effect of benzyl adenine and gibberellic acid concentrations and their combinations on means of total chlorophyll and total carotenoids contents (mg/100 g fresh leaves) of *Chrysanthemum morifolium* cv".Zambla White" during the two seasons of 2016 and 2017.

BA	GA_3	Total chlorophyll(mg/100gF.W.)		Mean	Total carotenoids(mg/100gF.W.)		Mean
(ppm)	(ppm)	Season			Season		
		2016	2017		2016	2017	
0	0	1.735	2.025	1.880	0.168	0.198	0.183
	50	1.986	2.338	2.162	0.185	0.225	0.205
	100	1.869	2.391	2.130	0.183	0.235	0.209
	200	2.710	2.434	2.572	0.252	0.242	0.247
	Mean	2.075	2.297	2.186	0.197	0.225	0.211
50	0	1.784	2.174	1.979	0.171	0.198	0.184
	50	2.074	2.368	2.221	0.197	0.229	0.213
	100	2.435	2.406	2.420	0.219	0.237	0.228
	200	2.760	2.524	2.642	0.259	0.245	0.252
	Mean	2.263	2.368	2.315	0.211	0.227	0.219
100	0	1.833	2.234	2.033	0.182	0.207	0.194
	50	2.124	2.365	2.244	0.202	0.232	0.217
	100	2.462	2.415	2.438	0.233	0.240	0.236
	200	2.942	2.557	2.749	0.329	0.245	0.287
	Mean	2.34	2.393	2.366	0.237	0.231	0.234
200	0	1.911	2.232	2.071	0.184	0.210	0.197
	50	2.197	2.404	2.300	0.210	0.235	0.222
	100	2.536	2.414	2.475	0.238	0.240	0.239
	200	2.685	2.521	2.603	0.248	0.241	0.244
	Mean	2.332	2.393	2.362	0.220	0.232	0.226
LSD at 0.05	BA	0.016	NS		0.011	0.004	
	GA_3	0.016	0.169		0.011	0.004	
	$BAXGA_3$	0.028	NS		0.016	NS	

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الملخص العربي

تأثير البنزيل أدينين وحامض الجبربللين علي النمو الخضري والزهري لنبات الأراولا

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أجري هذا البحث في مشتل الأرشاد التابع لقسم الزهور ونباتات الزينة وتنسيق الحدائق بكلية الزراعة-جامعة الأسكندرية بالشاطبي وذلك خلال موسمي 2016، 2017 وكان الهدف من هذا البحث هو دراسة تأثير الرش علي المجموع الخضرى بأربع تركيزات هي صفر، 50، 100،200 جزء في المليون من كل من حامض الجبريللين والبنزيل أدينين ثلاث مرات حيث أضيفت كل مادة إما منفردة أو مع عمل جميع التوافيق بينهما لتعطي 16 معاملة وذلك علي النمو الخضري والزهري وبعض التحليلات الكيماوية لنبات الأراولا صنف "Zambla White".

وقد أظهرت نتائج الموسمين أن رش النباتات بالبنزيل أدينين منفردا بتركيز 100أو 200 جزء فى المليون أدى إلى زيادة معنوية فى بعض الصفات المدروسة (وزن الفرع الجاف،وقت التفتح الكامل للنورات، مدة بقاء النورات على النبات، وزن النورات الجاف، محتوى الأوراق من الكاروتينات الكلية)، فى حين أن إستخدام حامض الجبريللين بتركيز 200 جزء فى المليون منفردا فقد أعطى زيادة معنوية فى جميع الصفات المدروسة على نبات الأراولا.

أما إستخدام البنزيل أدينين بتركيز 100 جزء فى المليون مع حامض الجبريللين بتركيز 200 جزء فى المليون فقد أعطى أقصى زيادة فى جميع الصفات المدروسة بالمقارنة بالمعاملات الأخرى.

وعموما يمكن التوصية برش نبات الأراولا صنف "Zambla White"أثناء فترة نموه الخضرى ثلاث مرات بالبنزيل أدينين بتركيز 100 جزء فى المليون مع حامض الجبريللين بتركيز 200 جزء فى المليون حيث يؤدى ذلك إلى تنشيط النمو الخضرى وإنتاج أزهار مبكرة بجودة عالية.