Effect of supplemental light, benzyl adenine (BA) on the growth and flowering of two cultivar of Chrysanthemum plant (*Dendranthema grandiflora* Tzvelev)

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DOI: https://doi.org/10.36077/kjas/2023/v15i2.10325

Received date: 11/9/2022

Accepted date: 3/10/2022

Abstract:

This study was conducted during the period from 23rd September 2021 to 1st May 2022 in Horticulture stations / Akre / Iraqi Kurdistan region, amid to schedule the flower production of Chrysanthemum (*Dendrathema grandiflora* Tzvelev), by use the supplemental light with (Natural (unlit), 1.5-month, 3-month), BA with 0, 200 and 400 mg.l^{-1} and two cultivars Avalon (pink) and Flirt (red). The study was performed by use Random Complete Block Design (RCBD). The best results include, use 3-monthof supplemental light significantly increased the number of day to flower bud appearance and the number of days to flower anthesis to 143.36 and 201.10 day for the two cultivars Avalon and Flirt respectively compared with 1.5 month which need 119.61, 175.02 day and clontrol which need 49.28, 78.31 day for the two cultivars respectively, this mean that 3-month delay the flower production by 122.79 day than control. Plant height**,** flower grade and Plant growth index also increased significantly with increased the supplemental light to 1.5 and 3-month compared with control. Sprayed Chrysanthemum with BA increased significantly the day to flower bud appearance, vase life and flower grade compared with control. The Flirt (red) cultivar significantly superior than Avalon (pink) in day to flower bud appearance, day to flowering anthesis, plant high and flower grade.

Keywords: Additional light, Cytokinin, Species. Chrysanthemum

Introduction

Chrysanthemum (*Dendranthema Grandiflora* Tzvelev), commonly known as Glory of East or Mum in the U.S.A., is a worldwide essential traditional crop and the second most important floricultural crop after Rose (15). Considered to be an herbaceous perennial flowering plant, it is very popular as a cut flower because of its long vase life,

beautiful and attractive flowers and numerous cultivars of various sizes, inflorescence shapes, and colours. It is believed to be native to the northern hemisphere, mainly Europe and Asia (3; 30; 19; 27). The tall and erect the growing cultivar (Standard Chrysanthemum) is used as cut flowers in bouquets and vases, and the dwarf and compact cultivar (Spray Chrysanthemum) is used as a potted plant for indoor and outdoor beautification.(5).

The Photoperiod manipulation is one of the most effective techniques for producing off-season flowers and to do flower-forcing in light-sensitive plants such as long-day and short-day plants. So, to controls and scheduling of flowering in many floriculture crops, the artificially photoperiod for lengthened or shortened to maintain vegetative growth in these crops or to induce flowering (4;13). In general, chrysanthemum will stimulate flowers under a critical day-length photo-period of less than 13.5 hours, and under longer critical day-length photoperiods, the plant fails to blossom (20).Year-round flowering of chrysanthemum is possible by providing long photoperiods in which the plants grow vegetative, producing stems and leaves, followed by short photoperiods in which the plants grow reproductively, producing flower (18). Ameen and Abdulaziz (2005) (2) found that long day treatment (14 hours light) increased the plant height, branch number, leave number, steam diameter and flower bud /plant while short day (8 hours light) significantly reduced the time to the appearance of flower buds and time to flower. Agata *et al*., (2011) (1) found that amount of light has a significant positive effect on the quantity of fresh mass of chrysanthemum and leaf area index (LAI).Using high-pressure sodium lamps to increase day length can significantly increase (plant height, leaf number, internode length and leaf area), effectively improving the vegetative growth of chrysanthemums (17). Hammo (2020) (12) showed that the exposure of chrysanthemums to a long day for two months, starting from 1st Oct. till 30th Nov. delayed the flowering-about 64 day than the short day and start in flowering in 2nd Jan. and continue till 3rd Mar. and increased most of the studied parameters significantly.

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 in nursery production, foliage plants and many other ornamental plants (26). Among the major groups of cytokinin's is a benzyl adenine (BA) which is one of the most active one (25). Gabrel *et al*, (2018) (11) found that using benzyl adenine on chrysanthemum plant at 100 – 200 mg.l^{-1} led to a significant elevation in some of the measured indices (branch dry weight, period from showing color to full opening

stage, flowering duration on plant, inflorescence dry weight and total carotenoids content). Benzyl adenine (BA) is used to reduce the susceptibility of flowers to leaf yellowing, reduce wilting, and delay leaf chlorosis during storage and transportation and also has activity as an antioxidant enzyme such as catalase (28).

The variations among chrysanthemum varieties are large in response to environment particularly temperature (33). Royal, (2004) (23) discovered that different pot-chrysanthemum cultivars fall into three categories: early cultivars, which bloom in a period of 7 to 8 weeks, medium cultivars, which bloom in a period of 8 to 9 weeks, and late cultivars, which bloom in a period of more than 9 weeks of short days. Chrysanthemum (*Dendranthema grandiflorum*) One of the 10 most famous traditional Chinese flowers, comprising the most abundant and diverse cultivars of any horticultural plant in the world, reviewed with particular emphasis on cultivar differences (8; 33).

Material and method

This study was carried out during the period from 23th Sep. 2021 to 1th May. 2022 in naturally ventilated plastic house in Akre horticulture directorate nursery/ Duhok/ Iraqi Kurdistan region, to study the effect supplemental light, benzyl adenine and cultivar on the growth and flowering of Chrysanthemum plant.

Rooted cuttings one month old of two cultivars, avalon (pink) and flirt (red) of Chrysanthemum (*Dendrathema grandiflora* Tzvelev) were taken from the nursery of Duhok University were used in this experiment then transplanted at 23th Sep in 5-liter pots by mixture of soil (loam) and peat moss (3:1) which its chemical characteristics were pH (7.2), Ec (0.3) ds.m^{-1}, $CaCo_3$ (12.5)%, K (73) mg.l^{-1}, P (56.5) mg.l^{-1}, N (1610) mg.l^{-1}, C/N ratio (45.5), Organic matter (2.98%). After two weeks from transplanting, the plants were pinched to 3 internodes and divided to three groups for each cultivar. The first one left to growth naturally without any treatment (control). The second after 4 weeks of the planting in the pot are subjected to supplement light (day length) from (5 PM to 12 PM)) by using incandescent lamps (100-watt, 1.25 m above pots) for 1.5 month starting from 15st Oct. till 1th Dec. And The third are subjected to supplement light for 3 months starting from 15st Oct. till 15th Jan. Thereafter, the plants were kept under natural day.

The third factor was Benzyl Adenine (BA) include three levels (0, 200 and 400) mg.l^{-1}.Sprayed in two time the first after 1 month after planting and the second after two months of planting.

So The experiment was included three factors 2 cultivars, 3 supplemental light and 3 BA (2×3×3=18) × 3 replicate × 5 plant so the experiment include (270) plants .The studied measurements included: Days to flower bud emergence (day) ,days to flower anthesis (flower maturity), Plant high (cm), the flower grade, which were calculated according to SAF (1996) (24) The flowers are graded to different classes according to their quality based on length, strength of stem and flower size, vase life of flower (day) and Plant growth index (cm^3) which were calculated according to Hidalgo (2001) (14) by the following formula?

Growth index (cm^3) =3.14[1/2× (less width + large width)/2]^2 × plant height.

This experiment was performed by use Randomized Complete Block Design (RCBD), the data were analyses by use SAS program the difference between various treatments means are tested with Duncan Multiple range test at 5% level.

Results and Discussion

1. Days taken for flower bud appearance (day)

The data in Table (1) indicates that 3-month supplemental light delayed the flower bud appearance significantly to (143.36) day compared with 1.5 and control which need 119.61, 49.28 day respectively. Sprayed with 200 and 400 mg.l^{-1} BA delayed the flower bud appearance to 104.04 and 106.09 day compared with control which need 102.12 day. The flower bud appearance for Flirt cultivar need (109.33) day compared with Avalon cultivar which need (98.85) day. The triple interaction among the three factors clarified that the 3-month supplemental light for the three concentration of BA increased the number of days to flower bud appearance of Flirt cultivar from 148.27 to 149.05 day for the three-concentration compared with least number 49.61 for control plant with delay reach to 99.44 day

Table 1. Effect of Supplemental light and Benzyl adenine on the number of days to flower bud appearance of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA (mg.l^{-1}) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	49.61^{hi}	54.26 ^{h}	53.77 ^{h}	109.33 ^{a}	without 49.28 c
	1.5	125.05 ^{de}	126.11^{de}	129.30 ^{cd}		1.5-month 119.61 b
	3	148.27 ^{a}	148.52 ^{a}	149.05 ^{a}		3-month 143.36 a
Avalon (pink)	without	43.58 ^{i}	47.49 ^{hi}	46.99 ^{hi}	98.85 ^{b}	
	1.5	107.21^{g}	110.76^{fg}	119.26 ^{ef}		
	3	139.02 ^{b}	137.11^{bc}	138.19 ^{bc}		
BA Effect		102.12 ^{b}	104.04^{ab}	106.09 ^{a}		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test

2.number of days to flower anthesis (flower maturity).

The data in Table (2) showed that 3-month supplemental light delayed the number of days to anthesis (flower maturity) significantly to (172.02) day compared with 1.5-month (201.14) and control (78.31) day, with delay reach 122.83 and 96.71 day than control for the two supplemental light respectively. Sprayed with 200 and 400 mg.l^{-1} BA has no any effect on this characteristic compared with control. the Flirt (red) cultivar had a significant effect on anthesis (flower maturity it needs (154.97) day as compared with Avalon (pink) cultivar (154.97) day.

The interaction among all factors on this character showed a significant effect, the largest delayed was for the Flirt cultivar plants that subjected to 3-month light and spray with 400 mg.l^{-1} BA (205.63) day compared with the least day (76.79) for the control of Avalon plant.

3. Plant high (cm)

The data in Table (3) indicated that supplemental light increased the Plant high significantly, the highest plant high reached (65.93) cm for 3-month treatment compared with least high 26.44 cm for control. All BA concentrations did not have any significantly effect on Plant high. Flirt (red) cultivar (51.75) cm significantly superior than Avalon (pink) cultivar (39.02) cm. The maximum plant high was between 73.98 to 76.56 cm noticed for the triple interaction of Flirt cultivar plants that subjected to 3-month light and all concentrations of BA while the least high was for Avalon plant subjected to natural light (control) and all BA concentration between 22.39 to 25.06 cm.

Table 2. Effect of Supplemental light and Benzyl adenine on the number of days to anthesis (flower maturity) of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA ($mg.l^{-1}$) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	80.46 ^{d}	78.00 ^{d}	78.00 ^{d}	154.97 ^{a}	without 78.31 c
	1.5	181.05 ^{b}	180.28 ^{b}	182.44 ^{b}		1.5-month 175.02 b
	3	203.42 ^{a}	205.42 ^{a}	205.63 ^{a}		3-month 201.14 a
Avalon (pink)	without	76.79 ^{d}	78.29 ^{d}	78.29 ^{d}	148.01 ^{b}	
	1.5	168.69 ^{c}	167.75 ^{c}	169.93 ^{c}		
	3	197.13 ^{a}	196.71 ^{a}	198.54 ^{a}		
BA Effect		151.25 ^{a}	151.08 ^{a}	152.14 ^{a}		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

Table 3. Effect of Supplemental light and Benzyl adenine on the plant high of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA ($mg.l^{-1}$) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	29.00 ^{fg}	30.44 ^{fg}	27.67 ^{fg}	51.75 ^{a}	without 26.44 c
	1.5	54.00 ^{bc}	51.89 ^{bc}	46.00 ^{cd}		1.5-month 43.80 b
	3	76.56 ^{a}	76.33 ^{a}	73.89 ^{a}		3-month 65.93 a
Avalon (pink)	without	24.11 ^{g}	25.06 ^{g}	22.39 ^{g}	39.02 ^{b}	
	1.5	40.33 ^{de}	36.22 ^{ef}	34.33 ^{ef}		
	3	55.33 ^{b}	54.33 ^{bc}	59.11 ^{b}		
BA Effect		46.56 ^{a}	45.71 ^{a}	43.90 ^{a}		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test

flowers grade (%)

The results in Table (4) showed that flowers grading affected significantly with supplemental light and the highest

percentage (84.05%) was obtained when 3-month of light used comparison with control light that gave (51.85%). Also increased BA concentrations from 0 to 200 and 400 mg.l^{-1} caused significant increase in flowers grade from 64.76 to 67.57 and 69.83 % respectively. Likewise, a significant variation between the two cultivars on flowers grading were noticed, and the highest flowers grading (70.04%) were Flirt (red) cultivar.

The triple interaction between all factors increased this character significantly the highest grade (90.67%) was for Flirt cultivar plants treated with 3-month supplemental light and 400 mg.l^{-1}BA compared with the least values (49.40 to 53.45%) for non-lighted plant (control) for Avalon cultivar that spray with the three BA concentrations respectively

Table 4. Effect of Supplemental light and Benzyl adenine on the flower grade (%) of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA (mg.l^{-1}) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	50.99^{h}	52.66^{h}	53.49^{h}	70.04^{a}	without 51.85 c
	1.5	65.08^{f}	69.25^{de}	71.90^{d}		1.5-month 66.26 b
	3	87.34^{a}	88.97^{a}	90.67^{a}		3-month 84.05 a
Avalon (pink)	without	49.40^{h}	51.11^{h}	53.45^{h}	64.74^{b}	
	1.5	59.88^{g}	64.84^{f}	66.59^{ef}		
	3	75.87^{c}	78.61^{c}	82.86^{b}		
BA Effect		64.76^{c}	67.57^{b}	69.83^{a}		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test

5. Vase life of flower (day)

From table (5) the data clarified that the supplemental light decreased the Vase life from 14.97 to 13.27 day 11.22 day as they increased from 0 (control) to 1.5 and 3 month respectively. Both BA concentrations 200 and 400 mg.l^{-1} increased the vase life of flower to 13.48 and 13.88 day which were different significantly with control day. the cultivar didn't have any significantly effect

on this character. The triple interaction among cultivar, supplemental light and BA concentrations indicated that both concentrations of BA 200 and 400 mg.l^{-1} and Flirt (red) cultivar with control light gave the highest number of day (16.12) compared with the least value (10.94) day for Avalon plant subjected to 3-month and spray with 400 mg.l^{-1}.

6.Plant growth index

The data in Table (6) showed that increased supplemental light from 0 (control) to 1.5 and 3-month increased significantly the growth index respectively to 2763, 15361, 38621 cm^3 Respectively. All BA concentrations did not have any significantly effect on plant growth index. In contrast, Avalon cultivar growth index that reach (20642) cm^3 significantly superior than Flirt (red) cultivar plant which gave 17188 cm^3. The triple

interaction among the three factors indicated that Avalon cultivar plants subjected to 3-month of light and spray with BA gave the highest value of growth index reach (45993) cm^3 whereas the less interaction effect was for Avalon plant non subjected to supplemental light and spray with 200 $mg.l^{-1}$ that gave (2315) cm^3.

Table 5. Effect of Supplemental light and Benzyl adenine on the Vase life of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA ($mg.l^{-1}$) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	13.39 a-d	16.12 a	16.12 a		Without
	1.5	12.56 b-d	14.32 a-c	13.77 a-d	13.33 a	14.97 a
	3	10.93 d	11.49 cd	11.27 cd		1.5-month
Avalon (pink)	without	12.41 cd	16.01 a	15.79 ab		13.27 b
	1.5	12.47 cd	13.56 a-d	12.96 a-d	12.98 a	3-month
	3	10.89 d	11.81 cd	10.94 d		11.22 c
BA Effect		12.11 b	13.88 a	13.48 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

6.Plant growth index

The data in Table (6) showed that increased supplemental light from 0 (control) to 1.5 and 3-month increased significantly the growth index respectively to 2763, 15361, 38621 cm^3 Respectively. All BA concentrations did not have any significantly effect on plant growth index. In contrast, Avalon cultivar growth index that reach (20642) cm^3 significantly superior than Flirt (red) cultivar plant which gave 17188 cm^3. The triple interaction among the three factors indicated that Avalon cultivar plants subjected to 3-month of light and spray with BA gave the highest value of growth index reach (45993) cm^3 whereas the less interaction effect was for Avalon plant non subjected to supplemental light and spray with 200 $mg.l^{-1}$ that gave (2315) cm^3.

It was obvious from the above-mentioned results in tables (1,2,3,4 and 6) that the number of days to flower bud appearance, number of days to anthesis**,** Plant high**,** flowers grade and Plant growth index were increased significantly when treated with supplemental light. These results might be referring to enhancing the photosynthetic activity under additional light conditions accompanied by accumulation of protein and carbohydrate **(9)** or might be refer to the supplemental light that it caused a shift in the hormonal balance resulting in an increase in substances such as GA_3 that would lead to an increase in vegetative growth. **(31).**

Table 6. Effect of Supplemental light and Benzyl adenine on the growth index of two Cultivars of Chrysanthemum plant.

Cultivars	Supplemental light (Month)	BA ($mg.l^{-1}$) 0	200	400	Cultivars effect	Supplemental light effect
Flirt (red)	without	2737 e	3108 e	2766 e		without
	1.5	12302 d	16168 d	13989 d	17188 b	2763 c
	3	34238 c	35982 bc	33400 c		1.5-month
Avalon (pink)	Without	2564 e	2315 e	3087 e	20642 a	15361 b
	1.5	16412 d	16058 d	17237 d		3-month

	3	40843 [ab]	41270 [ab]	45994[a]	38621 [a]
BA Effect		18183[a]	19150 [a]	19412 [a]	

Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.

light evidence supporting this finding has been reported by (10) on chrysanthemum plants and. Kaur (2014) who reported a similar decrease in flowering duration with increased exposure of chrysanthemum plants to night-interruption. Thakur and Grewl (2019) (31) showed that the night interruption durations studies were helpful to schedule the Chrysanthemum production. Also, with Carvalho and Heuvelink (2003) (6) whose suggested that an increased number of long days was shown to increase plant height in chrysanthemum. Whereas the tables (5) show that the best significant increase in vase life flowers was for the control and 1.5-month treatment this may be related to the lower temperature when they give there flowers and has been harvested which is the most effective factor in extending the vase life of the cut flowers (Dec. (14.6), Jan. (9.3), Feb. (15.6), Mar.(14.2), Apr. (26.4)c°) (21) or may be related to the affected of ethylene which accelerates the senescence of flowers and microorganisms that cause vascular blockage and thus reduce the cut flowers of vase life (35; 36). flower bud emergence and vase life as seen in tables (1 and 5) were significant difference as a result of spray with 200 and 400 mg.l^{-1} when compared with the control, These results were in accordance with the findings of (7) and (34) on chrysanthemum.

It was obvious from the above-mentioned result in table (1-4) show that Flirt cultivar significantly superior than Avalon cultivar on some vegetative growth and flowering characteristics such as number of days to flower bud appearance, number of days to anthesis, Plant high and the flower grade this may be due to presence of sufficient genetic variability. or might be due to their genetic potential which resulted in variation in phenotypic expression (22)

According to the results it can be concluded that the supplemental light with 3-month of supplemental light was more effective in delayed flower bud appearance, number of days to anthesis and enhancing Plant high**,** flowers grade and Plant growth index. Spray with BA with 200 and 400 mg.l^{-1} was more effective in hesitant the flower bud emergence, flower grade and vase life.

Conflict of Interest

The authors have no conflict of interest.

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