Influence of growth retardant (B-Nine) on the vegetative growth and flowering of four cultivars of *Chrysanthemum morifolium Ramat.*

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ABSTRACT

A study was undertaken to investigate the effect of foliar spray of a growth retardant B-Nine, Alar or Daminozide on the growth and flowering of four cultivars of *Chrysanthemum morifolium Ramat.* i.e. Kodiak (yellow), Ivyridgf (white), Auburn (red) and Lansing (pink) grown under greenhouse conditions. The plants were sprayed three times with four concentrations of B-nine ; 0, 1500, 3000 and 4500 ppm. All cvs. responded to the growth retardant significantly. B-Nine affected plant height, number of branches per plant, leaf area per plant, shoots dry weight, number of inflorescences per plant, inflorescences fresh and dry weights. While the effects of B-Nine on the number of leaves per plant, shoots fresh weight, roots fresh and dry weights and inflorescence diameter were not significant. Plant height was decreased by B-Nine application. The number of leaves per plant was increased, while leaf area per plant was decreased by the spray application of B-Nine. The present investigation suggested that three applications of B-Nine at 1500 ppm. can improve the display value of *Chrysanthemum* plants cvs. Kodiak and Auburn as pot plants.

INTRODUCTION

Chrysanthemum morifolium Ramat. is a popular ornamental crop of great commercial importance. It belongs to the family Compositae (Astraceae) and has been commonly grown in gardens for more than 2500 years (Bose *et al.*, 2003). *Chrysanthemum* is one of the most important ornamental crops around the world, and it is produced as a cut flower and pot plant (Van Der Pleg and Heuvelink, 2006). It is a perennial herb grown in Egypt as one of the most important ornamental plants. The inflorescence consists of several ray and disc flowers (florets) and such, is called a (flower head), which is valued in markets because of its beautiful shape and longevity in vases. *Chrysanthemum* is a short day plant because of its habit of flowering only under short day conditions. However, the time of flowering can be controlled throughout the year. The development of *Chrysanthemum* industry as a major ornamental cut flower and pot plant enterprises supports the major thrusts of the government to develop the non-traditional export products that will boost the industry to earn foreign currency. The immediate benefits from

Chrysanthemum production will substitute the imported flowers with locally produced ones (Kandil *et al.*, 2011).

The discovery and development of growth-retarding chemicals with a broad spectrum of activity is of considerable interest to nurserymen because such compounds can improve their capability to manipulate and control growth and cropping. In ornamental horticulture, for example, the availability of a facility for controlling plant height and form will largely determine whether certain species can be grown as pot plants.

Growth retardants have an inhibitory effect on cell division and enlargement of cell in plants. Therefore, they are widely used for height control in floriculture (Pasian, 1999). Meantime, growth retardants suppress the growth of vegetative shoots developing beneath resulting in a larger number of inflorescences (Whealy *et al.*, 1988; Keever and Foster, 1989). Height control in plants has an important role in avoiding unacceptably tall plants that require more space, labor and higher transport costs, as well as in promoting yield and quality (Hayashi *et al.*,2001; Jaime and Silva, 2003; and Karlovic *et al.*, 2004).

Chemical growth retardants placed on the market within the past few years have made it possible for bedding plant growers to reduce or eliminate excessive stem elongation by producing a more compact and sturdier plant requiring less frequent pruning. The chemical butanedioic acid mono (2, 2-dimethylhydrazide; B-Nine; Alar) is one of the most promising and useful growth retardants because it can be applied to the foliage of most species without causing injury. Some of the chemicals also appear to initiate precocious flowering suggesting a treatment that may be of value in slow-maturing species where flowering and fruiting are prized. Many plants treated with growth retardants also appear to have better ability to resist stress conditions such as drought, salinity, frost or chilling, and air pollution (Maire and Sachs,1967).

Daminozide has been observed to have its highest inhibitory effect immediately upon application, becoming less pronounced thereafter, so that continued retardation is accomplished by re-application at 10 to 14 days. Daminozide has to be applied more than once in order to give a good retardation in most pot plants (Adriansen, 1972) and, in particular, for Chrysanthemum (Mitlehner, 1966).

This paper studies the effect of daminozide (B – Nine) with four concentrations on four cultivars of *Chrysanthemum morifolium* Ramat., grown as pot plants.

MATERIALS AND METHODS

Rooted cuttings of 7 cm height with 4 to 5 leaves of four cultivars of*Chrysanthemum morifolium* Ramat., i.e. Kodiak (yellow), Ivyridgf (white), Auburn (red), and Lansing (pink) were used in this study. The cuttings were taken and planted on February 2 , 2010 at a rate of three cuttings per 6inch diameter plastic pot filled with a mixture of peat and perlite soil (2:1 by volume) amended with Osmocote plus 5-11-22 (2 g/l of substrate), under greenhouse condition. The minimum day and night temperature in the greenhouse was 16 ^{0}C, with the ventilators opening at 19 ^{0}C. Short days (10 h light) were maintained throughout either naturally or shading with black polyethylene sheets. Once the cuttings were established, they were decapitated (pinched) above, the 3rd – 4th leaf from the base to encourage production of lateral shoots. Three weeks later, all lateral shoots but one was removed. This procedure, which ensures that the apical meristems of all plants start active growth at the same time under the same conditions, increases the uniformity of flowering (Cockshull, 1976).

Chemical growth retardant daminozide (B- Nine/ Alar, Crompton/ Uniroyal Chemical Co.) was used at 0, 1500, 3000 and 4500 ppm. It was applied in an aqueous solution as a foliar spray to run-off for three applications on February 23rd, for the first time; March 3rd, for the second time and March 13th, for the third one, while the control plants were sprayed with distilled water.

The layout of the experiment was a spilt – plot design, with three replicates (Snedecor and Cochran, 1967). Every replicate contained 4 treatments for each cultivar. The main plot represented the cultivars, while the concentrations were the sub – plot. The total number of cuttings used in the experiment was 432 divided in 4 parts (4 conc. X 3 rep. X 3 pot. X 3 cut.) for each cultivar.

The following parameters were recorded throughout the experiment: plant height (cm), number of branches per plant, number of leaves per plant, leaf area (cm)^2 per plant, shoots fresh and dry weights, roots fresh and dry weights (g), number of inflorescences per plant, inflorescence diameter (cm), inflorescences fresh weight and inflorescences dry weight (g). Fresh weight was carefully

determined after removing the plants. Dry weight was determined after drying the plant material in an oven for 48 h at 70 °C and then placed in a desiccator for 12 h and weighed again to determine their dry weight.

RESULTS AND DISCUSSIN

Plant height: The control treatment of all cultivars Kodiak, Ivyridgf, Auburn, and Lansing had the tallest mean of plant height, while the least means were detected at the concentration of 3000 ppm. (14.47 and 15.83 cm) in the second and third of cultivars; and the concentration of 4500 ppm. (12.31 and 13.20 cm) in the first and forth of cultivars, respectively. It was found that Kodiak had the shortest one.

The average height of the sprayed plants with B-nine at was 1500 ppm. (16.65 cm) while compared with 23.48 cm of plants sprayed with distilled water. The plants which treated with B-nine at 3000 ppm. (14.16 cm) and 4500 ppm. (14.23 cm) showed a decrease in their heights. Generally, the plant height was decreased with increasing B-nine concentrations (Table1 and Figure 1).

One of the most important indicators for the market value is the plant height like in other cut flower species. Plant height was significantly affected by both day length and B-nine applications. This results are in agreement with the findings of Gregov *et al.*(1995); Karlovic *et al.* (2004) and El-Sheibany *et al.* (2007), who reported that short day and plant growth retardants reduced plant height of *Chrysanthemum*. B-nine are commonly used in height control of poinsettia, which inhibits the synthesis of *ent* kaurene; an early step in gibberellic acid biosynthesis pathway which is catalized by the enzyme *ent* kaurene synthase (Meijon *et al.*, 2009).

Number of branches per plant: The reported data showed that there were no significant differences among the treatments of the different cultivars and their interactions.

The comparison between the different means of concentrations indicated that the maximum average number of branches per plant was produced by 1500 ppm. (5.56), while the minimum number of branches per plant was detected in the 3000 ppm. (4.64) (Table1 and Figure 1). Daminozide is known to have inhibitory effect by interruption of the synthesis of gibberellins (Smith *et al.*, 1991), it

could interfere in the action of gibberellins and favor the action of cytokinins. In this way, an increase in the number of shoots could be obtained without morphological changes of its normal structure.

Number of leaves per plant: Data presented in Table (1) and Figure (1). show the mean values of number of leaves per plant by using the different treatments in all cultivars. Concerning Kodiak-yellow cv. , the greatest number of leaves per plant was found at the treatment of zero (35.22). As for Ivyridgf-White cv., the least number of leaves per plant was found at 4500 ppm. (21.83). Lansing-Pink cv. had the greatest number of leaves per plant (29.27) among all cultivars.

The reported data showed that there were no significant differences among B-nine concentrations. Observed that growth of slash and loblolly pine was reduced compared with that of the control. Increased branching and leaves of redwood (Sequoia sempervirens) seedling, caused by lateral buds escaping apical dominance, occurred after daminozide was applied to seedling foliage (Ruddat and Pharis, 1966).

Leaf area per plant: The data presented in Table (1) and Figure (1) show the mean values of leaf area per plant as affected by using different concentrations on the four chrysanthemum cultivars. Leaf area per plant registered a decreasing trend with the increase in the concentration of B-nine. The cv. Ivyridgf-White which received a foliar spray of 4500 ppm. B-nine showed the minimum value of leaf area (125.03 cm^2), whereas the maximum value was recorded in Kodiak-Yellow plants sprayed with the distilled water (384.63 cm^2). Auburn–Red cv. had the greatest leaf area per plant (263.35 cm^2) among all cultivars.

The maximum value of leaf area per plant was recorded at the control (269.51 cm^2), and with increasing the B-nine concentrations, the leaf area per plant was decreased.

The investigation also showed that the reduced leaf area was the characteristic feature of plants of *Chrysanthemum* sprayed with B-nine. Similar result were reported by El-Mokadem and Hadia, 2008 on *Encelia farinosa*. B-nine is known to have inhibitory effect by interruption of the synthesis of gibberellins (Smith *et al.*, 1991), it could interfere in the action of gibberellins and favor the action of cytokinins. In this way, a decrease in the leaf area per plant could be obtained without morphological changes of its normal structure.

Shoots fresh weight: The reported data showed that the different concentrations of B-nine had no significant effect on the different cultivars (Table,1 and Figure, 1).

Shoots dry weight: The shoots dry weight was relatively lower in plants sprayed with B-nine as compared to control treatment. The higher shoots dry weight was recorded in plants sprayed with distilled water (2.37 g), but it was lower in plants sprayed with 4500 ppm. (1.48 g).

Concerning Kodiak-Yellow cv., the highest shoots dry weight was found at the concentration of zero (2.87 g), and least shoots dry weight was found at 4500 ppm. (1.13 g).

The results agree with those of El-Mokadem and Hadia, (2008), who found in *Encelia farinosa* that B-Nine reduced the total fresh and dry weights. The observed increase in fresh and dry weights of wheat following alar treatment may presumably be explained on the basis that alar enhances accumulation of carbohydrates within the shoots particularly during the early stages of shoot development (Mansour *et al.* 1988).

Roots fresh weight: The reported data showed that there were no significant differences among the different concentrations of B-nine for the four cultivars. In the case of Auburn–red cv. (Table 2 and Figure 2), it was evident, that the heaviest roots fresh weight was obtained at the concentration of zero (6.80 g). The lowest value was detected at 4500 ppm. (2.31 g) for Kodiak.

Roots dry weight: The greatest roots dry weight was recorded at the Kodiak- yellow cv. control (1.41 g). While the lowest dry weight was obtained at the concentration of 4500 ppm. (0.53 g) in Lansing–Pink cv. (Table2 and Figure 2). The reported data showed that the different concentrations of B-nine had no significant effect on roots dry weight.

These results are in agreement with those reported by Wan, (1982) on *Gardenia jasminoides* who found that Alar was effective in stimulating adventitious roots formation, to being the optimum. The greater number of roots produced by Alar is reflected in the fresh and dry weights.

Number of inflorescences per plant: The maximum number of inflorescences per plant was recorded in Auburn–red cv. plants which sprayed with 1500 ppm. (29.51) followed by plants sprayed with distilled water (23.33), while the minimum number of

inflorescences per plant was recorded in plants sprayed with 4500 ppm. (13.26) Lansing–Pink cv. (Table2 and Figure 2).

The reported data showed that, there were significant differences among the different concentrations. The number of inflorescences per plant was significantly decreased in with increasing the level of the concentration.

One of the important quality criteria for spray *Chrysanthemum* is the number of flowers. The high number of flowers both affects the crop appearance and attracts the attention of consumers. In the study, short day conditions 10h. and B-nine application increased the number of flowers. There was a significant difference in the number of flowers between the cultivars. These results are in agreement with those of Bhat, *et al.*, 2011 on *Erysimum marshallii*, who reported that B-Nine applications slightly decreased the flowering yield per plant. On the other hand, the obtained results agree with the findings by Gregov *et al.*(1995) and Velmurugan and Vadivel (2003), who reported that treatments of growth retardants increased the number of flowers in *Chrysanthemum.*, it could activate the action of the cytokinins. In this way, an increase in the number of shoots and number of inflorescences per plant.

Inflorescence diameter: In Auburn–red cv., the least mean value of inflorescence diameter (4.73 cm) was recorded at the concentration of 3000 ppm. while the greatest ones were found at the concentration of control (7.74 cm) in Lansing–Pink cv. (Table2 and Figure 2). The reported data showed that, there were no significant differences among the different concentrations.

Similar finding was obtained by Haggag (1997) on *Chrysanthemum.* It was found that plant growth regulators increased flower diameter. On the other hand, Bhat, *et al.*, (2011) found on *Erysimum marshallii* that the flower diameter was slightly decreased in the plants sprayed with B-Nine. These results agree with this experimental date. Inflorescence diameter varied only, this varied only slightly from earlier reports in which daminozide foliar sprays at 4,000 or 8,000 mg•L–1 (Whipiker and Dasoju, 1998) resulted in a statistically smaller inflorescence (5% to12%). Although inflorescence diameter was statistically smaller, the differences would not be a detrimental reduction to commercial growers.

Inflorescences fresh and dry weights per plant: Data presented in Table 2 and Figure 2 show that the greatest values of the fresh and

dry weights of inflorescences were detected at the control (27.86 g) and (3.81 g) for Kodiak. But, in Ivyridgf–white cv. the control treatment had the lowest mean inflorescences fresh and dry weights (11.03 g) and (1.33 g), respectively. The fresh and dry weights per plant were significantly decreased, with increasing the B-Nine concentrations.

Similar results were reported by ByungJoo *et al.* (2004). Although, daminozide application slightly decreased the inflorescences fresh and dry weights. Shawareb and Orunfleh (1988) and Mahalle *et al.* (2001) reported that treatments of growth retardants decreased the inflorescences fresh and dry weights in *Chrysanthemum*. The observed increase in fresh and dry weights of spikes of wheat following alar treatment may presumably be explained on the basis that alar enhances accumulation of carbohydrates within the spikes particularly during the early stages of shoot development (Mansour *et al.* 1988).

CONCLUSION

The present investigation suggested that the growth retardants decreased the plant height as fresh and dry weights of the plants but did not improve the display value of plants in *Chrysanthemum morifolium* Ramat. Therefore, it may be concluded that the desired effects of plant growth regulators (PGRs) on the display value of ornamental plants are dependent on the dose of a particular PGR, time and method of application and more importantly the species and cultivar of the ornamental plants. The present investigation suggests spraying *Chrysanthemum morifolium* plants with B-Nine three times with the concentration of 1500 ppm. to improve the display value of Kodiak – yellow and Auburn – red.cvs.

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الملخص العربى

تأثير مثبط النمو (B-Nine) علي النمو الخضري والزهري لأربعة أصناف من الأراولا

ياسر إسماعيل النشار

مركز بحوث المنتزه – معهد بحوث البساتين – وزارة الزراعة – الاسكندرية – جمهورية مصر العربية

تم إجراء هذا البحث في أحد المزارع الخاصة لدراسة تأثير رش أوراق نبات الأراولا الأصفر Kodiak علي نمو وإزهار نبات الأراولا مستخدماً الأصناف (B-Nine)بمثبط النمو الوردي النامية تحت ظروف الصوبة Lansing الأحمر وAuburn الأبيض و vyridgfاو 4500 و3000 و1500الزجاجيةز تم رش النباتات بأربعة تركيزات هي :- صفر (كنترول) و B- Nine جزء في المليون ثلاث مرات. تمت الاستجابة لمثبط النمو B- في جميع الاصناف. أدي إلي ظهور تأثير معنوي علي أرتفاع النبات وعدد الأفرع ومساحة الأوراق ووزن Nine المجموع الخضري الجاف وعدد الأزهار والوزن الطازج والجاف للأزهار. بينما كان التأثير غير معنوي علي صفات عدد الأوراق ووزن المجموع الخضري الطازج والوزن الطازج إلي أنخفاض في أرتفاع B- Nine والجاف للمجموع الجذري وقطر الزهرة. أظهرت المعاملة رشاً علي النباتات أدي ذلك إلي زيادة عدد الأوراق وصغر B-nineالنبات. ومن خلال استعمال بتركيز B– Nine مساحتها. ويقدم هذا البحث أقتراح برش النباتات ثلاث مرات بأستخدام الأحمر.Auburn الأصفر وKodiak جزء في المليون لتحسين حجم النبات في صنفي 1500

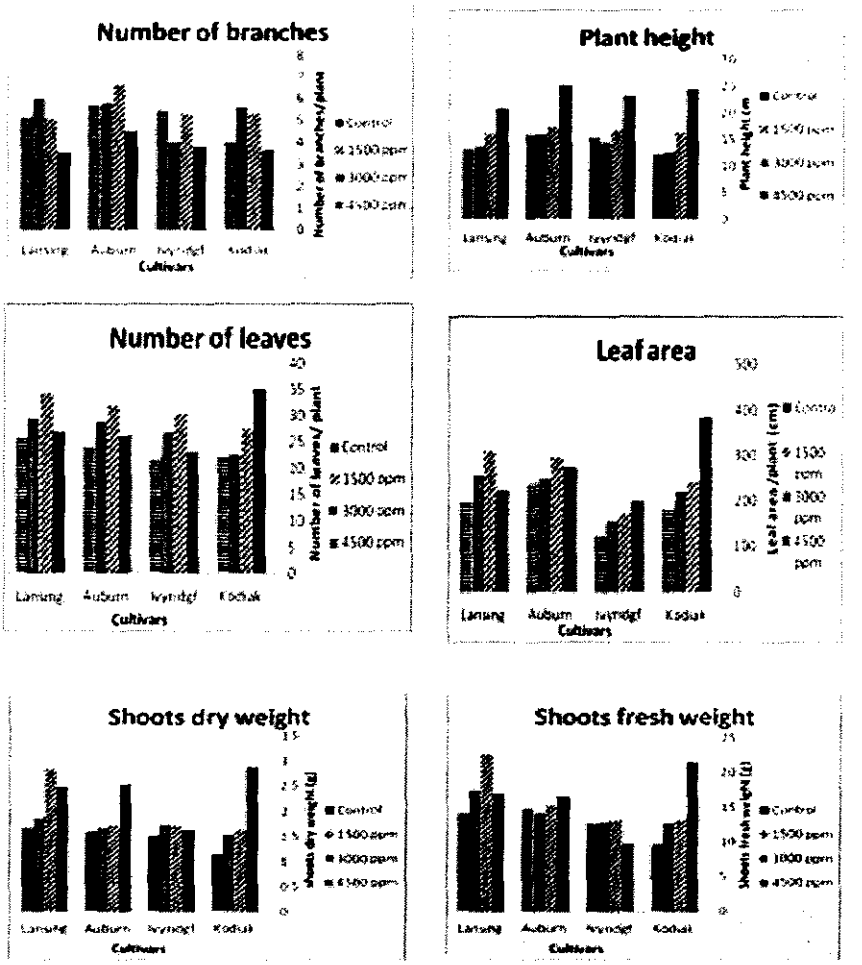

Figure 1: Mean values of plant height (cm), number of branches/ plant, number of leaves/ plant, leaf area/plant, shoots fresh weight (g) and shoots dry weight (g) of *Chrysanthemum morifolium* Ramat as affected by the different applications of B-Nine.

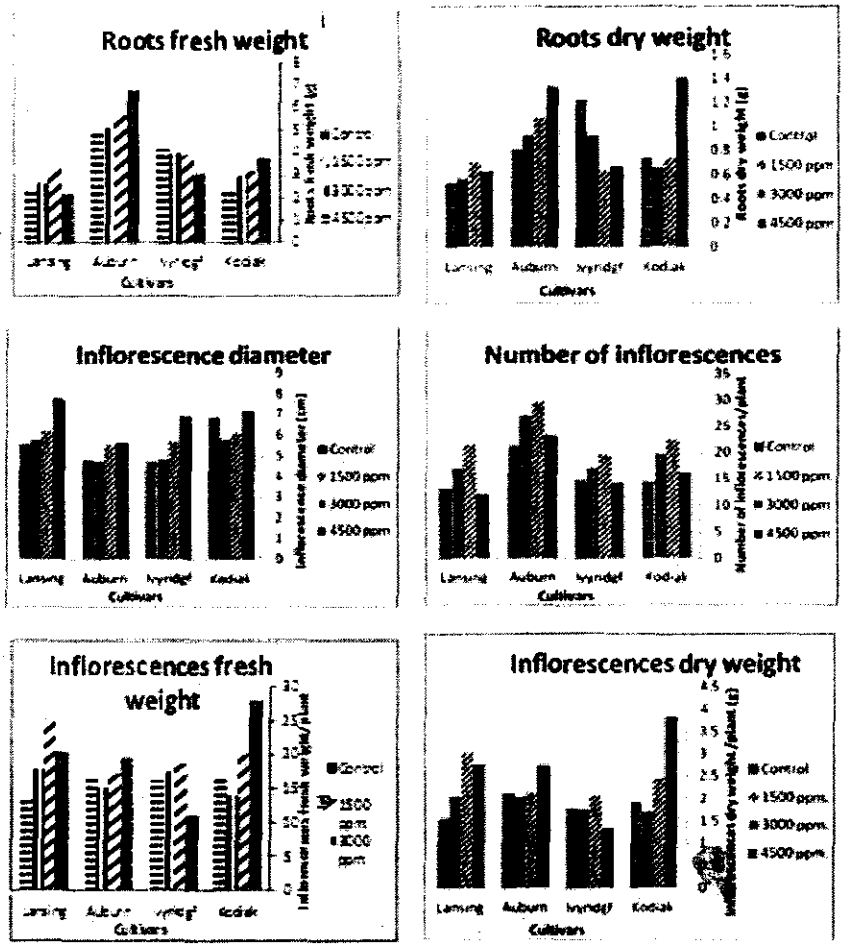

Figure 2: Mean values of roots fresh weight (g), roots dry weight (g), number of inflorescences/ plant, number of inflorescences/ plant, inflorescence diameter (cm), inflorescences fresh weight/ plant (g) and inflorescences dry weight/ plant (g) of *Chrysanthemum morifolium* Ramat. as affected by the different applications of B-Nine.

Table 1: Mean values of plant height (cm), number of branches/ plant, number of leaves/ plant, leaf area/plant, shoots fresh weight (g) and shoots dry weight (g) of the four cultivars of *Chrysanthemum morifolium* Ramat. as affected by the different concentrations of B-Nine.

cultivars	Concentrations	Plant Height (cm)	Number of branches/ plant	Number of leaves/ plant	Leaf area/ plant (cm^2)	Shoots fresh weight (g)	Shoots dry weight (g)
Kodiak (yellow)	Control	24.62	3.67	35.22	384.63	21.62	2.87
	1500 ppm.	16.30	5.34	27.66	241.56	13.24	1.62
	3000 ppm.	12.63	5.66	22.84	220.73	12.77	1.53
	4500 ppm.	12.31	4.01	22.29	181.83	9.63	1.13
Mean of Kodiak		15.46	4.67	26.92	257.19	14.29	1.77
Ivyridge (white)	Control	23.17	3.83	23.35	198.13	9.73	1.63
	1500 ppm.	16.86	5.32	30.46	171.07	13.27	1.71
	3000 ppm.	14.47	4.02	27.05	156.40	12.91	1.73
	4500 ppm.	15.43	5.49	21.83	125.03	12.67	1.52
Mean of Ivyridge		16.47	4.66	25.63	162.66	12.14	1.63
Auburn (red)	Control	25.23	4.54	26.30	273.73	16.62	2.53
	1500 ppm.	17.33	6.67	32.07	295.50	15.26	1.72
	3000 ppm.	15.83	5.83	29.11	247.31	14.13	1.67
	4500 ppm.	15.98	5.66	24.29	236.94	14.87	1.60
Mean of Auburn		18.59	5.68	27.92	263.35	15.21	1.88
Lansing (pink)	Control	20.90	3.52	27.05	221.53	17.02	2.47
	1500 ppm.	16.12	5.05	34.34	309.83	22.73	2.83
	3000 ppm.	13.71	6.03	29.67	256.23	17.50	1.87
	4500 ppm.	13.20	5.15	26.04	194.80	14.27	1.67
Mean of Lansing		15.98	4.94	29.27	220.60	17.88	2.21
L.S.D $_{0.5}$ for interaction		2.16**	N.S	5.96*	77.46**	N.S	0.62**
L.S.D $_{0.5}$ cultivars		1.64*	N.S	1.64**	53.00*	N.S	N.S
Concentrations	Control	23.48	3.89	31.13	269.51	16.31	2.37
	1500 ppm.	16.65	5.59	27.16	230.93	16.13	1.96
	3000 ppm.	14.16	4.64	27.16	185.80	14.32	1.70
	4500 ppm.	14.23	5.07	23.61	217.57	12.86	1.48
Mean of concentrations		17.13	4.79	27.46	225.95	14.91	1.88
L.S.D $_{0.5}$ concentrations		1.28**	0.74*	N.S	45.91**	N.S	0.36**

N.S = Not significant at 0.05%

* = Significant at 0.05%

** = Highly significant at 0.05%

Table 2: Mean values of roots fresh weight/ plant (g), roots dry weight/ plant (g),number of inflorescences/ plant, inflorescence diameter (cm), inflorescences fresh weight/ plant (g) and inflorescences dry weight/ plant (g) of the four cultivars of *Chrysanthemum morifloruin* Ramat. as affected by the different concentrations of B-Nine.

cultivars	Concentrations	Roots fresh weight (g)	Roots dry weight (g)	Number of inflorescences /plant	Inflorescence diameter (cm)	Inflorescences fresh weight /plant (g)	Inflorescences dry weight /plant (g)
Kodiak (yellow)	Control	3.73	1.41	16.02	7.17	27.86	3.81
	1500 ppm.	3.16	0.73	22.33	6.07	20.08	2.43
	3000 ppm.	2.93	0.66	19.68	5.81	13.92	1.72
	4500 ppm.	2.31	0.74	14.65	6.83	16.27	1.93
Mean of Kodiak		3.04	0.88	18.17	6.47	19.53	2.47
Ivyridgf (white)	Control	3.01	0.67	14.30	6.90	11.03	1.33
	1500 ppm.	3.86	0.64	19.66	5.65	18.56	2.07
	3000 ppm.	3.98	0.93	17.17	4.83	17.43	1.76
	4500 ppm.	4.12	1.23	14.83	4.72	16.26	1.76
Mean of Ivyridgf		3.74	0.86	16.49	5.53	15.83	1.71
Auburn (red)	Control	6.80	1.33	23.33	5.61	19.50	2.74
	1500 ppm.	5.66	1.07	29.51	5.53	17.11	2.12
	3000 ppm.	5.11	0.93	27.12	4.73	15.15	2.03
	4500 ppm.	4.96	0.80	21.30	4.80	16.66	2.14
Mean of Auburn		5.63	1.03	25.32	5.17	17.09	2.21
Lansing (pink)	Control	2.17	0.63	12.03	7.74	20.37	2.76
	1500 ppm.	3.31	0.71	21.66	6.17	25.06	3.03
	3000 ppm.	2.65	0.57	17.12	5.76	17.83	2.05
	4500 ppm.	2.36	0.53	13.26	5.54	13.66	1.55
Mean of Lansing		2.62	0.61	16.01	6.30	19.23	2.34
$L.S.D._{0.5}$ interaction		1.82*	0.48*	N.S	1.51*	5.86**	0.69**
$L.S.D._{0.5}$ cultivars		1.01**	0.23*	1.9**	0.82**	N.S	N.S
Concentrations	Control	3.93	1.01	16.42	6.86	19.69	2.65
	1500 ppm.	3.79	0.93	23.29	5.85	20.20	2.41
	3000 ppm.	3.59	0.68	20.27	5.28	16.07	1.88
	4500 ppm.	3.65	0.75	16.01	5.47	15.71	1.80
Mean of concentrations		3.74	0.84	18.99	5.87	17.92	2.19
$L.S.D._{0.5}$ concentrations		N.S	N.S	1.92*	N.S	5.85**	0.68**

N.S =Not significant at 0.05%

* =Significant at 0.05%

** =Highly significant at 0.05%