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Growth, physiology and flowering of chrysanthemum var. Punch as affected by daminozide and maleic hydrazide

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Growth retardants have been proven to prevent excessive stem elongation and reduce internode length in plants by inhibiting the effect of cell division and enlargement of cell in plants. This study was aimed to evaluate the effect of concentrations of daminozide and maleic hydrazide on growth, physiology and flowering of chrysanthemum cultivar Punch under protected condition. The treatments composed of two growth retardants: daminozide at four different concentrations (1000, 1500, 2000 and 2500 ppm) with three frequencies (7, 14 and 21 days after darkening) and maleic hydrazide at three different concentrations (500, 750 and 1000 ppm) with two frequencies (7 and 21 days after darkening) along with control (no spray given). Hence based on the results obtained, it can be concluded that single application of daminozide at 2500 ppm at seven days after darkening reduced the plant height at considerable height (34.33, 83.33 and 103.58 cm) at critical stages and improved total leaf area (1694.55 and 1745.27 cm^2) at bud appearance and peak flowering stage and showed earliness in flowering and days to harvest (44.72 and 81.33 day), increased pedicel length (5.87 cm), cut stem girth (3.24 cm), stem fresh weight (68.00 g/stem) and chlorophyll (1.93, 2.53 and 2.80 mg/g) and soluble protein content (65.66, 72.33 and 80.66 mg/g) at critical stages. Increased cut stem yield (77.34 stems/m^2) and improved vase life (12.50 day) were also recorded. This may be recommended to improve growth and flower quality of 'Punch' chrysanthemum under greenhouse conditions.

Key words: Chrysanthemum, daminozide, maleic hydrazide, growth, flowering.

INTRODUCTION

Chrysanthemum (Family: Asteraceae) is one of the most beautiful leading commercial flower crop grown as cut flower for interior decoration and as well as pot plant in the world. It ranks second in the international cut flower trade. Plants are able to modify their growth, development and physiology according to the variable

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environment. In tropical country like India, during summer months when the day length exceeds 12 h it resulted in excess stem elongation due to translocation of stored energy to the apical growing tip which causes ultimate reduction of flower stalk girth and flower quality. These problems associated and affected in meeting out the standard of cut chrysanthemum in the export market. So as to overcome this, in recent years scientists have given due attention to the idea of regulating the plant growth as the most important factor in improving the growth, yield and flower quality with the application of plant growth regulators in various ways. Growth retardants have been proven to prevent excessive stem elongation and reduce internode length in plants (Kuehny et al., 2001). Height control in floriculture can be succeeded by using growth retardants, since it has an important role in reducing "long neck" in chrysanthemum resulting in lower and stronger plants with less lodging (Karlovic et al., 2004). Retardants such as daminozide commercially known as B-Nine or Alar and Maleic Hydrazide are successfully applied to control lodging of plants, height, branching and obtain higher yield in chrysanthemum, like many other plant species (Karlovic et al., 2004). Kahar (2008) found that single application of B-9 at 2500 ppm in Chrysanthemum cv. Reagan Sunny delayed the time of flowering and improved the synchrony of flowering and double the vase life. In *Chrysanthemum morifolium*, foliar spraying of B-9 at 1000 ppm significantly decreased the plant height, the branch number and leaf number but the content of chlorophyll and soluble sugar in leaves was significantly increased was reported by Zhi-kai (2008).

Various growth regulators, especially growth retardants are nowadays being used for controlling growth with a view to have compact plants and to stretch out or retard the plant growth (Navalae et al., 2010). Daminozide inhibited gibberellin biosynthesis or action and induced flowering. Kazaz et al. (2010) reported that different day lengths and daminozide application at 3000 ppm had significant effect on days to flower by 42 days, increased chlorophyll a (11.50 µg/mg), chlorophyll b (5.93 µg/mg), compact and high quality flowers with desired stem length as compared to short day conditions. Piotr and Anita (2012) found that foliar spraying of daminozide 2500 ppm two times found no retardation of flowering in chrysanthemum cv. Leticia Time Yellow. Minimum plant height (142.25 cm) and internodal length (9.85 cm) was recorded in the plants treated with Alar at 1500 ppm reported by Vijai Ananth and Ramesh Kumar (2012)

In this context, the objective of this study was aimed to evaluate the effect of concentrations of daminozide and maleic hydrazide on growth, physiology and flowering of spray chrysanthemum var. Punch grown under greenhouse conditions. The research findings are based on the key parameters necessary for regulating the growth of chrysanthemum under protected conditions and hoped to be valuable information for flower growers and researchers.

MATERIALS AND METHODS

The study was conducted in a naturally ventilated greenhouse at a private farm of M/s Salem Green Plants Limited, Yercaud (Latitude 11° 04" to 11° 05" N, Longitude 78° 05" to 78° 23" E and Altitude 1500 m MSL), Salem, Tamil Nadu during 2011 - 2013 to evaluate the effect of concentrations of daminozide and maleic hydrazide on growth, physiology and flowering of spray chrysanthemum var. Punch. A naturally ventilated poly house of 50 × 56 m^2 area in East-West orientation was erected with 800 gauge UV stabilized poly ethylene sheet. The average temperature (Maximum: 22°C, Minimum: 16°C), relative humid (75%) and photoperiod (long day: 13 h during early vegetative stage and short day - 14 h during bud appearance stage) was maintained throughout the growing period. The experiment was laid out in a Randomized Block design (RBD) with 19 treatments and three replications. The treatment comprises two growth retardants: daminozide at four different concentrations (1000 ppm, 1500, 2000 and 2500 ppm) with three frequencies (7, 14 and 21 days after darkening) and Maleic Hydrazide at three different concentrations (500 ppm, 750 ppm and 1000 ppm) with two frequencies (7 and 21 days after darkening) along with control (no spray given) (Table 1).

Rooted cuttings of spray chrysanthemum var. Punch obtained from the mother stock were planted in raised beds (height - 45 cm) containing growing media consortia [Coco peat (3 kg/ m^2), Vermicompost (500 g/ m^2), Perlite (500 g/ m^2) and microbial consortia (50 g/m^2)] with a spacing of 12.5 x 10 cm accommodating 80 plants per m^2. The characteristics of greenhouse soil was analysed (soil type: sandy clay loam, pH: 5.5, EC (ds/m): 0.3, N - 526 kg/ha, P - 61.7 kg/ha and K - 332 kg/ha). Daminozide was sprayed to the experimental plots at 7, 14 and 21 days after darkening and Maleic Hydrazide at 7 and 21 days after darkening. Five plants were randomly tagged in each of the plot (treatment and replication wise) and observed for growth, physiology and flowering parameters at critical stages of the crop growth. All other agronomic operations and plant protection measures were done as per the schedule.

Plant height

The height was measured from the base of the plant to the terminal tip at the critical stages namely: peak vegetative, bud appearance and peak flowering stage and the mean values were expressed in centimeters (cm).

Total Leaf area per plant

The total leaf area per plant was measured using the leaf area meter (Make: Leaf Area Meter, Li- 3100) at the critical stages and the mean was worked out and expressed in square centimeter (cm^2).

Determination of chlorophyll content

Fresh leaves were collected and the total chlorophyll contents in the leaves were determined by following the method of Yoshida et al. (1971) and expressed in mg/g.

Determination of soluble protein content

Soluble protein content was estimated with tricarboxylic acid extract of leaf sample following the method of Lowery et al. (1957) and

Table 1. Treatment comprising two growth retardants.

T	Treatment details	T	Treatment details
T_1	Daminozide 1000 ppm spray at 7th day after darkening	T_{11}	Daminozide 2500 ppm spray at 7th and 14th days after darkening
T_2	Daminozide 1000 ppm spray at 7th and 14th day after darkening	T_{12}	Daminozide 2500 ppm spray at 7, 14 and 21st days after darkening
T_3	Daminozide 1000 ppm spray at 7th , 14 and 21st day after darkening	T_{13}	MH 500 ppm spray at 7th day after darkening
T_4	Daminozide 1500 ppm spray at 7th day after darkening	T_{14}	MH 500 ppm spray at 7th and 21st day after darkening
T_5	Daminozide 1500 ppm spray at 7th and 14th days after darkening	T_{15}	MH 750 ppm spray at 7th day after darkening
T_6	Daminozide 1500 ppm spray at 7, 14 and 21st days after darkening	T_{16}	MH 750 ppm spray at 7th and 21st day after darkening
T_7	Daminozide 2000 ppm spray at 7th day after darkening	T_{17}	MH 1000 ppm spray at 7th day after darkening
T_8	Daminozide 2000 ppm spray at 7th and 14th days after darkening	T_{18}	MH 1000 ppm spray at 7th and 21st day after darkening
T_9	Daminozide 2000 ppm spray at 7, 14 and 21st days after darkening	T_{19}	Control (no spray)
T_{10}	Daminozide 2500 ppm spray at 7th day after darkening		

T = Treatment.

expressedin milligrams per gram (mg/g) of fresh weight.

$$\text{Amount of soluble protein} = \frac{X}{1} \times \frac{25 \times 1000}{250}$$

Where, X = Corresponding concentration in the standard graph (µg)

Days to first flower bud appearance

The number of days taken from the date of planting to visible flower bud appearance was recorded and the mean was expressed in days.

Days to first harvest

The number of days taken from the date of planting to the first harvest was counted and expressed in days.

Flower stalk length (cm)

The length of flower stalk was measured from the fourth node to the base of flower and expressed in centimeters (cm).

Pedicel length

The pedicel length was measured from the point of pedicel attachment to the stalk to its attachment to the base of the flower and it expressed in centimeter (cm).

Stem girth

The girth of the stem at peak flowering stage was measured using thread and expressed in centimeters (cm).

Stem fresh weight

The cut stem along with flowers was cut at the peak flowering stage and weighed using weighing balance and the mean was expressed in gram (g).

Cut stem yield/m^2

The number of stems harvested per square meter area was counted and expressed in numbers for yield/m^2.

Vase life

The flower stalks harvested from experimental plot were kept in distilled water at room temperature and the vase life was evaluated daily by counting the number of days taken for the symptom of shriveling and wilting (Halevy and Mayak, 1979).

Statistical analysis

Data were analyzed statistically for analysis of variance per the method suggested by Panse and Sukhatme (1985). The critical differences were worked out for 5 per cent (0.05) probability. The mean differences were compared using the LSD test ($p<0.05$).

RESULTS AND DISCUSSION

Plant height recorded in the experiment were significantly ($p<0.05$) affected by growth retardant applications at varied frequencies and concentration (Table 2). The mean data presented in the table shows a difference in significant height reduction (14.66 and 7.48 cm) in chrysanthemum with single spray of daminozide 2000 ppm at 7th day after darkening (T_7) when compared to

Table 2. Influence of daminozide and maleic hydrazide on plant height (cm) and total leaf area per plant (cm^2) of spray chrysanthemum var. Punch.

Treatment	Plant height (cm)			Total leaf area per plant (cm^2)		
	Peak vegetative stage	Bud appearance stage	Peak flowering stage	Peak vegetative stage	Bud appearance stage	Peak flowering stage
T_1	31.20^{gh}	79.87^{efgh}	108.53^{gh}	657.17^{hi}	799.52^{j}	892.97^{hi}
T_2	33.00^{hi}	82.89^{fgh}	115.27^{hij}	1547.69^{a}	1694.55^{a}	1745.27^{a}
T_3	27.03^{d}	81.87^{fgh}	117.06^{ij}	984.00^{cd}	1095.22^{def}	1128.49^{de}
T_4	28.87^{def}	82.13^{efgh}	117.90^{j}	1142.71^{b}	1183.24^{c}	1235.04^{c}
T_5	22.13^{ab}	78.87^{efgh}	106.33^{fg}	732.36^{gh}	819.44^{j}	879.81^{hi}
T_6	27.00^{d}	80.60^{fgh}	107.60^{gh}	838.24^{defg}	921.24^{i}	984.04^{fg}
T_7	21.67^{a}	77.27^{efgh}	118.20^{j}	1048.14^{bc}	1167.63^{cd}	1211.03^{c}
T_8	24.80^{c}	80.60^{efgh}	109.96^{ghi}	956.40^{cde}	1102.46^{de}	1187.06^{cd}
T_9	29.63^{efg}	81.73^{fgh}	108.55^{gh}	830.69^{efg}	953.62^{ghi}	1054.08^{ef}
T_{10}	34.33^{ij}	83.33^{gh}	103.58^{efg}	1473.03^{a}	1576.95^{b}	1634.92^{b}
T_{11}	30.13^{fg}	82.40^{fgh}	114.80^{hij}	908.23^{cde}	1026.52^{fg}	1066.80^{e}
T_{12}	29.50^{efg}	79.50^{efgh}	106.97^{g}	939.58^{cd}e	1071.66^{ef}	1093.32^{e}
T_{13}	27.67^{de}	67.37^{ab}	99.01^{def}	662.31^{hi}	915.37^{i}	944.70^{gh}
T_{14}	23.97^{bc}	69.36^{bc}	91.60^{cd}	767.45^{fg}h	829.67^{j}	885.00^{hi}
T_{15}	26.93^{d}	74.93^{cde}	97.33^{de}	862.25^{defg}	940.69^{hi}	984.03^{fg}
T_{16}	23.50^{abc}	75.47^{bde}	87.80^{bc}	672.49^{hi}	805.54^{j}	817.64^{ij}
T_{17}	23.17^{abc}	71.30^{acd}	83.37^{b}	872.95^{def}	997.58^{gh}	1058.08^{ef}
T_{18}	23.67^{abc}	63.37^{a}	72.07^{a}	562.64^{ij}	723.14^{k}	768.66^{j}
T_{19} (control)	36.33^{j}	84.75^{h}	120.77^{j}	450.75^{j}	686.84^{k}	826.20^{ij}
S.Ed	1.029	2.806	3.836	74.682	36.238	38.092
CD (p=0.05)	2.087	5.690	7.780	151.479	73.503	77.263

Means followed by a common letter are not significantly different at the 5% level by LSD.

control (T_{19}) at peak vegetative and bud appearance stage. At the peak flowering stage, a single spray of daminozide 2500 ppm (T_{10}) recorded a considerable reduction in height difference (17.19 cm) without affecting the total stem length which is the most important criteria to be considered in the export market. Height reduction in the daminozide treatments might be due to reduction in number of cells in stem and complete suppression of apical dominance which inhibits the cell division. The result shows that single application of daminozide to 'Punch' chrysanthemum was sufficient because the inhibitory effect was long enough. This is in agreement with the findings of Mahalle et al. (2001), Khobragade et al. (2002), Karlovic et al. (2004), Zhi-kai (2008) and Piotr and Schroeter (2011) in chrysanthemum. Instead, maleic hydrazide treatments recorded drastic height control over daminozide treatments which resulted in severe reduction of stem length in spray chrysanthemum but poor flower quality was observed in terms of flower size and flowering synchrony.

Leaves serve as the index of measurement of vegetative growth and in determining the yield potential. Improvement in the total leaf area was observed in all the treatments receiving daminozide irrespective of concentrations. Foliar spray of daminozide 2500 ppm at 7^{th} day after darkening (T_{10}) significantly increased the total leaf area per plant at peak vegetative (1473.03 cm^2) and T_2 (daminozide 1000 ppm at 7 and 14^{th} day after darkening) at bud appearance (1694.55 cm^2) and flowering stage (1745.27 cm^2) over control. This might be due to the supplementary action of daminozide in cell division and the ability of the compound to be translocated to the meristematic tissue. This probably accounts for its effect on axillary leaf growth which resulted in increased number of leaves and ultimately reflected on the leaf area and leaf area index. This result is not in agreement with the findings of El-Mokadem and Hadia (2008) who reported that daminozide reduce the leaf number and area. On the other side, leaf area registered significantly a decreasing trend (T_{18}) with the increase in concentration of maleic hydrazide.

The leaf chlorophyll content is an important physiological factor as it directly influences the photosynthesis and it occurs in chloroplast as green pigments in all photosynthetic plant tissues. It also acts as an index of metabolic efficiency of plant to utilize the absorbed light radiation for dry matter production. Growth retardants affected the total chlorophyll contents at all the critical stages of the crop growth (Figure 1). Levels of total

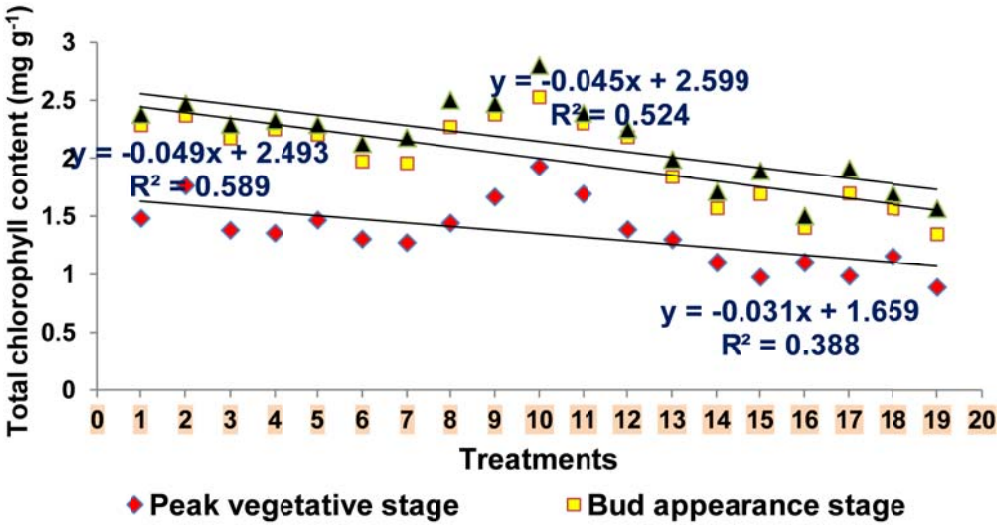

Figure 1. Total chlorophyll content in chrysanthemum 'Punch' with the application of different concentrations of daminozide and maleic hydrazide.

chlorophyll at peak vegetative, bud appearance and peak flowering stage was found to be higher (1.62, 1.81 and 2.05 mg/g) in T_{10} (daminozide 2500 ppm at 7 days after darkening) which was followed by T_2 (1.52 mg/g, 1.71 mg/g and 1.75 mg/g) and T_9 (1.46 mg/g, 1.70 mg/g and 1.78 mg/g) respectively. Daminozide significantly increased the content of chlorophyll in leaves, the leaf colour became deeper and photosynthetic efficiency was increased (Kazaz et al., 2010). Control (T_{19}) recorded the lowest total chlorophyll content at all the stages (0.85, 1.25 and 1.33 mg/g) of growth.

Soluble protein is a key factor in determining the photosynthetic efficiency of the crop plants. Analysis of soluble protein revealed that spraying of daminozide at 2500 ppm at 7th day alone (T_{10}) increased the protein content (65.66, 72.33 and 80.66 mg/g) at the critical stages. The results indicated that more soluble protein in the plant system leads to high RuBisCO activity, which ultimately induce high carbon fixation, improve photosyn-thetic efficiency and result in high yield (Table 3). The least soluble protein content was registered in the plots that not received any of the concentration of growth retardants at any frequency (control).

Days taken for first flowering were significantly affected by daminozide and maleic hydrazide application at different concentrations and intervals (Table 4). The earlier flowering (44.72 day) was recorded in the plants receiving daminozide at 2500 ppm spray at 7th day after darkening (T_{10}). However, the treatments receiving daminozide spray irrespective of frequencies showed positive influence on earliness in flowering and days to harvest. The earliness in flowering might be due to the effect of chemicals on height control, the stored food reserves translocated and diverted to the sink. This is not in agreement with the findings of Kahar (2008), Zhi-kai (2008), (Kazaz et al., 2010) and Piotr and Schroeter (2011) who have reported that daminozide delayed flowering in chrysanthemum. The delayed flowering in MH treatments was observed more than control. This might be due to the result of growth inhibition as it is necessary for increasing / decreasing the flower formation and their development. However there was improvement in the flowering synchrony with daminozide applications.

In general, daminozide application regulated the stalk length in 'Punch' chrysanthemum. Foliar application of daminozide at 2500 ppm at 7th day after darkening (T_{10}) recorded marketable reduction in flower stalk length than control. The results of the present study are in agreement with the findings of Karlovic et al. (2004) and El-Sheibany et al. (2007). On the other hand, maleic hydrazide treatments *viz*., T_{13}, T_{14} T_{15} T_{16} T_{17} and T_{18} recorded poorest stem length (93.61, 86.10, 92.43, 82.70, 79.07 and 67.07 cm) respectively. In the present studies, the effectiveness of daminozide and maleic hydrazide were compared. The effects of these substances depend on their concentration and frequencies. It was also observed that increasing concentrations and frequencies showed maximum reduction in plant height and also total stalk length in chrysanthemum var. Punch.

Significant differences were observed among the growth retardants for pedicel length. The mean data presented in the Table 5 reveals that single spray at 7 days after darkening with daminozide 2500 ppm (T_{10}) recorded the maximum pedicel length (5.87 cm) which is followed by T_8 (5.73 cm) and T_{15} (5.38 cm). This might be due to the action of daminozide which removes apical dominance and increase the pedicel length. The increase

Table 3. Effect of daminozide and maleic hydrazide on soluble protein content (mg/g) at critical stages of spray chrysanthemum var. Punch.

Treatment	Soluble protein content (mg/g)		
	Vegetative stage	Bud appearance stage	Flowering stage
T_1	59.93^{cd}	64.56^{d}	68.31^{c}
T_2	63.15^{b}	69.28^{b}	75.69^{b}
T_3	61.17^{bc}	64.99^{d}	61.06^{fgh}
T_4	52.95^{g}	58.37^{e}	63.52^{ef}
T_5	54.32^{g}	60.56^{e}	60.35^{ghi}
T_6	58.67^{de}	66.10^{c}	64.93^{de}
T_7	53.71^{g}	55.51^{f}	59.14^{hi}
T_8	56.73^{ef}	55.26^{f}	62.86^{efg}
T_9	60.02^{cd}	65.21^{d}	74.93^{b}
T_{10}	65.66^{a}	72.33^{a}	80.66^{a}
T_{11}	62.92^{b}	67.83^{bc}	67.06^{cd}
T_{12}	55.15^{fg}	48.95^{g}	66.30^{cd}
T_{13}	57.72^{de}	44.25^{h}	57.70^{ij}
T_{14}	54.64^{fg}	40.86^{jk}	50.27^{kl}
T_{15}	43.76^{h}	50.22^{g}	46.02^{m}
T_{16}	36.74^{j}	42.93^{j}	48.15l^{m}
T_{17}	32.75^{k}	38.75^{kl}	52.38^{k}
T_{18}	40.03^{i}	46.23^{h}	55.31^{j}
T_{19} (control)	30.50^{k}	36.41^{l}	45.74^{m}
SEd	1.162	1.222	1.345
CD (p=0.05)	2.358	2.478	2.728

Means followed by a common letter are not significantly different at the 5% level by LSD

Table 4. Effect of daminozide and maleic hydrazide on days to first flower bud appearance, days to harvest and flower stalk length (cm) of chrysanthemum.

Treatment	Days to first flower bud appearance (day)	Days to harvest (day)	Flower stalk length (cm)
T_1	50.95^{cde}	87.40^{abc}	104.53^{gh}
T_2	46.54^{ab}	84.67^{ab}	109.17^{hi}
T_3	54.03^{ef}	88.27^{bcd}	112.09^{ij}
T_4	53.60^{def}	90.37^{cde}	114.40^{ij}
T_5	49.56^{bcd}	95.78^{efg}	101.29^{fg}
T_6	52.64^{de}	89.33^{bcd}	102.10^{fg}
T_7	51.60^{cde}	92.56^{def}	113.60^{ij}
T_8	57.80^{fg}	86.93^{abc}	104.66^{gh}
T_9	47.31^{abc}	85.87^{abc}	104.25^{fgh}
T_{10}	44.72^{a}	81.83^{a}	98.58^{ef}
T_{11}	53.54^{def}	93.67^{ef}	109.30^{hi}
T_{12}	52.47^{de}	87.60^{bcd}	102.37^{fg}
T_{13}	66.50^{ij}	101.63^{h}	93.61^{de}
T_{14}	60.81^{gh}	95.97^{fg}	86.10^{c}
T_{15}	64.37^{hi}	99.37^{gh}	92.43^{d}
T_{16}	69.88^{j}	102.33^{h}	82.70^{bc}
T_{17}	69.60^{j}	104.73^{h}	79.07^{b}
T_{18}	74.81^{k}	110.50^{i}	67.07^{a}
T_{19} (control)	54.95^{ef}	90.07^{bcd}	115.37^{j}

Table 4. Contd,

SEd	2.138	2.769	2.905
CD (p=0.05)	4.337	5.616	5.891

Means followed by a common letter are not significantly different at the 5% level by LSD.

Table 5. Effect of daminozide and maleic hydrazide on pedicel length (cm), cut stem yield/m^2 and vase life (d) of spray chrysanthemum var. Punch.

Treatment	Pedicel length (cm)	Cut stem yield / m^2	Vase life (day)
T_1	4.36^{ij}	74.65^{abc}	10.00^{fg}
T_2	5.30^{cd}	76.21^{ab}	11.76^{b}
T_3	4.56^{ghi}	73.65^{bcd}	10.04^{fg}
T_4	4.51^{hi}j	71.33^{ef}	9.76^{g}
T_5	5.02^{def}	73.67^{bcd}	10.02^{fg}
T_6	4.71^{gh}	70.97^{efg}	8.97^{h}
T_7	4.73^{fgh}	73.15^{ce}f	10.75^{cd}
T_8	5.73^{ab}	72.66^{def}	9.68^{g}
T_9	5.47^{bc}	75.68^{abc}	10.95^{c}
T_{10}	5.87^{a}	77.34^{a}	12.50^{a}
T_{11}	5.26^{cde}	70.21^{fg}	10.20^{ef}
T_{12}	5.00^{ef}	68.34^{g}	10.47^{de}
T_{13}	4.25^{j}	64.84^{h}	8.44^{ij}
T_{14}	4.27^{ij}	60.21^{i}	8.21^{jk}
T_{15}	5.38^{c}	55.29^{j}	7.67^{l}
T_{16}	4.39^{ij}	52.40^{j}	8.64^{hi}
T_{17}	4.32^{ij}	47.31^{k}	6.95^{m}
T_{18}	4.81^{fg}	45.25^{k}	7.86^{kl}
T_{19} (control)	3.89^{k}	74.35^{bcd}	5.27^{m}
SEd	0.142	1.457	0.208
CD (p=0.05)	0.287	2.956	0.426

Means followed by a common letter are not significantly different at the 5% level by LSD.

in pedicel length due to daminozide was also observed by Zhang (2011) in *Chrysanthemum morifolium* Ramat. Cv. Youxiang. Maleic hydrazide treated plants recorded lesser pedicel length when compared to daminozide treated plots.

Stem girth is an important criterion for determining stem strength as it directly relates ability of the stem to bear numerous flowers and also in improving post harvest life. Growth retardant applications significantly increase the cut stem girth (Figure 2). The stem girth was measured as 5.87 cm in T_{10} (daminozide 2500 ppm at 7 days after darkening) which is on par with the treatment (T_8) which received daminozide 2000 ppm at 7 and 14 days after darkening (5.73 cm). In this study daminozide application irrespective of concentration increased the stem girth. Similar results were reported by Mahalle et al. (2001); Khobragade et al. (2002) and Kim et al. (2010), While T_{19} recorded the lowest stem girth of 3.89 cm.

The effect of daminozide and maleic hydrazide on stem fresh weight was found statistically significant (Figure 3). A higher stem fresh weight (68.00 g/stem) was recorded in T_{10} (daminozide 2500 ppm at 7 days after darkening) followed by T_2 (65.79 g/stem) and T_9 (61.98 g/stem) and lowest was recorded in control (39.50 g/stem). Spray chrysanthemums are graded by stem length, stem fresh weight and maturity at the Dutch Flower Auction Association (VBN). In this grading, stem fresh weight ranges from 25 to 105 g in spray chrysanthemum depending on the grading codes. The data on fresh weight of stems obtained in the study are in agreement with the above mentioned standards.

In general, the flower yield of any crop is determined by various yield components. Yield attributing characters *viz.*, total stalk length, pedicel length, stem girth and stem fresh weight have definite role in successful commercial cultivation of greenhouse chrysanthemums. Important yield components namely: marketable stem yield per sq.m was favourably influenced in the treatments receiving damino-

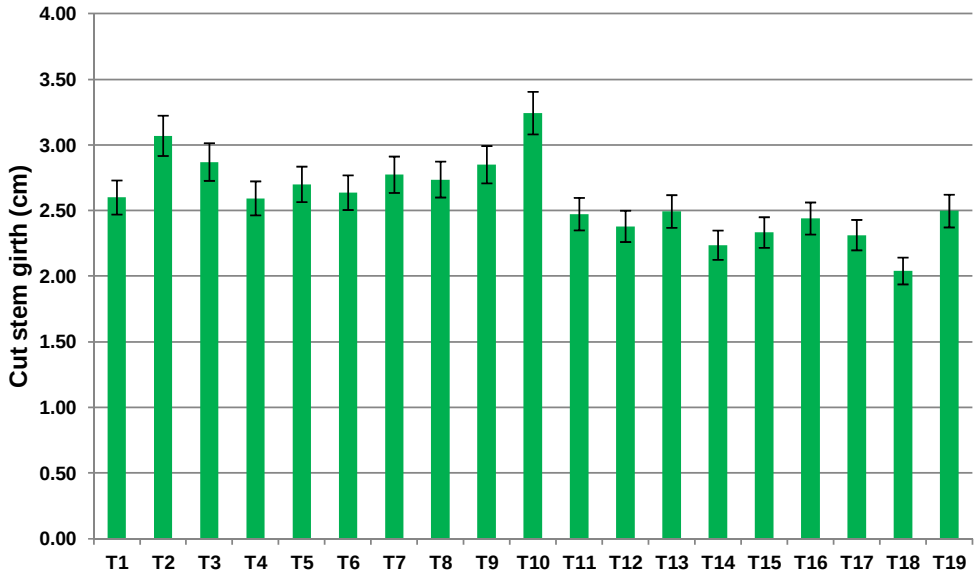

Figure 2. Cut stem girth of flowers in chrysanthemum 'Punch' with the application of different concentrations of daminozide and maleic hydrazide.

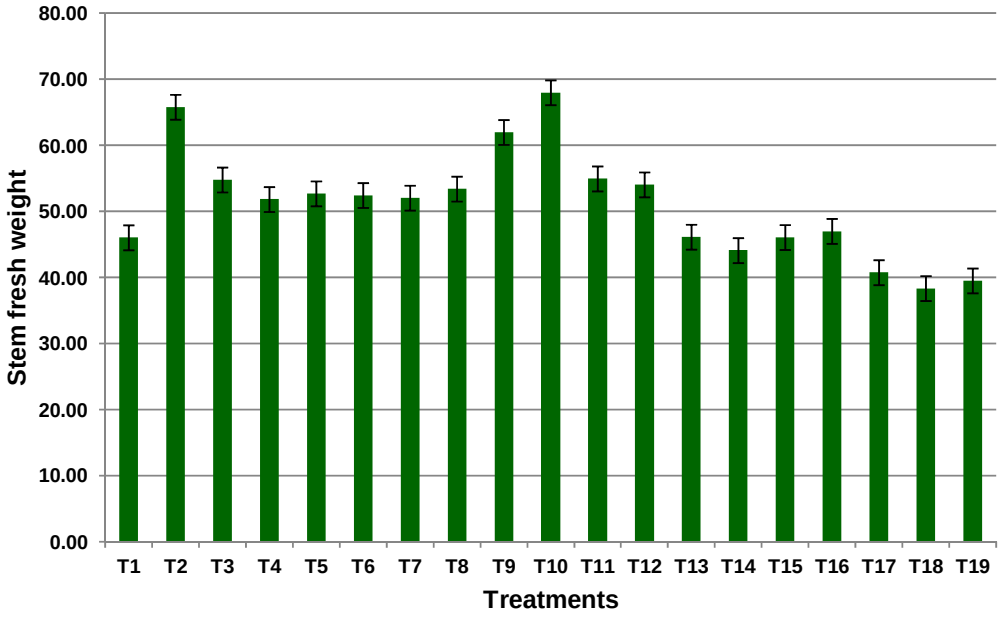

Figure 3. Fresh weight of cut stem chrysanthemum 'Punch' with the application of different concentrations of daminozide and maleic hydrazide.

zide, irrespective of frequencies (Table 5). This illustrates the ability of daminozide to enhance the number of flowers per spray, stem girth and stem fresh weight at proper concentration and in reliable frequency.

Longest vase life (12.50 days) was achieved in the treatment receiving daminozide at 2500 ppm at 7 days after darkening than the control (5.27 days). Internal physiological status of the cut stems might have helped in delaying early onset of senescence. Positive effect of daminozide on inhibiting suberin formation, improvement in water relations, hydraulic conductance, antirespiratory properties, maintaining carbohydrates and antimicrobial effect prevented vascular blockage and increased vase life of cut chrysanthemum var. Punch. This is not in

agreement with the findings of Navale et al. (2010) who reported that growth retardants decreased the vase life of cut flowers.

Conclusions

The effects of daminozide and maleic hydrazide at varied concentrations and frequencies on growth, flowering and chlorophyll content in spray chrysanthemum var. Punch were tested in the study. Daminozide had comprehensive effects on improving plant type of *D. grandiflora* and increasing its ornamental value and physiological quality. Daminozide also showed a longer inhibitory action than maleic hydrazide. Hence based on the results obtained, it can be concluded that single application of daminozide at 2500 ppm at seven days after darkening may be recommended for reducing the height of spray chrysanthemum var. 'Punch'.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

El-Mokadem HE, Hadia HA (2008). Induction of dwarfism in Encelia farinose by cycocel and evaluation regenerates using RADP and ISSR markers. Aust. J. Basic Appl. Sci. 2: 331-342.

El-Sheibany OM, El-Maki NA, Barras Ali A (2007). Effect of application of growth retardant Alar on some foliage characteristics of local cultivar of chrysanthemum. J. Sci. Appl. 2(1):15-20

Halevy AH, Mayak S (1979). Senescence and post harvest physiology of cut flowers - Part I. In J. Janick (Ed.). Hortic. Rev. 3: 59-143.

Kahar SA (2008). Effects of frequency and concentration of B-9 (Daminozide) on growth, flowering and flower quality of Reagan Sunny chrysanthemum (*Chrysanthemum morifolium* Ramat.) Acta Hortic. 788:141-148

Karlovic K, Vrsek I, Sindrak Z, Zidovec V (2004). Influence of growth regulators on the height and number of inflorescence shoots in the Chrysanthemum cultivar 'Revert'. Agric. Conspectus Sci. 69(2-3):63-66

Kazaz S, Arilla Askin M, Kilic S, Erosy N (2010). Effects of day length and daminozide on the flowering, some quality parameters and chlorophyll content of *Chrysanthemum morifolium* Ramat. Sci. Res. Essays 5(21):3281-3288

Khobragade YR, Belorkar PV, Damke MM, Badole WP, Hatmode CN (2002). Effect of B-9 on growth and flower diameter of chrysanthemum. J. Soils Crops 12(2):289-292

Kim YH, Khan AL, Hamayun M, Kim JT, Lee JH, Hwang IC, Yoon CS, Lee IJ (2010). Effects of prohexadionecalcium on growth and gibberellin contents of *Chrysanthemnum morifolium* R. cv. 'Monalisa white'. Sci. Hortic. 123:423-427

Kuehny JS, Peinter A, Branch PC (2001). Plug source and Growth retardants affect finish size of bedding plants. Hortic. Sci. 36(2):321-323.

Lowery OH, Rose Brought L, Farr A, Randall RJ (1957). Protein measurement with folin phenol measurement with folin phenol reagent. J. Biol. Chem. 193: 265-275.

Mahalle BV, Tidke SS, Khobragade MH, Belorkar PV (2001). Effect of foliar spray of B-9 on growth parameters and chlorophyll content of chrysanthemum. J. Soils Crops 11(1):120-124

Navale MU, Aklade SA, Desai JR, Nannavare PV (2010). Influence of plant growth regulators on growth, flowering and yield of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. 'IIHR-6'. Int. J. Pharma Biosci. 6(2):1-4

Panse VG, Sukhatme PV (1985). Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.

Piotr Z, Anita S (2012). Growth retardants in the cultivation of Chrysanthemum x grandiflorum (Ramat.) Kitam 'Leticia Time Yellow'. Folia Hortic. 23(2):139-143

Piotr Z, Schroeter Z (2011). Growth retardants in the cultivation of Chrysanthemum x grandiflorum (Ramat.) Kitan. 'Leticia Time Yellow'. Folia Hortic. 23 (2):139-143

Vijai Ananth A, Ramesh Kumar S (2012). Effect of growth substances on growth and flower yield of Nerium (*Nerium Oleander* L.). Indian J. Plant Sci. 1(2-3):187-191

Yoshida S, Forno DA, Cock JH (1971). Laboratory manual for physiological studies of rice. IRRI, Philippines. pp. 36-37.

Zhang L (2011). Study on promotion of cut summer flowering cultivar *Chrysanthemum morifolium* Ramat. Cv. Youxiang in Yinchuan, Northern Horticulture. 03

Zhi-kai Z (2008). Effects of B-9 and CCC on the growth, flowering and physiological characteristics of *Chrysanthemum morifolium*. J. Anhui Agric. Sci. 27.