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Effect of Plant Growth Retardants on Growth, Flowering and Yield of Chrysanthemum (*Chrysanthemum Morifolium Ramat.*) cv. IIHR-6

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ABSTRACT

The present experiment was conducted on chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. IIHR-6 at Jambu Vadi Farm, College of Agriculture, JAU, Junagadh during winter season of 2013-14 under South Saurashtra agro climatic condition. The experiment was laid out in Randomized Block Design with Factorial concept with two time of spray viz., spray at 30 days after transplanting (S_1) and spray at 60 days after transplanting (S_2) and six treatment of plant growth retardants *viz.*, MH 500 @ mg l^{-1} (P_1), MH 700 @ mg l^{-1} (P_2), CCC @ 2000 mg l^{-1} (P_3), CCC @ 2500 mg l^{-1} (P_4), PCB @ 0.4 ml l^{-1} (P_5), PCB @ 0.5 ml l^{-1} (P_6) were sprayed including control (P_7). The effect of different time of sprays and plant growth retardants on growth, flowering and yield of chrysanthemum cv. 'IIHR-6' were found significant. The vigorous growth in terms of plant height at 90 DAT (52.65 cm) and at the time of final harvest (63.34 cm) was noticed the highest in control (P_7) treatment while, the number of branches per plant at 90 DAT (28.80) and at the time of final harvest 34.89), plant spread in N - S (52.15 cm and 60.78 cm) and E - W direction (53.25 and 62.45 cm) at 90 DAT and at time of final harvest, respectively; fresh weight of plant (317.55 g) and dry weight of plant (35.87 g) recorded maximum under plant receiving MH @ 700 mg l^{-1} (P_2). Consequently, these plants produced early flowers (70.94 days), took minimum days for 50 per cent flowering (101.16 days) with maximum flowering span (46.36 days), flower diameter (6.33 cm), shelf life (5.00 days) of flower as well as vase life (9.05 days) of flower. The yield of flowers (13.43 t ha $^{-1}$) also produced maximum in these treatment. Interaction between different time of spray and plant growth retardants was found to be non significant in case of growth, flowering and yield of flowers, except diameters of flower. Economics of chrysanthemum indicated that the plant sprayed at 30 days after transplanting (S_1) and treated with MH @ 700 mg l^{-1} (P_2) found most remunerative as they gave highest net returns (Rs. 208980) with maximum Benefit Cost Ratio (1:4.50). It can be concluded that the foliar application of MH @ 700 mg l^{-1} at 30 days after transplanting proved superior in terms of growth, flowering, flower yield and more economical as compared to all other growth retardants treatments.

Key words: Growth retardants, time of spray, flower yield, chrysanthemum

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INTRODUCTION

Today with the advancement of technology, grower's main objectives in flower crop is perfection in the form of plants in the quality of flowers and increase in the flower production. Chrysanthemum, the golden flower is derived from two greek word (*Chryos* meaning golden and *anthus* meaning flower), is one of the most beautiful and perhaps the oldest flowering plants commercially grown in different parts of the world. Chrysanthemum botanically known as (*Chrysanthemum morifolium* Ramat.), belongs to the family Asteraceae, it is believed to have originated from China

(Carter, 1980). It is commonly known as Queen of East, Autumn Queen and Guldaudi. It is important for both as cut flower and as potted plant in the international market. In India, it has been recognized as one among the five important commercially potential flower crops. It is grown commercially for cut and loose flowers as well as pot plant. It is grown in many parts of the world. Owing to its excelling beauty and economic values. The plant grows erect and tall making it suitable for border planting, loose flower, or as cut flower. It is also grown in pots for flower shows. The utility and popularity of the chrysanthemum have increased greatly with the technique of year-round blooming habit based on the research in the field of photoperiodic and genetics. It is preferred practically due to its vast range of shapes and sizes of flowers, brilliance of colour tones, long lasting florets life, and diversity of height and growth habit of the plant, exceptionally hardy nature, relative ease to grow all the year round and versatility of use. In india it is grown in 2.18 lakh hectares with the production of 14.21 lakh million tones production of loose flowers and 75,413 million numbers of cut flowers. (Anonymous, 2013). Now a days various chemicals are being tried for controlling growth and flowering of chrysanthemum with a view to have compact plants and also to stretch out or retard the rate of plant growth. Exogenously applied growth substances produce their effect through the alteration in endogenous hormones, thus modifying the growth and development of plants. In recent years scientist have given due attention to the idea of regulating plant growth as third most important factors in improving the growth, yield and quality with the application of plant growth regulators by various ways. These substances modify the plant physiological processes within the plant, which ultimately affect the growth, yield and quality. Growth retardants treatments are increasingly studied with greater number of flowers and also to hasten or delay flowering according to the needs of growers in chrysanthemum (Dutta *et al.* 1993, Yewale *et al.* 1997). Regulation of flowering, through growth retardants has immense practical value. Timing of the peak flowering to coincide with the time of greatest demand and generally modifying the flowers sequence to avoid peak production at about the time would confer great advantage to the grower and consumers. Paclobutrazol results in retardation of vegetative growth and divers of assimilates to reproductive growth, giving increased growth potentional and 2-chloroethyl - trimethyl ammonium chloride or Cycocel (CCC) and Maleic Hydrazide (MH) have been found to retard plant height by reducing intermodal length and also simultaneously it reduces the formation of lateral shoots thereby plant produces more number of flower bearing shoot in chrysanthemum (Yewale *et al*. 1997, Navale *et al*. 2010 and Singh, 2001). Paclobutrazol reduces plant height by suppressing the apical dominance, increases the main and secondary branches thereby increasing the flower number with reduction of flower diameter (Henrsel, 1985). Therefore, the experiment was undertaken to find out effect of plant growth retardants on growth, flowering and yield of chrysanthemum.

MATERIALS AND METHODS

The field experiment was conducted to study the effect of plant growth retardants on growth, flowering and yield of chrysanthemum cv. IIHR-6 at College of Agriculture, JAU, Junagadh during winter season of 2013-14. Junagadh is situated at 21.5^0 N latitude and 70.5^0 E longitudes with an altitude of 60 meters above the mean sea level, on the western side at the foothill of mountain Girnar. The experiment was laid out in Randomized Block Design with Factorial concept with two time of spray viz., spray at 30 days after transplanting (S_1) and spray at 60 days after transplanting (S_2) and six treatment of plant growth retardants *viz.*, MH 500 @ mg l^{-1} (P_1), MH 700 @ mg l^{-1} (P_2), CCC @ 2000 mg l^{-1} (P_3), CCC @ 2500 mg l^{-1} (P_4), PCB @ 0.4 ml l^{-1} (P_5), PCB @ 0.5 ml l^{-1} (P_6) were sprayed including control (P_7). Cuttings were prepared from the mother block maintained in the polyhouse of Department of Horticulture, College of Agriculture, Junagadh. Herbaceous cuttings of 20-25 cm were prepared and planted in the flat bed in polyhouse. Fifty five days old, healthy free from pest and disease rooted suckers were transplanted in each plot at 45 x 45 cm spacing during September 2013. Well decomposed farmyard manure was incorporated uniformly in the soil during preparation of soil at the rate of 10 t ha^{-1} and mixed well. Fertilizers were applied @ 120 kg nitrogen (Urea), 60 kg of phosphorus (Single Super Phosphate) and 60 kg potash (Muriate of Potash) per hectare. Full dose of phosphorus and potash was applied uniformly as a basal dose to all the plots and half dose of nitrogen was applied at 10 days after transplanting and remaining half dose of nitrogen was given at 30 days after transplanting. Foliar application of each growth retardants was given as per treatments, first spray given on 30th October, 2013 i.e. 30 DAT and second at 30th November, 2013 i.e. 60 DAT. Irrigation was given before fertilization to the crop for maintaining soil moisture.

RESULTS AND DISCUSSION

Effect on growth parameters

The results from Table 1 revealed that growth parameter viz., number of branches and plant spread of the plant were maximum in chrysanthemum cv. 'IIHR-6' when sprayed at 30 days after transplanting (S_1) while, plant height was maximum when sprayed at 60 days after transplanting (S_2). Increase in number of branches in S_1 treatments might be due to stimulation of branching and production of number of nodes possibly attributed to the breakage of

apical dominance and thereby settings up of balance as well as enhanced differentiation of internodes. Similar results were reported earlier by Dani *et al*. (2010) in African marigold, Joshi and Reddy (2006) in China aster. Among all treatments, MH 700 mg l^{-1} observed maximum reduction of plant height. The reduction in plant height due to lowering of the auxin content and acts antagonistically to auxin thus completely suppresses the apical dominance by inhibiting the cell division on the apical meristem and thereby resulting in the reduction of the plant height. The results are in agreement with the findings of Sharma *et al*. (1995) and Kumar and Ughreja (1998) who obtained considerable growth reduction in chrysanthemum and Khandelwal *et al*. (2003) in marigold and Vasoya (2012) in gaillardia with MH. Cycocel (CCC) caused significant reduction in plant height as it is seen from the Table 1.

Table 1: Effect of growth retardants on growth parameters of chrysanthemum cv. IIHR-6

Treatments	Plant height (cm)		Plant spread in N-S (cm2)		Plant spread in E-W (cm2)		No. of branches per plant		Fresh weight of plant (g)	Dry weight of plant (g)
	90 DAT	At harvest	90 DAT	At harvest	90 DAT	At harvest	90 DAT	At harvest		
Time of sprays (S)										
S_1 - 30 DAT	46.85	56.91	49.56	57.47	50.74	59.19	26.45	32.84	300.99	32.54
S_2 - 60 DAT	49.41	59.76	47.16	54.31	48.40	56.07	25.06	30.51	278.66	30.65
S.Em.±	0.77	0.83	0.71	0.89	0.70	0.92	0.41	0.64	4.48	0.57
C.D. at 5%	2.25	2.43	2.06	2.58	2.04	2.69	1.19	1.87	13.02	1.65
Plant Growth Retardants (P)										
P_1 - MH-500 mg l^{-1}	46.00	56.00	50.32	58.15	52.19	60.00	27.26	33.61	299.11	33.15
P_2 - MH-700 mg l^{-1}	44.48	54.72	52.15	60.78	53.25	62.45	28.80	34.89	317.55	35.87
P_3 - CCC-2000 mg l^{-1}	46.75	56.75	47.24	54.80	48.24	56.46	25.59	30.60	289.28	31.72
P_4 - CCC-2500 mg l^{-1}	47.06	57.06	49.98	57.81	50.98	59.81	26.31	32.78	298.36	33.00
P_5 - PCB-0.4 ml l^{-1}	49.48	59.98	45.05	52.30	46.55	53.97	23.14	28.77	267.81	27.38
P_6 - PCB-0.5 ml l^{-1}	50.50	60.50	46.78	53.08	47.78	54.75	25.04	31.33	284.85	30.33
P_7 - Control (Water spray)	52.65	63.34	47.00	54.31	48.00	55.98	24.16	29.75	271.82	29.72
S.Em.±	1.64	1.77	1.50	1.88	1.49	1.96	0.87	1.36	9.50	1.20
C.D. at 5%	4.78	5.15	4.37	5.46	4.33	5.70	2.53	3.96	27.63	3.50
Interaction (S×P)										
S.Em.±	2.32	2.50	2.13	2.66	2.11	2.77	1.23	1.93	13.44	1.70
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	8.36	7.43	7.62	8.24	7.36	8.33	8.27	10.53	8.03	9.32

The reduction in plant height due to the anti-auxin activity, distributed carbohydrate metabolism and inhibition of cell division and elongation of apical meristem might contribute to growth reduction and shortening of internodes in plant treated with CCC. Reduced plant height due to CCC treatment was also reported earlier by Talukdar and Paswan (1997) and Navale *et al*. (2010) in chrysanthemum. The result also indicated that the reduction of plant height was obtained with treatment of PCB. The reason for reduction in plant height due to PCB treatments might be attributed to the inhibition of gibberellins synthesis which caused reduction in stem elongation resulting in restricted growth of internodes. Corroboratory results have been obtained by Muhammad *et al*. (1997), Yewale *et al*. (1998a) and Kulkarni and Reddy (2003) in chrysanthemum.

All the chemical treatments significantly increase the plant spread in both the directions (N - S and E - W). Increased in the plant spread may be due to suppression of apical dominance that produced greater number of main and lateral branches, resulting in increased plant spread in both the directions. MH at all the concentrations significantly increased the plant spread in both the directions because of suppression in apical dominance that produced greater number of main and secondary branches. These finding are in accordance with the findings of Meher *et al*. (1999) and Navale *et al*. (2010) in chrysanthemum.

MH at 700 mg l^{-1} increased the number of branches which induces the lateral growth and ultimately increases the branches. These findings are supported by Dutta and Ramdas (1998), Kumar and Ughreja (1998) and Meher *et al*. (1999) in chrysanthemum. Considering the effect of CCC, number of secondary shoots was significantly increased in the number of internodes and increased photosynthetic efficiency of the plant due to an increase in chlorophyll. A similar effect of CCC on number of branches was also observed by Dhiman *et al*. (2003) in chrysanthemum. Increase in fresh weight and dry weight of plant with MH and CCC treatments concentration might be due to accumulation of more metabolite and also availability of reserve food for the reproductive growth. Similar results were also obtained earlier by Dutta and Ramdas (1998) and Moond *et al*. (2006) in chrysanthemum.

The interaction effect of different time of spray and plant growth retardants was found non significant in all the growth parameters viz., plant height, plant spread, number of branches per plant, fresh weight and dry weight of plant.

Effect on flowering and yield parameters

All the treatment of growth retardants differed significantly with respect to days to first flower bud appearance and first flowering, days to 50 per cent flowering were significantly minimum when plant was sprayed at 30 DAT (S_1) which accumulated of vegetative bud into the reproductive bud. The treatments of MH and CCC significantly delayed bud formation as compared to control. Maximum delay in bud formation was observed with MH 700 mg l^{-1} treatment. The delay in flower bud formation may be due to reduction in the flower bud development and inhibition of GA biosynthesis by the applied chemicals. Similar finding were also obtained by Dutta and Ramdas (1998), Kumar and Ughreja (1998) and Navale *et al*. (2010) in chrysanthemum. In the present investigation, response of different treatments to days required for opening of first flower after transplanting differed significantly. The delay due to MH is as a result of growth inhibition. Higher concentration of MH delays flower opening because of its action as an antiauxin, which is necessary for increase or decrease of the tissue favouring the flower formation and their development. Similar results were obtained in chrysanthemum sprayed with MH by Khandelwal *et al*. (2003) in African marigold and Navale *et al*. (2010) in chrysanthemum.

Data presented in Table 2 revealed that the treatment of MH and CCC significantly increased the flowering span of chrysanthemum. This might be due to availability of more photosynthetic for the longer time, so as to prolong reproductive phase. Increase in weight of flower with MH and CCC treatments concentration might be due to accumulation of more metabolite and also availability of reserve food for the reproductive growth. This result is in conformity with the findings of Dutta and Ramdas (1998) and Moond *et al*. (2006) in chrysanthemum.

In yield parameters the results indicated that number of flower per plant and flower yield was recorded maximum under plant spraying at 30 DAT (S_1). The more number of branches and maximum plant spread in this treatment had accumulated more carbohydrates through photosynthesis and were directly used for increasing the number of flowers and flower yield. In the present investigation maximum number of flowers per plant and flower yield was observed with MH 700 mg l^{-1} (Table 2).

Table 2: Effect of growth retardants on flowering and flower yield of chrysanthemum cv. IIHR-6

Treatments	Days required to first flower bud	Days required for opening of first flower	Days to 50 per cent flowering	Flowering span (days)	Fresh weight of flower per plant (g)	Number of flowers per plant	Number of flowers per plot	Yield of flowers per plot (kg)	Yield of flowers (t ha-1)
Time of sprays (S)									
S_1 - 30 DAT	69.01	75.48	106.24	43.26	102.73	30.89	741.34	2.52	10.88
S_2 - 60 DAT	72.60	80.23	111.44	38.53	95.34	28.78	690.64	2.39	9.59
S.Em.±	1.03	1.40	1.32	0.73	2.06	0.62	14.80	0.04	0.18
C.D. at 5%	3.00	4.06	3.85	2.12	6.00	1.79	43.04	0.11	0.52
Plant Growth Retardants (P)									
P_1 - MH-500 mg l^{-1}	67.07	73.62	102.58	41.39	110.59	31.87	764.80	2.59	11.71
P_2 - MH-700 mg l^{-1}	64.51	70.94	101.16	46.36	120.46	33.62	806.80	2.64	13.43
P_3 - CCC-2000 mg l^{-1}	69.65	74.24	106.57	40.07	98.87	29.50	707.88	2.40	10.06
P_4 - CCC-2500 mg l^{-1}	71.70	79.88	113.50	43.15	103.39	30.04	720.84	2.56	10.91
P_5 - PCB-0.4 ml l^{-1}	76.75	83.70	118.72	37.89	93.43	27.12	650.84	2.28	6.83
P_6 - PCB-0.5 ml l^{-1}	72.40	80.76	109.65	39.25	80.17	28.79	690.96	2.39	9.78
P_7 - Control (Water spray)	73.54	81.84	109.69	38.19	86.33	27.91	669.80	2.36	8.93
S.Em.±	2.19	2.96	2.81	1.55	4.38	1.31	31.40	0.08	0.38
C.D. at 5%	6.37	8.62	8.16	4.50	12.72	3.80	91.31	0.22	1.11
Interaction (S×P)									
S.Em.±	3.10	4.19	3.97	2.19	6.19	1.85	44.41	0.11	0.54
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	7.58	9.32	6.32	9.27	10.82	10.74	10.74	7.66	9.15

This increase in number of flowers per plant might be due to increased number of branches which ultimately enhanced the flower production. Increase in flower yield might be due to reduced plant height by suppressing the apical dominance, increased the main and secondary branching, thereby increasing the flower number which ultimately resulted in increased yields of flowers. The results are in conformity with the findings of Navale *et al*. (2010), Dutta and Ramdas (1998), Sharma *et al*. (1995), Sen and Maharana *et al.* (1971) and Meher *et al.* (1999) in chrysanthemum.

The interaction effect between time of spray and plant growth retardants was found non significant with respect to flowering and yield parameters viz., days required for opening of first flower, days to 50 per cent flowering, flowering span, fresh weight of flower and yield parameters. Economics indicated that the plant sprayed at 30 days after transplanting (S_1) and sprayed with MH 700 mg l^{-1} (P_2) were found most remunerative as they gave highest net returns with maximum Benefit Cost Ratio (BCR). These findings are in agreement with the reports of Navale *et al*. (2010) and Talukdar and Paswan (1997) in chrysanthemum; Khimani *et al*. (1994) and Makwana (1999) in gaillardia; Dani *et al*. (2010) in marigold; and Joshi and Reddy (2006) in China aster.

Table 3: Economics of different treatments of growth retardants in chrysanthemum cv. IIHR-6

Treatments	Yield (q/ha)	Gross realization (Rs. ha^{-1})	Total expenditure (Rs. ha^{-1})	Net realization (Rs. ha^{-1})	Cost: Benefit ratio
Time of sprays (S)					
S_1 - 30 DAT	10.88	217600	60017	157583	1:3.62
S_2 - 60 DAT	9.59	191800	60017	131783	1:3.19
Plant Growth Retardants (P)					
P_1 - MH-500 mg l^{-1}	11.71	234200	59520	174680	1:3.93
P_2 - MH-700 mg l^{-1}	13.43	268600	59620	208980	1:4.50
P_3 - CCC-2000 mg l^{-1}	10.06	201200	60265	140935	1:3.33
P_4 - CCC-2500 mg l^{-1}	10.91	218200	60515	157685	1:3.60
P_5 - PCB-0.4 ml l^{-1}	6.83	136600	59353	77247	1:2.30
P_6 - PCB-0.5 ml l^{-1}	9.78	195600	59378	136222	1:3.29
P_7 - Control (Water spray)	8.93	178600	59267	119333	1:3.01

Note: Selling price of flowers (Rs. 20 per Kg)
Urea: 304 Rs. per bag (50 kg), SSP: 357 Rs. per bag (50 kg) and MOP: 893 Rs. per bag (50 kg)
MH: 9.4 Rs. per g, CCC: 950 Rs. per 500g and PCB: 6000 Rs. per litre

CONCLUSION

The foliar spray of MH 700 mg l^{-1} at 30 days after transplanting recorded the highest number of branches, plant spread, fresh and dry weight of the plant, early flowering with maximum flower production. Same treatment also proved to be superior and more economical as compared to all other treatments in chrysanthemum cv. IIHR-6 in winter season of South Saurashtra agro climatic condition.

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