

UNDER PEER REVIEW

1 "Effect of growth regulators on plant growth and flowering in dahlia (*Dahlia variabilis*) cv.
2 Charmit"

3
4 **Abstract:** The experiment entitled "Effect of growth regulators on plant growth and
5 flowering in dahlia (*Dahlia variabilis*) cv. Charmit" was conducted at Urban
6 Technology Park, Habak during 2013, to evaluate the response of dahlia to different
7 growth regulators (Ethephon @ 500, 750 and 1000 ppm, Alar @ 1000, 2000 and 3000
8 ppm and Maleic hydrazide @ 500, 750, and 1000 ppm). Ten different treatment
9 combinations were replicated thrice in a Randomized Completely Block Design.
10 Significant differences were observed in vegetative and flowering parameters under the
11 influence of growth regulators. ~~Growth regulators significantly reduced plant height,~~
12 ~~length of primary branches but increased number of primary and secondary branches,~~
13 ~~leaf number and stem diameter.~~ MH 1000 ppm was very effective recording minimum
14 plant height (50.56 cm), maximum leaf number (206.75), stem diameter (24.25 mm),
15 primary (11.83) and secondary (9.02) branch number. Significant influence of growth
16 regulators was observed on various floral parameters. Flower bud appearance and
17 colour break was delayed while flowering duration shortened. However, flower bud
18 size, flower number, diameter and fresh weight increased. Maximum days to flower bud
19 appearance (129.13) and colour break (138.11), maximum flower diameter (11.78 cm),
20 flower fresh weight (14.08g) and minimum peduncle length (14.73 cm) was observed
21 with ethephon 1000 ppm. Highest flower number (45.18) was recorded with MH 500
22 ppm while maximum flower bud diameter (18.25 mm) with MH 1000 ppm. Among all
23 growth regulators Maleic hydrazide was found more effective followed by Ethephon
24 and Alar in modifying the plant architecture of dahlia.

25 **Keywords:** Dahlia, growth regulators, flowering, tubers, PGR

26 Introduction

27 The native land of dahlia is known to be Mexico (Willis, 1966). Dahlia is half-hardy herbaceous
28 perennial with tuberous roots belonging to family Asteraceae. There are at least 42 species of
29 dahlia and numerous hybrids. It was named by the pioneering Swedish botanist and taxonomist
30 Carl Linnaeus to honour his late student, Anders Dahl. Dahlias were introduced to India as early
31 as 1857 under the auspices of the Agri-Horticultural Society of India, Calcutta. Dahlia is
32 amongst the popular bulbous flowers found in the most gardens of the world. The Netherland is
33 the largest producer of tuberous-rooted dahlias. In India, the commercial cultivation of dahlias is
34 limited to the hills and plains of Eastern India. Dahlias are grown for various purposes and used
35 in several situations and locations.

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36 Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth and/or
37 development and applied for specific purposes to elicit specific plant responses (Joyce, 2012).
38 Controlling plant size is one of the most important aspects in floricultural crops which can be
39 achieved genetically, environmentally, culturally or chemically. However, effective strategy for
40 controlling plant height is to use plant growth retardants. ~~These are Plant growth regulators that~~
41 ~~have growth-inhibiting properties.~~ These PGRs reduce plant height by inhibiting the production
42 of gibberellins (hormones responsible for cell elongation) by interfering gibberellin biosynthesis
43 pathway in treated plants. — give reference

44 Material and Methods

45 The present investigation entitled "Effect of growth regulators on plant growth and flowering in
46 dahlia (*Dahlia varibilis*) (cv) Charmit" was carried out under open field conditions at Urban *Italic*
47 Technology Park, Habak during ~~the dahlia growing season of~~ 2013. The Urban Technology Park,
48 Habak is situated at 34° 9' N latitude and 74° 50' E longitude at an elevation of 1606 meters ~~delete~~
49 above sea level. Uniform sized tubers of dahlia cv. Charmit, with at least one growing bud were
50 selected after division of previous year's tuber clumps that were kept under underground
51 trenches during the winter (November 2012 to May 2013). The climate of the area in general is
52 temperate-cum-mediterranean and of continental type characterized by hot summers and severe
53 winters. Hottest months are July and August during which temperature shoots upto 32°C. Winter
54 is severe, extending over 70 days from the middle of December to March, when the temperature
55 often goes below the freezing point and the whole of Kashmir valley remains covered under
56 snow. The plants were planted in plots of size 2m x 1m, with 8 plants in each plot. The
57 experiment was laid out in Randomized Complete Block Design (RCBD), the total number of
58 treatments were ten with three replications. Three different growth regulators (*viz.*) Ethephon *Italic*
59 (500, 750 and 1000 ppm), Alar (500, 750 and 1000 ppm) and Maleic hydrazide (500, 750 and
60 1000 ppm) were used. The growth regulators were sprayed 20 days after first pinching. The
61 stock solution of ethephon, alar and maleic hydrazide was prepared by dissolving the weighed
62 quantity of these substances in ethanol and then diluted with distilled water to prepare the
63 required concentrations. The experimental land was well prepared by cultivator and leveled. The
64 land was divided into three blocks each with a width of 1 m leaving a path of 0.3 m between the
65 blocks. Each block was divided into 10 plots of 2.0x1.0 m size. Uniform dose of fertilizers and
66 FYM was added to each plot at the final preparation prior to planting of tuber. The tubers were
67 planted at the spacing of 50cm x 50cm as per the treatment combinations and layout
68 specification. The tubers were sown on 16th of May, 2013 at a depth of 7cm in plots of size 2m x
69 1m. Eight tubers were sown in each plot. Vigorous and healthy uniform sized tubers were
70 planted in the well prepared land. Light irrigation with rose cane was given immediately after
71 planting and subsequent irrigations were given at the appropriate stages. Following sprouting of
72 tubers, pinching off the tip of main shoot was done on 25th of July, when the shoots were about at
73 least two pairs of leaves. Only one main shoot was maintained per tuber. Extra shoot developing

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74 from the tuber were removed. Staking was done when plants achieved an average height of 1 ft
75 to avoid lodging. The harvesting of the tubers was done on 16th of November, 2013, when plant
76 growth retarded and leaves begin to change colour towards yellow due to onset of low
77 temperatures. All the adhering soil was removed from the tuber clumps. Above ground portion of
78 the plants was removed from the tuber keeping about 10 cm stem portion attached to each tuber
79 clump. After taking the necessary observations, tubers were stored in underground tranches for
80 the winter. Observations on different vegetative and floral characters were recorded from
81 randomly selected plants from each treatment in every replication at the appropriate time.

— Please provide
name of statistical
analysis

82 Result and Discussion

83 ~~The present work was undertaken to study the effect of some growth regulators in *Dahlia*~~
84 ~~*varabilis* cv. Charmit with the ultimate aim to improve their display or ornamental value. Results~~
85 ~~presented in table 1, revealed that the growth and flowering parameters of *Dahlia varabilis* cv.~~
86 ~~Charmit plants were significantly altered due to the application of growth regulators.~~

Delete

87 Effect of Ethephon, Alar and Maleic Hydrazide on Vegetative parameters

88 All the growth regulator treatments (table 1) significantly reduced plant height except lowest
89 concentrations of ethephon and Alar which were at par with the control. Maximum reduction in
90 plant height was recorded with MH 1000 ppm (50.56 cm). Decrease in plant height by the
91 growth regulators is due to inhibition of gibberellin biosynthesis which results in cell elongation
92 and also by the suppression of apical dominance by inhibiting cell division. These results are in
93 accordance with Tekalign and Hammes, 2005. The number of primary and secondary branches
94 increased with the increase in the concentration of growth regulators. Among different growth
95 regulator treatments, application of MH at 1000 ppm recorded highest number of primary
96 (11.83) and secondary branches (9.02). The lowest number of primary (4.95) and secondary
97 branches per plant (2.53) was recorded in control. It might be due to suppression of apical
98 dominance by the growth regulators thereby diverting the polar transport of auxins towards the
99 basal buds leading to increase in the number of laterals. These results were in accordance with
100 Kher (1973) and Leopold and Klein (1952). Higher concentrations of all the three growth
101 regulators decreased the primary branch length. Among different growth regulators, application
102 of alar at 3000 ppm recorded shortest primary branches (44.70 cm). Lower concentrations of
103 ethephon and alar increased the length of primary branches. Longest primary branches (64.54
104 cm) was recorded by Ethephon at 500 ppm which is significantly different from control (60.12).
105 Decrease in primary branch length with the higher concentrations of growth regulators is due to
106 inhibition of gibberellins biosynthesis which results in decrease in cell elongation while these
107 growth regulators at lower concentration act as growth promoters thus leading to the increase in
108 the length of the primary branches. Similar results were obtained by Pinto, (2005) in *Zinnia*
109 *elegans* and Khangoli (2001) in Rose. All the growth regulator treatments showed an increasing
110 trend in the number of leaves with the increase in their concentration. However, among the three

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111 growth regulators, application of MH at 1000 ppm recorded highest number of leaves per plant
112 (206.75). The lowest number of leaves was recorded with ethephon 500 ppm (123.76) which was
113 at par with control (128.91). It might be due to increase in the number of primary and secondary
114 branches. These results are in accordance with Grzesik and Rudnicki, 1985. Stem diameter was
115 significantly influenced by different growth regulator treatments. MH at 1000 ppm recorded
116 highest stem diameter (24.25 mm). Lowest stem diameter was recorded by ethephon at 500 ppm
117 (19.17 mm). Ethephon had non significant effect on stem diameter. It is due to decrease in the
118 plant height by the growth regulators which increases the partition distribution of nutrients
119 towards the lower parts. Similar results were obtained by Khan and Tewari, 2003.

120 **Table 1. Effect of Ethephon, Alar and Maleic Hydrazide on Vegetative parameters**

Treatment	Plant height (cm)	No. of primary branches	No. of secondary branches	Average length of primary branches (cm)	No. of leaves/plant	Stem diameter (cm)
Control (Distilled water)	74.63	4.95	2.53	60.12	128.91	19.52
Ethephon @ 500 ppm	71.61	6.50	4.33	64.54	123.76	19.17
Ethephon @ 750 ppm	64.06	7.03	4.50	51.66	134.14	20.21
Ethephon@1000 ppm	56.14	8.51	7.02	46.62	155.65	20.43
Alar @ 1000 ppm	71.08	6.99	4.58	62.62	128.10	21.63
Alar @ 2000 ppm	67.15	7.55	6.03	54.14	141.64	23.08
Alar @ 3000 ppm	56.10	9.27	6.04	44.70	157.70	24.20
MH @ 500 ppm	67.17	6.02	5.67	59.14	161.28	19.94
MH @ 750 ppm	61.18	9.08	6.52	52.04	176.17	22.66
MH @ 1000 ppm	50.56	11.83	9.02	46.65	206.75	24.25
CD ($p \leq 0.05$)	6.28	0.74	0.19	2.71	11.54	2.66

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122 **Effect of Ethephon, Alar and Maleic Hydrazide on Floral parameters**

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123 All the growth regulators in general delayed the flower bud appearance and colour break. (Table 2),
124 Maximum number of days to flower bud appearance was recorded ^{with} by ethephon 1000 ppm and
125 MH 1000 ppm (129.13 days), ^{while} Minimum number of days taken to flower bud appearance
126 (112.04 days) was recorded in control. Maximum number of days taken to first flower colour
127 break (138.11 days) was recorded in plants treated with Ethephon 1000 ppm followed by 137.04.
128 Minimum number of days taken to first flower colour break was recorded in control (116.13
129 days). This delay in flower bud appearance and colour break might be attributed to the
130 suppression of apical dominance and increased vegetative growth in the form of primary and
131 secondary branches by the growth retardants. Delay of flowering is often observed following
132 application of growth retardants, especially at very higher concentration (Pobudkiewicz, 2008).
133 Similar results were recorded by Bhattacharjee (1984) with alar and ethephon in dahlia, Karaz
134 and Karaguzel (2010) with paclobutrazol in golden rod and Kumar *et al.* (2013) with CCC and
135 MH in tulip, Sharifuzzaman *et al.* (2011) in chrysanthemum with CCC and MH, and
136 Pobudkiewicz and Treder (2006) in oriental lily cv. Mona Lisa.

137 The growth regulators in general delayed the appearance of first flower bud.
138 Minimum number of days taken to flower bud appearance (112.04 days) was recorded in control.
139 This delay in bud appearance may be attributed to the long vegetative phase by the retardants.
140 Saika and Talukdar (1997) recorded the same with MH in chrysanthemum. Similar results were
141 recorded by Bhattacharjee (1984) with alar and ethephon in dahlia, Karaz and Karaguzel (2010)
142 with paclobutrazol in golden rod and Kumar *et al.* (2013) with CCC and MH in tulip.

143 Among the three regulators ethephon and MH resulted in increase in bud size with the increase
144 in concentration while reverse trend was shown by alar. Largest bud size (18.25 mm) was
145 recorded at 1000 ppm MH while smallest bud size was recorded in control (14.42 mm). Increase
146 in bud size by ethephon and MH is due to availability of more carbohydrates during the
147 development of the buds while in alar increase in compactness of the cells decreases the bud
148 size. Similar results were obtained by Cathay and Staurt (1961). All the growth regulator
149 treatments decreased the flowering period. Maximum flowering period (63.05 days) was
150 recorded in control which is statistically at par with alar 1000 ppm (61.17 days). Shortest
151 flowering period (41.06 days) was recorded by ethephon 1000 ppm followed by MH 1000 ppm
152 (42.11). Decrease in flowering duration might be attributed to prolonged vegetative phase
153 resulting in delayed flower bud appearance. Arshid (2009) also reported reduction in flowering
154 duration in chrysanthemum following treatment with chemical retardants. All the growth

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regulators in general increased the flower number per plant. However, there was a decrease in flower number per plant with the increase in the concentration of growth regulators, but still the highest concentration of each growth regulator recorded a flower number greater than the control. Among different growth regulators, MH 500 ppm recorded highest flower number (45.18) followed by alar 1000 ppm (40.13), while lowest flower number (20.04) was recorded in control. Increase in the flower number might be attributed to production of more number of primary and secondary branches under the influence of growth retardants. Gowda and Jayanthi (1991) attributed the increase in number of flowers per plant in African marigold to the development of large number of auxiliary shoots as a result of cessation of terminal growth following application of growth retardants. Whipker *et al.* (2000) also observed increased flower number in geraniums after application of growth retardants. Haque *et al.* (2007) and Pushkar and Singh (2012) also reported increase in flower yield with application of growth retardants. However, decrease in the flower number with the increase in concentration of growth retardants might be due to reduction in the length of primary and secondary branches, many of which remained unproductive. The results are in accordance with Sen and Maharana (1972) and (Mushtaq, 2010). Flower diameter significantly increased with the application of growth regulators. Ethephon and MH showed an increasing trend in bud size with the increase in their concentration but alar showed a reverse trend i.e. flower diameter decreased with the increase in concentration. Among different growth regulators, ethephon 1000 ppm recorded highest flower diameter (11.78 cm) followed by ethephon 750 ppm (11.06 cm) and alar 1000 ppm (10.90). Lowest flower diameter (9.95 cm) was recorded in control. The increase in flower size due to MH and ethephon might be due to availability of more carbohydrates during the development of buds while alar increased the compactness rather than increasing size. Similar results were obtained by Cathay and Stuart (1961) in chrysanthemum and Abbas *et al.* (2007) in *Rosa damascene*. The effect of growth regulators on peduncle length showed that all growth regulators in general decreased the peduncle length. Longest peduncle length (16.80 cm) was recorded in control and shortest (14.39 cm) with alar 3000 ppm. Decrease in peduncle length may be attributed to the inhibition of cell elongation by the growth retardants due to their inhibitory effect on gibberellin biosynthesis. Shorter pedicels were also observed in dwarf pot roses (Pobudkiewicz and Goldsberry, 1989), asiatic hybrid lily (Pobudkiewicz and Nowak, 1992), chrysanthemum cvs. Altis and Surf (Pobudkiewicz and Nowak, 1997) and oriental lily cv. Mona Lisa (Pobudkiewicz and Treder, 2006) following growth retardant application. The results are in close conformity with the findings of Kumar *et al.* (2013) in tulip. All the growth regulators resulted in an increase in the fresh weight of the flower with increase in their concentrations. Among different growth regulators, ethephon 1000 ppm resulted in highest flower fresh weight (14.08 g) which differed significantly from control (12.02 g). Lowest fresh weight (10.43 g) was recorded with MH 500 ppm. Increasing trend in ethephon and MH is due to increase in the flower size while increase in alar is due to increase in thickness of the petals. The results were in line with Arshid (2009) and Saika and Talukdar (1997).

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194 Table 2. Effect of Ethephon, Alar and Malic Hydrazide on Floral parameters

<u>Growth regulators</u> <u>Treatments</u>	Days to flower bud appearance	Days to colour break	Bud size (mm)	Duration of flowering (days)	No. of flowers/plant	Flower diameter (cm)	Peduncle length (cm)	Fresh weight (g)
Control (Distilled water)	112.04	116.13	14.42	63.05	20.04	9.95	16.80	12.02
Ethephon @ 500 ppm	123.11	130.09	16.14	49.11	33.12	10.63	15.73	12.00
Ethephon @ 750 ppm	126.10	134.03	16.82	45.13	28.08	11.06	15.01	12.34
Ethephon@1000 ppm	129.13	138.11	17.29	41.06	21.17	11.78	14.73	14.08
Alar @ 1000 ppm	115.19	118.21	17.51	61.17	40.13	10.90	15.88	11.49
Alar @ 2000 ppm	117.21	122.05	16.76	57.21	29.11	10.77	15.47	12.07
Alar @ 3000 ppm	124.02	132.11	16.28	47.18	25.16	10.22	14.39	12.62
MH @ 500 ppm	121.11	129.17	16.97	50.12	45.18	10.09	16.28	10.43
MH @ 750 ppm	124.14	131.13	17.54	48.08	37.10	10.45	15.68	11.41
MH @ 1000 ppm	129.13	137.04	18.25	42.11	26.16	10.78	14.86	11.69
CD ($p \leq 0.05$)	9.09	7.99	1.67	5.64	1.29	0.23	1.34	0.98

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196 Conclusion

197 Among the three growth regulators, MH was most effective in reducing plant height, increasing
 198 number of branches, leaves and stem diameter. Ethephon was most effective in delaying
 199 flowering, has shortest flowering period, minimum number of flowers but has highest flower
 200 weight (fresh) while alar was most effective in reducing bud size and flower diameter.

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- 204 **LITERATURE CITED** → should strictly follow journal guideline - . . .
It has not been followed here throughout.
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