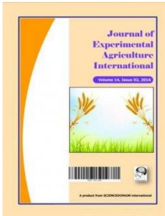

Journal of Experimental Agriculture International
15(3): 1-7, 2017; Article no.JEAI.32007
Previously known as American Journal of Experimental Agriculture
ISSN: 2231-0606

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Effect of Growth Regulators on Plant Growth and Flowering in Dahlia (*Dahlia variabilis*) cv. Charmit

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAM and ZAR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAW and AD managed the analyses of the study. Author ITN managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2017/32007
Editor(s):
(1) Özge Çelik, Department of Molecular Biology and Genetics, Istanbul Kultur University, Turkey.
Reviewers:
(1) Mahesh Choudhary, Vidya Bhawan Krishi Vigyan Kendra, Rajasthan, India.
(2) Sagar Mohapatra, Institute of Minerals and Materials Technology (CSIR), Orissa, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/17927

Original Research Article

Received 2nd February 2017
Accepted 14th February 2017
Published 22nd February 2017

ABSTRACT

An experiment entitled "Effect of growth regulators on plant growth and flowering in dahlia (*Dahlia variabilis*) cv. Charmit" was conducted to evaluate the response of dahlia to different growth regulators (Ethephon @ 500, 750 and 1000 ppm, Alar @ 1000, 2000 and 3000 ppm and Maleic hydrazide @ 500, 750, and 1000 ppm). Ten different treatment combinations were replicated thrice in a Randomized Completely Block Design. The investigation revealed that MH 1000 ppm was very effective and recorded minimum plant height, maximum leaf number, stem diameter, primary and secondary branch number. Significant influence of growth regulators was observed on various floral parameters. Flower bud appearance and colour break was delayed while flowering duration shortened. However, flower bud size, flower number, diameter and fresh weight increased. Maximum days to flower bud appearance and colour break, maximum flower diameter, flower fresh weight and minimum peduncle length was observed with ethephon 1000 ppm. Highest flower number was recorded with MH 500 ppm while maximum flower bud diameter with MH 1000 ppm. Among all growth regulators Maleic hydrazide was found more effective followed by Ethephon and Alar in modifying the plant architecture of dahlia.

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Keywords: Dahlia; growth regulators; flowering; tubers; PGR.

1. INTRODUCTION

Dahlia is half-hardy herbaceous perennial with tuberous roots belonging to family Asteraceae. There are at least 42 species of dahlia and numerous hybrids. The native land of dahlia is known to be Mexico [1]. It was named by the pioneering Swedish botanist and taxonomist Carl Linnaeus to honour his late student, Anders Dahl. Dahlias were introduced to India as early as 1857 under the auspices of the Agri-Horticultural Society of India, Calcutta. Dahlia is amongst the popular bulbous flowers found in the most gardens of the world. The Netherland is the largest producer of tuberous-rooted dahlias. In India, the commercial cultivation of dahlias is limited to the hills and plains of Eastern India. Dahlias are grown for various purposes and used in several situations and locations. The state (J&K) is endowed with ample natural resources including soil, water diversity in topography, climatic conditions, rich natural flora facilitating the cultivation of a wide range of flowers [2], including Dahlia. Various bulbs/tubers are imported from The Netherlands and planted in open field or under shade net during the summer and in unheated polyethylene houses for the September crop [3].

Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth and/or development and applied for specific purposes to elicit specific plant responses [4]. Controlling plant size is one of the most important aspects in floricultural crops which can be achieved genetically, environmentally, culturally or chemically. However, effective strategy for controlling plant height is to use plant growth retardants. These PGRs reduce plant height by inhibiting the production of gibberellins (hormones responsible for cell elongation) by interfering gibberellin biosynthesis pathway in treated plants [5].

2. MATERIALS AND METHODS

The present investigation entitled "Effect of growth regulators on plant growth and flowering in dahlia (*Dahlia varibilis*) *cv.* Charmit" was carried out under open field conditions at Urban Technology Park, Habak during 2013. The Urban Technology Park, Habak is situated at 34^0.9´ N latitude and 74^0.50´ E longitude at an elevation of 1606 meters above sea level. Uniform sized tubers of dahlia cv. Charmit, with at least one growing bud were selected after division of previous year's tuber clumps that were kept under underground trenches during the winter (November 2012 to May 2013). The climate of the area in general is temperate-cum-mediterranean and of continental type characterised by hot summers and severe winters. Hottest months are July and August during which temperature shoots upto 32°C. Winter is severe, extending over 70 days from the middle of December to March, when the temperature often goes below the freezing point and the whole of Kashmir valley remains covered under snow. The plants were planted in plots of size 2 m x 1 m, with 8 plants in each plot. The experiment was laid out in Randomized Complete Block Design (RCBD), the total number of treatments were ten with three replications. Three different growth regulators *viz;* Ethephon (500, 750 and 1000 ppm), Alar (500, 750 and 1000 ppm) and Maleic hydrazide (500, 750 and 1000 ppm) were used. The growth regulators were sprayed 20 days after first pinching. The stock solution of ethephon, alar and maleic hydrazide was prepared by dissolving the weighed quantity of these substances in ethanol and then diluted with distilled water to prepare the required concentrations. The experimental land was well prepared by cultivator and leveled. The land was divided into three blocks each with a width of 1 m leaving a path of 0.3 m between the blocks. Each block was divided into 10 plots of 2.0x1.0 m size. Uniform dose of fertilisers and FYM was added to each plot at the final preparation prior to planting of tuber. The tubers were planted at the spacing of 50 cm × 50 cm as per the treatment combinations and layout specification. The tubers were sown on 16th of May, 2013 at a depth of 7 cm in plots of size 2 m x 1 m. Eight tubers were sown in each plot. Vigorous and healthy uniform sized tubers were planted in the well-prepared land. Light irrigation with rose can was given immediately after planting and subsequent irrigations were given at the appropriate stages. Following sprouting of tubers, pinching off the tip of main shoot was done on 25th of July, when the shoots were about at least two pairs of leaves. Only one main shoot was maintained per tuber. Extra shoot developing from the tuber were removed. Stacking was done when plants achieved an average height of 1 ft to avoid lodging. The harvesting of the tubers was done on 16th of November, 2013, when plant growth retarded and leaves begin to change colour towards yellow due to onset of low temperatures. All the adhering soil was removed from the tuber clumps. Above ground portion of the plants was removed from the tuber keeping about 10 cm stem portion attached to each tuber clump. After taking the necessary observations, tubers were stored in underground trenches for the winter. Observations on different vegetative and floral characters were recorded from randomly selected plants from each treatment in every replication at the appropriate time. The statistical analysis was done at 5% level of significance.

3. RESULTS AND DISCUSSION

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

3.1 Effect of Ethephon, Alar and Maleic Hydrazide on Vegetative Parameters

All the growth regulator treatments (Table 1) significantly reduced plant height except lowest concentrations of ethephon and Alar which were at par with the control. Maximum reduction in plant height was recorded with MH 1000 ppm (50.56 cm). Decrease in plant height by the growth regulators is due to inhibition of gibberellin biosynthesis which results in cell elongation and also by the supression of apical dominance by inhibiting cell division. These results are in accordance with [6]. The number of primary and secondary branches increased with the increase in the concentration of growth regulators. Among different growth regulator treatments, application of MH at 1000 ppm recorded highest number of primary (11.83) and secondary branches (9.02). The lowest number of primary (4.95) and secondary branches per plant (2.53) was recorded in control. It might be due to suppression of apical dominance by the growth regulators thereby diverting the polar transport of auxins towards the basal buds leading to increase in the number of laterals. These results were in accordance with [7] and [8]. Higher concentrations of all the three growth regulators decreased the primary branch length. Among different growth regulators, application of alar at 3000 ppm recorded shortest primary branches (44.70 cm). Lower concentrations of ethephon and alar increased the length of primary branches. Longest primary branches (64.54 cm) were recorded by Ethephon at 500 ppm which is significantly different from control (60.12). Decrease in primary branch length with the higher concentrations of growth regulators is due to inhibition of gibberellins biosynthesis which results in decrease in cell elongation while these growth regulators at lower concentration act as growth promoters thus leading to the increase in the length of the primary branches. Similar results were obtained by [9] in *Zinnia elegans* and [10] in Rose. All the growth regulator treatments showed an increasing trend in the number of leaves with the increase in their concentration. However, among the three growth regulators, application of MH at 1000 ppm recorded highest number of leaves per plant (206.75). The lowest number of leaves was recorded with ethephon 500 ppm (123.76) which was at par with control (128.91). It might be due to increase in the number of primary and secondary branches. These results are in accordance with [11]. Stem diameter was significantly influenced by different growth regulator treatments. MH at 1000 ppm recorded highest stem diameter (24.25 mm). Lowest stem diameter was recorded by ethephon at 500 ppm (19.17 mm). Ethephon had non-significant effect on stem diameter. It is due to decrease in the plant height by the growth regulators which increases the partition distribution of nutrients towards the lower parts. Similar results were obtained by [12].

3.2 Effect of Ethephon, Alar and Maliac Hydrazide on Floral Parameters

All the growth regulators, in general, delayed the flower bud appearance and colour break (Table 2). Maximum number of days to flower bud appearance was recorded with ethephon 1000 ppm and MH 1000 ppm (129.13 days), while minimum number of days taken to flower bud appearance (112.04 days) was recorded in control. Maximum number of days taken to first flower colour break (138.11 days) was recorded in plants treated with Ethephon 1000 ppm followed by 137.04. Minimum number of days taken to first flower colour break was recorded in control (116.13 days). This delay in flower bud appearance and colour break might be attributed to the suppression of apical dominance and increased vegetative growth in the form of primary and secondary branches by the growth retardants. Delay of flowering is often observed following application of growth retardants, especially at very higher concentration [13] Similar results were recorded by [14] with alar and ethephon in dahlia, [15] with paclobutrazol in golden rod and [16] with CCC and MH in tulip, [17] in chrysanthemum with CCC and MH, and [18] in oriental lily cv. Mona Lisa.

The growth regulators, in general, delayed the appearance of first flower bud. Minimum number of days taken to flower bud appearance (112.04 days) was recorded in control. This delay in bud appearance may be attributed to the long vegetative phase by the retardants. [19] recorded the same with MH in chrysanthemum. Similar results were recorded by [14] with alar and ethephon in dahlia, [15] with paclobutrazol in golden rod and [16] with CCC and MH in tulip.

Among the three regulators ethephon and MH resulted in increase in bud size with the increase in concentration while reverse trend was shown by alar. Largest bud size (18.25 mm) was recorded at 1000 ppm MH while smallest bud size was recorded in control (14.42 mm). Increase in bud size by ethephon and MH is due to availability of more carbohydrates during the development of the buds while in alar increase in compactness of the cells decreases the bud size. Similar results were obtained by [20]. All the growth regulator treatments decreased the flowering period. Maximum flowering period (63.05 days) was recorded in control which is statistically at par with alar 1000 ppm (61.17 days). Shortest flowering period (41.06 days) was recorded by ethephon 1000 ppm followed by MH 1000 ppm (42.11). Decrease in flowering duration might be attributed to prolonged vegetative phase resulting in delayed flower bud appearance. [21] also reported reduction in flowering duration in chrysanthemum following treatment with chemical retardants. All the growth 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. [22] 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. [23] also observed increased flower number in geraniums after application of growth retardants. [24] and [25] 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 [26] and [27]. 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 [20] in chrysanthemum and [28] 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 gibberrelin biosynthesis. Shorter pedicels were also observed in dwarf pot roses [29], asiatic hybrid lily [30], chrysanthemum cvs. Altis and Surf [31] and oriental lily cv. Mona Lisa [18] following growth retardant application. The results are in close conformity with the findings of [16] 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 [21] and [19].

Table 1. Effect of ethephon, alar and maleic hydrazide on vegetative parameters

Treatments	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

Table 2. Effect of ethephon, alar and maliac hydrazide on floral parameters

Treatments	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

4. CONCLUSION

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

ACKNOWLEDGEMENTS

Authors wish to thank SKUAST-K, for supporting the research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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