Original Research Article

Response of Plant Growth Regulators on Vegetative Growth, Flowering and Flower Quality of Chrysanthemum at Central India

ABSTRACT

A study on the effect of plant growth regulators on growth and flowering of chrysanthemum was carried out at K.N.K. College of Horticulture, Mandsaur. Experiment was laid out in CRD with three replications. Chrysanthemum cultivar Hybrid-2 was used for the experiment. Six PGR treatments consisting of three concentrations each of GA and NAA *i.e.*, GA_3 (100, 150 & 200 ppm) and NAA (75 ppm, 125 ppm and 200 ppm) were applied. GA_3 (200 ppm) recorded the maximum values for plant height, plant spread, number of branches per plant, number of leaves per plant, leaf length (cm), leaf stalk length (cm), number of suckers per plant, number of flowers per plant, flower stalk length (cm), flower diameter and flowering duration as well as the earliest first flower bud appearance and first flower opening. This treatment also recorded the longest vase life of cut flowers (days), the maximum total water uptake in vase and the maximum diameter of fully opened flower in vase life.

Key words: Chrysanthemum, Flower quality, GA_3, Growth attributes, NAA, PGR, Vase life.

1. INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora*) is a leading commercial crop grown for cut and loose flowers and also as a pot plant [29]. Plant growth regulators are organic substances with important functions in regulating growth, and acting as inhibitors or stimulants, depending on its concentration and other intrinsic characteristics of the plant. Among the groups with the possibility of hormone use is exogenous gibberellins [24]. Gibberellic acid (GA) has been used 3 to increase the length or height of plants, increase the number of flowers and induce flowering.

In India it occupies third position in flower production. The most important of all factors is the immense number and diversity of shape, size and colour displayed by its different cultivars. Chrysanthemum can be grown all the year round [30]. Due to more urbanization and increasing aesthetic value in the modern society and civilization, the demand for the loose and cut flower is increasing tremendously. It is commercially propagated by terminal cuttings. Chrysanthemum has a shallow but fibrous root system which is sensitive to water logging and prone to attack by diseases [30,31]. Sandy loams retain sufficient moisture and provide optimum aeration, which is ideal for chrysanthemum growing. In general, it requires high light intensity and plants grown under reduced light become taller have strong stem and larger leaves.

The use of plant growth regulators has been highlighted as a very common practice in agriculture. Plant growth regulators are organic substances with important functions in regulating growth, and acting as inhibitants or stimulants, depending on its concentration and other intrinsic characteristics of the plant. Among the groups with the possibility of hormone use is exogenous gibberellin [40]. Gibberellic acid (GA_3) has been used to increase the length or height of plants, increase the number of flowers and induce flowering [18]. According to some reports, it is possible to note the efficiency of application of GA_3 in the field of quality flowers. [24] observed in rhododendron (*Rhododendron pulchrum*) that the application of GA_3 was effective on the growth of buds and flowers per plant.

Plant demand for N can be satisfied from a combination of soil and fertilizer to ensure optimum physiological growth. Phosphorus application P to legumes plays a key role in formation of energy rich bonds, phospholipids and for development for root system [31]. Phosphorus increased chickpea grain yield and other quality parameters in legumes such as protein and amino acids [13]. [22] application of FYM @ 20t ha^{-1} to maize followed by FYM @ 5t ha^{-1} to chickpea increased the productivity and nutrient uptake in chickpea, improved soil physico-chemical properties and reflected as viable technique in improving soil nutrient availability on sustainable basis. Plant demand for N can be satisfied from a combination of soil and fertilizer to ensure optimum growth [8,14,24]). It is one of the most complexes in behavior, occurring in soil health, air and water in organic and inorganic forms [11,12,26]. For this reason, it poses the most difficult problem in making fertilizer recommendations [1,9]. Potassium (K) is a major plant nutrient, which is needed by the plants in large amount and is supplied by the K fertilizers (Dotaniya *et al.,* 2020). Sulphur is reported from two natural growth regulators *viz.,* thiamine and biotin. Sulphur plays an important role in chlorophyll formation because it has been observed that sulphur deficient soil and plants contain as 40 to 60% in comparison with those receiving normal amounts of this elements [6,15,19,20,]. Plant growth regulators can influence the yield and the quality of the blooms, foliage and production; several of them are widely used for many ornamental plants, and their effect has been demonstrated in previous research. Onion is one of the most important vegetable bulb crops produced in India [2].

2. MATERIALS AND METHODS

The present investigation was conducted during August 2014 to January 2015 at the Department of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.). The experiment was conducted in net house in pots with soil, sand and FYM (1:1:1) as medium in Completely Randomized Design with three replications. Chrysanthemum cultivar Hybrid-2 was used for this experiment. Six PGR treatments consisting of three concentrations each of GA and NAA *i.e.*, GA (100 ppm, 150 ppm and 200 ppm) and NAA (75 ppm, 125 ppm and 200 ppm) were applied. One healthy rooted cutting was planted per pot. The cuttings were planted at the centre of the pots and light irrigation was given to each pot using a rose can. Soil was used for analysis of different physico-chemical parameters outlined by [22] in soil. Observations were recorded for various growth and flowering parameters *viz.*, plant height, plant spread, number of leaves per plant, number of suckers per plant, the earliest first flower bud appearance, first flower opening, number of flowers per plant, flower stalk length, flower diameter and flowering duration. Vase life of the cut flowers in distilled water was observed. Observations on the total water uptake and diameter of fully opened flower in vase were noted.

Plate 1 :- A view of the experimental layout at planting.

Plate 2:- Plants of chrysanthemum cv. Hybrid-2 at flowering stage.

Plate 3:- A view of the experiment at full bloom stage.

Plate 4:- Vase life study in the lab.

3. RESULTS AND DISCUSSION

3.1 Plant growth regulators on vegetative growth

It is evident from the tabulated data (**Table 1**) that the vegetative growth was significantly affected by different PGR treatments. It was observed that T (GA 200 ppm) recorded the maximum plant height, the maximum plant spread, the maximum number of leaves and the maximum number of suckers followed by T (GA 150 ppm) and T (GA 100 ppm) while the minimum value of all these parameters was recorded by T (control). Promotion of protein synthesis by GA application exogenously might have resulted in enhanced vegetative growth. Similar results were reported by [4] in chrysanthemum and [17] in daisy. The extension in plant height with GA might be due to hyper elongation of internodal length. GA was known to increase the plant height by influencing the internodal length, attributable to both cell division and cell elongation [32]. Variation in leaf production was pronounced by the application of different growth regulators. The higher number of suckers by using GA might be due to increase the number and size of leaves as a result of higher translocation of the photosynthates and eventually that would have been used for the production of propagules (suckers) [25,29,35].

Table 1. Effect of plant growth regulators on vegetative growth in chrysanthemum at central India

Treatments	Plant height (cm)	Plant spread (cm)	Number of leaves per plant	Number of suckers per plant
T_1	41.43	10.93	70.45	2.33
T_2	47.11	12.31	80.33	4.00
T_3	47.73	12.83	83.11	4.67
T_4	47.80	14.65	86.11	5.44
T_5	42.16	11.20	73.96	2.50
T_6	42.27	11.46	75.00	2.78
T_7	46.07	12.22	77.29	3.78
S.Em.±	**1.27**	**0.65**	**2.56**	**0.59**
C.D. at 5%	**2.73**	**1.39**	**5.50**	**1.27**

3.2 Plant growth regulators on flowering parameters

It can be observed from **Table 2** that the earliest first flower bud appearance, the earliest first flower opening and the longest flowering duration were recorded in T (GA 200 ppm) followed by T (GA 150 ppm) and T (GA 100 ppm). The most delayed first flower bud appearance, the most delayed first flower opening and the shortest flowering duration were recorded by T (control). Early flowering may be 1 due to increase in the endogenous gibberellins level in the plant, as gibberellins are well known for inducing early flower bud initiation and flowering in several crops plants. Gibberellins reduce juvenile period and with the termination of juvenile phase, the shoot apical meristem instead of producing leaves and branches starts producing buds. Similar findings were also reported by [29] in marigold. Longer flowering duration with the application of gibberellins is in conformity with earlier reports by [36] in chrysanthemum and [34] in China aster. In the present study T (GA 200 ppm) recorded the maximum number of flowers and the maximum flower diameter followed by T (GA 150 ppm) and T (GA 100 ppm). The minimum value for these parameters was recorded by T1 (control). These findings are in agreement with the findings of [33] in chrysanthemum. Here, food reserves may have been diverted to only a fewer sinks that enhanced to produce bigger flowers [35].

Table 2. Effect of plant growth regulators on flowering parameters in chrysanthemum at central India

Treatments	Days to first flower bud appearance	Days to first flower opening	Number of flowers per plant	Flower diameter (cm)	flowering duration (days)
T_1	47.83	81.33	13.73	5.70	132.33
T_2	44.93	75.67	19.93	6.73	134.33
T_3	43.97	74.07	20.33	6.80	134.67
T_4	43.80	70.77	21.34	6.83	135.00
T_5	45.53	77.73	15.73	5.73	132.67
T_6	45.43	80.47	16.18	6.43	133.00
T_7	45.10	76.80	18.67	6.53	134.00
S.Em.±	**0.70**	**1.85**	**1.63**	**0.17**	**0.549**
C.D. at 5%	**1.51**	**3.96**	**3.49**	**0.37**	**1.178**

3.3 Plant growth regulators on growth and flowering parameters

It can be observed from **Table 3** that the earliest at 75 DAP also a similar trend was observed with T_4 (GA_3 200 ppm) recording the maximum number of branches per plant (15.40) followed by T_3 (GA_3 150 ppm) and T_2 (GA_3 100 ppm) which recorded values of 14.81 and 14.22 respectively. T_7 (NAA 200 ppm) and T_6 (NAA 125 ppm) recorded 13.44 and 13.18 branches per plant respectively. The minimum number of branches per plant at this stage (11.89) was recorded by T_1 (control). Increase in the number of branches with GA_3 treatment may be due to the hyper elongation of internode and the resultant increase in nodal count on the main axis. Consequently these nodes increased number of dormant buds from where the primary branches may have originated [18]. These observation and findings in the present investigation are in conformity with those reported earlier by [36] in chrysanthemum [5,16,23] in gaillardia. The data (**Table 3**) 75 DAP also a similar trend was observed with T_4 (GA_3 200 ppm) recording the maximum leaf length (6.03 cm) followed by T_3 (GA_3 150 ppm) and T_2 (GA_3 100 ppm) which recorded values of 5.07 cm and 4.95 cm respectively. T_7 (NAA 200 ppm) and T_6 (NAA 125 ppm) recorded 4.86 cm and 4.83 cm leaf length respectively. The minimum leaf length at this stage (4.66 cm) was recorded by T_1 (control). This is similar to the findings of [27,39], who observed more number of leaves by the application of GA_3 and less number of leaves by foliar application of CCC. The leaf length was also significantly increased with the application of GA_3 at different concentrations, of which GA_3 @ 150 ppm gave the longest leaf length (8.35 cm). Leaf length highly reduced even in respect of control with the use of CCC growth regulators irrespective of concentrations. These findings confirmed that GA_3 acted as growth promoter and that of CCC as growth retardants on different plant characters of chrysanthemum [29,35]. At crop harvest also a similar trend was observed with T_4 (GA_3 200 ppm) recording the maximum leaf stalk length (1.83 cm) which was statistically at par with treatment T_3 (GA_3 150 ppm) and T_2 (GA_3 100 ppm) which recorded values of 1.77 cm and 1.73 cm respectively(Table 3). The minimum leaf stalk length at this stage (1.48 cm) was recorded by T_1 (control). T_4 (GA_3 200 ppm) recorded the maximum flower stalk length (25.33 cm) which was statistically at par with T_3 (GA_3 150 ppm) and T_2 (GA_3 100 ppm) which recorded values of 24.76 cm and 24.42 cm respectively. T_7 (NAA 200 ppm) and T_6 (NAA 125 ppm) recorded flower stalk length of 19.07 cm and 17.99 cm respectively. The minimum flower stalk length (16.56 cm) was recorded by T_1 (control). The minimum flower stalk length was recorded by T_1 (control). This was in line with the findings of

[3, 23] in chrysanthemum. This might be due to the fact that gibberellic acid promotes cell division and cell elongation resulting in longer stalks [35]in chrysanthemum.

Table-3 Effect of plant growth regulators on Growth and flowering parameters in chrysanthemum at central India

Treatments	Number of branches per plant	Leaf length (cm)	Leaf stalk length (cm)	Flower stalk length (cm)
T_1	11.89	4.66	1.48	16.56
T_2	14.22	4.95	1.73	24.42
T_3	14.81	5.07	1.77	24.76
T_4	15.40	6.03	1.83	25.33
T_5	13.00	4.78	1.57	16.88
T_6	13.18	4.83	1.61	17.99
T_7	13.44	4.86	1.67	19.07
S.Em.±	**0.51**	**0.22**	**0.05**	**0.97**
C.D. at 5%	**1.10**	**0.47**	**0.11**	**2.08**

3.4 PGR on vase life, total water uptake and diameter

It can be seen from **Table 4** that the longest vase life was recorded in T (GA 200 ppm) followed by T (GA 150 ppm) and T (GA 100 ppm). The shortest vase life of flower was recorded by T (control). Gibberellic acid increases water uptake and reduces transpiration [18]. Maintenance of turgidity is important in extension of vase life. In the present study, it was observed that the effect of GA 3 and NAA on total water uptake was statistically nonsignificant (**Table 4**). The maximum water uptake was recorded in T (GA 200 ppm) followed by T (GA 150 ppm) and T (GA 100 ppm). The minimum total water uptake was recorded by T (control). This could be due to the improvement in turgidity of the cut flowers owing to the increased water uptake caused by gibberellic acid. The diameter of fully opened flower in vase was influenced significantly by plant growth regulators (**Table 4**). The diameter of fully opened flower in vase was recorded in T 4 (GA 200 ppm) followed by T (GA 150 ppm) and T (GA 100 ppm), respectively. The minimum diameter of fully opened flower in vase was recorded by T (control).This finding is comparable with the finding of [30,36], who reported maximum flower diameter in chrysanthemum with GA (200 ppm).

Table 4. Effect of PGR on vase life, total water uptake and diameter of fully opened flower in vase of chrysanthemum cut flowers at central India

Treatments	Vase life of flower (days)	Total water uptake	Diameter (cm) of fully opened flower in vase
T_1	22.00	18.30	5.73
T_2	27.67	20.47	6.23
T_3	28.33	22.57	6.33
T_4	29.00	23.00	6.73
T_5	26.33	18.60	5.97
T_6	27.00	19.70	6.13
T_7	27.33	19.87	6.17
S.Em.±	**0.80**	**1.89**	**0.14**
C.D. at 5%	**1.71**	**NS**	**0.30**

4. CONCLUSIONS

In conclusion, the different PGR treatments had a significant influence on the vegetative growth and flowering parameters of chrysanthemum in the present study at central India. Among the PGR treatments, T_4 (GA_3 200 ppm) recorded the maximum values of plant height (cm), plant spread (cm), number of branches per plant, number of leaves per plant, and number of suckers per plant. T_4 (GA_3 200 ppm) recorded the earliest first flower bud appearance and the earliest first flower opening. Application of T_4 (GA_3 200 ppm) was found superior in flowering parameters as well, as it recorded the maximum number of flowers per plant, flower stalk length (cm), flower diameter (cm), flowering duration (days), vase life of the flower (days), total solution uptake (ml), and diameter (cm) of a fully opened flower in a vase.

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