RESEARCH ARTICLE

SEASONAL INFLUENCE OF PINCHING AND GIBBERELLIC ACID ON GROWTH AND YIELD PARAMETERS OF AFRICAN MARIGOLD

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Abstract: A field experiment was conducted at Experimental Orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar to study the seasonal influence of pinching and gibberellic acid on growth and yield parameters of African marigold. This experiment was laid out as a factorial randomized block design with three replications. It consists of two seasons viz., summer and winter with four levels of pinching viz., no pinching, pinching at 2 WAT (Weeks After Transplanting), pinching at 3 WAT, pinching at 4 WAT and four levels of gibberellic acid (GA_3) viz., control, 150 ppm, 250 ppm, 350 ppm. Results revealed that foliar spray of 250 ppm GA_3 on plants pinched at 2 WAT attained maximum fresh weight of plant in summer, whereas, the maximum flower yield/plant as well as flower yield/plot was recorded in winter. Application of 250 ppm GA_3 with pinching at 2 WAT was found promising with respect to growth and yield of African marigold.

Keywords: African marigold, Gibberellic acid, Growth and yield, Pinching, Season

INTRODUCTION

Flowers have always played an important role in human lives. Now, they are playing a vital role and will be of great importance even in the future. In past decades, floriculture was just a hobby of flower lovers, but now, it has emerged as an economically feasible commercial trade due to vast bio-diversity, favorable agro-climatic conditions and low labor cost. The total estimated area under floriculture in India is about 307 thousand hectares with an estimated production of 694 thousand MT cut flowers and 2300 thousand MT loose flowers. Rose, carnation, gladiolus, chrysanthemum, lily, gerbera, orchids, tuberose, jasmine, marigold, etc. are important commercial flower crops grown in India.

Marigold (*Tagetes* spp.) is an extensively cultivated traditional and loose flower crop of India due to its hardiness, easy cultivation and high productivity. The total area under marigold production in India is about 64.65 thousand hectares with loose flower production of 608.97 thousand MT and 7.90 thousand MT cut flowers. In Haryana, the area under floriculture is 5962 hectares with a production of 72795.5 MT of loose flower and 45363228 sticks of cut flowers, out of which 5288.4 hectare area is covered under marigold cultivation with loose flower production of 71470.5 MT.

Marigold is popularly known as *Gainda* and belongs to the family Asteraceae. Two types of marigold viz., African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) are mainly grown for flower production. African marigold is hardy ornamental annual and grows tall with beautiful dark green foliage. It has single to fully double globular flowers. Flower color varies from lemon yellow to bright yellow, golden yellow, orange and almost white. The French marigold is a dwarf annual and has smaller single or double flowers of yellow, orange, mahogany, rusty red, tangerine, or a combination of these.

Marigold flowers are generally used in garlands, social functions and religious offerings, apart from their applications in landscaping as flower beds and borders or even as pot plants. These flowers are also rich in carotenoids, which have diverse uses as medicine, poultry feed additives, food additives and natural colorants in pharmaceutical, poultry, food and textile industries, respectively. Its root releases a chemical substance with a strong pungent odor useful for inhibiting attacks from root-knot nematodes and insects. It is traditionally used in the treatment of various diseases like ulcers, kidney troubles and eye diseases.

It is a very hardy and sun-loving plant. It requires a mild climate for luxuriant growth and profuse flowering. Sowing of marigold is done during rainy, winter and summer seasons in northern India for round the year flower production. It ceases to grow at high temperatures thereby plants remain mostly vegetative with sparse flowering. So flower quantity and quality are adversely affected.

Pinching is done mostly in annuals and herbaceous perennials to encourage branching and to make the plant bushy. More shoots would provide more scope to bear flowers and in turn, contributing to higher flower yield. Among all the plant growth regulators, gibberellic acid is considered the most potent plant growth regulator in flower crops. It has manifold effects and is generally used to increase plant height

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by promoting cell elongation and induce flowering in plants.

The effect of pinching and gibberellic acid on various physiological processes and growth is fairly well understood but limited information exists concerning the interactive effect of season, pinching and GA_3 on the growth and yield of African marigold plants. Some of the agro-techniques like pinching and gibberellic acid application in marigold under agro-climatic conditions of Haryana have not yet been standardized so far. So keeping in view the above facts, this field experiment was planned to study the seasonal influence of pinching and gibberellic acid on growth and yield parameters of African marigold.

MATERIALS AND METHODS

The present experiment was conducted at Experimental Orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the crop season of 2015-16. The climate of Hisar region is semi-arid having very hot summer and cool winter with average annual rainfall of around 450 mm. This experiment was designed in a factorial randomized block design (RBD) with three replications. It consists of two seasons (S_1 - Summer and S_2 – Winter) with four levels of pinching viz., P_1 - No pinching, P_2 - Pinching at 2 WAT (Weeks After Transplanting), P_3- Pinching at 3 WAT, P_4 - Pinching at 4 WAT and four levels of gibberellic acid (GA_3) viz., G_0 - Control, G_1 - 150 ppm, G_2 - 250 ppm, G_3 - 350 ppm. A basal dose of FYM (10 kg/plot) was applied uniformly to all the experimental plots and mixed well into the soil 20 days before transplanting. The full dose of phosphorus (20g/m^2) and potassium (10g/m^2) along with a half dose of nitrogen (10g/m^2) was applied before transplanting in the form of single super phosphate, muriate of potash and urea, respectively and the remaining dose of nitrogen (10g/m^2) was applied 30 days after transplanting.

Seeds of African marigold cv. Local Selection (MGH 133-1-2) were taken from previously maintained germplasm at Experimental Orchard of the Department of Horticulture, CCS HAU, Hisar. One month old seedlings were transplanted at a spacing of 40 cm × 40 cm in plots of 1.60×2.00 m^2 size. Immediately after transplanting light irrigation was given. The plants were pinched by removing the apical portion as per the time mentioned in the treatments. Foliar spray of gibberellic acid (GA_3) was done uniformly over the plants at four weeks after transplanting as per treatments, whereas, control plants were sprayed with water. Five plants were selected randomly and tagged in each experimental plot for recording various growth and yield parameters. The data recorded for various growth and yield parameters were subjected to the statistical analysis using factorial Randomized Block Design for analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Growth parameters

Season, pinching and gibberellic acid played a significant role in influencing plant height, plant spread, number of primary branches/plant, fresh weight of plant and dry weight of plant (Table 1 & 2). Plants grown in the summer season attained the maximum plant height (81.58 cm), plant spread (61.66 cm), fresh weight of plant (490.89 g) and dry weight of plant (57.47 g), while the minimum plant height (70.46 cm), plant spread (47.98 cm), fresh weight of plant (360.61 g) and dry weight of plant (40.21 g) was recorded in winter season irrespective of pinching and gibberellic acid (Table 1&2). It might be due to the availability of better light intensity and temperature required for the overall growth of the plant in the summer season. The maximum number of primary branches/plant (12.75) was recorded in the winter than summer (9.93) irrespective of pinching and gibberellic acid. In winter because of less elongation, the lateral branches were found more, which might be resulted in the formation of more primary branches/plant. Similar findings are also reported by Meena *et al.* (2015) in African marigold.

The maximum plant spread (59.20 cm), number of primary branches/plant (12.65), fresh weight of plant (486.34 g) and dry weight of plant (56.26 g) was recorded in plants pinched at two weeks after transplanting, while the minimum plant spread (49.48 cm), number of primary branches/plant (10.15), fresh weight of plant (358.01 g) and dry weight of plant (41.49 g) was recorded in un-pinched plants irrespective of the season and gibberellic acid (Table 1&2). It might be due to the suppression of vertical growth and expression of horizontal growth in pinched plants caused by the diversion of plant assimilates to lateral buds for their growth. Although, the maximum plant height (79.85 cm) was measured in un-pinched plants and minimum plant height (71.84 cm) was recorded in plants pinched at four weeks after transplanting irrespective of the season and gibberellic acid (Table 1). The reduction in plant height in pinched plants might be due to the removal of the terminal growing shoot, which broke the apical dominance and diverted the plant metabolites to lateral buds for their growth. Similar results were quoted by Pushkar and Singh (2012), Rajyalakshmi and Rajasekhar (2014) and Mohanty *et al.* (2015) in African marigold.

Foliar spray of 350 ppm GA_3 significantly resulted in the maximum plant spread (59.48 cm) and number of primary branches/plant (13.26), whereas, the minimum plant spread (48.44 cm) and number of primary branches/plant (9.62) were recorded in control irrespective of season and pinching (Table 1). This might be because GA_3 increased the inter-nodal length of marigold plants. Plant height, fresh weight of plant and dry weight of plant increased significantly with the increase in levels of GA_3 up to 250 ppm but thereafter a small but significant decrease in plant height, fresh weight of plant and dry weight of plant was recorded. The maximum plant height (83.32 cm), fresh weight of plant (504.42 g) and dry weight of plant (58.75 g) was recorded in 250 ppm GA_3 treatment, while the minimum plant height (66.69 cm), fresh weight of plant (353.77 g) and dry weight of plant (40.95 g) was recorded in control irrespective of season and pinching (Table 1&2). It may be because of the reason that GA_3 250 ppm might be optimum for increasing the plant height, fresh and dry weight of the plant. Similar findings were also obtained by Rajyalakshmi and Rajasekhar (2014) and Kumar *et al*. (2020) in African marigold.

Table 1. Seasonal influence of pinching and gibberellic acid on various growth parameters of African marigold cv. Local Selection

Treatment	Plant height (cm)	Plant spread (cm)	No. of primary branches/plant
Season (S)			
Winter (S_1)	70.46	47.98	12.75
Summer (S_2)	81.58	61.66	9.93
C. D. (P = 0.05)	0.60	0.59	0.59
Pinching (P)			
No pinching (P_1)	79.85	49.48	10.15
Pinching at 2 WAT* (P_2)	77.37	59.20	12.65
Pinching at 3 WAT* (P_3)	75.03	57.35	11.57
Pinching at 4 WAT* (P_4)	71.84	53.24	10.99
C. D. (P = 0.05)	0.85	0.84	0.84
Gibberellic acid (G) (ppm)			
Control (G_0)	66.69	48.44	9.62
150 ppm (G_1)	75.04	53.92	10.62
250 ppm (G_2)	83.32	57.44	11.86
350 ppm (G_3)	79.04	59.48	13.26
C. D. (p = 0.05)	0.85	0.84	0.84
Season × Pinching (S × P)			
C. D. (P = 0.05)	1.20	1.18	1.18
Season × Gibberellic acid (S × G)			
C. D. (p = 0.05)	NS**	1.18	1.18
Pinching × Gibberellic acid (P × G)			
C. D. (p = 0.05)	1.70	1.67	1.67
Season × Pinching × Gibberellic acid (S × P × G)			
C. D. (p = 0.05)	2.41	NS**	NS**
*Weeks After Transplanting **Non-Significant			

Various interactions viz. S×P, S×G and P×G had exerted a significant effect on plant spread, number of primary branches/plant (Table 1) and fresh weight of plant (Table 2). However, S×P×G interaction did not influence plant spread and number of primary branches/plant (Table 1), but it significantly increased the fresh weight of plant (Table 2). Plant height differed significantly due to the influence of all interactions except S×G interaction (Table 1) but no interaction influenced the plant dry weight (Table 2).

The maximum plant height was recorded in un-pinched plants (S_2P_1), whereas, the plants pinched at 2 WAT (S_2P_2) recorded the wider spread in the summer season. However, the winter plants pinched at 2 WAT (S_1P_2) recorded the maximum number of primary branches/plant and fresh weight of plant. Summer plants attained maximum spread and fresh weight with the application of 350 ppm GA_3 (S_2G_3) and 250 ppm GA_3 (S_2G_2), respectively, however, the maximum number of primary branches/plant was recorded with the application of 350 ppm GA_3 in the winter season (S_1G_3). Un-pinched plants sprayed with GA_3 250 ppm (P_1G_2) acquired the maximum plant height. The widest plant spread was recorded in plants pinched at 2 WAT and treated with GA_3 350 ppm (P_2G_3). Spraying of GA_3 350 ppm over plants pinched at 2 WAT (P_2G_3) resulted in the production of the maximum number of primary branches/plant, while the maximum fresh weight of plant was recorded in plants pinched at 2 WAT along with 250 ppm GA_3 (P_2G_2). These results are in agreement with the findings of Rajyalakshmi and Rajasekhar (2014) in African marigold.

Significantly maximum plant height was recorded when un-pinched plants were treated with foliar spray of 250 ppm GA_3 during summer season ($S_2P_1G_2$). However, the maximum fresh weight of plant was recorded with foliar spray of GA_3 250 ppm on plants pinched at 2 WAT in the summer season ($S_2P_2G_2$).

Table 2. Seasonal influence of pinching and gibberellic acid on fresh weight and dry weight of plant (g) in African marigold cv. Local Selection

Treatment	Fresh weight of plant (g)	Dry weight of plant(g)
Season (S)		
Winter (S_1)	360.61	40.21
Summer (S_2)	490.89	57.47
C. D. (p = 0.05)	4.94	1.50
Pinching (P)		
No pinching (P_1)	358.01	41.49
Pinching at 2 WAT (P_2)	486.34	56.26
Pinching at 3 WAT (P_3)	444.23	51.73
Pinching at 4 WAT (P_4)	414.43	45.87
C. D. (p = 0.05)	6.98	2.13
Gibberellic acid (G) (ppm)		
Control (G_0)	353.77	40.95
150 ppm (G_1)	398.37	44.57
250 ppm (G_2)	504.42	58.75
350 ppm (G_3)	446.44	51.09
C. D. (p = 0.05)	6.98	2.13
Season × Pinching (S × P)		
C. D. (p = 0.05)	9.87	NS**
Season × Gibberellic acid (S × G)		
C. D. (p = 0.05)	9.87	NS**
Pinching × Gibberellic acid (P × G)		
C. D. (p = 0.05)	13.96	NS**
Season × Pinching × Gibberellic acid (S × P × G)		
C. D. (p = 0.05)	19.74	NS**
*Weeks After Transplanting **Non-Significant		

Yield parameters

The data presented in Table 3 showed that season, pinching and gibberellic acid had played a significant role in influencing flower yield/plant as well as flower yield/plot. Higher flower yield/plant (174.28 g) as well as flower yield/plot (3.49 kg) was recorded in the winter season, while lower flower yield/plant (136.59 g) as well as flower yield/plot (2.73 kg) was observed in the summer season irrespective of pinching and gibberellic acid (Table 3). Similar results were also reported by Mohanty *et al.* (2015) and Joshna and Pal (2015) in African marigold.

Table 3. Seasonal influence of pinching and gibberellic acid on yield parameters of African marigold cv. Local Selection

Treatment	Flower yield/plant (g)	Flower yield/plot (kg)
Season (S)		
Winter (S_1)	174.28	3.49
Summer (S_2)	136.59	2.73
C. D. (p = 0.05)	8.28	0.17
Pinching (P)		
No pinching (P_1)	145.46	2.91
Pinching at 2 WAT*(P_2)	165.27	3.31
Pinching at 3 WAT*(P_3)	158.68	3.18
Pinching at 4 WAT*(P_4)	152.32	3.05
C. D. (p = 0.05)	11.71	0.23
Gibberellic acid (G) (ppm)		
Control (G_0)	110.50	2.21
150 ppm (G_1)	148.85	2.98

250 ppm (G_2)	184.42	3.69
350 ppm (G_3)	177.98	3.56
C. D. (p = 0.05)	11.71	0.23
Season × Pinching (S × P)		
C. D. (p = 0.05)	16.56	0.33
Season × Gibberellic acid (S × G)		
C. D. (p = 0.05)	NS**	NS**
Pinching × Gibberellic acid (P × G)		
C. D. (p = 0.05)	NS**	NS**
Season × Pinching × Gibberellic acid (S × P × G)		
C. D. (p = 0.05)	NS**	NS**
*Weeks After Transplanting **Non-Significant		

Among various pinching treatments, the maximum flower yield/plant (165.27 g) and flower yield/plot (3.31 kg) was recorded in plants pinched at two weeks after transplanting, which was found at par with plants pinched at three weeks after transplanting (158.68 g & 3.18 kg, respectively) irrespective of the season and gibberellic acid. However, the minimum flower yield/plant (145.46 g) and flower yield/plot (2.91 kg) was recorded in un-pinched plants, which was found at par with plants pinched at four weeks after transplanting (152.32 g & 3.05 kg, respectively) irrespective of the season and gibberellic acid (Table 3). This increase in flower yield might be due to removal of apical dominance by pinching and thus extra metabolites get diverted towards production of more flowers. These results are in the harmony with the findings of Rajyalakshmi and Rajasekhar (2014) and Mohanty *et al*. (2015) in African marigold.
Flower yield/plant as well as flower yield/plot increased significantly with increasing levels of gibberellic acid up to 250 ppm gibberellic acid, after that a small but non-significant decrease in flower yield/plant and flower yield/plot was recorded. The maximum flower yield/ plant (184.42 g) as well as flower yield/plot (3.69 kg) was recorded with 250 ppm gibberellic acid, which was found at par with 350 ppm gibberellic acid (177.98 g & 3.56 kg, respectively) and minimum flower yield/plant (110.50 g) as well as flower yield/plot (2.21 kg) was recorded in control irrespective of season and pinching (Table 3). It might be due to gibberellic acid application resulted in better crop growth, more branches and flowers per plant and ultimately increased flower yield. Similar results were obtained by Kanwar and Khandelwal (2013), Kumar *et al.* (2014) and Kumar *et al*. (2020) in marigold. Among all interactions, only S×P interaction was found significant in affecting the flower yield/plant as well as flower yield/plot (Table 3). In the case of S×P interaction, the maximum flower yield/plant and flower yield/plot was recorded in plants pinched at two weeks after transplanting in the winter season (S_1P_2), which was found at par with S_1P_3 and S_1P_4.

CONCLUSION

It is inferred from the present investigation that foliar application of 250 ppm gibberellic acid on plants pinched at two weeks after transplanting showed better results in terms of growth and yield of African marigold. In the summer season, plants pinched at two weeks after transplanting attained maximum fresh weight and dry weight of plant with 250 ppm dose of gibberellic acid and maximum plant spread with 350 ppm dose of gibberellic acid. In the winter season, plants pinched at two weeks after transplanting produced the maximum flower yield/plant as well as flower yield/plot with 250 ppm dose of gibberellic acid and the maximum number of primary branches/plant with 350 ppm dose of gibberellic acid.

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