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Effect of Pinching and Gibberellic Acid on Seed Attributes of African Marigold in Different Seasons

Sonu Sheoran, B. S. Beniwal1, R. P. S. Dalal

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ABSTRACT

An investigation was carried out to study the effect of pinching and gibberellic acid on seed attributes of African marigold in different seasons at the experimental orchard of the Department of Horticulture and laboratory of the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar during 2015-16. This experiment was laid out in Randomized Block Design (factorial) with thirty two treatments and three replications. It comprised of two seasons (winter and summer) with four levels of pinching (no pinching, pinching at 2 weeks after transplanting, pinching at 3 weeks after transplanting and pinching at 4 weeks after transplanting) and four levels of gibberellic acid (control, 150 ppm, 250 ppm and 350 ppm). Results revealed that season, pinching and gibberellic acid played a significant role in influencing various seed attributes. Winter plants produced the maximum number of seeds per capitulum (236.12), number of black seeds per capitulum (135.86), seed yield per plant (17.22 g), per plot (344.40 g) as well as per hectare (1076.25), 1000 seeds weight (3.310 g), seedling root length (4.00 cm), seedling dry weight (2.97 mg) and seed vigour index-II (0.232) however, the maximum seed germination (78.71%), seedling shoot length (7.19 cm) and seed vigor index-I (860.27) was observed in summer. In case of pinching, the maximum seed yield per plant (16.26 g), per plot (325.27 g) as well as per hectare (1016.46 kg), 1000 seeds weight (3.037 g), seed germination (83.39 %), seedling root length (4.11 cm), seedling shoot length (7.08 cm), seedling dry weight (2.52 mg), seed vigor index-I (935.10) and seed vigor index-II (0.211) was recorded in plants pinched at 2 weeks after transplanting. Among various gibberellic acid treatments, the maximum seed yield per plant (18.73 g), per plot (374.58 g) as well as per hectare (1170.57 kg), 1000 seeds weight (3.034 g), seed germination (83.59%), seedling root length (4.18 cm), seedling shoot length (7.15 cm), seedling dry weight (2.55 mg) and seed vigor index-I (949.31) and seed vigor index-II (0.214) was noticed with foliar spray of 250 ppm GA_3. However, application of GA_3 350 ppm resulted in to production of maximum number of seeds per capitulum (240.81) and number of black seeds per capitulum (142.47).

Keywords African marigold, GA_3, Pinching, Season, seed attributes.

Sonu Sheoran*, B. S. Beniwal, R. P. S. Dalal
Department of Horticulture, College of Agriculture, CCS Haryana Agricultural University Hisar 125004, Haryana, India

Email: 100nursheoran@gmail.com
*Corresponding author

INTRODUCTION

Floriculture is increasing at a fast pace due to an

increase in urbanization and modernization. Loose flowers and their value added products are commonly used in vivid forms during various social and religious ceremonies. Commonly grown loose flower crops of India are rose, tuberose, jasmine and marigold. Marigold is a multipurpose plant with vigors nature and compact growth habit. It is native to Mexico and belongs to the Asteraceae family. African marigold (*Tagetes erecta*) and French marigold (Tagetes patula) are two commonly grown species of the marigold throughout India. The African marigold is a hardy ornamental herb with beautiful dark green foliage. It has single to fully double globular flowers. These flowers are available in different shades of yellow and orange colors and are generally used in garlands, social functions and religious offerings. It is also used in landscaping as flower beds and borders or even as pot plants.

African marigold can be grown in well-drained soil in almost all seasons except in very hot weather. Suitable growing season with ideal environmental conditions and adequate nutrition are some prerequisites for better seed development and seed maturation. Mild climatic condition with a cooler growing period and low relative humidity during the seed maturity stage is considered best for obtaining the maximum seed yield of good quality. The occurrence of rain at the time of seed harvesting in marigold is not desired as it will enhance the fungal disease development in flowers and result in decreased seed yield and seed quality.

Pinching is mostly practiced in ornamental herbs to reduce the plant height ; enhance lateral growth and delay flowering, so it plays an important role in crop regulation. It removes apical dominance and diverts plant metabolites towards the production of more healthy side shoots, which will ultimately contribute to increasing in flower and seed yield potential of the plant.

Among various plant growth hormones, gibberellic acid is considered the most potent plant growth regulator in flower crops. It is generally used to increase internodal length, plant height, number of flowers, flower weight and yield in plants by promoting cell elongation. Gibberellic acid stimulates seed germination, internode elongation, floral initiation and grain development in response to diverse environmental factors like light, temperature and water (Gupta and Chakrabarty 2013).

Marigold is commercially propagated by seed. Seed quantity as well as seed quality, both determine the growth and performance of marigold crop under field conditions. Lack of availability of quality seeds with a reasonable price of marigold is a common problem faced by marigold growers. Application of pinching and gibberellic acid can be a sustainable approach towards crop regulation of African marigold crop in order to obtain more seeds of better quality. These crop regulation practices have not been standardized in African marigold under the agro-climatic conditions of Haryana so far.

So there is a need to find out the suitable season, pinching time and optimum dose of gibberellic acid in African marigold for better seed yield and quality attributes. Considering the above facts, the present experiment was planned with the objective to study the effect of pinching and gibberellic acid on seed attributes of African marigold in different seasons.

MATERIALS AND METHODS

The present experiment was carried out at the experimental orchard of the Department of Horticulture and the laboratory of the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar during 2015-16. This experiment was laid out in Randomized Block Design (factorial) with thirty two treatments and three replications. It comprised of two seasons (S_1 - Winter and S_2 – Summer) 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 viz., G_0 - Control, G_1 - 150 ppm, G_2 - 250 ppm, G_3 - 350 ppm. The Physico-chemical analysis of soil was conducted before the start of the experiment (Table 1). The soil of the experimental field was sandy loam, medium in available phosphorus (10 kg/ha), nitrogen (146 kg/ha) and organic carbon (0.36%) but high in available potassium (470 kg/ha). Based on pH (7.6) and electrical conductivity (0.34 dS/m), the soil was well suited for the cultivation of African

Table 1. Physico-chemical analysis of the experimental field.

Sl. No.	Characters	Contents	Methods used for analysis
1.	Texture	Sandy loam	International pipette method (Piper 1966)
2.	Organic carbon (%)	0.36	Walkley's and Black Rapid Titration method (Jackson 1973)
3.	pH	7.60	Glass electrode pH meter, 1:2 soil water suspension (Anonymous 1954)
4.	E.C. (dSm^{-1})	0.34	EC meter, 1:2 soil water suspension (Anonymous 1954)
5.	Available nitrogen (kg/ha)	146.0	Alkaline permanganate oxidation method (Subbaiah and Asija 1956)
6.	Available phosphorus (kg/ha)	10.0	Olsen's method of extraction with $NaHCO_3$ at pH 8.5 (Olsen *et al.* 1954)
7.	Available potassium (kg/ha)	470.0	Flame photometer method (Anonymous 1954)

marigold. Planting material of African marigold cv Local Selection (MGH 133-1-2) was taken from previously maintained germplasm at Experimental Orchard of the Department of Horticulture, CCS HAU, Hisar. Healthy and vigorus looking seeds were sown in rows spaced at 6-8 cm with a depth of 2-3 cm in well prepared nursery beds of 3m ×1m×15 cm size once in January and again in September 2015. A thin layer of well decomposed and sieved farmyard manure was used for covering the seeds sown in rows to ensure their proper germination. The field was prepared well in advance to a fine tilth by repeated ploughing and harrowing. After this, it was leveled and experimental plots of 1.60×2.00 m size were prepared. Well decomposed 10 kg FYM was applied in each experimental plot before 20 days of transplanting. A basal fertilizer dose of nitrogen (10 g/m^2), phosphorus (20 g/m^2) and potassium (10 g/m^2) was applied in each experimental plot. A second dose of nitrogen (10 g/m^2) was applied 30 days after transplanting. One month old healthy and vigorus seedlings having 5-7 leaves were transplanted by maintaining a spacing of 40×40 cm on 19th February 2015 for summer season crop and again on 16th October 2015 for winter season crop. Light irrigation was given immediately after transplanting for better establishment of seedlings in the field. Depending upon weather and as per crop requirement; all experimental plots were irrigated at an interval of 5 to

Table 2. Effect of pinching and gibberellic acid on various seed yield parameters of African marigold in different seasons.

Treatment	Number of seeds per capitulum	Number of black seeds per capitulum	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per hectare (kg)
Season (S)					
Winter (S_1)	236.12	135.86	17.22	344.40	1076.25
Summer (S_2)	205.64	123.20	13.51	270.24	844.52
CD (p=0.05)	2.05	2.21	2.21	6.70	20.93
Pinching (P)					
No pinching (P_1)	235.34	140.40	15.01	300.28	938.37
Pinching at 2 weeks after transplanting (P_2)	207.55	118.34	16.26	325.27	1016.46
Pinching at 3 weeks after transplanting (P_3)	216.44	126.50	15.39	307.81	961.62
Pinching at 4 weeks after transplanting (P_4)	224.20	132.88	14.80	295.93	924.78
CD (p=0.05)	2.90	3.13	3.13	9.47	29.60
Gibberellic acid (G) (ppm)					
Control (G_0)	196.58	114.68	10.23	204.69	639.65
150 ppm (G_1)	214.86	126.67	14.31	286.22	894.45
250 ppm (G_2)	231.28	134.31	18.73	374.58	1170.57
350 ppm (G_3)	240.81	142.47	18.19	363.79	1136.85
CD (p=0.05)	2.90	3.13	3.13	9.47	29.60

Table 3. Effect of pinching and gibberellic acid on various seed quality parameters of African marigold in different seasons.

Treatments	1000 seeds weight (g)	Seed germination (%)	Seed vigour index-I	Seed vigour index-II
Season (S)				
Winter (S_1)	3.310	77.82	821.24	0.232
Summer (S_2)	2.513	78.71	860.27	0.141
CD (p=0.05)	0.019	0.27	3.57	0.002
Pinching (P)				
No pinching (P_1)	2.938	75.97	839.78	0.185
Pinching at 2 weeks after transplanting (P_2)	3.037	83.39	935.10	0.211
Pinching at 3 weeks after transplanting (P_3)	2.868	80.47	847.63	0.188
Pinching at 4 weeks after transplanting (P_4)	2.803	73.22	741.91	0.164
CD (p=0.05)	0.027	0.38	5.05	0.003
Gibberellic acid (G) (ppm)				
Control (G_0)	2.766	71.42	708.16	0.152
150 ppm (G_1)	2.890	77.74	817.06	0.183
250 ppm (G_2)	3.034	83.59	949.31	0.214
350 ppm (G_3)	2.955	80.30	889.90	0.199
CD (p=0.05)	0.027	0.38	5.05	0.003

7 days and 10 to 12 days during summer and winter, respectively. Irrigation was suspended near the seed maturity stage. Pinching was done by removing apical portion of the plant as per the time mentioned in the treatments. Foliar spray of gibberellic acid was done uniformly with the help of a knapsack sprayer pump over the plants and control plants were sprayed with water at four weeks after transplanting as per treatments. Five representative plants were selected randomly from each experimental plot by excluding border plants and tagged for recording various seed attributes. The germination test was performed as per ISTA (Anonymous 1999). Total 100 seeds of each treatment per replication were put on top of the paper (TP) and kept at 20°C. After 14 days, the seedlings were counted and the total number of normal seedlings was recorded. Ten normal seedlings were taken at random and their shoot length and root length were measured at the time of the final count. The average seedling shoot length and seedling root length of ten seedlings were taken and recorded in centimeters. These seedlings were kept in a hot air oven and dried at 80°C for 16 h for measuring seedling dry weight. The average seedling dry weight was recorded in milligram. Seed vigour index was calculated on the basis of seedling length and seedling dry weight as per the methods of Abdul-Baki and Anderson (1973) given as under:

Seed vigour index-I = Germination percentage × Seedling length (in cm)

Seed vigour index-II = Germination percentage × Seedling dry weight (in gram)

The data recorded on various seed quality and yield attributes during the entire course of the investigation was subjected to the statistical analysis using factorial Randomized Block Design as suggested by Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

Seed yield attributes

Season, pinching and gibberellic acid exerted a significant influence on the number of seeds per capitulum, the number of black seeds per capitulum, seed yield per plant, seed yield per plot as well as seed yield per hectare (Table 2). More number of seeds per capitulum (236.12), number of black seeds per capitulum (135.86), seed yield per plant (17.22 g), seed yield per plot (344.40 g) and seed yield per hectare (1076.25 kg) was recorded in the winter season (S_1) as compared to the summer season (S_2) (205.64, 123.20, 13.51 g, 270.24 g and 844.52 kg, respectively) (Table 2). This increase in the number

Table 4. Effect of pinching and gibberellic acid on various seedling parameters of African marigold in different seasons.

Treatments	Seedling root length (cm)	Seedling shoot length (cm)	Seedling dry weight (mg)
Season (S)			
Winter (S_1)	4.00	6.51	2.97
Summer (S_2)	3.70	7.19	1.79
CD (p=0.05)	0.02	0.02	0.03
Pinching (P)			
No pinching ($P_{1)}$	4.00	7.00	2.43
Pinching at 2 weeks after transplanting (P_2)	4.11	7.08	2.52
Pinching at 3 weeks after transplanting (P_3)	3.74	6.78	2.34
Pinching at 4 weeks after transplanting (P_4)	3.55	6.56	2.24
CD (p=0.05)	0.03	0.02	0.04
Gibberellic acid (G) (ppm)			
Control (G_0)	3.36	6.54	2.13
150 ppm (G_1)	3.79	6.70	2.36
250 ppm (G_2)	4.18	7.15	2.55
350 ppm (G_3)	4.06	7.01	2.48
CD (p=0.05)	0.03	0.02	0.04

of seeds per capitulum and seed yield may be occurred due to the availability of favorable environmental conditions for seed development in the winter season. Similar results were quoted by Mohanty *et al.* (2015) in African marigold.

A significant reduction in the number of seeds per capitulum and number of black seeds per capitulum was recorded with increasing levels of pinching. The maximum number of seeds per capitulum (235.34) and number of black seeds per capitulum (140.40) was recorded in un-pinched plants (P_1) and minimum (207.55 and 118.34, respectively) was recorded in plants pinched at 2 WAT (P_2) (Table 2). This reduction in the number of seeds per capitulum might be due to the fact that more branches per plant emerged from main shoots in pinching treatment which in turn produced more number of flowers per plant having reduced flower diameter comparatively and ultimately resulted into less number of seeds per capitulum. Similar results were also recorded by Mohanty *et al.* (2015) and Singh *et al.* (2017) in African marigold.

The maximum seed yield per plant (16.26 g) was recorded from plants pinched at 2 WAT (P_2) and the minimum seed yield per plant (14.80 g) was recorded from plants pinched at 4 WAT (P_4), however all pinching treatments were found at par with each other in influencing seed yield per plant. The maximum seed yield per plot (325.27 g) and seed yield per hectare (1016.46 kg) was recorded in plants pinched at 2 WAT (P_2), while minimum seed yield per plot (295.93 g) and seed yield per hectare (924.78 kg) was recorded in plants pinched at 4 WAT (P_4) followed by un-pinched plants (P_1) (300.28 g and 938.37 kg, respectively) which was at par with P_3 (307.81 g and 961.62 kg, respectively) (Table 2). These results are in conformity with the findings of Mohanty *et al.* (2015) in African marigold. Similar results were reported by Dorajeerao and Mokashi (2012) and Wani *et al.* (2019) in garland chrysanthemum and china aster cv Powder Puff, respectively.

The maximum seed yield per plant (18.73 g), seed yield per plot (374.58 g) as well as per hectare (1170.57 kg) was obtained from plants treated with 250 ppm GA_3 and minimum was obtained in control (G_0) (10.23 g, 204.69 g and 639.65 kg, respectively). Although the maximum number of seeds per capitulum (240.81) and maximum number of black seeds per capitulum (142.47) were recorded from plants sprayed with 350 ppm GA_3, while the minimum (196.58 and 114.68, respectively) was obtained in control (G_0) (Table 2). This increase in seed yield might be due to increasing flower diameter as a result of GA_3 spray. The present results are in conformity with the reports of Rajhansa *et al.* (2013), Patil *et al.* (2016) and Kumar *et al.* (2020) in African marigold.

Similar results were also obtained by Sainath *et al.* (2014) in annual chrysanthemum and Kumar *et al.* (2015) in china aster cv Kamini.

Seed quality attributes

The perusal of data presented in Table 3 revealed that season, pinching and gibberellic acid had played a significant role in influencing 1000 seeds weight, seed germination, seed vigour index-I and seed vigor index-II. More 1000 seeds weight (3.310 g) and seed vigor-II (0.232) was recorded in seeds harvested from winter season crop as compared to summer (2.513 g and 0.141 respectively). However, higher seed germination (78.71%) and seed vigour index-I (860.27) was recorded in seeds collected from summer than of winter season (77.82 % and 821.24, respectively) (Table 3). The higher value of 1000 seeds weight and seed vigor index-II in winter may be due to the favourable temperature for the growth and development of seed in the flower. On the other hand, better seed germination and seed vigor-I in the summer season might be due to the high temperature suitable for the process of germination. Results obtained were in harmony with the findings of Mohanty *et al.* (2015) in African marigold.

The maximum 1000 seeds weight (3.037 g), seed germination (83.39 %), seed vigor index-I (935.10) and seed vigor index-II (0.211) was obtained from seeds of plants pinched at 2 WAT and the minimum (2.803 g, 73.22 %, 741.91 and 0.164) was recorded from seeds of plants pinched at 4 WAT (P_4) (Table 3). Pinching might have led to the reduction in vegetative growth and thus plant photosynthates might have been utilized for the development of better seeds as a result of all seed qualitative parameters increased. Similar findings were reported by Mohanty *et al.* (2015) in African marigold and Wani *et al.* (2019) in china aster cv Powder Puff.

A significant increase in 1000 seeds weight, seed germination, seed vigor index-I and seed vigor index-II was recorded by increasing the level of GA_3 from 0 to 250 ppm, but further increase in its level to 350 ppm caused a significant decrease in all these parameters. The maximum 1000 seeds weight (3.034 g), seed germination (83.59%), seed vigor index-I (949.31) and seed vigor index-II (0.214) was recorded with 250 ppm dose of GA_3 (G_2) and minimum (2.766 g, 71.42%, 708.16 and 0.152) was recorded in control (G_0) (Table 3). With GA_3 application germination percentage was improved, this may be because of the reason that GA_3 might have helped the hydrolysis of reserve food material in the seed and thus enhanced the germination percentage. As seed vigour index is a multiplication of seedling growth so that also might have been improved. Results are in agreement with the findings of Rajhansa *et al.* (2013), Patil *et al.* (2016) and Kumar *et al*. (2020) in African marigold. Similar results were also recorded by Sainath *et al.* (2014), Kumar *et al.* (2015) and Singh *et al.* (2020) in annual chrysanthemum, china aster and pot marigold, respectively.

Season, pinching and gibberellic acid significantly influenced the seedling root length, seedling shoot length and seedling dry weight. More seedling root length (4.00 cm) and seedling dry weight (2.97 mg) was recorded in the winter season (S_1) than summer season (S_2) (3.70 cm and 1.79 mg, respectively), though longer seedling shoot length (7.19 cm) was found in summer season (S_2) than winter season (S_1) (6.51 cm) (Table 4).

Among various pinching treatments, the maximum seedling root length (4.11 cm), seedling shoot length (7.08 cm) and seedling dry weight (2.52 mg) was recorded from seeds of plants pinched at 2 WAT (P_2), whereas, the minimum seedling root length (3.55 cm), seedling shoot length (6.56 cm) and seedling dry weight (2.24 mg) were obtained from seeds of plants pinched at 4 WAT (P_4) (Table 4).

A linear increase in the seedling shoot length, seedling root length and seedling dry weight was recorded with increasing levels of GA_3 up to 250 ppm; thereafter it decreased significantly (Table 4). Foliar spray of 250 ppm GA_3 (G_2) resulted in the maximum seedling root length (4.18 cm), seedling shoot length (7.15 cm) and seedling dry weight (2.55 mg), while the minimum seedling root length (3.36 cm), seedling shoot length (6.54 cm) and seedling dry weight (2.13 mg) was recorded from seeds of control plants (G_0) (Table 4). It may be due to GA_3 mediated stimulation of hydrolytic enzymes activity that speeds up the seed

germination process and enhances seedling growth. Current results are in harmony with the findings of Sainath *et al.* (2014) in annual chrysanthemum and Singh *et al.* (2020) in pot marigold.

CONCLUSION

From the present investigation, it may be concluded that winter season was found best for various seed yield and quality attributes. Plants that were pinched at 2 weeks after transplanting showed better performance in terms of seed yield, test weight (1000 seeds weight), seed germination, seedling root length, seedling shoot length, seedling dry weight and seed vigor. Application of 250 ppm gibberellic acid resulted into the production of maximum seed yield, seed germination, test weight (1000 seeds weight), seedling root length, seedling shoot length, seedling dry weight and seed vigor.

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