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Effect of GA_3 and *Azotobacter* on growth and flowering in African marigold (*Tagetes erecta* L.) cv. PUSA NARANGI GAINDA

■ **NARESH KUMAR[1], JITENDRA KUMAR[1], J.P. SINGH, HIMANSHU KAUSHIK[1] AND R.K. SINGH[2]**

Members of the Research Forum

Associated Authors:
[1]Department of Horticulture, C.C.S. University, MEERUT (U.P.) INDIA

[2]Department of Horticulture, C.C.R. (P.G.) College, MUZAFFARNAGAR (U.P.) INDIA

Author for correspondence :
J.P. SINGH
Department of Horticulture, Gochar Mahavidhyalaya, Rampur Maniharan, SAHARANPUR (U.P.) INDIA

ABSTRACT : The field experiment was conducted at Horticulture Research Farm of Choudhary Charan Singh University campus, Meerut U.P. during 2011-12. The nine treatments A_1 (*Azotobacter* by root treatment 0.20g/15 plants), A_2 (*Azotobacter* by soil treatment 0.40g/plot), G_1 (Gibberellic acid 100 ppm spray at 30 DAT), G_2 (Gibberellic acid 150 ppm spray at 30 DAT), A_1G_1 (*Azotobacter* by root treatment 0.20g/15 plants and gibberellic acid 100 ppm spray at 30 DAT), A_1G_2 (*Azotobacter* by root treatment 0.20g/15 plants and gibberellic acid 150 ppm spray at 30 DAT), A_2G_1(*Azotobacter* by soil treatment 0.40g/plot and gibberellic acid 100 ppm spray at 30 DAT), A_2G_2 (*Azotobacter* by soil treatment 0.40g/plot and gibberellic acid 150 ppm spray at 30 DAT) and A_0G_0 (No *Azotobacter* and no gibbrellic acid) were evaluated in Randomized Block Design with three replications. The experimental finding revealed that the treatment A_2G_2 (Soil treatment with *Azotobacter* + spray of GA_3@ 150 ppm) gave the maximum plant height, maximum number of primary branches per plant, maximum number of secondary branches per plant, maximum plant spread, minimum number of days taken for flower bud appearance, maximum number of flowers per plant, maximum flower diameter, maximum fresh weight of flowers per plant and maximum yield of flower in comparison to individual application of GA_3 and *Azotobacter*.

KEY WORDS : Bio fertilizer, Plant growth regulator, Growth, Flowering, Yield, Marigold

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Among the flowery plants African marigold (*Tagetes erecta* L.) is an important annual, beautiful flower with a long blooming period and excellent keeping quality. It belongs to family Asteraceae, is native of central and South America, especially Mexico. In India these were introduced by Portuguess (Kaplan, 1960).

The uses of marigold are manifold. Often referred to as the "versatile crop with golden harvest," it is commonly cultivated as a loose flower crop throughout India. The loose flowers are utilized for making garlands, baskets, veni etc. The petals are often used for embedding in handmade paper for making exquisite greeting cards, stationary items, envelopes and corporate gifts. African marigold is a major source of carotenoids and has various physiological and morphological uses. Carotenoids extracts from *Tagetes erecta* application in poultry feeds as additives to enhance chicken skin and egg yolk coloration (Scott *et al*., 1968) at considerably lower cost than synthetic or other natural carotenoids (Seemann,

1998). It has been noticed that marigold is highly effective to controlling the nematodes population, are very harmful eel worm to many vegetables, fruits, and ornamental plants and cause substantial reduction in yield and quality. Marigold is also grown as a trap crop for the management of *Helicoverpa armigera* (Hubber) in crop like tomato (Srinivasan *et al*., 1994) and tobacco (Patel and Yadav, 1992) and used as an eco-friendly component of IPM.

Since, the demand of marigold flowers is rapidly increased throughout the year; the standardization of production technology of this crop on commercial basis should be explored. Over a last few decades, significant changes have occurred in the cultivation of floricultural crops as new production techniques have introduced and evaluated. The use of growth regulators in increasing quality and quantity with regard to flower production have been found effective in various ornamental crops. Gibberellic acid (GA_3) is shown to cause rapid growth of flower primordium. Application of GA_3 induce early flowering. GA_3 has shown promise in inducing flowering in majority of long day plants and also in plants in which flower is induced by cold. It enhances flowering in short day plants growing under inductive condition. Gibberellin is widely used in seed germination experiments.

Growth and flowering in marigold are affected by availability of various nutrients. Generally, chemical fertilizers are applied for quick result. At present, excessive and non-judicial use of chemical fertilizers, pesticides and fungicides are responsible for deterioration of soil health and ultimately our green planet. In India, most of the farmers are small and marginal. Therefore, it is very difficult for them to purchase the chemical fertilizers in large quantities that too at high cost. Under these circumstances, biofertilizers hold good promise as these are micro-organisms, which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. Biofertilizers are cheap, eco-friendly and good source of nutrients. Biofertilizer like *Azotobacter* can play a very significant role in improving soil fertility. Atmospheric nitrogen is fixed by *Azotobacter. Azotobacter* is free-living nitrogen fixing bacteria which fix 25 to 30 kg nitrogen per hectare. Nitrogen fixing bacteria and phosphate solubilizers are the main biofertilizers for horticultural crops. They also improve crop growth and quality of product by producing phytohormones, enhancing the uptake of plant nutrients by plant roots and thus help in sustainable crop production through maintenance of soil productivity.

RESEARCH METHODS

The field experiment was conducted at Horticulture Research Farm of Choudhary Charan Singh University campus, Meerut, U.P. during 2011-12. The nine treatments A_1 (*Azotobacter* by root treatment 0.20g/15 plants), A_2 (*Azotobacter* by soil treatment 0.40g/plot), G_1 (Gibberellic acid 100 ppm spray at 30 DAT), G_2 (Gibberellic acid 150 ppm spray at 30 DAT), A_1G_1 (*Azotobacter* by root treatment 0.20g/15 plants and gibberellic acid 100 ppm spray at 30 DAT), A_1G_2 (*Azotobacter* by root treatment 0.20g/15 plants and gibberellic acid 150 ppm spray at 30 DAT), A_2G_1(*Azotobacter* by soil treatment 0.40g/plot and gibberellic acid 100 ppm spray at 30 DAT), A_2G_2 (*Azotobacter* by soil treatment 0.40g/plot and gibberellic acid 150 ppm spray at 30 DAT) and A_0G_0 (No *Azotobacter* and no gibbrellic acid) were evaluated in Randomized Block Design with three replications. After preparing the land with repeated ploughing and leveling the field was laid out as per the experiment plan with the help of rope and measuring tape. Twenty eight days old seedlings were planted in the afternoon for their better survival. The plants of marigold were maintained healthy by using appropriate culture practice during the course of investigation and five plants were randomly selected from each plot and were tagged for recording various observations on growth, flowering, yield and quality of marigold.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Effect of GA_3 on growth and flowering parameters:

Growth parameters:

Application of GA_3 significantly increased all growth parameters in comparison to control. Application of GA_3 showed better results on parameters *viz.*, plant height, number of primary branches per plant and plant spread in comparison to *Azotobacter* treatments. The maximum plant height (62.33 cm), maximum number of primary branches per plant (11.00) and maximum plant spread (43.67 cm) were recorded under the treatment G_2 (Spray of GA_3@ 150 ppm) (Table 1a). The increase in plant height, number of primary branches per plant and plant

spread by the application of GA_3 might be due to the fact that it helps in cell elongation as well as cell division leading to an overall growth and development in the plant. Similar findings were also reported by Girwani *et al*. (1990) in African marigold, Dabas *et al*. (2001) in African marigold, Ramdevputra *et al*. (2009), in African marigold and Kumar *et al*. (2010), in African marigold.

Flowering parameters:

Early appearance of flower bud and first flowering by the application of GA_3 might be due to the fact that it helps in cell elongation as well as cell division leading to an overall growth and development in the plant. Minimum number of days taken for flower bud appearance and number of days taken for first flowering were recorded under the treatment G_2 (Spray of GA_3@ 150 ppm) in comparison to treatment G_1 (Spray of GA_3@ 100 ppm) and control. Similar findings have been reported by Girwani *et al*. (1990) in African marigold and Dabas *et al*. (2001) in African marigold.

The maximum number of flowers per plant (21.33) flower diameter (4.23 cm) and yield of flowers (146.67q/ha) were recorded under the treatment G_2 (Spray of GA_3@ 150 ppm) in comparison to G_1 and control, while maximum fresh weight of flower per plant (151.20g/plant) was recorded under the treatment G_1 (Table 1a). The increasment in number of flowers per plant, flower diameter (cm), fresh weight of flowers per plant and yield of flowers by the application of GA_3 over control might be due to the fact that it helps in cell elongation as well as cell division leading to an overall growth and development in the plant. These findings are in close conformity with the findings of Girwani *et al*. (1990) in African marigold, Dabas *et al*. (2001) in African marigold and Ramdevputra *et al*. (2009) in African marigold.

Table 1 (a) : Effect of GA_3 and *Azotobacter* on vegetative growth, flowering and yield parameters

Treatments	Plant height (cm)	Number of primary branches/ plant	Number of secondary branches/ plant	Plant spread (cm)	No. of days taken for flower bud appearance	Number of days taken for first flowering	Number of flowers/ plant	Flower diameter (cm)	Fresh weight of flowers/ plant (g)	Yield of flowers (q/ha)
Azotobacter										
A_1 (Root treatment)	61.33	10.33	13.33	43.00	45.33	60.03	19.00	4.07	150.47	140.33
A_2 (Soil treatment)	62.00	10.67	14.67	42.00	48.00	61.00	20.67	4.50	151.57	142.33
Gibberellic acid										
G_1 (GA_3@ 100 ppm)	61.67	10.66	13.67	41.00	46.33	59.67	19.33	4.10	151.20	137.33
G_2 (GA_3@ 150 ppm)	62.33	11.00	14.66	43.67	45.67	58.67	21.33	4.23	150.33	146.67
Control	50.00	7.67	11.67	37.33	53.67	67.00	14.67	3.77	124.00	132.33
S.E.±	0.4207	0.2115	0.2796	0.4439	0.6443	0.5876	0.2546	0.0790	0.7222	0.4525
C.D. (P=0.05)	1.2613	0.6343	0.8384	1.3309	1.9318	1.7618	0.7633	0.2367	2.1665	1.3567

Table 1 (b) : Interaction effect of GA_3 and *Azotobacter* on vegetative growth flowering and yield parameters

Treatments	Plant height (cm)	Number of primary branches/ plant	Number of secondary branches/ plant	Plant spread (cm)	No. of days taken for flower bud appearance	Number of days taken for first flowering	Number of flowers/ plant	Flower diameter (cm)	Fresh weight of flowers/ plant (g)	Yield of flowers (q/ha)
A_1G_1 (Root treatment + GA_3@ 100 ppm)	62.33	13.33	18.00	43.67	46.67	58.00	24.00	5.20	171.16	153.00
A_1G_2 (Root treatment + GA_3@ 150 ppm)	63.33	13.00	17.67	45.00	46.00	58.33	23.67	5.33	179.83	150.00
A_2G_1 (Soil treatment + GA_3@ 100 ppm)	65.67	13.67	19.33	47.67	43.33	52.33	28.33	5.73	184.33	156.67
A_2G_2 (Soil treatment + GA_3@ 150 ppm)	68.00	15.67	20.33	52.00	42.00	53.00	30.00	5.87	189.00	160.67
Control	50.00	7.67	11.67	37.37	53.67	67.00	14.67	3.77	124.00	132.33
S.E.±	0.7286	0.3664	0.4843	0.7688	1.1160	1.0177	0.4410	0.1368	1.2509	0.7837
C.D. (P=0.05)	2.185	1.099	1.452	2.305	3.346	3.052	1.322	0.410	3.751	2.350

Effect of *Azotobacter* on growth and flowering parameters :

Growth parameters:

Maximum number of secondary branches per plant (14.67) were recorded under the treatment A_2 (Soil treatment with *Azotobacter*) in comparison to other individual treatment *i.e.* A_1, G_1 and G_2, while maximum plant spread (43.00 cm) was recorded under the treatment A_1 (Root treatment with *Azotobacter*) (Table 1a). The improvement number of secondary branches per plant and plant spread due to the production of growth promoting substances and increase nutrient availability around the rhizosphere by *Azotobacter*. Similar results were also obtained by Rajadurai *et al.* (2000) in African marigold and Bhaskaran *et al*. (2002) in African marigold.

Flowering parameters:

The minimum number of days taken for flower bud appearance and minimum number of days taken for first flowering were obtained under the treatment A_1 (Root treatment with *Azotobacter*). The possible reason for decreasing number of days taken for flower bud appearance and number of days taken for first flowering might be due to increased nutrients and also produced some growth promoting harmonsis. Similar results were obtained by Ahmad *et al*. (2007) in African marigold and Karuppaiah and Krishna (2005) French marigold.

The maximum number of flowers per plant (20.67), maximum flower diameter (4.50 cm), maximum fresh weight of flowers per plant (151.57 g) and maximum yield of flowers (142.33q/ha) were recorded under the treatment A_2 (Soil treatment with *Azotobacter*) in comparison to treatment A_1 and control (Table 1 a). It might be due to increased availability of nitrogen and other nutrients, and also produced some growth promoting hormones, which induces the vegetative growth towards the development better effect on flowering parameters. Similar results were obtained by Ahmad *et al*. (2007) in African marigold and Karuppaiah and Krishna (2005).

Interaction effect of GA_3 and *Azotobacter* on growth and flowering parameters:

Growth parameters:

The maximum plant height (68.00 cm), maximum number of primary branches per plant (15.67), maximum number of secondary branches per plant (20.33) and plant spread (52.00 cm) were recorded under the treatment combination A_2G_2 (Soil treatment with *Azotobacter* + spray of GA_3@ 150 ppm) as compared to other treatments (Table 1b). The maximum plant height, number of primary branches per plant, number of secondary branches per plant and plant spread might be due to increase cell elongation by GA_3 and increased nitrogen availability by *Azotobacter*. Similar results were also recorded by Girwani *et al.* (1990) in African marigold, Syamal *et al*. (1990) in African marigold and Sunita *et al*. (2007) in African marigold.

Flowering parameters:

The minimum number of days taken for flower bud appearance (42.00 days), number of flowers per plant (30.00), flower diameter (5.87 cm), fresh weight of flowers per plant (189.00 g) and yield of flowers (160.67 q/ha) were recorded under the interaction A_2G_2 (Soil treatment with *Azotobacter* + spray of GA_3@ 150 ppm), while minimum number of days taken for first flowering (52.33 days) was recorded under the treatment A_2G_1 (Soil treatment with *Azotobacter* + spray of GA_3@ 100 ppm) as compared to other treatments (Table 1b). Similar results were also obtained by Ahmad *et al*. (2007) in African marigold, Karuppaiah and Krishna (2005) French marigold, Pushkar *et al*. (2008) in African marigold and Bhaskaran *et al*. (2002) in African marigold.

Conclusion:

On the basis of above studies it may be concluded that combined application of Azotobacter and GA_3 *i.e.* A_2G_2 (Soil treatment with *Azotobacter* + spray of GA_3@ 150 ppm) gave the maximum all parameters except minimum number of days for flowering.

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