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Response of African marigold to pinching and gibberellic acid on growth performance and its economics

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Abstract
The experiment was carried out at Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat (Assam) during 2015-17. The experiment was laid out in Factorial Randomized Block Design with three replications comprising 15 treatment combinations of five different concentration of gibberellic acid (GA_3 0ppm, 50ppm, 100ppm, 150ppm and 200ppm) and three pinching levels *viz.*, no pinching, pinching at 20 days and pinching at 40 days after transplanting (DAT). The result indicated that the important growth characters were significantly influenced by gibberellic acid and pinching treatments. The application of GA_3 at 200 ppm recorded significantly higher plant height (85.36cm), number of primary branches (15.65branches/plant), stem diameter (1.37 cm), root volume (70.92 cc) and chlorophyll content (1.34mg g^{-1}FW). Among the pinching treatments, pinching at 40 DAT recorded significantly lower plant height (72.01cm), maximum number of primary branches (15.95 branches/plant), highest stem diameter (1.35 cm) and maximum root volume (69.77 cc); whereas maximum plant height (86.61 cm) was found under no pinching. As far as flowering characters are concerned, number of flowers per plant (63.80), number of petals per flower (318.06), diameter of flower (4.55cm) and flower yield per plant (206.45g/plant) was significantly increased by the application of GA_3 at 200ppm. The self life (7.38days) and storage life as garland (6.99days) were also improved with the application of 200ppm GA_3. Among the pinching treatments, pinching at 40 DAT recorded highest number of flowers per plant (62.78), highest number of petals (317.20), maximum flower yield per plant (206.55g/plant),maximum self life of loose flower (7.21 days) and highest storage life as garland (7.04days) followed by pinching at 20 DAT. The combination of pinching at 40 days after transplanting along with foliar spray of gibberellic acid at the rate of 200ppm gives the highest benefit cost ratio (2.340).

Keywords: Pinching, GA_3, marigold, growth**,** storage, benefit-cost ratio

Introduction
Assam with wide agro-climatic diversity is one of the leading states for commercial cultivation of loose flowers among which the most important is African Marigold grown at a large scale mainly in the Kamrup district. The major problems of marigold cultivation in Assam are lack of off season production technology, lack of proper scientific cultivation knowledge and very poor post harvest handling practices. The African marigold is an annual flowering crop with tall and profuse branching habit. It produces large-size quality flowers of different colours, which fetches high prices in the market. However, apical dominance causes delay in flowering. Long and weak stems are some of problems causing yield loss. It has been felt that standard horticultural practices *e.g.* pinching and gibberellic acid spray can play an important role in the improvement of flowering and yield of marigold. In marigold, the flowering and yield is mainly dependent on number of flower bearing branches which can be manipulated by checking vertical growth of plants and encouraging side shoots by means of apical bud pinching. Gibberellic acid is used to overcome the growth limiting factors to harness maximum benefit from flower production for increasing the yield. Although, marigold is grown by a large number of farmers in India, yet a very little research work has been done on this crop with special reference to the effect of pinching and gibberellic acid on growth and physiological characteristics aspects. Keeping in view the above facts, an experiment was undertaken with the objectives to find out optimum pinching time and effective concentration of GA_3.

Materials and Methods
The experiment was conducted in the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during 2016-2017.

The experimental area is located at 26°47′N latitude, 94°12′E longitude and at an altitude of 86.6 meter above mean sea-level. Jorhat is located within the Upper Brahmaputra Valley agro-climatic zone of Assam and is characterized by a subtropical climatic condition with hot and humid summer and relatively dry and cool winter. The soil in the farm is sandy loam with pH (4.82), organic matter (0.53%), available nitrogen (165.11Kg/ha), available phosphorus (48.92 kg/ha) and available potassium (89.54kg/ha). During growing period mean maximum (31.1 ºC) and minimum (22.3 ºC) temperature, relative humidity (81.56%) and rain fall (111.14mm) was recorded. Fifteen different treatment combinations of five levels of gibberellic acid (GA_3 @ 0ppm, 50ppm, 100ppm, 150ppm and 200ppm) and three pinching levels *viz*. no pinching, pinching at 20 days and pinching at 40 days after transplanting was laid out in randomized block design with three replication on African marigold cv. Pusa Narangi Gainda. Twenty five days old uniform and healthy seedling were transplanted at the spacing of 45×45 cm on October 25, 2016. 10 kg FYM, 10 g each N, P_2O_5 and K_2O per square meter was applied in experimental block. The full dose of well rotten FYM, P_2O_5, K_2O and half dose of N was mixed in beds before transplanting. The remaining dose of N was applied one month after transplanting.

Hand sprayer was used to spray gibberellic acid uniformly. Gibberellic acid treatment was applied twice at first and third weeks after transplanting while the control plants were sprayed with distilled water. Regarding pinching treatments, 4-5 cm terminal portion of growing tip was nipped out as per treatments' time mentioned above. Observation on growth parameters like plant height, number of primary branches, stem diameter, number of flowers per plant, petal number of flowers, flower size, flower yield of individual plants were recorded and presented in Table 1. Various physiological characteristic viz., root volume, chlorophyll content, self life, storage life as garlands were also recorded and presented in Table 2. Five plants were selected randomly and tagged for different treatments in each replication for taking observations. The parameters were calculated using standard procedures. The statistical analysis was carried out to know the variance for each parameter and effect of treatments using the standard procedure.

Results and Discussion

Effect of pinching

The data presented in Table 1 revealed that pinching treatments responded different growth parameters. Significantly maximum reduction in plant height (72.01cm) was recorded in pinching at 40 DAT followed by pinching at 20 DAT (76.90cm). The treatment no pinching had recorded significantly maximum plant height (86.61cm). However, highest number of primary branches (15.95), stem diameter (1.35cm), number of flowers/plant (62.78), yield of flowers per plant (206.55g) were recorded significantly maximum with pinching at 40 DAT followed by pinching treatment at 20 DAT. While, minimum number of primary branch (9.24), lowest stem diameter (1.27cm), lowest number of flowers per plant (51.46), lowest petal number (273.82), largest flower (4.41 cm diameter) and lowest flower yield per plant (186.27g) was noticed under the control (no pinching) treatment. The similar results were quoted by Shinde *et al*. (2010), Sharma *et al*. (2006), Maharnor *et al*. (2011), Pushkar and Singh (2012), Sehrawat *et al.* (2003), Sunitha *et al.* (2007) [11, 10, 4, 5, 13] in marigold

Regarding the physiological characteristics maximum root volume (69.77cc), leaf chlorophyll content (1.36mg g^{-1}FW), self life (7.21 days), storage life as garlands (7.04 days) were found under pinching at 40 DAT treatment followed by pinching at 20 DAT. Whereas, minimum root volume (66.89cc), leaf chlorophyll content (1.13mg g^{-1}FW), self life (5.12 days), storage life as garlands (5.11 days) were found under no pinching treatment. The reduction in the plant height in pinched plant was mainly due to the removal of apical meristematic tissue which inhibited the apical dominance and diverted plant metabolites from vertical growth to horizontal growth which might have favoured in increasing the number of branches and ultimately the flower yield. These results are in close agreement with the findings of Ramdevputra *et al*. (2009), Srivastava *et al*. (2002), Rathore *et al.* (2011) [7, 12, 9] in marigold and Shinde *et al.* (2010) [11] in chrysanthemum.

Effect of gibberellic acid

During the experimental period, gibberellic acid treatment resulted in outstanding increase in all vegetative, flowering and other physiological growth parameters studied under the experiment. The growth parameters such as height of plant (85.36cm), number of primary branches/plant (15.95), stem diameter (1.37cm), number of flowers per plant (63.80), petal numbers per flower (318.06), diameter of flower (4.55cm) yield of flowers per plant (206.45g) were recorded significantly maximum with the application of gibberellic acid @ 200 ppm followed by application of gibberellic acid @ 150 ppm and 100 ppm and minimum height of plant (73.56cm), number of primary branches/plant (9.89), stem diameter (1.26cm), days to flower bud opening (16.95 days), number of flowers per plant (50.68), petal number (271.60), diameter of flower (3.71cm) yield of flowers per plant (182.61g) were recorded in control treatment (gibberellic acid 0ppm). Thus, it was found that plant growth parameters increased with increase in gibberellic acid concentrations. This was due to the fact that gibberellic acid increased the growth of plant by increasing intermodal length and cell enlargement and enhanced the apical dominance indirectly by increasing auxin content. The increasing leaf area might be due to increasing plant height and number of branches. Similar results were recorded by Taygi and Kumar (2006), Swaroop *et al.* (2007); Ramdevputra *et al.* (2009); Ramesh Kumar *et al*. (2010); Amit Kumar *et al.* (2012), Badge *et al*. (2013) [15, 14, 7, 8, 1, 2] in marigold.

The data presented in Table 2 clearly showed that significantly maximum root volume (70.92cc), total chlorophyll content (1.34mg g^{-1}FW) and self life (7.38days) and storage life as garlands (6.99) were registered under the application of gibberellic acid 200 ppm followed by gibberellic acid 150 ppm, gibberellic acid 100 ppm and gibberellic acid 50 ppm. The minimum root volume (65.66cc), total chlorophyll content (1.15mg g^{-1}FW) and self life (5.20days) and storage life as garlands (5.28 days) were recorded in control treatment. This might be due to greater dry matter accumulation which was certainly suggestive to better photosynthetic activity, other metabolite activities and uptake of nutrients from soil. Therefore, the growth promoting substances might have positive influence on the yield of flowers. Similar results were reported by Ramdevputra *et al*. (2009) [7] in marigold, Ramalingam (2008), Kumar *et al.* (2012) [6, 3] in rose and by Shinde *et al.* (2010) [11] in chrysanthemum.

Interaction Effect

The data presented in Tables 1 and Table 2 exhibit non-significant differences for all growth and yield parameters due to an interaction of the pinching and application of gibberellic acid.

Table 1: Effect of pinching and gibberellic acid on vegetative and flowering characteristics of Marigold

Treatment	Plant height (cm)	Number of primary branches	Diameter of main stem	Number of flower per plant	Number of petals	Diameter of flower	Flower yield per plant
Factor A - Pinching(P)							
P_0 -No pinching	86.61	9.24	1.27	51.46	317.20	4.41	186.27
P_1-Pinching at 20 DAT	76.90	11.57	1.32	56.70	288.62	4.14	190.08
P_2-Pinching at 40 DAT	72.01	15.95	1.35	62.78	273.82	3.78	206.55
SE(d)±	0.63	0.53	0.009	0.83	0.77	0.02	0.34
C.D. (P=0.05)	1.35	1.14	0.02	1.77	1.64	0.05	0.73
Factor B - Gibberellic acid (G)							
G_0-GA_3 0 ppm	73.56	9.89	1.26	50.68	271.60	3.71	182.61
G_1-GA_3 50 ppm	75.12	10.70	1.28	53.70	281.19	3.98	188.74
G_2-GA_3 100 ppm	76.26	11.62	1.31	55.27	292.81	4.09	194.81
G_3-GA_3 150 ppm	82.22	13.41	1.34	61.45	302.42	4.23	198.89
G_4-GA_3 200 ppm	85.36	15.65	1.37	63.80	318.06	4.55	206.45
SE(d)±	0.82	0.69	0.01	1.07	0.99	0.03	0.44
C.D. (P=0.05)	1.75	1.48	0.02	2.28	2.12	0.06	0.94
Interaction Effect (A x B)							
SE(d)±	1.42	1.20	0.02	1.85	1.72	0.05	0.76
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS

NS. : Not Significant

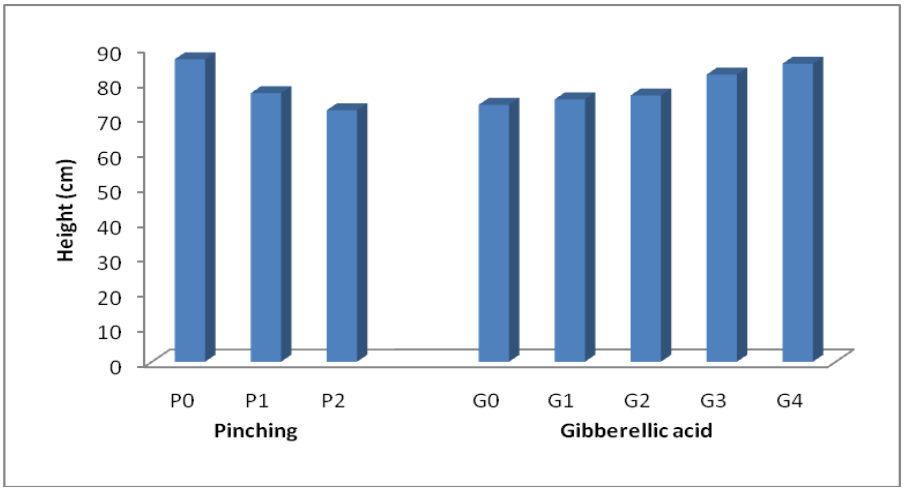

Fig 1: Plant height (cm)

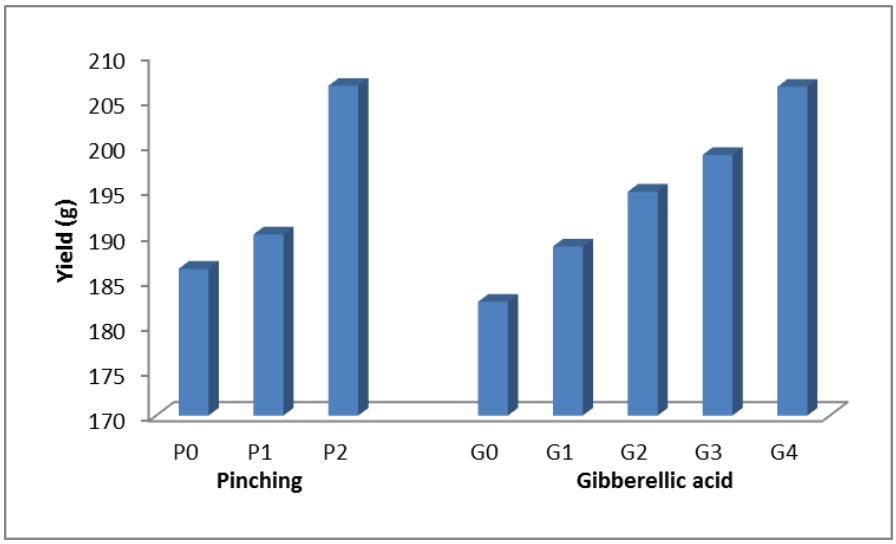

Fig 2: Flower yield per plant (g)

Table 2: Response of pinching and gibberellic acid on physiological characteristics of African marigold

Treatment	Root volume (cc)	Chlorophyll content (mg g^{-1}FW)	Self life (Days)	Storage life as garlands (Days)
Factor A - Pinching(P)				
P_0 -No pinching	66.89	1.13	5.12	5.11
P_1-Pinching at 20 DAT	68.29	1.28	6.06	6.13
P_2-Pinching at 40 DAT	69.77	1.36	7.21	7.04
SE(d)±	0.12	0.004	0.24	0.058
C.D. (P=0.05)	0.26	0.009	0.52	0.12
Factor B - Gibberellic acid (G)				
G_0-GA_3 0 ppm	65.66	1.15	5.20	5.28
G_1-GA_3 50 ppm	67.13	1.20	5.58	5.75
G_2-GA_3 100 ppm	68.49	1.29	6.07	6.07
G_3-GA_3 150 ppm	69.40	1.31	6.44	6.38
G_4-GA_3 200 ppm	70.92	1.34	7.38	6.99
SE(d)±	0.16	0.005	0.32	0.075
C.D. (P=0.05)	0.34	0.01	0.68	0.16
Interaction effect (A x B)				
SE(d)±	0.28	0.009	0.55	0.13
C.D. (P=0.05)	NS	NS	NS	NS

NS. : Not Significant

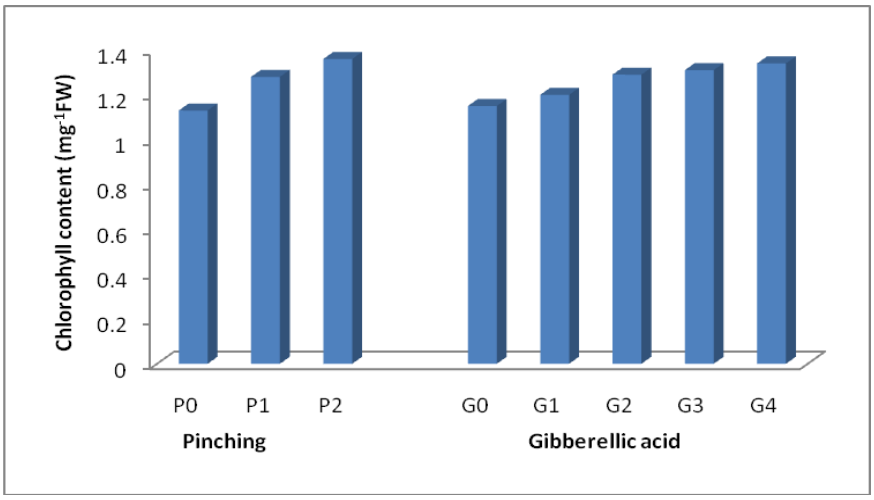

Fig 3: Total chlorophyll content (mg g^{-1} FW)

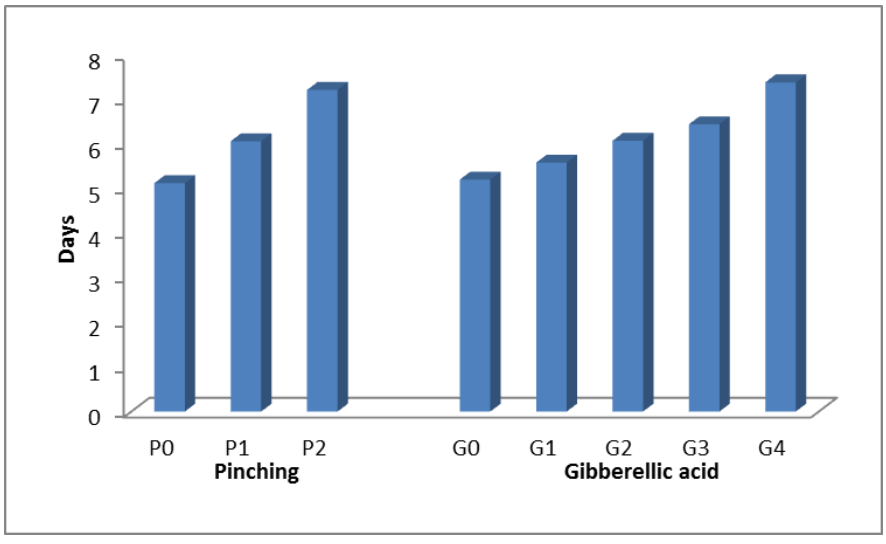

Fig 4: Self life of loose flower

Economic analysis

The economic analysis of cultivating marigold by these treatments in one hectare area was worked out and are presented in Table no. 3 and Table no. 4. It was found that treatment combination of GA_3 at 200 ppm as foliar spray and pinching at 40 days after transplanting gives the highest benefit cost ratio (2.340) whereas treatment combination of no pinching along with GA_3 at 200ppm gives lowest benefit cost ratio (1.780). In the Table no. 3 total variable costs are worked out for different inputs and in Table no. 4 benefit cost ratio is calculated by taking average market price of the locality.

Table 3: Calculation of total expenditure

Treatment	Land preperation (Rs/ha)	Labour cost @ RS. 134/MD	Planting material @ Rs. 1/ seedling	FYM @ Rs. 500/t (50 t/ ha)	Urea @ Rs.10/kg	SSP@ Rs.10/kg	MOP @Rs. 18/kg	Plant protection (Rs/ha)	Lime (Rs/ha)	Gibberellic acid (15000/kg) 600 lit solution/ha	Staking (Rs/ha)	Miscellaneous (Rs/ha)	Total variable cost	Total working capital	Interest on working capital @10%	Total expenditure
T_0	6000.00	10452.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	0.00	3000.00	1000.00	115708.00	115708.00	11570.80	127278.80
T_1	6000.00	11256.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	9000.00	3000.00	1000.00	125512.00	125512.00	12551.20	138063.20
T_2	6000.00	11256.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	18000.00	3000.00	1000.00	134512.00	134512.00	13451.20	147963.20
T_3	6000.00	11256.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	27000.00	3000.00	1000.00	143512.00	143512.00	14351.20	157863.20
T_4	6000.00	11256.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	36000.00	3000.00	1000.00	152512.00	152512.00	15251.20	167763.20
T_5	6000.00	12462.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	0.00	3000.00	1000.00	117718.00	117718.00	11771.80	129489.80
T_6	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	9000.00	3000.00	1000.00	127388.00	127388.00	12738.80	140126.80
T_7	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	18000.00	3000.00	1000.00	136388.00	136388.00	13638.80	150026.80
T_8	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	27000.00	3000.00	1000.00	145388.00	145388.00	14538.80	159926.80
T_9	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	36000.00	3000.00	1000.00	154388.00	154388.00	15438.80	169826.80
T_{10}	6000.00	12462.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	0.00	3000.00	1000.00	117718.00	117718.00	11771.80	129489.80
T_{11}	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	9000.00	3000.00	1000.00	127388.00	127388.00	12738.80	140126.80
T_{12}	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	18000.00	3000.00	1000.00	136388.00	136388.00	13638.80	150026.80
T_{13}	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	27000.00	3000.00	1000.00	145388.00	145388.00	14538.80	159926.80
T_{14}	6000.00	13132.00	49330.00	25000.00	2170.00	6250.00	3006.00	5000.00	4500.00	36000.00	3000.00	1000.00	154388.00	154388.00	15438.80	169826.80

Table 4: Calculation of benefit cost ratio

Treatment	Total cost (Rs)	Yield (q/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit-Cost ratio
T_0	127278.80	135.25	270512.82	143233.20	2.125
T_1	138063.2	138.46	276923.07	138859.90	2.005
T_2	147963.20	141.66	283333.33	135370.10	1.914
T_3	157863.20	145.51	291025.64	133162.40	1.843
T_4	167763.20	149.35	298717.94	130954.70	1.780
T_5	129489.80	137.82	275641.02	146151.20	2.128
T_6	140126.80	140.38	280769.23	140642.40	2.003
T_7	150026.80	145.51	291025.64	140998.80	1.939
T_8	159926.80	150.00	300000.00	140073.20	1.875
T_9	169826.80	155.76	311538.46	141711.70	1.834
T_{10}	129489.80	150.00	300000.00	170510.20	2.316
T_{11}	140126.80	153.84	307692.30	167565.50	2.195
T_{12}	150026.80	157.69	315384.61	165357.80	2.102
T_{13}	159926.80	160.89	321794.87	161868.10	2.012
T_{14}	169826.80	198.71	397435.89	227609.10	2.340

Conclusion

Utilization of GA_3 in marigold during different crop growth stages proved beneficial. From the above experiment it may be concluded that GA_3 at 200 ppm during first and third weeks after transplanting as foliar spray and pinching at 40 days after transplanting may be recommended for good growth and physiological characteristics of African Marigold.

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