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Effect of humic acid and gibberellic acid on growth and flowering parameters of summer African marigold

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Abstract
The present study was carried out at Horticulture Section, College of Agriculture, Nagpur during 2020-21 and 2021-22 to assess the effect of foliar application of humic acid and gibberellic acid on growth and flowering parameters of summer African marigold (*Tagetes erecta* L.) The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications with two factors *viz*., Factor A consist of four levels of humic acid (i.e., Control, 0.2% humic acid, 0.4% humic acid and 0.6% humic acid) and factor B consist of five levels of gibberellic acid (i.e., 100 ppm, 200 ppm, 300 ppm, 400ppm and control). Growth attributes were determined as vegetative growth such as plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1} and stem girth (mm). Flowering characters i.e., days to first flower bud initiation (days), days taken for opening of first flower (days), days to 50% flowering and duration of flowering. Results showed that humic acid and gibberellic acid recorded the best results of all studied characters, however, humic acid at 0.2% and gibberellic acid at 100 ppm achieved the highest mean values in all growth and flowering attributes as compared with the control treatment which gave the lowest mean values of all observed characters in African marigold.

Keywords: Humic acid, gibberellic acid, foliar application, African marigold, growth attributes, flowering characters

Introduction
African marigold (*Tagetes erecta*) an annual herbaceous plant belongs to the Compositae subfamily of the Asteraceae. There is great scope to increase the area under this crop due to its wider adoptability, suitability under varied agro-climatic condition and huge demand in the market. Due to its chemical makeup, which includes terpenes, flavonoids, tannins, coumarins, and basic oils, it has various distinct uses in addition to being created for decorative purposes (Ashwlayan *et al*., 2018) [5]. The remedial, dietary, and pharmaceutical industries may thus find marigold to be a lucrative plant. Due to its cultural and religious significance, marigold may be a prospective undertaking bloom with growing demand in the environment (Adhikari *et al.*, 2020) [1]. Marigolds are famous among gardeners and flower dealers due to their ease of cultivation, extensive adaptation to varied soil and climatic conditions, long flower duration, short duration to produce marketable blooms, a wide range of beautiful colours, form, size, and high maintaining quality of flowers with elegant and pretty foliage.

Apical dominance, stretch in blooming (Sharma *et al.*, 2006) [33], and promotion of long and inclined stems (Gawle *et al.*, 2012) [10] are a few of the significant drawbacks associated with the development of this modification. These, in turn, result in poor yields or economic returns. However, setting up the surrounding climatic conditions through location selection, and adjusted dietary and physiological controls through pressing or the use of plant growth regulators can help to improve the plant growth. It is the taller species, growing reaching a height of 80- 100 cm.

Humic acid, an organic polymer produced naturally by the breakdown of peat, lignin, and organic waste, can be used to increase the quality and output of a product. With an increase in chlorophyll content, an acceleration of respiration, hormonal responses to growth, an increase in penetration in plant membranes, or a combination of these mechanisms, humic acid directly affects plant development. Additionally, humic acid increases nutrient absorption through chelation and regeneration actions, as well as root and shoot growth, which affects plant growth indirectly (Atiyeh *et al.* 2002). Gibberellic acid advances the blossom's top quality and is used to go around the factors that restrict growth to maximize benefit.

Additionally, it affects plant development by increasing the variety of both primary and secondary branches, which are combined to improve bloom quality and maintain consistency in bloom size and variety, which in the long run ensures better bloom generation. Gibberellic acid that is exogenously connected limits the vegetative, blooming, and exceptional parameters in both greater and lesser concentrations even though it worked to the fullest extent possible up to the greatest possible recognition and comments hindrance surpassed off past such concentrations. In view of the above the present investigation have been planned to assess effect of foliar application of humic acid and gibberellic acid on growth and flowering parameters of summer African marigold.

Materials and Methods

Field experiment was conducted during summer season of the year 2020-21 and 2021-22 at Horticulture Section, College of Agriculture, Nagpur, with an objective to study the effect of foliar application of humic acid and gibberellic acid on growth and flowering in summer African marigold.

The experiment was laid out in factorial randomized block design with twenty treatments combinations replicated thrice. Treatments comprising of factor A with four concentrations of humic acid *viz*., H_1 - control, H_2 – 0.2% HA, H_3 - 0.4% HA and H_4 - 0.6% HA and factor B with four concentrations of gibberellic acid *viz*., G_1 - control, G_2 - 100 ppm, G_3 - 200 ppm, G_4 - 300 ppm and G_5 - 400 ppm.

Seeds of African marigold var. African Double Orange were procured from horticulture section. The raised beds were prepared after mixing the well rotten FYM. The seeds were sown on bed at a distance of 10 cm between the row and 2 to 3 cm within the row at 1-1.5 cm depth. Four weeks old healthy, stocky seedlings were used for transplanting. Transplanting was done in the month of January at the spacing of 45 cm x 30 cm. The recommended dose of fertilizers (N: P_20_5: K_20 @ 100:50:25 kg ha^{-1}) were applied in the form of urea, single supper phosphate and muriate of potash. Full dose of single supper phosphate and muriate of potash and ½ dose of urea was applied at the time of transplanting and remaining ½ dose of urea was applied one month after transplanting.

The foliar application of humic acid and gibberellic acid was done twice at 15 DAT and 30 DAT as per treatment concentration. The observations *viz*., plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$ and stem girth (mm). Similarly flowering characters i.e., days to first flower bud initiation (days), days taken for opening of first flower (days), days to 50% flowering and duration of flowering were recorded. The appropriate standard error of mean S.E., (m) and the critical difference (C.D.) were calculated at 5% level of probability.

Results and Discussion

The results obtained from present investigation are presented below on the basis of pooled mean of two years experimentation (2020-21 and 2021-22).

Effect of humic acid

Plant height (cm): The pooled result exhibited the significant differences among the different concentration of humic acid regarding plant height at 90 DAT. Significantly maximum plant height (91.89 cm) was recorded with the foliar application of humic acid 0.2% (H_2) followed by the treatment H_3 i.e. foliar application of humic acid 0.4% (76.03 cm) and foliar application of humic acid 0.6% (84.94) under the treatment H_4. Whereas, the control treatment (H_1) recorded significantly minimum plant height (82.19). This might be due to fact that, humic acid improve nutrient uptake by the plant by facilitating the movement of micronutrients through the leaf surface and into the plant's vascular system, which increase nutrient availability and uptake that supports plant growth and development, ultimately resulting in increased plant height Similar results were observed by Jawaharlal *et al*. (2013) [15] and Muhammad *et al.* (2017) [23] in marigold.

Number of primary branches $plant^{-1}$

The pooled result exhibited the significant differences among the different concentration of humic acid regarding number of primary branches $plant^{-1}$ at 90 DAT. Significantly maximum number of primary branches $plant^{-1}$ (21.35) was recorded with the treatment H_2 i.e. foliar application of humic acid 0.2% followed by the treatments H_3 i.e. foliar application of humic acid 0.4% (20.08) and the foliar application of humic acid 0.6% (19.50) under the treatment H_4. However, the control treatment (H_1) recorded significantly minimum number of primary branches $plant^{-1}$ (18.62). This might be due to fact that foliar spray of humic acid can directly interact with the plant cells and tissues, promoting hormone production such as auxins and cytokinins, which are responsible for cell division, elongation, and differentiation, which can lead to the formation of more primary branches. Similar results were observed by Sendhilnathan *et al*. (2019) [32], Murugan *et al*. (2019) [24] in marigold.

Number of secondary branches $plant^{-1}$

The pooled results exhibited the significant differences among the different concentration of humic acid regarding number of secondary branches $plant^{-1}$ at 90 DAT. Significantly maximum number of secondary branches $plant^{-1}$ (31.86) was recorded with the treatment H_2 i.e. foliar application of humic acid 0.2% followed by the treatment H_3 i.e. foliar application of humic acid 0.4% (29.94) and foliar application of humic acid 0.6% (28.80) under the treatment H_4. However, the control treatment (H_1) recorded significantly minimum number of secondary branches $plant^{-1}$ (26.69). This might be due to the use of humic acid which promotes photosynthesis, respiration and chlorophyll content, thus improving plant carbohydrate contents and the commercial products containing abundant nutrients improves soil fertility and increase the availability of nutrients to plants and thus increasing the secondary branches $plant^{-1}$. Similar results were observed by Murugan *et al*. (2019) [24] in marigold.

Stem girth (mm): The pooled result exhibited the significant differences among the different concentration of humic acid regarding stem girth at 90 DAT. Significantly maximum stem girth (15.68 mm) was recorded with the treatment H_2 i.e. foliar application of humic acid 0.2% followed by the treatment's H_3 i.e. foliar application of humic acid 0.4% (14.64 mm) and the treatment H_4 i.e. foliar application of humic acid 0.6% (13.99 mm). However, the control treatment (H_1) recorded significantly minimum stem girth (13.22 mm). This might be due to the ability to chelate or bind to nutrients, making them more available to plants, leading to increased nutrient uptake, which can promote plant growth and development, including stem girth. Similar results were observed by Jawaharlal *et al*. (2013) [15], Husein (2015), Muhammad *et al.* (2017) [23] and Sendhilnathan *et al.* (2019) [32].

Effect of Gibberellic acid

Plant height (cm): The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding plant height at 90 DAT. Significantly maximum plant height (92.38 cm) was recorded with the treatment G_4 i.e. foliar application of gibberellic acid 300 ppm and it was followed by the treatment G_3 i.e. foliar application of gibberellic acid 200 ppm (89.50 cm), treatment G_2-foliar application of gibberellic acid 100 ppm (87.38 cm) and G_5 - foliar application of gibberellic acid 400 ppm (85.00 cm). However, the control treatment (G_1) had recorded significantly minimum plant height (78.62 cm). The maximum plant height might be due to fact that, application of gibberellic acid might have enhanced the plant height by increasing the intermodal length which could have attributed the cell elongation and promotion of protein synthesis. Similar, results were obtained by Hore and Sen (1986) [13], Girwani (1988) and Girwani *et al.* (1990) [12].

Number of primary branches plant^{-1}

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding number of primary branches plant^{-1} at 90 DAT. Significantly maximum number of primary branches plant^{-1} (22.88) was observed with the treatment G_2 i.e. foliar application gibberellic acid @ 100 ppm and was followed by the treatment G_3 i.e. foliar application of gibberellic acid @ 200 ppm (19.80), G_4-foliar application of gibberellic acid 300 ppm (19.40) and in the treatment G_5-foliar application of gibberellic acid 400 ppm (18.79). However, the control treatment (G_1) recorded significantly minimum number of primary branches plant^{-1} (18.44). This might be due to the higher elongation of internodal length and a resultant increase in nodal count on the main axis. Consequently, these nodes increased number of dormant buds from where the primary branches have originated. These findings are in close agreement with the findings of Ramdevputra *et al*. (2009) [31] and Meshram *et al*. (2015) [25].

Number of secondary branches plant^{-1}

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding number of secondary branches plant^{-1} at 90 DAT. Significantly maximum number of secondary branches plant^{-1} (33.94) was observed with the treatment G_2 i.e. foliar application gibberellic acid 100 ppm which was followed by the treatments G_3 i.e. foliar application of gibberellic acid 200 ppm (29.59), G_4 - foliar application of gibberelliic acid 300 ppm (28.95) and in the treatment G_5 i.e. foliar application of gibberelliic acid 400 ppm (27.65). However, the G_1, (control) treatment recorded significantly minimum number of secondary branches plant^{-1} (26.48). The foliar application of gibberellic acid can promote the development of secondary branches in plants through the promotion of cell division and elongation in the lateral meristem, inhibition of apical dominance, and induction of secondary branches. Similar results were observed by Dabas (2000) [8] and Anuradha *et al.* (2017) [4].

Stem girth (mm)

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding stem girth at 90 DAT. Significantly maximum stem girth (16.72 mm) was observed with the treatment G2 i.e. foliar application gibberellic acid 100 ppm which was followed by the treatment G_3-foliar application of gibberellic acid 200 ppm (14.90 mm), the treatment G_4-foliar application of gibberelliic acid 300 ppm (14.13 mm) and G_5 i.e. foliar application of gibberelliic acid 400 ppm (13.14 mm). However, the G_1 (control) treatment recorded significantly minimum stem girth (13.01 mm). This might be due to the reason that, plant height increases the stem girth of plant proportionately. Therefore, with the increase in the concentration of GA_3, the stem girth increases due to a reflection of the stimulation of cambium and its immediate cell progeny i.e. the cambial and vascular cells continue to divide over a longer period and these results increases in thickness of the stem. Similar results were reported by Dabas *et al.* (2000) [8], Pandey and Chandra *et al.* (2000) and Shivaprakash *et al.* (2011) [34].

Interaction effect

The data presented in Table 1 revealed that, interaction effect due to foliar application of humic acid and gibberellic acid on growth parameters of African marigold was found non-significant at all growth stages during both the year of experimentation (2020-21 and 2021-22).

Flowering parameters

The data regarding flowering parameters as influenced due to the foliar application of humic acid and gibberellic acid treatments during the years 2020-21 and 2021-22 are presented in Table 2 and 3.

Effect of humic acid

Days to first flower bud initiation

The pooled result exhibited the significant differences among the different concentration of humic acid regarding first flower bud initiation. Significantly minimum days required for first flower bud initiation (35.66 days) was recorded with the treatment H_1 (control) followed by the treatment H_3 i.e., foliar application of humic acid 0.4% (38.25 days) which was at par with the treatment H_2 i.e., foliar application of humic acid 0.2%. However, the foliar application of humic acid 0.6% (H_4) recorded significantly maximum days (38.84 days) required for first flower bud initiation. This might be due to fact that number of days required for flower bud initiation, higher concentrations of humic acid in foliar spray may actually delay the process. This is because humic acid can stimulate plant growth and development, which can lead to an overall increase in vegetative growth at the expense of reproductive growth. Therefore, a high concentration of humic acid in foliar spray may result in a delay in flower bud initiation, as the plant focuses on building up its vegetative structures before allocating resources to reproductive structures. These findings are in accordance with Ahsan *et al.* (2012) [2], Kiesam *et al.* (2014) and Ameena *et al.* (2018) [3] in marigold.

Days taken for opening of first flower

The pooled result exhibited the significant differences among the different concentration of humic acid regarding first flower opening. Significantly minimum days (45.55 days) required for first flower opening was recorded with the treatment H_1 (control) followed by the treatments H_2 i.e., foliar application of humic acid 0.2% (38.25 days) which was at par with the treatment H_3 i.e., foliar application of humic acid 0.4%. However, the foliar application of humic acid 0.6% treatment (H_4) recorded significantly maximum days (46.77 days) required for first flower opening. This might be due to fact that the control treatment may have opened the first flower earlier because the plant did not receive any additional nutrients or stimulants that could have potentially delayed the initiation of the first flower. Similar results were obtained from Kiesam *et al.* (2014) Ameena *et al.* (2018) [3] and Sendhilnathan *et al.* (2019) [32] in marigold.

Days to 50 percent flowering

The pooled result exhibited the significant differences among the different concentration of humic acid regarding days to 50 percent flowering. Significantly minimum days observed for days to 50 percent flowering (63.27 days) was recorded with the treatment H_2 i.e., foliar application of humic acid 0.2% which was at par with the treatments H_3 i.e., foliar application of humic acid 0.4% (63.92 days) and H_4 i.e., foliar application of humic acid 0.6% (64.15 days). However, significantly maximum days to 50 percent flowering (65.27 days) was recorded in H_1 (control) treatment. This might be due to the fact that foliar application of humic acid might have increased the photosynthetic rate in plants. This is the process by which plant produces energy from sunlight and produced early flowering in marigold plant. Similar results were obtained from Kiesam *et al.* (2014) Ameena *et al.* (2018) [3] and Sendhilnathan *et al.* (2019) [32].

Duration of flowering

The pooled result exhibited the significant differences among the different concentration of humic acid regarding duration of flowering. Significantly maximum duration of flowering (48.89 days) was recorded with the treatment H_2 i.e., foliar application of humic acid 0.2% which was at par with the treatment H_3 i.e., foliar application of humic acid 0.4% (48.53 days) and H_4 i.e., foliar application of humic acid 0.6% (48.16 days). However, significantly minimum duration of flowering (46.10 days) was observed in H_1 (control) treatment. This might me due to fact that, humic acid can help to improve the tolerance of plants to environmental stresses, such as heat, drought or disease, when plants are better able to cope up with stress, they are more likely to continue flowering for a longer duration. Similar results were obtained from Ameena et al (2018) [3].

Effect of gibberellic acid

Days to first flower bud initiation

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding first flower bud initiation. Significantly minimum days required for first flower bud initiation (35.89 days) was recorded with the treatment G_5 i.e., foliar application of GA_3 400 ppm followed by the treatments G_1 -control (37.75 days) which was at par with the treatment G_4 and G_3 i.e., foliar application of GA_3 300 ppm and 200 ppm respectively. However, the foliar application of GA_3 100 ppm (G_2) recorded significantly maximum days required for first flower bud initiation (40.98 days). This might be due to the fact that, foliar application of gibberellic acid might have stimulated and enhanced the vegetative growth, increased photo- synthesis and respiration which enhanced carbon-di-oxide fixation in the treated plants and reduced juvenile period which would have associated with an early flowering. The results obtained in the present study are in close agreement with the findings of Mithileshkumar *et al.* (2014) [22], Badge *et al.* (2015) [6], Kumar *et al.* (2016) [21] and Khangiarakpam *et al.* (2019) [18].

Days taken for opening of first flower

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding first flower opening. Significantly minimum days (44.68 days) required for first flower opening was recorded with the treatment G_5 i.e., foliar application of GA_3 400 ppm followed by the treatments G_1-control (46.03 days). The treatment G_1-control was at par with the treatment G_4 and G_3 i.e., foliar application of GA_3 300 ppm and 200 ppm respectively. However, the foliar application of GA_3 100 ppm (G_2) recorded significantly maximum days required for first flower opening (47.98 days). This might be due to the fact that, an early flower bud emergence in African marigold caused due to the plants treated with GA_3 400 ppm might have reduced the days required for opening of first flower from initiation of first flower bud. The results obtained in the present study are in close conformity with the findings of Hore and sen (1986) [13], Kulkarni *et al.* (2003) [20], Rakesh *et al.* (2003) [30], Dalal *et al.* (2003) [9], Shinde *et al.* (2003) and Mithileshkumar *et al.* (2003) [22].

Days to 50 percent flowering

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding days to 50 percent flowering. Significantly minimum days required for days to 50 percent flowering (61.56 days) was recorded with the treatment G_1 i.e., foliar application of GA_3 100 ppm followed by the treatments $G_{3,\ G4}$ and G_5 i.e., foliar application of GA_3 200 ppm (64.12 days), GA_3 300 ppm (64.70) and GA_3 400 ppm (65.23). However, the G_1-control treatment was recorded significantly maximum days required for days to 50 percent flowering (65.41 days) in marigold. The foliar application of GA_3 have enhanced the biological activities like, cell elongation and protein synthesis and ultimately which might have enhanced the vegetative growth of African marigold plant due to which days required for initiation of flower bud as well as 50 percent flowering have been reduced. Similar results were reported by Padmapriya and Chezhiyan (2002) [27] and Kadam *et al.* (2020) [16].

Duration of flowering

The pooled result exhibited the significant differences among the different concentration of gibberellic acid regarding duration of flowering. Significantly maximum days required for duration of flowering (62.78 days) was recorded with the treatment G_2 i.e., foliar application of GA_3 100 ppm followed by the treatments G_1-control (57.85 days) G_3-GA_3 200 ppm (57.68 days) and G_4-GA_3 300 ppm (57.33). However, the GA_3 400 ppm treatment recorded significantly minimum duration of flowering (53.96 days) in marigold. The increase in duration of flowering with foliar application of 300 ppm GA_3 might be due to advanced flower buds' formation and stimulating flowering in GA_3 treated plant. The results are in resemblance of Chada *et al.* (2001), Padmapriya and Chezyian (2001) [27] and Moond and Gehlot (2001) [26].

Interaction effect

Days to first flower bud initiation

The pooled result exhibited the significant differences among the different concentration of humic acid gibberellic acid regarding first flower bud initiation. Significantly minimum days required for first flower bud initiation (34.99 days) was recorded with the (H_1G_5) i.e., 400 ppm gibberellic acid which was found at par with the treatment combination of H_4G_5 i.e., foliar application of humic acid 0.6% and foiliar application of gibberellic acid 400 ppm (36.05 days) and H_2G_5 i.e., foliar application of humic acid 0.4% and gibberellic acid 400 ppm (36.17 days). However, the foliar application of humic acid 0.6% and gibberellic acid 100 ppm (H_4H_2) treatment combination recorded significantly maximum days required for first flower bud initiation (43.27 days).

Days taken for opening of first flower

The pooled result exhibited the significant differences among the different concentration of humic acid gibberellic acid regarding first flower opening. Significantly minimum days required for first flower opening (43.95 days) was recorded with the treatment combination of H_2G_5, and was found at par with the treatment combinations H_1G_5 (44.39) and H_4G_5 (44.72). However, H_2G_2 treatment combination was recorded significantly maximum days required for first flower opening (50.05 days).

Days to 50 percent flowering

The pooled result exhibited the significant differences among the different concentration of humic acid regarding duration of flowering. Significantly maximum duration of flowering (48.89 days) was recorded with the treatment H_2 i.e., foliar application of humic acid 0.2% and it was at par by the treatment H_3 i.e., foliar application of humic acid 0.4% (48.53 days) and humic acid 0.6% (48.16 days). However, significantly minimum duration of flowering (46.10 days) was required in H_1 (control) treatment.

Duration of flowering

The pooled result exhibited the significant differences among the different concentration of humic acid and gibberellic acid regarding duration of flowering. Significantly maximum duration of flowering (66.03 days) was recorded with the treatment combination of H_2G_2, which was followed by the treatments H_3G_2 (63.90 days). However, H_1G_5 treatment combination was recorded significantly minimum duration of flowering (52.80 days) in marigold.

Table 1: Effect of foliar application of humic acid and gibberellic acid on growth parameters in African marigold (mean pooled data over two year)

Factors	Growth parameters			
	Plant Height	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Stem girth
	Pooled	Pooled	Pooled	Pooled
A) Humic acid (H)				
H_1- Control	82.19	18.62	26.69	13.22
H_2- 0.2%	91.89	21.35	31.86	15.68
H_3- 0.4%	87.28	20.08	29.94	14.64
H_4- 0.6%	84.94	19.50	28.80	13.99
‘F’ test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.83	0.27	0.52	0.25
CD at 5%	2.39	0.77	1.48	0.71
B) Gibberellic acid (G)				
G_1- Control	78.62	18.58	26.48	13.01
G_2- 100 ppm	87.38	22.88	33.94	16.72
G_3- 200 ppm	89.50	19.80	29.59	14.90
G_4- 300 ppm	92.38	19.40	28.95	14.13
G_5- 400 ppm	85.00	18.79	27.65	13.14
‘F’ test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.93	0.30	0.58	0.28
CD at 5%	2.67	0.87	1.65	0.80
C) Interaction effect (AxB)				
‘F’ test	NS	NS	NS	NS
SE (m) ±	1.86	0.60	1.15	1.15
CD at 5%	-	-	-	-

Table 2: Effect of foliar application of humic acid and gibberellic acid on flowering parameters in African marigold (mean pooled data over two year)

Factors	Flowering parameters			
	Days to first flower bud initiation	Days taken for opening of first flower	Days to 50 percent flowering	Duration of flowering
	Pooled	Pooled	Pooled	Pooled
A) Humic acid (H)				
H_1- Control	36.60	45.55	65.27	46.10
H_2- 0.2%	38.25	46.46	63.47	48.89
H_3- 0.4%	38.60	46.74	63.92	48.53
H_4- 0.6%	38.84	46.77	64.15	48.16
‘F’ test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.20	0.20	0.25	0.36

CD at 5%	0.58	0.58	0.71	1.02
B) Gibberellic acid (G)				
G_1- Control	37.75	46.03	65.41	47.85
G_2- 100 ppm	40.98	47.98	61.56	52.78
G_3- 200 ppm	37.89	46.68	64.12	47.68
G_4- 300 ppm	37.84	46.51	64.70	47.33
G_5- 400 ppm	35.89	44.68	65.23	43.96
'F' test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.23	0.23	0.28	0.40
CD at 5%	0.65	0.65	0.79	1.14

Table 3: Interaction effect on flowering parameters as influenced by humic acid and gibberellic acid

Treatment combinations	Flowering parameters			
	Days to first flower bud initiation	Days taken for opening of first flower	Days to 50 percent flowering	Duration of flowering
	Pooled	Pooled	Pooled	Pooled
H_1G_1	36.88	46.20	67.72	45.80
H_1G_2	36.75	45.48	65.33	47.63
H_1G_3	38.00	45.95	63.80	47.71
H_1G_4	36.38	45.72	64.67	46.56
H_1G_5	34.99	44.39	64.83	42.80
H_2G_1	37.73	45.27	63.43	48.83
H_2G_2	41.54	50.05	59.14	56.03
H_2G_3	37.73	46.33	64.47	48.53
H_2G_4	38.10	46.73	64.66	46.63
H_2G_5	36.17	43.95	65.67	44.40
H_3G_1	38.33	46.33	65.60	48.80
H_3G_2	42.37	47.73	60.94	53.90
H_3G_3	37.80	47.37	64.20	47.80
H_3G_4	38.13	46.58	63.80	48.90
H_3G_5	36.37	45.68	65.07	43.27
H_4G_1	38.07	46.33	64.90	47.97
H_4G_2	43.27	48.67	60.83	53.57
H_4G_3	38.03	47.08	64.00	46.68
H_4G_4	38.77	47.03	65.67	47.21
H_4G_5	36.05	44.72	65.35	45.37
F test	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.45	0.45	0.55	0.80
CD at 5%	1.30	1.30	1.58	2.28

Conclusion

The experiment conducted on African marigold showed that the foliar application of humic acid at a concentration of 0.2% and gibberellic acid at 100 ppm at 15 and 30 days after transplanting resulted in the best outcome in terms of growth and flowering parameters. Both treatments showed significant improvements, indicating their potential for enhancing African marigold production.

Therefore, it can be concluded that foliar application of humic acid and gibberellic acid at 15 DAT and 30 DAT is an effective approach to promote the growth and flowering of African marigold during summer season.

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