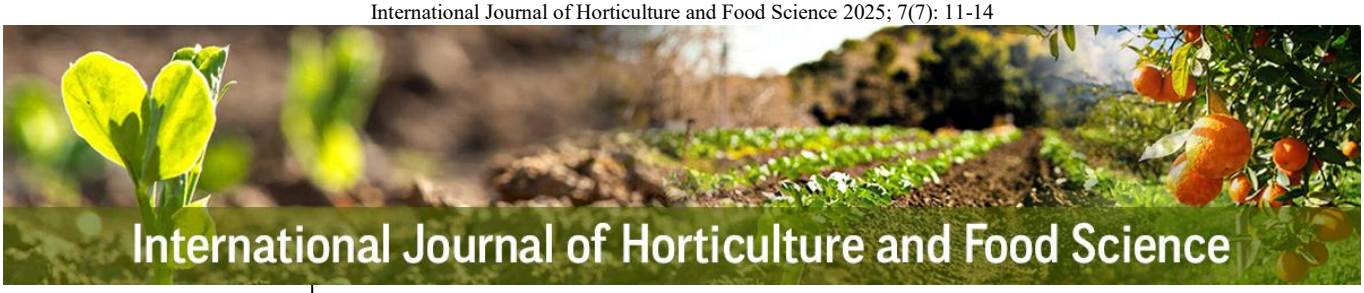

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Effect of foliar application of micronutrients and humic acid on growth and flowering of French marigold (*Tagetes patula*) cv. Local

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Abstract
The experiment entitled, "Effect of micronutrients and humic acid on growth, yield and quality of french marigold (*Tagetes patula* L.) cv. Local" was carried out at the Instructional Farm, Jambuvadi, Department of Floriculture and Landscaping, College of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) in season of *rabi* during the year October 2024 to February 2025. The experiment was laid out in as per Randomized Block Design with factorial concept with three replication and twelve treatment combinations consisting, four levels of micronutrients *i.e.,* M0 (micronutrients grade IV 0%), M1 (micronutrients grade IV 0.5%), M2 (micronutrients grade IV 1%) and M3 (micronutrients grade IV 1.5%) and three levels of humic acid *i.e.,* H0 (humic acid 0%), H1 (humic acid 0.2%) and H2 (humic acid 0.4%). The result of experiment revealed that among the different levels of micronutrients, (M3) micronutrients grade IV (1.5%) recorded better result for the growth and flowering parameters as compared to other treatments. Among the humic acid acid levels, (H2) humic acid (0.4%) recorded better result for the growth and flowering parameters as compared to other treatments. In case of interaction, treatment combination of micronutrients (1.5%) with humic acid (0.4%) well performed in plant height (37.12 cm).

Keywords: French marigold, micronutrients grade IV, humic acid, growth, flowering

Introduction
Marigold (*Tagetes* spp.), a member of the family Asteraceae is one of the most popular and commercial loose flower crop cultivated in India. The two most popularly cultivated species are African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) which have their origin in Mexico and South Africa, respectively. It is popularly known as 'Gainda' in our country. Huge demand of this flower is for garland making and other decorative purposes during various festive occasions that attracts the attention of flower growers in the country as well as of state.

Micronutrients are needed in very small amount. Their concentration in plants are generally below the 100 parts per million (ppm) level. Out of 17 essential elements, Fe, Zn, B, Cu, Mn, Mo although required in very little amount but their importance for the plant is no way less than those of major elements. Due to deficiency of these minor elements the leaves, branches and flower may not grow properly and they may even affect the flower quality as well as production. These elements also help in development of hormone, enzyme, chlorophyll and in the absorption of the major elements.

Humic acid is an organic molecule that plays an essential role in improving soil properties, plant growth, and agronomic parameters. The sources of HA include coal, lignite, soil, and organic materials. Humic acid-based products have been used in crop production in recent years to ensure the sustainability of agriculture production. It also increases crop growth by increasing plant growth promoting hormones such as auxin and cytokinin, which aids in stress resistance, nutrients metabolism and photosynthesis.

Materials and Methods
A field experiment entitled, "Effect of micronutrients and humic acid on growth, yield and quality of french marigold (*Tagetes patula* L.) cv. Local" was carried out at the Instructional

Farm, Jambuvadi, Department of Floriculture and Landscaping, College of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) in season of *rabi* during the year October 2024 to February 2025. The experiment was laid out in as per Randomized Block Design with factorial concept with three replication and twelve treatment combinations consisting, four levels of micronutrients *i.e.,* M0 (micronutrients grade IV 0%), M1 (micronutrients grade IV 0.5%), M2 (micronutrients grade IV 1%) and M3 (micronutrients grade IV 1.5%) and three levels of humic acid *i.e.,* H0 (humic acid 0%), H1 (humic acid 0.2%) and H2 (humic acid 0.4%).

The combination of treatments comprised of (M0H0) Micronutrients grade IV (0%) + Humic acid (0%), (M0H1) Micronutrients grade IV (0%) + Humic acid (0.2%), (M0H2) Micronutrients grade IV (0%) + Humic acid (0.4%), (M1H0) Micronutrients grade IV (0.5%) + Humic acid (0%), (M1H1) Micronutrients grade IV (0.5%) + Humic acid (0.2%), (M1H2) Micronutrients grade IV (0.5%) + Humic acid (0.4%), (M2H0) Micronutrients grade IV (1%) + Humic acid (0%), (M2H1) Micronutrients grade IV (1%) + Humic acid (0.2%), (M2H2) Micronutrients grade IV (1%) + Humic acid (0.4%), (M3H0) Micronutrients grade IV (1.5%) + Humic acid (0%), (M3H1) Micronutrients grade IV (1.5%) + Humic acid (0.2%), (M3H2) Micronutrients grade IV (1.5%) + Humic acid (0.4%). Micronutrients grade IV and humic acid were applied with spray. First spray was done 30 DAT and second spray was done 45 DAT.

Results and Discussion

The effect of different levels of micronutrients grade IV and humic acid with their interaction affect growth and flowering are depicted in Tables 1 and 2.

Growth Parameters

Effect of micronutrients grade IV

The effect of micronutrients grade IV significantly improved the growth parameters such as plant height, plant spread (N-S and E-W). Number of primary branches per plant.

The maximum plant height (34.12 cm), plant spread in N-S (44.89 cm) and E-W direction (38.24 cm), number of primary branches per plant (11.22) were observed in treatment of micronutrients grade IV (1.5%) as compared to other treatments. This might be due to the fact that, FeSO4 and ZnSO4 is known to influence translocation and transcription mechanism of protein biosynthesis, also stimulation of cell division and cell elongation while increasing plasticity of cell wall and formation of energy rich phosphates resulting in an increased plant height with more number of productive branches and plant spread. Similar findings were reported by Chopde *et al*. (2015) in gladiolous, Verma *et al*. (2017) [15] in China aster and Tayade *et al*. (2018) [14] in tuberose.

Table 1: Effect of micronutrients grade IV and humic acid on growth parameters of french marigold

Treatments	Plant height (cm)	Plant spread (cm)		Number of primary branches per plant
		N-S	E-W	
Factor A – Micronutrients grade IV				
M0	26.97	35.85	33.79	8.28
M1	30.55	37.52	35.46	9.04
M2	32.00	38.19	37.40	10.65
M3	34.12	44.89	38.24	11.22
S.Em.±	0.641	1.073	1.022	0.232
C.D. at 5%	1.82	3.05	2.91	0.66
Factor B – Humic acid				
H0	27.90	37.15	34.29	8.64
H1	31.82	39.71	36.70	9.47
H2	33.01	40.47	37.67	11.28
S.Em.±	0.555	0.929	0.885	0.201
C.D. at 5%	1.58	2.64	2.52	0.57
Interaction: M × H				
S.Em.±	1.110	1.858	1.769	0.402
C.D. at 5%	3.16	NS	NS	NS
C.V.%	6.22	8.23	8.46	7.10

Effect of humic acid

The effect of humic acid significantly improved the growth parameters such as plant height, plant spread (N-S and E-W). Number of primary branches per plant.

The maximum plant height (33.01 cm), plant spread in N-S (40.47 cm) and E- W direction (37.37 cm), number of primary branches per plant (11.28) were observed in treatment of humic acid (0.4%) as compared to other treatments. Increase in growth parameters might be due to easy absorption of nutrients, which would promote protein synthesis from reserved carbohydrate leading and regulator activity of humic substances which promote growth could be due to both a direct action of soluble humic complexes and an increase of endogenous hormone concentration in the tissues as a consequence of the inhibition of some catabolic enzymes such as IAA oxidase by soluble humic complexes. Similar findings were also reported by Cacco and Dell' Angola (1984) [4], Sankari *et al*., (2015) [11], Pradeep *et al*., (2014) [9] in Gladiolus, Soad *et al*. (2013) [13] in Gerbera and Mazhar *et al*. (2012) [7].

Interaction effect of micronutrients grade IV and humic acid

The interaction effect of micronutrients and humic acid was observed as significant for plant height. The maximum plant height was found in treatment combination micronutrients grade IV (1.5%) with humic acid (0.4%) (M3H2) (37.12 cm). Similar findings were observed by Shukla *et al*., 2009 [12].

Flowering Parameters

Effect of micronutrients grade IV

The effect of micronutrients grade IV significantly improved the flowering parameters such as number of days taken to first flowering, number of days taken to 50% flowering, diameter of flowers (cm), fresh weight of 10 flowers (g), dry weight of 10 flowers, flowering span (days).

Table 2: Effect of micronutrients grade IV and humic acid on flowering parameters of french marigold

Treatments	Number of days taken to first flowering (days)	Number of days taken to 50% flowering (days)	Diameter of flower (cm)	Fresh weight of 10 flowers (g)	Dry weight of 10 flowers (g)	Flowering span (days)
Factor A – Micronutrients grade IV						
M0	46.98	54.04	3.05	19.22	1.26	40.74
M1	46.63	50.46	3.48	22.78	1.88	42.20
M2	44.82	48.27	3.80	23.78	2.47	44.11
M3	43.50	47.80	4.01	25.07	2.89	45.06
S.Em.±	0.925	1.044	0.090	0.641	0.056	0.901
C.D. at 5%	2.63	2.97	0.26	1.82	0.16	2.56
Factor B – Humic acid						
H0	46.85	51.34	3.13	21.68	1.91	41.76
H1	46.14	50.89	3.60	22.64	2.10	42.69
H2	43.46	48.19	4.02	23.81	2.37	44.64
S.Em.±	0.801	0.904	0.078	0.555	0.048	0.780
C.D. at 5%	2.28	2.57	0.22	1.58	0.14	2.22
Interaction: M × H						
S.Em.±	1.602	1.807	0.156	1.110	0.096	1.560
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V.%	6.10	6.24	7.56	8.46	7.85	6.28

The minimum number of days taken to first flowering (43.5 days), number of days taken to 50% flowering (47.8 days), diameter of flower (4.01 cm), fresh weight (25.07 g) and dry weight (2.89 g) of 10 flowers, flowering span (45.06 days) were observed in treatment of micronutrients grade IV (1.5%) as compared to other treatments. This might be due to iron application which enhanced the flowering parameters, relieved the plant from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of flower growth which may in turn increased the flower production and ultimately yield. Micronutrients grade IV play a vital role in production of vegetative growth and ultimately encouraged the number of primary branches, secondary branches, leaves and shoots of plants by involving in oxidation-reduction process and photosynthesis process. This in turn leads to increase in fresh weight and dry weight of the flower. Similar results were also reported by Balkrishnan *et al*. (2005) in marigold, Kakade *et al*. (2009) [6], Verma *et al*. (2017) [15] in china aster, Muthumanickam *et al*. (1999) [8] in gerbera and Sabale *et al*. (1992) [10] in rose.

Effect of humic acid

The effect of humic acid significantly improved the flowering parameters such as number of days taken to first flowering, number of days taken to 50% flowering, diameter of flowers (cm), fresh weight of 10 flowers (g), dry weight of 10 flowers, flowering span (days).

The minimum number of days taken to first flowering (43.46 days), number of days taken to 50% flowering (48.19 days), diameter of flower (4.02 cm), fresh weight (23.81 g) and dry weight (2.37 g) of 10 flowers, flowering span (44.64 days) were observed in treatment of humic acid (0.4%) as compared to other treatments. This might be due to humic acid improves nutrient availability to plants, particularly for essential nutrients like nitrogen, phosphorus and potassium. Also, it can promote the production of cholorophyll and sustain photosynthetic tissues, leading to increased flower diameter all contributing to a higher fresh weight and thus increasing the dry weight of flower. Also, humic acid acts like a natural plant growth regulator by stimulating the synthesis of auxins, cytokinins and gibberellins which influences flowering positively. Cytokinin delay senescence, thus extending the life of flowers. Also, reduced stress leads to healthier flowers and longer bloom periods. Similar results were also reported by Boogar *et al.* (2014) [3] and Ambreen *et al*., (2014) [1].

Interaction effect of micronutrients grade IV and humic acid

The interaction effect of micronutrients grade IV and humic acid on number of days taken to first flowering, number of days taken to 50% flowering, diameter of flowers (cm), fresh weight of 10 flowers (g), dry weight of 10 flowers, flowering span (days) was found non-significant at different levels of treatment.

Conclusion

On the basis of experimental data, it can be concluded that among different levels of micronutrients, (M3) micronutrients grade IV (1.5%) recorded better result for the growth and flowering parameters and among the humic acid acid levels, (H2) humic acid (0.4%) recorded better result for the growth and flowering parameters. Thus it can be concluded that application of micronutrients grade IV (1.5%) with humic acid (0.2%) is best for growth and flowering parameters of french marigold.

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