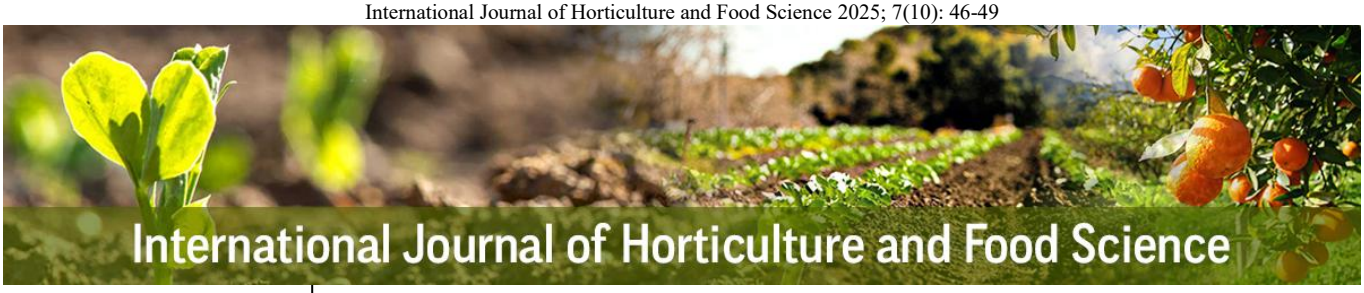

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Effect of pinching and micronutrients on African marigold

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Abstract
The experiment on "Effect of pinching and micronutrients on African marigold (*Tagetes erecta* L.)" was carried out at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The experiment was laid out in Randomized Block Design (RBD) with factorial concept replicated thrice with fourteen treatment combinations, consisting two levels of pinching *viz*., single pinching at 25 DAT (P_1) and double pinching at 25 and 45 DAT (P_2) and seven levels of micronutrients *viz*., $ZnSO_4$ @ 0.5% (M_1), $FeSO_4$ @ 0.5% (M_2), H_3BO_3 @ 0.5% (M_3), $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% (M_4), $ZnSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_5), $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_6) and $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7).
Single pinching produced maximum plant height (107.43 cm), minimum days to first flower bud appearance (45.98), days to 50 per cent flowering (66.73), flower diameter (5.24 cm) and fresh weight of single flower (6.92 g). While, double pinched plants produced maximum number of primary branches (17.91), stem diameter (1.98 cm), plant spread (63.85 cm in E-W and 65.08 cm in N-S directions) at 90 DAT, duration of flowering (93.33 days), number of flower per plant (126.71), flower yield (552.57 g/plant, 7.42 kg/plot and (15.46 t/ha) along with better flower longevity and shelf life of flowers (22.19 and 4.43 days, respectively).
Similarly, combined foliar application of micronutrients as $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7) was found best for all the growth attributes as well as flowering parameters under study. It also recorded maximum number of flowers per plant (131.83) and higher flower yield (593.63 g/plant, 8.16 kg/plot and 16.99 t/ha).
So, it can be concluded that double pinching (P_2) done at 25 and 45 DAT and foliar application of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7) at 30 and 50 DAT enhanced all vegetative and flowering parameters along with yield of African marigold var. Punjab Gainda 1.

Keywords: African marigold, pinching and micronutrients

Introduction
In India, marigold is one of the most important hardy flower crops which is commercially grown and used extensively on religious and social functions in different forms as well as in landscaping. It has gained popularity amongst gardeners and flower dealers on account of its easy cultivation and wide acceptability. Its profuse flowering habit, short duration to produce marketable flowers, wide spectrum of attractive colours, shape, size and good keeping quality attracted the attention of producers and traders most. Flowers are sold in the market in loose or as garlands. In marigold important practices like pinching i.e. removal of terminal portion of about 2 to 3 cm is done to remove apical dominance and for enhancing lateral growth which in terms increases flower production. In case of tall cultivars of African marigold, the plant first grows to its full height and later produces axillary branches. If apical portion is removed at an early stage of formation, a large number of lateral shoots arise resulting in well-shaped bushy plant bearing more number of uniform flowers. Double pinching can also be done especially during *kharif* season as the growth of the plant is very fast and vigorous.
Nutrients as well as micronutrients are also the key elements for growth and development of plants. Micronutrient play a vital role in various enzymatic activities and synthesis of assimilates and hormones. Their acute deficiencies some time causes the problem of incurable nature (Kumar, 2000). These micronutrients also help in the uptake of major nutrients and play an active role in the plant metabolism process like cell wall development, respiration, photosynthesis, chlorophyll formation, enzymatic activity, hormone synthesis,

nitrogen fixation, *etc*., (Das, 2003) [1]. Among micronutrients, zinc is important for the formation and activity of chlorophyll and in the functioning of several enzymes. It is an important constituent of tryptophane, a precursor of growth hormone (auxin). It is also essential for the transformation of carbohydrates and regulates consumption of sugars (Kavitha *et al.,* 2000) [7]. Plants also need iron to produce chlorophyll and to activate several enzymes including those involved in the oxidation/reduction processes during photosynthesis and respiration. It also provides link between enzyme and substrate (Kumar, 2000). Boron is another one of the important nutrients required for cell division and development in the growth region of the plant especially near the tips of shoots and roots. It aids production of sugar and carbohydrates. It also affects sugar transport and appears to be associated with some of the functions of calcium. In view of considering the above facts, the present investigation was planned to study the effect of pinching and micronutrients on vegetative growth, flowering and yield parameters of African marigold (*Tagetes erecta* L.).

Materials and Methods

The experiment was carried out at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The experiment was laid out in Randomized Block Design (RBD) with factorial concept replicated thrice with fourteen treatment combinations, consisting two levels of pinching *viz*., Single pinching at 25 DAT (P_1) and Double pinching at 25 and 45 DAT (P_2) and seven levels of micronutrients *viz*., $ZnSO_4$ @ 0.5% (M_1), $FeSO_4$ @ 0.5% (M_2), H_3BO_3 @ 0.5% (M_3), $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% (M_4), $ZnSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_5), $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_6) and $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7). The seeds of var. Punjab Gainda 1 were sown on the raised beds of 3.0 m x 1.0 m x 0.5 m size at 1-2 cm deep and were properly covered with vermicompost to ensure quick germination in nursery. Seedlings were then transplanted at 30 DAS and all the standard practices were followed as per requirement of crop. Pinching was done by removing the apical portion of the plants at 25 and 45 DAT according to the treatments while foliar spray of all the above micronutrients was done twice at 30 and 50 days after transplanting of seedlings. The growth parameters were recorded at 90 DAT and the data collected for all the characters were subjected to the statistical analysis by adopting 'Analysis of Variance' technique as described by Panse and Sukhatme (1985) [12].

Results

Effect of pinching

It is evident from the data as presented in Table-1 and 2 that single pinched plants produced maximum plant height (107.43 cm) after 90 days of transplanting, minimum days to first flower bud appearance (45.98), days to 50 per cent flowering (66.73), flower diameter (5.24 cm) and fresh weight of single flower (6.92 g). It might be due to removal of apical meristematic tissue which inhibited the apical dominance and diverts plant metabolites from vertical to horizontal growth. These results are in close agreement with the findings of Dweepjyoti *et al*. (2018) [2], Sheena *et al*. (2017) [15], Maharnor *et al*. (2011) [10] and Mohanty *et al*. (2015) [11] in marigold.

Whereas, double pinched plants produced maximum number of primary branches (17.91), stem diameter (1.98 cm), plant spread (63.85 cm in E-W and 65.08 cm in N-S directions), duration of flowering (93.33 days), number of flowers per plant (126.71), flower yield (552.57 g/plant, 7.42 kg/plot and 15.46 t/ha) along with better flower longevity and shelf life of flowers (22.19 and 4.43 days, respectively). It might be due to the fact that pinching reduces the plant height and encourages the side branches due to removal of apical dominance, as the apical dominance is removed usually the plant itself adjusts to encourage the growth of auxiliary buds, which may be converted into branches. This might have favoured in increasing the stem diameter, number of primary branches and plant spread. The results of present investigation are also in confirmation with findings of Sheena *et al*. (2017) [15], Maharnor *et al*. (2011) [10] and Singh *et al*. (2017) [17] in marigold.

Effect of micronutrients

Vegetative parameters were significantly influenced by foliar application of different micronutrients and their combinations (Table-1). Maximum plant height (108.77 cm), number of primary branches (18.30), stem diameter (2.06 cm) and plant spread in E-W direction (66.97 cm) as well as in N-S direction (68.00 cm) at 90 DAT were observed with the foliar application of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7). It might be due to the combine application of micronutrients that can be attributed to improved root system of plants, resulting in absorption of more water and nutrients and its utilization. Moreover, micronutrients activate several enzymes (catalase, peroxidase, alchohol, dehydrogenase, carbonic dehydrogenize, tryptophane synthates *etc*.) and involved themselves in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged (Kumar and Arora, 2000 in gladiolus). These findings are also in accordance with Patokar *et al*. (2017) [13], Gupta and Kumar (2015) [3] in marigold, Saini *et al.* (2015) [14] and Karuppaiah (2014) [6] in chrysanthemum, Kakade *et al*. (2009) [5] in China aster.

Further an early flower bud appearance (46.17 days) as well as days to 50 percent flowering (64.47), maximum flowering duration (96.25 days), flower diameter (5.62 cm), fresh weight of single flower (7.80 g), number of flowers per plant (131.83), flower yield (593.63 g/plant, 8.16 kg/plot and 16.99 t/ha), flower longevity (23.83 days) and shelf life (5.00 days) of flowers were also found with M_7, (Table-2) which might be due to enhanced growth and development of plants as micronutrients favours the storage of more carbohydrates through photosynthesis, involves in synthesis of plant hormones, plays an important role in chlorophyll synthesis, respiration, enhanced cell division and cell enlargement, promotes protein synthesis coupled with higher dry matter production, improves translocation of carbohydrates, water, amino acid and mineral from source to sink particularly on flower and also play a vital role in the growth and reduced the amount of ethylene and abscisic acid as a result of which recorded better flower life. Similar results are also obtained by Hussain *et al.* (2020) [4], Shyala *et al.* (2019) [16], Patokar *et al*. (2017) [13] and Gupta and Kumar (2015) [3] in marigold,

Interaction effect

It is evident from the data that the interaction effect of different pinching and micronutrients treatments was found non-significant on all growth, flowering and yield parameters.

Table 1: Effect of pinching and micronutrients on growth parameters of African marigold

Treatments	Plant height (cm)	No. of primary branches per plant	Stem diameter (cm)	Plant spread (E-W) (cm)	Plant spread (N-S) (cm)
Pinching (P)					
P_1: Single pinching at 25 DAT	107.43	16.04	1.87	60.23	61.57
P_2: Double pinching at 25 and 45DAT	93.30	17.91	1.98	63.85	65.08
S.Em. ±	1.83	0.32	0.03	1.14	1.17
C.D. at 5%	5.33	0.92	0.08	3.33	3.40
Micronutrients (M)					
M_1: $ZnSO_4$ @ 0.5%	99.70	17.13	1.85	59.73	60.47
M_2: $FeSO_4$ @ 0.5%	100.00	17.10	1.87	69.63	61.00
M: H_3BO_3 @ 0.5%	90.47	14.90	1.79	57.07	58.57
M_4: $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	102.70	17.37	1.99	64.33	66.67
M_5: $ZnSO_4$ @ 0.5% + H_3BO_3 @ 0.5%	100.20	17.17	1.94	63.07	64.67
M_6: $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5%	100.73	16.87	1.96	63.47	63.90
M_7: $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% H_3BO_3 @ 0.5%	108.77	18.30	2.06	66.97	68.00
S.Em. ±	3.43	0.59	0.05	2.14	2.19
C.D. at 5%	9.97	1.73	0.15	6.22	6.36
Interaction Effect (P X M)					
S.Em. ±	4.85	0.84	0.08	3.03	3.09
C.D. at 5%	NS	NS	NS	NS	NS
C.V.%	8.37	8.57	6.78	8.45	8.46

Table 2: Effect of pinching and micronutrients on flowering and yield parameters of African marigold

Treatments	Days to first flower bud appearance	Days to 50% flowering	Duration of flowering (days)	Flower diameter (cm)	Fresh weight of single flower (g)	No. of flowers/ plant	Flower yield/ plant (g)	Flower yield/ plot (kg)	Flower yield/ hectare (t)	Flower longevity (days)	Shelf life (days)
Pinching (P)											
P_1: Single pinching at 25 DAT	45.98	66.73	83.15	5.24	6.92	98.38	481.11	6.09	12.69	20.76	4.05
P_2: Double pinching at 25 and 45DAT	56.22	76.36	93.33	4.97	6.35	126.71	552.58	7.42	15.46	22.19	4.43
S.Em. ±	0.95	1.30	1.61	0.09	0.13	1.99	9.31	0.17	0.35	0.37	0.10
C.D. at 5%	2.76	3.79	4.69	0.27	0.38	5.79	27.06	0.49	1.02	1.06	0.30
Micronutrients (M)											
M_1: $ZnSO_4$ @ 0.5%	50.80	72.27	88.20	5.07	6.67	109.00	487.68	6.32	13.16	21.50	4.17
M_2: $FeSO_4$ @ 0.5%	50.67	71.37	88.97	5.12	6.55	106.83	488.85	6.31	13.16	21.33	4.17
M_3: H_3BO_3 @ 0.5%	55.42	77.63	79.93	4.55	5.72	95.17	435.35	5.23	10.91	19.17	3.50
M_4: $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	50.17	71.20	89.33	5.15	6.48	119.17	541.92	7.16	14.92	21.50	4.33
M_5: $ZnSO_4$ @ 0.5% + H_3BO_3 @ 0.5%	52.50	72.30	87.30	5.20	6.50	109.67	529.75	7.01	14.61	21.67	4.17
M_6: $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5%	51.97	71.60	87.70	5.02	6.75	116.17	540.73	7.10	14.79	21.33	4.33
M_7:$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% H_3BO_3 @ 0.5%	46.17	64.47	96.25	5.62	7.80	131.83	593.63	8.16	16.99	23.83	5.00
S.Em. ±	1.77	2.44	3.02	0.17	0.25	3.73	17.41	0.31	0.65	0.68	0.19
C.D. at 5%	5.16	7.09	8.78	0.50	0.71	10.84	50.62	0.91	1.90	1.99	0.57
Interaction Effect (P X M)											
S.Em. ±	2.51	3.45	4.23	0.24	0.35	5.27	24.619	0.44	0.93	0.97	0.28
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	8.51	8.35	8.38	8.24	9.04	8.11	8.25	11.40	11.39	7.80	11.24

Conclusion

On the basis of the results obtained in the present investigation it may be concluded that double pinching (P_2) and foliar application of $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% + H_3BO_3 @ 0.5% (M_7) enhanced all vegetative and flowering parameters along with yield thus found best for production of African marigold var. Punjab Gainda 1.

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