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Effect of Starter Solution, Micronutrient Mixture and Humic Acid on Growth, Flowering and Yield of African Marigold (*Tagetes erecta* L.)

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ABSTRACT: The present investigation was conducted at the Herbal Garden, College of Agriculture, Raichur was initiated during late *rabi* 2021-22. The experiment was carried out with eight treatments comprising of starter solution, micronutrient mixture and humic acid was laid in Randomized Block Design and replicated thrice. The absorption of nutrients by roots from soil is adversely affected after transplanting thereby causing reduced growth and mortality of seedlings which are the main handicaps in successful floriculture. Commercial exploitation of the flowers for xanthophylls extraction has made this flower crop much more popular among the flower growers and industries. An optimum and balanced level of liquid nutrients and biostimulant are necessary for optimum growth and higher production of quality flowers. The results of the study indicated that application of starter solution at 0.5% and foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% (T_8) recorded taller plants, number of branches per plant, number of leaves per plant and larger leaf area. Minimum number of days for flower initiation, 50 per cent flowering, number of flowers per plant, test weight (10 flowers), duration of flowering and flower yield per hectare. Results confirmed that improved growth and flowering of African marigold *cv*. Pusa Narangi Gainda.

Keywords: Foliar spray, starter solution, flower yield, micronutrients.

INTRODUCTION

Marigold is one of the commercially exploited flower crops, cultivated as flowering annual in different states and latter for its high content of essential oil. *Tagetes erecta* and *Tagetes patula* are more commonly grown for the ornamental values. *Tagetes erecta* (African marigold) has wider adaptability to various growing conditions, short duration, free flowering nature, ease of growing and good keeping quality compared to other flowering annuals. Marigold is grown for loose flower production and it has great demand during various festivals for garland and decorative purposes (De and Bhattacharjee, 2011). Commercially flowers are used in pigment extraction industry and in dry flower making, being natural source of carotenoids, oleoresins and natural dyes (Raghava, 2000). Transplanting young seedlings to main field disturbs the soil root relationship. The absorption of nutrients by roots from soil is adversely affected, thereby causing reduced growth and mortality of seedlings. All plants require more or less the same minerals to complete their life cycle, yet, an optimum and balanced level of nutrients is necessary for optimum growth and higher production of quality flowers. Starter solutions is dilute solution of fertilizer applied to plants immediately after transplanting. The basic purpose is to provide the nutrients to the young plants before the establishment of root system. They are utilized to give higher survival rate and early renewed growth of plants. Liquid NPK (Nitrogen, Phosphorus, Potassium) supplements as starter solutions can boost early growth with survival rate of seedlings. Besides the use of major nutrient fertilizers to increase crop yield, micronutrient is of the latest origin in flower crops. Many crops are found to respond well to the application of small quantities of these micronutrients. Micronutrient mixture are needed in very small amounts. Micronutrient mixture is involved in all metabolic and cellular functions. Plant differs in their need of micronutrient mixture like boron, iron, zinc, copper, chlorine, manganese, molybdenum and nickel. Improvement in growth characters due to micronutrient application might basically due to enhanced photosynthetic and other metabolic activities related to cell division and cell elongation as opined by Hatwar *et al.* (2003). The use of humic acid and chemical fertilizers which improves nutrient absorption. It produces visibly better and healthier plant growth and increased the flower yield and quality of flowers. In this view, this experiment was conducted to study the effect of Nutrient management to enhance growth and flower yield of African marigold (*Tagetes erecta* L.).

MATERIAL AND METHODS

A field experiment was conducted during *rabi* 2021-22 at Herbal Garden, Main Agricultural Research Station, UAS, Raichur Karnataka (16º15´N, 77º20´ E, altitude 389 m). The experiment was laid out in red sandy clay loam soil. The soil was low available nitrogen (145.46 kg ha^{-1}), phosphorus (30.23 kg ha^{-1}) and potassium (229.01 kg ha^{-1}) with pH of 7.31. The experiment was laid out in randomized block design (RBD) with three replications. The treatments were consisting of starter solution (0.5%), foliar application of micronutrient mixture (0.25%) and humic acid (0.2%). The starter solution of 19:19:19 (NPK) were applied @ 250 ml per plant immediately after transplanting to the root zone of plants. Micronutrient mixtureand Humic acid were sprayed on the 25th and 50th days after transplanting. The recommended rate of NPK (225:60:60 kg ha^{-1}) was applied in the form of urea, diammonium phosphate and muriate of potash. At the time of transplanting, half of the dose of N and the full dose of P_2O_5 and K_2O were applied in a circular band. The remaining half dose of nitrogen was applied to the soil 40 days after transplanting. The marigold seedlings were transplanted at 60 × 45 cm spacing in ridges and furrows on October 08, 2021. From randomly tagged five plants, plant height, number of branches, number of leaves and leaf area were measured. The observation on flowering and yield was recorded at flower initiation, 50 percent flowering, number of flowers per plant, test weight (10 flowers), duration of flowering and flower yield per hectare. The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fischer's method of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' test was P=0.05.

RESULT AND DISCUSSION

A. Plant height

African marigold was significantly influenced by starter solution, foliar application of micronutrient mixture and humic acid (Table 1). Application of Starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% was recorded significantly taller plants. Significantly dwarf plants of marigold were recorded in control. Taller plants in starter solution at 0.5%, foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% was due to the beneficial effects of dilute liquid starter solution in combination with micronutrient mixture and humic acid as they play important role in several metabolic activities and thereby favoring plant growth through easy availability of nutrients and improves root growth and stimulation of auxiliary buds. This also attribute to the availability of nitrogen in the starter solution which promoted vegetative growth starting from the early stage was also reported by Abedini *et al.* (2015); Kabariel *et al.* (2016) in marigold.

B. Number of branches per plant

Application of starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2% has exhibited significantly maximum number of branches per plant in marigold (17.4 at 120 DAT), which was on par with application of Foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% (15.4 at 120 DAT). Minimum number of branches per plant (13.1) were recorded in control. More branches might have attributed to adequate availability of needed micronutrient mixture and plant biostimulant into the plant applied with starter solution, micronutrient mixture and humic acid. It was also due to the humic acid rise in chlorophyll content, leaf N, P, K content, and K concentration leading to an increased number of branches. This also might be due quicker availability of needy nutrients from the starter solution accelerated the process of cell division and differentiation. Similar results with the findings of Jat *et al*. (2007) in marigold and Azza *et al*. (2012) in chrysanthemum.

C. Number of leaves per plant

Marigold at various growth stages was significantly affected by the application of starter solution, foliar application of micronutrient mixture and humic acid (Table 1). Application of starter solution at 0.5%, foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% was recorded significantly maximum number of leaves per plant in marigold (108.7 at 120 DAT). However, it was found on par with the application of Foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% (105.3 at 120 DAT). Significantly minimum number of leaves per plant was observed in control (87.1 at 120 DAT). The maximum leaves were recoded because of more nitrogen available, which is a crucial component of proteins and chlorophyll that are needed for photosynthesis. There were also more growth-promoting substances due to the action of micronutrient mixture and humic acid. Similar trend of increased number pf leaves per plant were also recorded by Pandey *et al*. (2010) in chrysanthemum.

D. Leaf area per plant

Application of starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2% has exhibited significantly maximum leaf area per plant in marigold (6.4 dm^2 at 120 DAT), which was on par with application of Foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% (6.2 dm^2 at 120 DAT). Minimum leaf area per plant (4.9 dm^2 at 120 DAT) was recorded in control. Micronutrient mixture and humic acid had a substantial impact on the maximum leaf area by boosting the absorption of ions, allowing the dispersion of heavy metals as chelates inside the plant, and influencing metabolic processes as well as the high water and mineral consumption of plants. When Zn is increased from insufficient to sufficient, leaf extension increases, demonstrating the significance of Zn in the generation of auxin.

Cytokines and gibberellins, two plant growth hormones, encourage leaf expansion and result in an increase in leaf area. Similar results were reported by Patil and Agasimani (2013) in China aster.

E. Days required for initiation and 50 percent flowering

Marigold were6influenced by application of starter solution, foliar spray of micronutrient mixture and humic acid is showed in Table 2. Minimum days taken for flower initiation (30.2 days) and 50 percent flowering (45.0 days) was noticed in application of starter solution at 0.5%, foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2%. Control treatment has recorded maximum number of days taken for flower initiation (37.3 days) and 50 percent flowering (51.5 days). This might be due to the early recovery of plants from transplanting shock through easy availability of major nutrients The increased uptake of NPK might have resulted in a rapid acceleration in- development of vegetative growth parameters leading to early cessation of vegetative growth and floral primordial development which consequently led to early flower initiation and production of 50 percent flowering. Similar results were recorded by Rathi *et al*. (2005) in marigold and Palanisamy *et al*. (2015) in gerbera.

F. Number of flowers per plant

Application of starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2% has exhibited significantly maximum number of flowers per plant (54.4), which was on par with application of Foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% (52.8). The control treatment recorded significantly least number of flowers per plant (47.2) as compared to other treatments (Table. 3). Maximum number of flowers per plant might be due to increased concentration of carbohydrates and their translocation from the leaves to the developing flower buds and production of higher number of flowers per plant. It was also due to application of zinc which plays vital role for extended vegetative growth, pollen function, fertilization, metabolism of RNA, proteins and DNA formation. These results could paint in the same direction of Nag *et al.* (2003) in marigold and Saba *et al*. (2014) in zinnia.

G. Test weight of flowers

The significantly higher test weight of flowers (79.5 g) was recorded in the treatment T_8 as compared to other treatments. The treatments T_7 (74.4 g) and T_6 (73.6 g) were found on par with T_8. The minimum test weight of flowers (67.1 g) was observed in control. The increased test weight may be attributed to the better uptake of nutrients especially nitrogen is the chief constituent of protein and protoplasm which leads to cell division, cell enlargement and ultimately resulted in increased plant growth and higher accumulation dry matter, which might have resulted in more diversion of photo assimilates to the developing flower buds leading to increased flower weight. The increment of flower weight might also be due to the association of zinc in regulating semi permeability of cell walls, thus mobilizing more water into flower and increasing the size of the flowers. These results are in accordance to Mona *et al.* (2002) in marigold and Khosa *et al.* (2011) in gladiolus.

H. Flowering duration

The longest flowering duration (78.8 days) was significantly recorded in T_8 than other treatments except T_7. The shortest flowering duration (66.6 days) was recorded T_1 (control) treatment. The longer duration of flowering might be due to higher uptake of N, P, and K and their utilization might have produced more photosynthates consequently leading to longer flower duration. Balanced nutrition is of considerable importance in improving the yield and duration of flowering, and higher production of auxin and growth substances by humic acid at early phase of growth would have contributed to early flowering and the duration of flowering. This might be due to beneficial effects of zinc on the physiological and other activities of the plant, thereby lengthening the duration. Similar findings were recorded by Katiyar *et al.* (2005) in gladiolus and Chopde *et al.* (2015) in marigold.

I. Flower yield

Application of starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2% has exhibited significantly maximum flower yield (13.2 t ha^{-1}) over other treatments except T_7. Increase in growth parameters which might have increased the flower production in African marigold. The rich source of macro and micronutrient mixture like Fe, Zn, enzymes, growth hormones and beneficial effects of microflora might have played a role in producing more number of flowers, which resulted in increased number of flowers per plant and lead to a maximum number of harvest and more number of flowers per square meter and ultimately increases flower yield. This might be due to influence of zinc on the synthesis of growth promoting substances and at the same time it monitors enzymatic activity within the plant which is ultimately on the yield. Flower yield results might be due to the superiority of vegetative growth might have led to the higher productivity and good quality of flowers in marigold, leading to production of maximum number of flowers per plant, maximum diameter of flowers, long duration of flowering and higher flower yield per plant. Similar findings were reported by Aruna *et al*. (2007) in crossandra.

Table 1: Effect of nutrient management on vegetative parameters.

Treatment Details		Plant height (cm)	Number of branches / plants	Number of leaves / plants	Leaf area (dm^2)
T_1	Control	90.1	13.1	87.1	4.9
T_2	Starter solution at 0.5%	92.5	13.8	96.0	5.8
T_3	Foliar spray of micronutrient mixture at 0.25%	90.1	14.1	97.0	5.6
T_4	Foliar spray of Humic acid at 0.2%	91.8	13.7	104.3	5.5
T_5	Starter solution at 0.5% and Foliar spray of micronutrient mixture at 0.25%	97.1	15.3	97.7	5.7
T_6	Starter solution at 0.5% and Foliar spray of humic acid at 0.2%	91.0	15.3	101.7	5.6
T_7	Foliar spray of Micronutrient mixture at 0.5% and humic acid at 0.2%	94.5	15.4	105.3	6.2
T_8	Starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2%	99.0	17.4	108.7	6.4
Mean		**93.3**	**14.8**	**99.7**	**5.7**
S.Em. ±		1.75	0.88	2.45	0.25
CD @ 5%		5.31	2.68	7.50	0.77

Table 2: Effect of nutrient management on flowering of African marigold.

	Treatment Details	Flower budinitiation	50 percent Flowering
T_1	Control	37.3	51.5
T_2	Starter solution at 0.5%	30.3	45.2
T_3	Foliar spray of micronutrient mixture at 0.25%	31.3	45.3
T_4	Foliar spray of Humic acid at 0.2%	34.0	46.6
T_5	Starter solution at 0.5% and Foliar spray of micronutrient mixture at 0.25%	32.6	45.6
T_6	Starter solution at 0.5% and Foliar spray of humic acid at 0.2%	33.3	46.0
T_7	Foliar spray of Micronutrient mixture at 0.5% and humic acid at 0.2%	31.0	45.6
T_8	Starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2%	30.2	45.0
Mean		**32.5**	**46.3**
S.Em. ±		1.51	1.13
CD @ 5%		4.57	3.44

Table 3: Effect of nutrient management on yield and yield attributes.

Treatment Details		Number of flowers	Test weight (g)	Duration of flowering (days)	Yield (t/ha)
T_1	Control	47.2	67.1	66.6	8.2
T_2	Starter solution at 0.5%	50.3	68.9	67.3	10.1
T_3	Foliar spray of micronutrient mixture at 0.25%	51.6	68.8	70.8	9.4
T_4	Foliar spray of Humic acid at 0.2%	50.9	72.5	70.3	10.4
T_5	Starter solution at 0.5% and Foliar spray of micronutrient mixture at 0.25%	50.4	69.5	67.3	11.6
T_6	Starter solution at 0.5% and Foliar spray of humic acid at 0.2%	51.0	73.6	70.3	10.7
T_7	Foliar spray of Micronutrient mixture at 0.5% and humic acid at 0.2%	52.8	74.4	75.6	11.7
T_8	Starter solution at 0.5%, Foliar spray of micronutrient mixture at 0.25% and humid acid at 0.2%	54.4	79.5	78.8	13.2
Mean		**51.1**	**71.8**	**65.9**	**10.7**
S.Em. ±		0.57	1.93	2.23	0.57
CD @ 5%		1.76	5.84	6.77	0.74

CONCLUSIONS

It is concluded that the treatment combination of starter solution at 0.5%, foliar spray of micronutrient mixture at 0.25% and humic acid at 0.2% has resulted in better vegetative parameters like plant height, number of branches, number of leaves and leaf area per plant. Also, early flower initiation, 50 percent flowering, number of flowers per plant, test weight (10 flowers), duration of flowering and flower yield per hectare was noticed in the same treatment.

FUTURE SCOPE

1. There is a need of testing the starter solution in combination with humic acid as a seedlings dip.
2. There is a need of studying the use of micronutrients of different concentrations in flower crops.

3. There is a need of assessing the use of biofertilizers along with starter solution.

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