Effect of Micro - Nutrients and KNO₃ on Vegetative Growth, Flower Yield and Pigments of Tagetes erecta cv. ‘Pusa Narangi’

K.K. Dhatt, S. Bhandari and T. Thakur*

Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, Punjab, India

*Corresponding author

ABSTRACT

The present study was carried to standardize the dose of micro - nutrients and KNO₃ for improving vegetative growth, flower yield and pigment production of Tagetes erecta cv. ‘Pusa Narangi’. The seedlings were sprayed with different combinations of micro - nutrients and KNO₃ treatments after one month of transplanting. The results showed that minimum time to bud initiation and anthesis was recorded under KNO₃ + FeSO₄ @ 1.25% + 0.5% i.e. 52.00 days and 70.67 days, respectively. The longest flowering duration of 62.50 days was recorded in KNO₃ + FeSO₄ @ 1.25% + 0.5%. The maximum plant height (77.33 cm) was recorded in KNO₃ (1.25%) and maximum plant spread (69.04 cm) was observed in ZnSO₄ + MgSO₄ @ 0.5%. The maximum flower yield/plant (357.78g) and flower yield/m² (2.23 kg) was recorded under KNO₃ @ 1.25%. The treatment KNO₃ @1.25% produced bigger flowers (6.69 cm) with longer stalk length of 6.93 cm and higher flower weight 7.27 g. The maximum chlorophyll content of 2.040mg/g was recorded in FeSO₄ + ZnSO₄ (0.5% + 0.5%) and xanthophyll content in FeSO₄ + Na₂MoO₄ @ 0.5%.

Keywords
Marigold, Micro - nutrients, Foliar spray, KNO₃, Pigments

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Introduction

Marigold (Tagetes spp.) is one of the common commercial flowers which are grown for its ornamental beauty, bright colour and delightful appearance. It gained popularity because of adaptability to various soil, climatic condition and longer blooming period. Nowadays marigold is being used as bedding plant and commercially cultivated for loose flowers, as a source of carotenoid pigment and for extraction of xanthophylls. The flowers of marigold are rich source of a natural yellow to orange dye which is in high demand by national and international companies. Integrated supply of micro - nutrients with macro - nutrients in adequate amount and suitable proportions is one of the most important factors that control the plant growth in flowering crops. Marigold is a heavy feeder of nutrients specially nitrogen and phosphorus (Nalawadi, 1982). Marigold crop respond well to micro - nutrients like iron and zinc. The available information regarding
the impact of micro - nutrients on flower crops is scanty (Ganesh et al., 2013). Foliar application of micro - nutrients had been found effective in overcoming the deficiencies in gladiolus (Arora and Nayyar, 1992). Though the African marigold is one of the important commercial flower crops of India, its yield levels are quite low and hence, there is a need to standardize the optimum dose of micro - nutrients and KNO3 for improving the soil structure, physico - chemical properties and flower yield. Varieties of micro - nutrients in soluble form are available these days which are directly sprayed on the leaves of plants. As these are readily absorbed and utilized more efficiently. Improvement in growth characters due to micro - nutrient application might be due to enhanced photosynthetic and other metabolic activities related to cell division and elongation (Hatwar et al., 2003). The present study was planned to standardize the dose of micro - nutrients and KNO3 for improving plant growth and flower production of marigold.

Materials and Methods

The present investigation was carried in Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, during 2013 - 2014. Four week old seedlings of marigold were transplanted during 1st week of January 2014 at 40 x 40 cm spacing. The experiment consisted of 16 treatments viz., ZnSO4 - 0.5%, FeSO4 - 0.5%, MgSO4 - 0.5%, Na2MoO4 - 0.5%, KNO3 - 1.25%, FeSO4 + ZnSO4 - 0.5% + 0.5%, ZnSO4 + MgSO4 - 0.5% + 0.5%, MgSO4 + Na2MoO4 - 0.5% + 0.5%, FeSO4 + MgSO4 - 0.5% + 0.5%, FeSO4 + Na2MoO4 - 0.5% + 0.5%, ZnSO4 + Na2MoO4 - 0.5% + 0.5%, ZnSO4 + KNO3 - 0.5% + 1.25%, KNO3 + FeSO4 - 1.25% + 0.5%, KNO3 + MgSO4 - 1.25% + 0.5%, KNO3 + Na2MoO4 - 1.25% + 0.5% and control. There were three replications in each treatment and experiment was laid out in Randomized Block Design (RBD). The seedlings of cultivar “Pusa Narangi” were sprayed with different combinations of micro - nutrients and KNO3 after one month of transplanting. The observations were recorded on 14 traits viz. plant height, plant spread, number of branches per plant, days to bud initiation, days to first flower opening, flower stalk length, flower diameter, average flower weight, number of flowers per plant, duration of flowering, flower yield per plant, flower yield per m2, chlorophyll content and xanthophyll content. The data was analyzed statistically by ANOVA test (Steel et al., 1997) and critical differences were worked out at five percent level to draw statistical conclusion which indicated the significant differences existed among all treatments for all character except for plant height, plant spread and number of branches per plant.

Results and Discussion

Plant height (cm), plant spread (cm) and number of branches per plant

The observations pertaining to plant height, plant spread and number of branches per plant shows non - significant effect of micro - nutrients and KNO3 combinations in Tagetes erecta cv. ‘Pusa Narangi’ (Table 1). The maximum plant height of 77.33 cm was observed in KNO3 (1.25%) followed by KNO3 + FeSO4 (1.25% + 0.5%) i.e. 76.33 cm, ZnSO4 + MgSO4 (0.5% + 0.5%) with 75.25 cm plant height and ZnSO4 + KNO3 (0.5% + 1.25%) with 75.00 cm plant height. The maximum plant spread of 69.04 cm was recorded in ZnSO4 + MgSO4 (0.5% + 0.5%) followed by 68.87 cm under KNO3 (1.25%). The maximum number of branches i.e. 14.08/plant were observed under treatment KNO3 + FeSO4 (1.25% + 0.5%) which is closely followed by KNO3 (1.25%). It is evident from results that maximum plant height, plant spread and number of branches per plant was recorded
under KNO₃ and FeSO₄ treatments. These results corroborate the findings of Balakrishnan et al., (2007) and Arora and Khanna (1986) in marigold. The increased vegetative growth due to foliar application of KNO₃ or in combination with FeSO₄ and ZnSO₄ may be due to positive effect of KNO₃ to enhance the synthesis and accumulation of proteins, amino acids, enzymes for cell division and cell elongation. Kumar et al., (2003), Mukhopadhyay and Banker (1986) reported increase in plant height in tuberose due to application of nitrogen. These results are in line with the findings of Khalifa et al., (2011), Arora and Khanna (1986) in marigold who reported significant increase in vegetative growth due to nitrogen application.

**Days to bud initiation, bud initiation to flower opening, first flower opening and duration of flowering (days)**

The effect of micro - nutrients and KNO₃ was significant on days to bud initiation, bud initiation to flowering, first flower opening and duration of flowering in *Tagetes erecta* cv. ‘Pusa Narangi’ (Table 1). The minimum time was taken to bud initiation was observed under KNO₃ + FeSO₄ (1.25% + 0.5%) i.e. 52.00 days followed by KNO₃ (0.5%) and Na₂MoO₄ (0.5%) i.e. 53.56 days. The maximum time to bud initiation was 60.22 days taken by ZnSO₄ + MgSO₄(0.5% + 0.5%) followed 59.11 days in ZnSO₄ (0.5%). The minimum days to flower opening after bud initiation was taken by KNO₃ (1.25%) i.e. 17.67 days followed by (FeSO₄ + ZnSO₄), (ZnSO₄ + MgSO₄) and (FeSO₄ + MgSO₄) i.e. 18.00 days. The minimum days to first flower opening were taken by treatment KNO₃ + FeSO₄ (1.25% + 0.5%) i.e. 70.67 days followed by KNO₃ (1.25%) i.e. 71.55 days. The maximum time was taken by control 79.44 days and it was at par with (ZnSO₄ + KNO₃) and (MgSO₄ + Na₂MoO₄) i.e. 78.22 days and 78.33 days. The longest flowering duration (62.50 days) was recorded in KNO₃ + FeSO₄ (1.25% + 0.5%) followed by KNO₃ + MgSO₄ @ 1.25% + 0.5% i.e. 60.44 days. The shortest flowering duration of 50.66 days and 51.39 days was observed in untreated plants and MgSO₄@ 0.5%. The plants which received KNO₃ alone or in combination with FeSO₄ showed early bud initiation and early flowering that might be due to maximum nutrient uptake resulting in improved photosynthesis. These results are in line with the findings of Pal and Ghosh (2010). The results for days to flower opening after bud initiation are in line with findings of Balakrishnan et al., (2007) in marigold who reported ZnSO₄ and FeSO₄ (0.5%) as the superior treatment as compared to other treatments of micro - nutrients. Application of iron and zinc relieved the plants from chlorosis and resulted in higher assimilate synthesis and partitioning of the flower growth. The results for flower duration also corroborate the findings of Rao et al., (2005), Pal and Ghosh (2010).

**Number of flowers per plant, flower yield per plant and flower yield per m²**

The observations presented Table 2 indicate significant differences for number of flowers due to various micro - nutrients and KNO₃ combinations in *Tagetes erecta* cv. ‘Pusa Narangi’.

The maximum number of flowers 40.44 per plant was observed in treatment KNO₃ (1.25%). The results were at par with KNO₃ + FeSO₄ (1.25% + 0.5%) resulting in production of 37.89 flowers per plant and MgSO₄ + Na₂MoO₄ (0.5% + 0.5%) having 37.39 flowers per plant. The maximum flower yield 357.78g per plant was observed under KNO₃ (1.25%) followed by 340.33g under KNO₃ + FeSO₄ (1.25% + 0.5%) and 296.66g under ZnSO₄ (0.5%). The minimum flower yield of 258.89g was recorded under untreated plants.
Table 1 Effect of micro - nutrients and KNO₃ on plant height, spread, branches and flowering time in *Tagetes erecta* cv. ‘Pusa Narangi’

| Treatments                  | Plant height (cm) | Plant spread (cm) | Number of branches/ plant | Days to bud initiation | Days from bud initiation to flower opening | Days to first flower opening | Duration of flowering (days) |
|-----------------------------|------------------|------------------|---------------------------|------------------------|-------------------------------------------|-------------------------------|-----------------------------|
| T₁  ZnSO₄ - 0.5%            | 72.00            | 64.08            | 11.66                     | 59.11                  | 19.33                                     | 77.44                         | 55.11                       |
| T₂  FeSO₄ - 0.5%            | 69.67            | 60.54            | 11.41                     | 56.00                  | 19.89                                     | 75.55                         | 56.16                       |
| T₃  MgSO₄ - 0.5%            | 74.50            | 66.04            | 13.00                     | 57.89                  | 18.67                                     | 76.89                         | 51.39                       |
| T₄  Na₂MoO₄ - 0.5%          | 70.33            | 64.45            | 10.16                     | 53.56                  | 19.67                                     | 73.44                         | 55.16                       |
| T₅  KNO₃ - 1.25%            | 77.33            | 68.87            | 13.83                     | 53.56                  | 17.67                                     | 71.55                         | 58.77                       |
| T₆  ZnSO₄ + FeSO₄ - 0.5% + 0.5% | 66.83          | 62.95            | 11.00                     | 56.11                  | 18.00                                     | 74.22                         | 53.83                       |
| T₇  ZnSO₄ + MgSO₄ - 0.5% + 0.5% | 75.25          | 69.04            | 12.50                     | 60.22                  | 18.00                                     | 77.77                         | 57.61                       |
| T₈  MgSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 73.91          | 66.91            | 11.08                     | 58.78                  | 19.34                                     | 78.33                         | 60.44                       |
| T₉  FeSO₄ + MgSO₄ - 0.5% + 0.5% | 71.50           | 64.20            | 9.50                      | 58.00                  | 18.00                                     | 76.00                         | 55.89                       |
| T₁₀ FeSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 69.33           | 60.45            | 12.08                     | 58.78                  | 18.44                                     | 77.55                         | 55.50                       |
| T₁₁ ZnSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 61.83           | 60.66            | 13.16                     | 57.00                  | 19.55                                     | 77.66                         | 54.88                       |
| T₁₂ KNO₃ + ZnSO₄ - 1.25% + 0.5% | 75.00           | 68.54            | 10.25                     | 58.33                  | 20.00                                     | 78.22                         | 54.28                       |
| T₁₃ KNO₃ + FeSO₄ - 1.25% + 0.5% | 76.33           | 65.33            | 14.08                     | 52.00                  | 18.67                                     | 70.67                         | 62.50                       |
| T₁₄ KNO₃ + MgSO₄ - 1.25% + 0.5% | 64.33           | 61.04            | 9.50                      | 54.89                  | 18.33                                     | 72.66                         | 60.44                       |
| T₁₅ KNO₃ + Na₂MoO₄ - 1.25% + 0.5% | 68.17           | 62.50            | 12.08                     | 57.00                  | 18.89                                     | 75.78                         | 53.00                       |
| T₁₆ Control                  | 67.83            | 60.37            | 9.33                      | 58.89                  | 20.22                                     | 79.44                         | 50.66                       |
| C.D. (p=0.05)                | NS               | NS               | NS                        | 3.07                   | 1.57                                      | 2.75                          | 4.93                        |
| Treatments                  | Number of flowers/plant | Flower yield per plant (g) | Flower yield per m² (kg) | Flower diameter (cm) | Average Flower Weight (g) | Stalk length (cm) | Chlorophyll content (mg/g) | Xanthophyll content (g/100g) |
|-----------------------------|-------------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------|---------------------------|-------------------------------|
| T1  ZnSO₄ - 0.5%            | 35.55                   | 296.66                    | 1.85                    | 6.25                 | 6.34                     | 5.87              | 1.315                     | 1.487                         |
| T2  FeSO₄ - 0.5%            | 32.55                   | 285.11                    | 1.78                    | 6.52                 | 6.73                     | 6.33              | 2.025                     | 1.900                         |
| T3  MgSO₄ - 0.5%            | 31.00                   | 263.33                    | 1.73                    | 6.19                 | 6.31                     | 6.57              | 1.705                     | 1.733                         |
| T4  Na₂MoO₄ - 0.5%          | 36.33                   | 293.56                    | 1.83                    | 6.16                 | 6.74                     | 6.23              | 1.870                     | 1.777                         |
| T5  KNO₃ - 1.25%            | 40.44                   | 357.78                    | 2.23                    | 6.69                 | 7.27                     | 6.93              | 1.640                     | 1.670                         |
| T6  ZnSO₄ + FeSO₄ - 0.5% + 0.5% | 32.11                   | 287.00                    | 1.79                    | 6.42                 | 6.60                     | 6.03              | 2.040                     | 1.587                         |
| T7  ZnSO₄ + MgSO₄ - 0.5% + 0.5% | 33.33                   | 288.22                    | 1.80                    | 6.20                 | 6.65                     | 6.23              | 1.885                     | 1.713                         |
| T8  MgSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 37.39                   | 285.78                    | 1.78                    | 6.32                 | 6.01                     | 5.83              | 1.830                     | 1.730                         |
| T9  FeSO₄ + MgSO₄ - 0.5% + 0.5% | 33.22                   | 324.22                    | 2.02                    | 6.17                 | 6.65                     | 6.37              | 1.715                     | 1.723                         |
| T10 FeSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 31.00                   | 274.00                    | 1.71                    | 6.42                 | 6.86                     | 5.80              | 1.505                     | 1.987                         |
| T11 ZnSO₄ + Na₂MoO₄ - 0.5% + 0.5% | 34.33                   | 266.33                    | 1.61                    | 6.46                 | 5.86                     | 5.80              | 1.440                     | 1.550                         |
| T12 KNO₃ + ZnSO₄ - 1.25% + 0.5% | 30.11                   | 294.89                    | 1.84                    | 6.47                 | 6.84                     | 6.23              | 1.705                     | 1.700                         |
| T13 KNO₃ + FeSO₄ - 1.25% + 0.5% | 37.89                   | 340.33                    | 2.12                    | 6.58                 | 7.12                     | 6.80              | 1.850                     | 1.803                         |
| T14 KNO₃ + MgSO₄ - 1.25% + 0.5% | 34.22                   | 278.22                    | 1.73                    | 6.40                 | 6.28                     | 6.53              | 1.710                     | 1.640                         |
| T15 KNO₃ + Na₂MoO₄ - 1.25% + 0.5% | 33.33                   | 290.22                    | 1.82                    | 6.24                 | 6.68                     | 6.10              | 1.655                     | 1.617                         |
| T16 Control                 | 29.56                   | 258.89                    | 1.62                    | 6.13                 | 6.07                     | 5.30              | 1.665                     | 1.643                         |
| C.D. (p=0.05)               | 2.92                    | 32.44                     | 0.23                    | 0.79                 | 0.31                     | 0.172             | 0.210                     |                                |
The maximum flower yield per unit area was obtained under KNO₃ (1.25%) i.e. 2.23 kg and it was closely followed by KNO₃ + FeSO₄ i.e. 2.12 kg. In present study it was noticed that KNO₃ foliar application resulted in more number of flowers per plant. The results also show that vigorous plants were produced under this treatment resulted in increased flower production. The FeSO₄ favours storage of more carbohydrates through photosynthesis which may be attributing factor in significant increase in flower yield. These findings are in line with Jat et al., (2007) and Girwani et al., (1990) in marigold. Similar type of results in increased flower production due to plant height, plant spread and branch count has been recorded by Balakrishnan et al., (2007) in marigold. These results justify the findings of Kumar et al., (2010) in marigold that recorded improved vegetative characters and higher flower production due to application of ferrous sulphate.

Flower diameter (cm), average flower weight (g), flower stalk length (cm)

The effect of combinations of micro - nutrients and KNO₃ on flower size, average flower weight and flower stalk length of ‘Tagetes erecta’ cv. ‘Pusa Narangi’ was significant as presented in Table 2. The largest flower diameter 6.69 cm was observed in treatment KNO₃ (1.25%) followed by treatment KNO₃ + FeSO₄ (1.25% + 0.5%) i.e. 6.58 cm and FeSO₄ (0.5%) i.e. 6.52 cm. The maximum average flower weight 7.27 g was recorded in treatment in KNO₃ (1.25%) followed by treatment KNO₃ + FeSO₄ (1.25% + 0.5%) with average flower weight 7.12 g which are statistically at par. The stalk length was longest 6.93 cm under KNO₃ @ 1.25% followed by 6.80 cm under KNO₃ + FeSO₄ (1.25% + 0.5%). The flowers with shortest stalk length were produced under control 5.30 cm. This might be due to association of zinc in regulating semi permeability of cell walls, thus mobilizing more water into flowers and also increase synthesis of iron which promotes cell size which in turn increases flower size and weight of flowers (Agarwal and Sharma, 1978). These results also justify the findings of Pal and Ghosh (2010) and Ahmad et al., (2010) in roses.

Chlorophyll content (mg/g) and Xanthophyll content (g/100g)

The significance difference was recorded among different combinations of micro - nutrients and KNO₃ in chlorophyll and xanthophyll content of ‘Tagetes erecta’ cv. ‘Pusa Narangi’ (Table 2). Maximum chlorophyll content 2.040 mg/g was recorded in treatment FeSO₄ + ZnSO₄ (0.5% + 0.5%) followed by 2.025 mg/g under FeSO₄ (0.5%). The micro - nutrient combination of ZnSO₄ + MgSO₄ (0.5% + 0.5%) resulted in 1.885 mg/g chlorophyll content which was at par with KNO₃ + FeSO₄ (1.25% + 0.5%) and Na₂MoO₄ (0.5%). The maximum xanthophyll content (1.987g/100g) was observed under FeSO₄ + Na₂MoO₄ (0.5% + 0.5%) followed by FeSO₄ @ 0.5% i.e. (1.900g/100g) and KNO₃ + FeSO₄ @ 1.25% + 0.5% i.e. 1.803g/100g. Increase in chlorophyll content might be due to iron which enhances the functioning of photosystem and increase the chlorophyll content of leaves. Similar results have been reported by Balakrishnan et al., (2007) in marigold and El - Naggar (2009) in Dianthus caryophyllus. Plants sprayed with KNO₃ + FeSO₄ resulted in increased level of xanthophyll which is in line with findings of Kumar et al., (2003) in tuberose. Similar types of results have been reported by Sindhu and Gupta (1993) in roses.

It is concluded that foliar treatment of KNO₃ and FeSO₄ resulted in early flowering and longer flowering duration. The flower yield was recorded maximum under KNO₃@
1.25%. The maximum xanthophyll content was recorded under FeSO₄ + Na₂MoO₄ (0.5% + 0.5%) which can further be exploited for future experiment to increase the xanthophyll content in marigold.

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