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Effect of Micro - Nutrients and KNO_3 on Vegetative Growth, Flower Yield and Pigments of *Tagetes erecta* cv. 'Pusa Narangi'

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A B S T R A C T

The present study was carried to standardize the dose of micro - nutrients and KNO_3 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 KNO_3 treatments after one month of transplanting. The results showed that minimum time to bud initiation and anthesis was recorded under KNO_3 + $FeSO_4$ @ 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 KNO_3 + $FeSO_4$ @ 1.25% + 0.5%. The maximum plant height (77.33 cm) was recorded in KNO_3 (1.25%) and maximum plant spread (69.04 cm) was observed in $ZnSO_4$ + $MgSO_4$ @ 0.5%. The maximum flower yield/ plant (357.78g) and flower yield/m^2 (2.23 kg) was recorded under KNO_3 @ 1.25%. The treatment KNO_3 @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 $FeSO_4$ + $ZnSO_4$ (0.5% + 0.5%) and xanthophyll content in $FeSO_4$ + Na_2MoO_4 @ 0.5%.

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 KNO_3 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 KNO_3 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., $ZnSO_4$ - 0.5%, $FeSO_4$ - 0.5%, $MgSO_4$ - 0.5%, Na_2MoO_4 - 0.5%, KNO_3 - 1.25%, $FeSO_4$ + $ZnSO_4$ - 0.5% + 0.5%, $ZnSO_4$ + $MgSO_4$ - 0.5% + 0.5%, $MgSO_4$ + Na2MoO_4 - 0.5% + 0.5%, $FeSO_4$ + $MgSO_4$ - 0.5% + 0.5%, $FeSO_4$ + Na_2MoO_4 - 0.5% + 0.5%, $ZnSO_4$ + Na_2MoO_4 - 0.5% + 0.5%, $ZnSO_4$ + KNO_3 - 0.5% + 1.25%, KNO_3 + $FeSO_4$ - 1.25% + 0.5%, KNO_3 + $MgSO_4$ - 1.25% + 0.5%, KNO_3 + Na_2MoO_4 - 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 m^2, 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 KNO_3 combinations in *Tagetes erecta* cv. 'Pusa Narangi' (Table 1). The maximum plant height of 77.33 cm was observed in KNO_3 (1.25%) followed by KNO_3 + $FeSO_4$ (1.25% + 0.5%) i.e. 76.33 cm, $ZnSO_4$ + $MgSO_4$ (0.5% + 0.5%) with 75.25 cm plant height and $ZnSO_4$ + KNO_3 (0.5% + 1.25%) with 75.00 cm plant height. The maximum plant spread of 69.04 cm was recorded in $ZnSO_4$ + $MgSO_4$ (0.5% + 0.5%) followed by 68.87 cm under KNO_3 (1.25%). The maximum number of branches i.e. 14.08/plant were observed under treatment KNO_3 + $FeSO_4$ (1.25% + 0.5%) which is closely followed by KNO_3 (1.25%). It is evident from results that maximum plant height, plant spread and number of branches per plant was recorded

under KNO_3 and $FeSO_4$ 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 KNO_3 or in combination with $FeSO_4$ and $ZnSO_4$ may be due to positive effect of KNO_3 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 KNO_3 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 KNO_3 + $FeSO_4$ (1.25% + 0.5%) i.e. 52.00 days followed by KNO_3 (0.5%) and Na_2MoO_4 (0.5%) i.e. 53.56 days. The maximum time to bud initiation was 60.22 days taken by $ZnSO_4$ + $MgSO_4$ (0.5% + 0.5%) followed 59.11 days in $ZnSO_4$ (0.5%). The minimum days to flower opening after bud initiation was taken by KNO_3 (1.25%) i.e. 17.67 days followed by ($FeSO_4$ + $ZnSO_4$), ($ZnSO_4$ + $MgSO_4$) and ($FeSO_4$ + $MgSO_4$) i.e. 18.00 days. The minimum days to first flower opening were taken by treatment KNO_3 + $FeSO_4$ (1.25% + 0.5%) i.e. 70.67 days followed by KNO_3 (1.25%) i.e. 71.55 days. The maximum time was taken by control 79.44 days and it was at par with ($ZnSO_4$ + KNO_3) and ($MgSO_4$ + Na_2MoO_4) i.e. 78.22 days and 78.33 days. The longest flowering duration (62.50 days) was recorded in KNO_3 + $FeSO_4$ (1.25% + 0.5%) followed by KNO_3 + $MgSO_4$ @ 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 $MgSO_4$@ 0.5%.The plants which received KNO_3 alone or in combination with $FeSO_4$ 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 $ZnSO_4$ and $FeSO_4$ (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 m^2

The observations presented Table 2 indicate significant differences for number of flowers due to various micro - nutrients and KNO_3 combinations in *Tagetes erecta* cv. 'Pusa Narangi'.

The maximum number of flowers 40.44 per plant was observed in treatment KNO_3 (1.25%).The results were at par with KNO_3 + $FeSO_4$ (1.25% + 0.5%) resulting in production of 37.89 flowers per plant and $MgSO_4$ + Na_2MoO_4 (0.5% + 0.5%) having 37.39 flowers per plant. The maximum flower yield 357.78g per plant was observed under KNO_3 (1.25%) followed by 340.33g under KNO_3 + $FeSO_4$ (1.25% + 0.5%) and 296.66g under $ZnSO_4$ (0.5%). The minimum flower yield of 258.89g was recorded under untreated plants.

Table.1 Effect of micro - nutrients and KNO_3 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)
T_1	$ZnSO_4$ - 0.5%	72.00	64.08	11.66	59.11	19.33	77.44	55.11
T_2	$FeSO_4$ - 0.5%	69.67	60.54	11.41	56.00	19.89	75.55	56.16
T_3	$MgSO_4$ - 0.5%	74.50	66.04	13.00	57.89	18.67	76.89	51.39
T_4	Na_2MoO_4 - 0.5%	70.33	64.45	10.16	53.56	19.67	73.44	55.16
T_5	KNO_3 - 1.25%	77.33	68.87	13.83	53.56	17.67	71.55	58.77
T_6	$ZnSO_4$ + $FeSO_4$ - 0.5% + 0.5%	66.83	62.95	11.00	56.11	18.00	74.22	53.83
T_7	$ZnSO_4$ + $MgSO_4$ - 0.5% + 0.5%	75.25	69.04	12.50	60.22	18.00	77.77	57.61
T_8	$MgSO_4$ + Na_2MoO_4 - 0.5% + 0.5%	73.91	66.91	11.08	58.78	19.34	78.33	60.44
T_9	$FeSO_4$ + $MgSO_4$ - 0.5% + 0.5%	71.50	64.20	9.50	58.00	18.00	76.00	55.89
T_{10}	$FeSO_4$ + Na_2MoO_4 - 0.5% + 0.5%	69.33	60.45	12.08	58.78	18.44	77.55	55.50
T_{11}	$ZnSO_4$ + Na_2MoO_4 - 0.5% + 0.5%	61.83	60.66	13.16	57.00	19.55	77.66	54.88
T_{12}	KNO_3 + $ZnSO_4$ - 1.25% + 0.5%	75.00	68.54	10.25	58.33	20.00	78.22	54.28
T_{13}	KNO_3 + $FeSO_4$ - 1.25% + 0.5%	76.33	65.33	14.08	52.00	18.67	70.67	62.50
T_{14}	KNO_3 + $MgSO_4$ - 1.25% + 0.5%	64.33	61.04	9.50	54.89	18.33	72.66	60.44
T_{15}	KNO_3 + Na_2MoO_4 - 1.25% + 0.5%	68.17	62.50	12.08	57.00	18.89	75.78	53.00
T_{16}	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

Table.2 Effect of micro - nutrients and KNO_3 on flower yield, chlorophyll and xanthophyll content in *Tagetes erecta* cv. 'Pusa Narangi'

	Treatments	Number of flowers/ plant	Flower yield per plant (g)	Flower yield per m^2 (kg)	Flower diameter (cm)	Average Flower Weight (g)	Stalk length (cm)	Chlorophyll content (mg/g)	Xanthophyll content (g/100g)
T_1	**$ZnSO_4$ - 0.5%**	35.55	296.66	1.85	6.25	6.34	5.87	1.315	1.487
T_2	**$FeSO_4$ - 0.5%**	32.55	285.11	1.78	6.52	6.73	6.33	2.025	1.900
T_3	**$MgSO_4$ - 0.5%**	31.00	263.33	1.73	6.19	6.31	6.57	1.705	1.733
T_4	**Na_2MoO_4 - 0.5%**	36.33	293.56	1.83	6.16	6.74	6.23	1.870	1.777
T_5	**KNO_3 - 1.25%**	40.44	357.78	2.23	6.69	7.27	6.93	1.640	1.670
T_6	**$ZnSO_4$ + $FeSO_4$ - 0.5% + 0.5%**	32.11	287.00	1.79	6.42	6.60	6.03	2.040	1.587
T_7	**$ZnSO_4$ + $MgSO_4$ - 0.5% + 0.5%**	33.33	288.22	1.80	6.20	6.65	6.23	1.885	1.713
T_8	**$MgSO_4$ + Na_2MoO_4 - 0.5% + 0.5%**	37.39	285.78	1.78	6.32	6.01	5.83	1.830	1.730
T_9	**$FeSO_4$ + $MgSO_4$ - 0.5% + 0.5%**	33.22	324.22	2.02	6.17	6.65	6.37	1.715	1.723
T_{10}	**$FeSO_4$ + Na_2MoO_4 - 0.5% + 0.5%**	31.00	274.00	1.71	6.42	6.86	5.80	1.505	1.987
T_{11}	**$ZnSO_4$ + Na_2MoO_4 - 0.5% + 0.5%**	34.33	266.33	1.61	6.46	5.86	5.80	1.440	1.550
T_{12}	**KNO_3 + $ZnSO_4$ - 1.25% + 0.5%**	30.11	294.89	1.84	6.47	6.84	6.23	1.705	1.700
T_{13}	**KNO_3 + $FeSO_4$ - 1.25% + 0.5%**	37.89	340.33	2.12	6.58	7.12	6.80	1.850	1.803
T_{14}	**KNO_3 + $MgSO_4$ - 1.25% + 0.5%**	34.22	278.22	1.73	6.40	6.28	6.53	1.710	1.640
T_{15}	**KNO_3 + Na_2MoO_4 - 1.25% + 0.5%**	33.33	290.22	1.82	6.24	6.68	6.10	1.655	1.617
T_{16}	**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 KNO_3 (1.25%) i.e. 2.23 kg and it was closely followed by KNO_3 + $FeSO_4$ i.e. 2.12 kg. In present study it was noticed that KNO_3 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 $FeSO_4$ 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 KNO_3 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 KNO_3 (1.25%) followed by treatment KNO_3 + $FeSO_4$ (1.25% + 0.5%) i.e. 6.58 cm and $FeSO_4$ (0.5%) i.e. 6.52 cm. The maximum average flower weight 7.27 g was recorded in treatment in KNO_3 (1.25%) followed by treatment KNO_3 + $FeSO_4$ (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 KNO_3 @ 1.25% followed by 6.80 cm under KNO_3 + $FeSO_4$ (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 KNO_3 in chlorophyll and xanthophyll content of '*Tagetes erecta'* cv. 'Pusa Narangi' (Table 2). Maximum chlorophyll content 2.040 mg/g was recorded in treatment $FeSO_4$ + $ZnSO_4$ (0.5% + 0.5%) followed by 2.025 mg/g under $FeSO_4$ (0.5%). The micro - nutrient combination of $ZnSO_4$ + $MgSO_4$ (0.5% + 0.5%) resulted in 1.885 mg/g chlorophyll content which was at par with KNO_3 + $FeSO_4$ (1.25% + 0.5%) and Na_2MoO_4 (0.5%). The maximum xanthophyll content (1.987g/100g) was observed under $FeSO_4$ + Na_2MoO_4 (0.5% + 0.5%) followed by $FeSO_4$ @ 0.5% i.e. (1.900g/100g) and KNO_3 + $FeSO_4$ @ 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 KNO_3 + $FeSO_4$ 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 KNO_3 and $FeSO_4$ resulted in early flowering and longer flowering duration. The flower yield was recorded maximum under KNO_3@

1.25%. The maximum xanthophyll content was recorded under $FeSO_4$ + Na_2MoO_4 (0.5% + 0.5%) which can further be exploited for future experiment to increase the xanthophyll content in marigold.

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