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Impact of Water Soluble Fertilizers and Silica on the Growth of African Marigold (*Tagetes erecta* L.)

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ABSTRACT: African marigold (*Tagetes erecta* L.) is an important traditional flower crop under cultivation throughout India. It belongs to the family Asteraceae/Compositae. It has a great economic potential as loose flower which finds industrial application in preparation of natural dyes, essential oils and also used as nematode and mosquito repellents. The current investigation on "Impact of water soluble fertilizers and silica on the growth of African marigold (*Tagetes erecta* L.)" for the hybrid Tennis ball orange was carried out at Grapes Research Station, Theni. The experiment was laid out in Randomized Block Design (RBD) with fifteen treatments replicated thrice. The results revealed that application of the treatment T_9 [Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%] resulted in the maximum growth. The highest values for vegetative parameters *viz.*, plant height, internodal length, leaf length, leaf width, number of branches and stem diameter were recorded in the treatment T_9 followed by T_7 [Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1%] when compared to the control (T_{15}).

Keywords: *Tagetes erecta* L., Tennis ball orange, water soluble fertilizers, ortho silicic acid and *Ascophyllum nodosum*.

INTRODUCTION

The African marigold (*Tagetes erecta* L.), which belongs to the Asteraceae/Compositae family, is a popular loose flower among flower cultivation. It is cultivated commercially throughout the India, including Tamil Nadu and it has gained increasing popularity among flower gardeners because of its ease in cultivation and adaptabilities (Patokar *et al.,* 2017). Marigold farming covers 84.09 thousand hectares in India with a production of 916.24 thousand tonnes of loose flowers during 2021-22. Whereas in Tamil Nadu, it occupies 3.39 000 hectares of area with the loose flower production of 96.31 thousand MT during 2021-22 (NHB Data Base, 2022).

Foliar fertilization is an effective technique for proper absorption that may be adapted to meet the plants with specific needs for one or more macro nutrients like Nitrogen (N), Phosphorous (P) and Potassium (K) and micro nutrients, particularly trace minerals and can be used to correct deficiencies, strengthen, weak or damaged crops, quicken growth and make plants grow better (Said-Al Ahl and Mahmoud 2010). Meanwhile, other than macro and micro nutrients application of silica and seaweed extracts showed the greater effects in the growth and development of African marigold. Therefore, the present investigation has been formulated to standardize the vegetative growth of African marigold.

MATERIAL AND METHODS

The experiment was conducted in a Randomized Block Design (RBD) with 15 treatments combinations and replicated thrice at Grapes Research Station, Theni during the year 2023. Healthy and uniform seedlings of twenty one days old marigold hybrid - Tennis Ball Orange were collected from nursery and transplanted in ridges and furrows by adopting a spacing of 60 cm × 45 cm in the open field condition.

The treatments include T_1 - Water soluble NPK mixture - 19:19:19 @ 0.5% + Mono ammonium phosphate(12:61:0) @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1%, T_2 - Water soluble NPK mixture - 19:19:19 @ 0.5% + Mono ammonium phosphate (12:61:0) @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2%, T_3 - Mono ammonium phosphate (12:61:0) @ 0.5% + Mono potassium phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1%, T_4 - Mono ammonium phosphate (12:61:0) @ 0.5% + Mono potassium phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2%, T_5 - Mono Ammonium Phosphate (12:61:0) @ 0.5% + Mono potassium phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%, T_6 - Mono ammonium phosphate (12:61:0) @ 0.5% + Mono potassium phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.2%, T_7 - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1%, T_8 - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2%, T_9 - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%, T_{10} - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.2%, T_{11} - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Potassium schoenite @ 0.2% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1%, T_{12} - Mono potassium phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Potassium schoenite @ 0.2% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2%, T_{13} - Mono potassium phosphate (0:52:34) @ 0.3% + Potassium Nitrate (13:0:45) - @ 0.3% + Potassium schoenite @ 0.2% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%, T_{14} - Mono potassium phosphate (0:52:34) @ 0.3% + Potassium Nitrate (13:0:45) - @ 0.3% + Potassium schoenite @ 0.2% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of silica @ 0.2% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.2%, T_{15} - Control (No spray) in 14 different combinations were sprayed as foliar spray on 20 to 25 DAT, 40 to 45 DAT, 60 to 65 DAT and 80 to 85 DAT along with water spray as control. The vegetative parameters like plant height, internodal length, leaf length, leaf width, number of branches and stem diameter were recorded at 15, 30, 45 and 60 days after planting (DAP). The data recorded were subjected to statistical analysis using AGRES software and MS Excel® spread sheet.

RESULTS AND DISCUSSION

The data of this investigation showed that growth parameters were positively influenced by foliar application. The plant height, the number of branches, leaf length, leaf width, number of leaves, stem diameter and internodal length, the fresh and dry weight of shoots and leaf area increased significantly by foliar application of water soluble fertilizers, chelated micronutrients, silica and sea weed extract.

A. Plant height

The treatment T_9 [Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*] @ 0.1%) envisaged the highest plant height (41 cm at 30 DAT (Fig. 1) and 56 cm at 45 DAT) than all other treatments followed by T_7 [Mono Potassium Phosphate(0:52:34) @ 0.5%+ Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1%] with 38 cm at 30 DAT and 52 cm at 45 DAT and T_5 [Mono Ammonium Phosphate (12:61:0) @ 0.5% + Mono Potassium Phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%] with 36 cm at DAT and 51.67 cm at 45 DAT both are statistically on par with each other. The least plant height was recorded in the T_{15} (control) at 30 DAT (Fig. 2) and T_3 [Mono Ammonium Phosphate (12:61:0) @ 0.5% + Mono Potassium Phosphate (0:52:34) @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1%] at 45 DAT. Similar results were reported by Shyala *et al*., (2019).

B. Number of branches

Number of branches shows the significance difference between all the treatments and the highest number of branches was recorded in the treatment T_9[Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%] with 32.39 Nos at 45 DAT and least number of branches was recorded in treatment T_2 [Water soluble NPK mixture - 19:19:19 @ 0.5% + Mono Ammonium Phosphate (12:61:0) @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of Silica @ 0.2%] with 24.76 Nos. Increased number of branches could be due to micronutrients like $ZnSO_4$ and $FeSO_4$, which are essential components of several dehydrogenase, proteinase, peptidase and promote hormone growth and are closely associated with growth. All of these factors contributed to cell multiplication, cell division and cell differentiation, resulting in increased photosynthesis and translocation of food material, which increased the number of branches, above result was confirmed by Pal *et al*. (2016). Similar results were recorded by Kumar and Moon (2014); Polara *et al*. (2015).

C. Leaf length and width

Leaf length shows significantly variation among the treatments and leaf width shows non-significant at 30 DAT and shows significant at 45 DAT. The treatment T_9 [Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%] recorded the highest leaf length (3.55 cm at 30 DAT and 4.55 cm at 45 DAT) than all other treatments followed by T_7 [Mono Potassium Phosphate(0:52:34) @ 0.5%+ Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1%] with 3.43 cm at 30 DAT and 4.35 cm at 45 DAT and the least leaf length was recorded in the treatment T_6 [Mono Ammonium Phosphate (12:61:0) @ 0.5% + Mono Potassium Phosphate (0:52:34) @ 0.5%+ Chelated micronutrient @ 0.2% + Ortho silicic acid form of Silica @ 0.2% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.2%] at 45 DAT and the least leaf width was recorded in the treatment T_{10} [Mono Potassium Phosphate(0:52:34) @ 0.5%+Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.2% + Ortho silicic acid form of Silica @ 0.2% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.2%] at 45 DAT.

DISCUSSION

Fertilizing a plant through foliar spray can make plant to quickly absorb the nutrients and reduce the usage of bulk fertilizers. Water soluble fertilizers are easily adopted to this methodology. Potassium plays an important role in protein and starch synthesis which is responsible for vegetative growth and nitrogen increases the meristematic activity and amino acid formation has significant effect on plant growth (Dali *et al*., 2019). Phosphorus treatment influences the plant spread and total leaf chlorophyll content, but had little effect on other plant growth indices by Polara *et al*., (2015) and Shah *et al*., (2018). Micronutrients stimulate many enzymes (catalase, carbonic dehydrogenase and tryptophan synthases etc.) and plays a vital role in a various physiological functions. Zn enhances cell multiplication, division, and differentiation, which results in higher photosynthesis and food material translocation, which increases plant height (Thirumalmurugan *et al*., 2021). By the application of micronutrients, Kakade *et al*. (2009) reported that spraying of $ZnSO_4$ produces maximum vegetative growth in China aster and similarly, Balakrishnan (2005) reported in marigold, Pradhan & Mitra (2020) in marigold. Many of the studies emphasised the importance of silicon in plant resilience to both biotic and abiotic stresses including salinity (Crusciol *et al*., 2009). Many researchers also confirms that, by silicon foliar spray, plants can withstand long periods of drought conditions and also increases flower shelf life.

Table 1: Impact of water soluble fertilisers and silica on the growth of African marigold after 15 DAT.

Treatments	15 Days After Transplanting					
	Plant height (cm)	**Internodal length (cm)**	**Leaf length (cm)**	**Leaf width (cm)**	**No. of branches per plant**	**Stem diameter (cm)**
T_1	20.00	2.53	2.60	0.45	13.85	1.23
T_2	17.46	2.40	2.58	0.40	13.05	1.10
T_3	19.40	2.43	2.70	0.40	12.05	1.13
T_4	18.18	2.37	2.65	0.37	13.25	1.07
T_5	18.05	2.47	2.68	0.40	13.95	1.10
T_6	18.43	2.33	2.57	0.35	12.45	1.20
T_7	21.63	2.60	2.82	0.47	15.34	1.33
T_8	20.00	2.37	2.65	0.35	12.21	1.20
T_9	22.00	2.83	2.92	0.52	18.75	1.43
T_{10}	18.43	2.37	2.65	0.35	10.27	1.10
T_{11}	17.46	2.37	2.72	0.37	12.37	1.20
T_{12}	19.00	2.40	2.65	0.38	11.58	1.13
T_{13}	17.46	2.37	2.70	0.37	13.24	1.17
T_{14}	19.40	2.37	2.62	0.40	12.62	1.20
T_{15}	19.19	2.37	2.65	0.35	13.71	1.20
Mean	**19.33**	**2.44**	**2.7**	**0.49**	**13.25**	**1.19**
SE (d)	**0.43**	**0.07**	**0.06**	**0.53**	**0.30**	**0.05**
CD (0.05)	**0.87**	**0.15**	**0.12**	**1.08**	**0.61**	**0.10**
	**	**	**	**NS**	**	**

(** - Significance, NS – Non-significance)

Table 2: Impact of water soluble fertilisers and silica on the growth of African marigold after 30 DAT.

Treatments	30 Days After Transplanting					
	Plant height (cm)	Internodal length (cm)	Leaf length (cm)	Leaf width (cm)	No. of branches per plant	Stem diameter (cm)
T_1	37.33	3.30	3.23	0.65	22.67	2.73
T_2	36.00	3.20	3.23	0.68	21.43	2.60
T_3	36.00	3.23	3.37	0.72	21.78	2.60
T_4	36.67	3.27	3.35	0.67	22.76	2.53
T_5	37.33	3.30	3.34	0.70	22.83	2.57
T_6	36.00	3.23	3.27	0.63	22.91	2.70
T_7	38.00	3.40	3.43	0.82	24.62	2.83
T_8	36.67	3.30	3.27	0.70	23.27	2.70
T_9	41.00	3.48	3.55	1.07	26.87	2.93
T_{10}	36.00	3.20	3.23	0.70	22.08	2.60
T_{11}	36.00	3.30	3.27	0.70	22.61	2.70
T_{12}	37.33	3.30	3.40	0.73	23.08	2.63
T_{13}	36.00	3.28	3.25	0.72	22.68	2.67
T_{14}	36.67	3.28	3.28	0.69	22.91	2.70
T_{15}	36.00	3.28	3.27	0.69	22.63	2.70
Mean	**36.8660**	**3.2896**	**3.3167**	**0.8091**	**23.0087**	**2.6800**
SE (d)	**0.8054**	**0.8054**	**0.0723**	**0.4594**	**0.5058**	**0.0583**
CD (0.05)	**1.6498**	**1.6498**	**0.1481**	**0.9410**	**1.0362**	**0.1194**
	**	*	**	**NS**	**	**

(** - Significance, NS – Non-significance)

Table 3: Impact of water soluble fertilisers and silica on the growth of African marigold after 45 DAT.

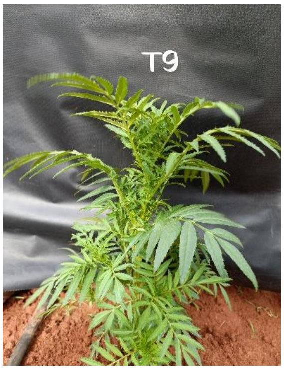
Treatments	45 Days After Transplanting					
	Plant height (cm)	Internodal length (cm)	Leaf length (cm)	Leaf width (cm)	No. of branches	Stem diameter (cm)
T_1	49.67	3.83	4.17	1.13	27.42	3.10
T_2	49.67	3.77	4.10	1.06	24.76	3.23
T_3	44.33	3.70	4.07	1.05	28.08	3.40
T_4	48.00	3.77	4.00	1.05	25.71	3.32
T_5	51.67	3.83	4.13	1.00	28.04	3.45
T_6	49.67	3.63	3.97	1.07	26.75	3.35
T_7	52.00	3.87	4.35	1.14	29.89	3.72
T_8	49.67	3.70	4.07	1.03	25.68	3.54
T_9	56.00	3.93	4.55	1.25	32.31	3.98
T_{10}	48.00	3.70	4.00	0.98	26.81	3.43
T_{11}	50.00	3.70	4.15	1.00	27.03	3.54
T_{12}	49.67	3.68	4.13	1.02	28.01	3.32
T_{13}	49.00	3.70	4.22	1.07	27.98	3.45
T_{14}	49.00	3.73	4.12	1.01	26.88	3.48
T_{15}	48.00	3.73	4.03	1.02	26.64	3.44
Mean	**49.6227**	**3.7518**	**4.1371**	**1.0642**	**27.4660**	**3.4500**
SE (d)	**1.0929**	**0.0826**	**0.0826**	**0.0689**	**0.6075**	**0.0759**
CD (0.05)	**2.2387**	**0.1691**	**0.1859**	**0.1411**	**1.2445**	**0.1555**
	**	**NS**	**	**	**	**

(** - Significance, NS – Non-significance)

Table 4: Impact of water soluble fertilisers and silica on the dry matter production and Leaf area of African marigold.

Treatments	Fresh weight of leaf (g)	Dry weight of leaf (g)	Leaf area (cm)
T_1	1.50	1.09	27.61
T_2	1.57	1.11	28.43
T_3	1.55	1.07	27.18
T_4	1.56	1.09	29.31
T_5	1.43	1.06	26.43
T_6	1.30	1.06	27.68
T_7	1.67	1.12	31.90
T_8	1.40	1.06	28.67
T_9	1.75	1.15	34.15
T_{10}	1.50	1.07	26.45
T_{11}	1.45	1.08	29.38
T_{12}	1.59	1.08	29.58
T_{13}	1.60	1.07	30.20
T_{14}	1.58	1.06	28.38
T_{15}	1.56	1.05	25.65
Mean	**1.53**	**1.08**	**28.7336**
SE (d)	**0.0341**	**0.0221**	**0.6274**
CD (0.05)	**0.0698**	**0.0452**	**1.2853**
	**	**	**

(** - Significance, NS – Non-significance)



Treatment 9 – 30 DAT

Fig. 1.

Treatment 15 – 30 DAT

Fig. 2.

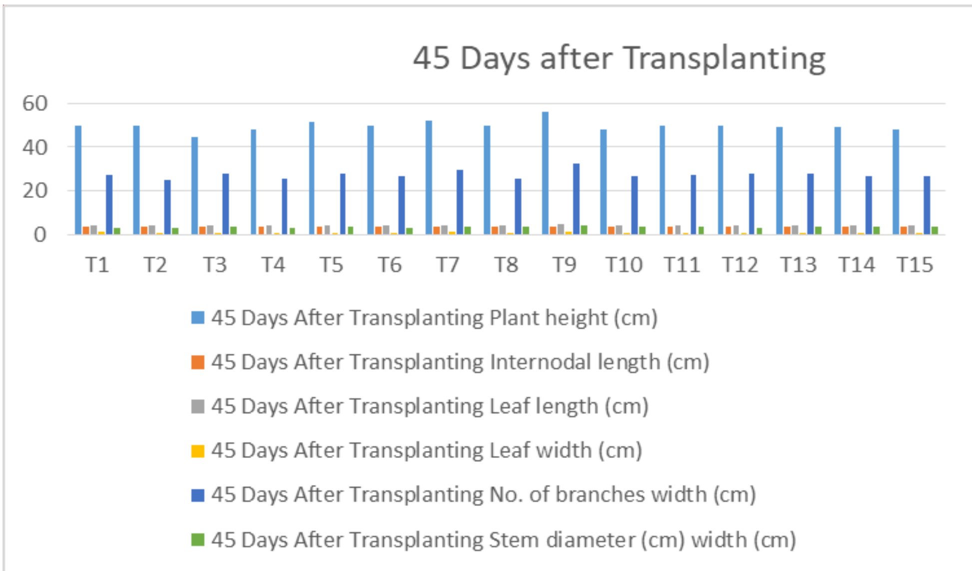


Fig. 3. Impact of water soluble fertilizers and silica on the growth of African marigold after 45 DAT.

CONCLUSIONS

The study concluded that application of the treatment T_9 (Mono Potassium Phosphate (0:52:34) @ 0.5% + Potassium Nitrate (13:0:45) - @ 0.5% + Chelated micronutrient @ 0.1% + Ortho silicic acid form of Silica @ 0.1% + Norwegian sea weed extract (*Ascophyllum nodosum*) @ 0.1%) recorded maximum growth with the highest values for vegetative parameters *viz.*, plant height, internodal length, leaf length, leaf width, number of branches and stem diameter when compared to the control (T_{15}).

FUTURE SCOPE

The main aim of this study is to access the efficiency of fertilizers through foliar application and thereby reducing the usage of bulk quantities of fertilizers which also increases benefit cost ratio to farmers and have practical benefit.

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