Impact of integrated Zinc and Iron management on biochemical attributes and nutrient uptake of marigold cv. Local Orange

ABSTRACT

A pot culture experiment was conducted to study the response of integrated zinc and iron management practices on biochemical attributes and nutrient uptake of marigold cv. Local Orange. The experiment was laid out in completely randomized design (CRD) with eight treatments and three replications. The eight treatments included an untreated control (T_1) , 100% RDF expand(T_2) , RDF + FYM enriched with $ZnSO_4$ and $FeSO_4$ @ 10 and 15 kg ha^{-1} respectively (T_3), RDF + FYM enriched with $ZnSO_4$ and $FeSO_4$ @ 15 and 20 kg ha^{-1} respectively (T_4), RDF + FYM enriched with $ZnSO_4$ and $FeSO_4$ @ 20 and 25 kg ha^{-1} respectively (T_5), RDF + foliar spray of $ZnSO_4$ and $FeSO_4$ each @ 0.5% (T_6), RDF + foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5 and 1.0 % respectively (T_7), RDF + foliar spray of liquid multi micronutrient @ 1.0 % (T_8). The application of integrated zinc and iron was observed to exhibit a significant effect on growth, yield, biochemical attributes and nutrient uptake. Maximum total chlorophyll content in leaf (mg g^{-1}) and nutrient uptake was observed with the application of RDF + foliar spray of $ZnSO_4$ and $FeSO_4$ each @ 0.5% (T_6) while regarding biochemical attributes *viz.*, total carotenoid content in petals (mg g^{-1}) and total phenols (mg g^{-1}) maximum was observed with the application of RDF + foliar spray of liquid multi micronutrient @ 1.0 % (T_8) which contains the proper amount of zinc and iron.

Key words: Zinc, Iron, nutrient uptake, carotenoid, phenol, marigold

INTRODUCTION

Flowers play an inevitable role in the lives of human beings and they find an inseparable role in all stages of the human life and are associated with all human cultures and civilizations prevalent worldwide. Among the numerous flower crops being cultivated for commercial and aesthetic values, African marigold (*Tagetes erecta* L.) from the family Asteraceae is a very popular and widely cultivated crop. Marigold is an herbaceous annual native to South and Central America, especially Mexico. It is popular due to its easy cultural needs and wider adaptability. Though widely popular as a loose flower for making garlands and as a garden plant, marigold is also used as cut flower (Gupta *et al.*, 2022).

The addition of micronutrients with macronutrient fertilizers in right amount in micronutrient deficient soils enhance the productivity and growth of plants through balanced fertilization. Iron plays a crucial role in numerous physiological and metabolic processes in plants. It is necessary for a variety of biological processes since it is a component of numerous essential enzymes, including cytochromes (an electron transport chain). Iron is a component of chlorophyll production in plants and is necessary for the preservation of chloroplast structure and prevention of numerous physiological anomalies including chlorosis, rosetting, etc. (Rout and Sahoo, 2015). Zn is important for the formation of essential auxins. It is necessary for the production of tryptophan, which is a precursor to IAA. Zn is necessary for cellular membrane integrity in order to maintain macromolecular structural orientation and ion transport mechanisms. The maintenance of membranes is aided by its interaction with phospholipids and the sulphydryl groups of membrane proteins (Hafeez et al., 2013).

Though marigold farming is expanding in India, the growers are not fully aware of the importance of micronutrients, particularly Fe and Zn in enhancing yields of high-quality marigold flowers. Even though they are needed in small amounts, micronutrients are essential for crop growth and development and have an impact on the quality of marigold flowers. The market price of marigold flowers which is traded for using as loose flowers is greatly influenced by the visual appearance.

With this background, the present study was undertaken to determine the effects of various Fe and Zn doses on the growth, quality, flower production, and biochemical parameters of marigold cv. Local Orange.

MATERIALS AND METHODS

The present study was conducted at Radio Isotope (Tracer) Laboratory, Department of Soil Science and Agricultural University TNAU, Coimbatore, India during 2021-2022. The experimental soil is Sandy clay loam in texture and was slightly alkaline in reaction has pH 7.52 and electrical conductivity 0.25 dS m^{-1}. The soil was non-calcareous with $CaCO_3$ content of (5 %). The soil was medium in organic carbon content (0.54%) and cation exchange capacity (CEC) of 11.8 Cmol (p^+) kg^{-1}. The soil was low in available N (191 kg ha^{-1}), medium in available P (19 kg ha^{-1}) and high available K (297 kg ha^{-1}) states. The soil was medium in available S (12 mg kg^{-1}), exchangeable Ca (82 mg kg^{-1}) and exchangeable Mg (40.6 mg kg^{-1}). The soil was deficient in DTPA Zn (0.74 mg kg^{-1}), DTPA Fe (1.32 mg kg^{-1}) and sufficient in DTPA Mn (2.08 mg kg^{-1}), DTPA Cu (2.20 mg kg^{-1}) content. The $ZnSO_4$ and $FeSO_4$ were mixed with FYM in 1:10 ratio as per the treatments. The mixture was incubated in polythene bags under anaerobic condition for 21 days. The mixture turned over periodically and moisture content was checked twice in a week. The twenty first days seedlings had brought from nursery. Before transplanting the soil was fertilized as per the blanket dose of 90:90:75 kg N: P_2O_5: K_2O ha^{-1} recommended by TNAU crop production guide 2021. Full dose of the recommended phosphorus and potassium were applied as basal using single super phosphate and muriate of potash respectively as source of fertilizers. Half of the recommended dose of nitrogen was applied basally and the remaining half was applied as top dressing after transplanting. At the time of transplanting of marigold seedlings, the $ZnSO_4$ and $FeSO_4$ as an enriched FYM were applied as per the treatments. Seedlings were transplanted in 25cm height with 25 cm inner diameter earthen pots containing 10 kg soil. As per the treatment schedule, marigold crop was given foliar application of $ZnSO_4$ and $FeSO_4$ at various concentrations and liquid multi micronutrient at different growth stages viz., 20DAT (vegetative stage) and 35 DAT (pre flowering stage). Water spraying was given in the control pot. The sprayings were given using hand operated sprayer during the evening hours.

Data were taken at vegetative (30 DAT), flowering (45 DAT), post flowering (60 DAT) and harvest (75 DAT) stages.

Table 1. Treatment details

T_1	Absolute Control
T_2	100% RDF (90:90:75 NPK kg ha^{-1})
T_3	RDF + FYM enriched with $ZnSO_4$ @10 kg ha^{-1} and $FeSO_4$ @ 15 kg ha^{-1}
T_4	RDF + FYM enriched with $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 20 kg ha^{-1}
T_5	RDF + FYM enriched with $ZnSO_4$ @ 20 kg ha^{-1} and $FeSO_4$ @ 25 kg ha^{-1}
T_6	RDF + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% (Foliar spray)
T_7	RDF + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 1.0% (Foliar spray)
T_8	RDF + liquid multi micronutrient @ 1.0% (Foliar spray)

Liquid Multi Micronutrient: Zn-0.3567%, Fe-0.9651%, Mn-0.1456% and Cu-1.1345%

Table 2. Details of the analytical procedures employed for biochemical parameters

S. No	Parameters	Procedure	References
1.	Total chlorophyll	Acetone method	(Palta, 1990)
2.	Total carotenoid	Acetone method	(Kirk and Allen, 1965)
3.	Total phenol	Folin-Ciocalteu method	(Gonçalves *et al.*, 2012)

Data analysis

Utilizing the Gomez and Gomez (1984) approach, the data on numerous observations from the pot culture experiment that were collected during the course of the studies were statistically examined. Fisher's method of analysis of variance was used to analyze the data and P=0.05 was utilized as the level of significance for the F-test. The data are accounted and the critical difference was estimated at a 5% level of probability. Significant comparisons are expressed by the symbol ** for 1% probability level and * for 5% probability level and the non-significant comparisons indicated as NS.

RESULTS

Biochemical attributes

Close analysis of data (Table 3) revealed the significant impact of integrated zinc and iron on total chlorophyll content of marigold leaves over control. Total chlorophyll content of leaves increased with marigold growth at all stages. Among all treatments, at all the stages, remarkably higher chlorophyll content was recorded with the application of

RDF + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.5 % (foliar spray) (T_6) with 1.93 mg g^{-1} at 30 DAT, 2.07 mg g^{-1} at 45 DAT and at 2.07 mg g^{-1} 60 DAT and it was significantly superior to control and it was statistically on par with RDF + liquid multi micronutrient @ 1.0 % (T_8) with 1.87 mg g^{-1} at 30 DAT, 2.00 mg g^{-1} at 45 DAT and 2.12 mg g^{-1} at 60 DAT.

The data pertaining in Table 4 showed that significant influence of total carotenoid content of flower by application of integrated $ZnSO_4$ and $FeSO_4$ at different growth stages of marigold and the value ranged from 1.27 to 1.46 mg g^{-1}. Among all treatments application of RDF+ liquid multi micronutrient @ 1.0 % (T_8) recorded the maximum total carotenoid content 1.46 mg g^{-1} and it was significantly on par with RDF + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5 % (foliar spray) (T_6) 1.44 mg g^{-1}. The lowest 1.27 mg g^{-1} noted in control (T_1). The best treatment caused 13.92 per cent increase in total carotenoid content over untreated control (T_1).

A glance on the data in Table 4 on total phenol content was found significantly higher with the application of integrated zinc and iron and the values varied from 30.22 to 32.11 mg g^{-1}. Among all treatments RDF+ liquid multi micronutrient @ 1.0 % (T_8) showed maximum phenol content 32.11 mg g^{-1} compared to least in control (30.22 mg g^{-1}). Next to this application of RDF + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5 % (foliar spray) (T_6) recorded 31.99 mg g^{-1}. Compared to control 6.06 per cent increase was observed with the application of RDF+ liquid multi micronutrient @ 1.0 % (foliar spray).

Table 3. Effect of integrated Zinc and Iron on biochemical attributes of marigold cv. Local Orange

Treatments	**Total chlorophyll content in leaf (mg g^{-1})**			**Total carotenoid content (mg g^{-1})**	**Total phenol (mg g^{-1})**
	30DAT	**45DAT**	**60DAT**		
T_1	1.10	1.17	1.23	1.27	30.22
T_2	1.50	1.57	1.64	1.29	30.98
T_3	1.68	1.82	1.95	1.34	31.22
T_4	1.72	1.85	1.97	1.37	31.45
T_5	1.73	1.88	2.02	1.39	31.48
T_6	1.93	2.07	2.20	1.44	31.99
T_7	1.80	1.93	2.06	1.42	31.68
T_8	1.87	2.00	2.12	1.46	32.11
SE_d	0.039	0.046	0.053	0.29	0.35
CD (p = 0.05)	0.68	0.75	0.79	0.61	0.71

Nutrient uptake of Marigold plant

Major plant nutrients are constantly necessary for superior growth and enhanced yield of the crop. The uptake of nutrients by plant was increased when the nutrient availability was enormous which ultimately resulted in good yield. In the present investigation, highest uptake of nitrogen, phosphorus and potassium was recorded with the application of RDF + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.5 % (T_6) at all stages of crop growth. The sustainable availability of nutrients might be due to the addition of recommended dose of fertilizer with integrated zinc and iron throughout the crop growth revealed in maximum absorption of nutrients. The uptake was increased progressively from the vegetative stage (30 DAT) to flowering stage (45 DAT) and remarkable decreased from flowering stage to harvest stage (75 DAT).

The application of zinc and iron recorded valid influence on the micronutrient uptake of marigold plant (Table 4). The uptake was increased progressively from vegetative stage (30 DAT) to harvest stage (75 DAT) with the development of crop growth. Among all the treatments, RDF + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.5 % (T_6) treatment recorded significantly enhanced on uptake and it was found significantly superior over control (T_1) which was followed by RDF + liquid multi micronutrient @1.0%.

Table 4. Effect of integrated Zinc and Iron on macronutrient uptake (g pot^{-1}) of marigold cv. Local Orange

Treatments	N uptake (g pot^{-1})				P uptake (g pot^{-1})				K uptake (g pot^{-1})			
	30DAT	45DAT	60DAT	75DAT	30DAT	45DAT	60DAT	75DAT	30DAT	45DAT	60DAT	75DAT
T_1	0.54	0.72	0.68	0.50	0.102	0.118	0.130	0.110	0.46	0.62	0.72	0.61
T_2	0.85	1.01	0.88	0.65	0.168	0.175	0.189	0.157	0.73	0.87	0.94	0.80
T_3	0.99	1.13	0.97	0.69	0.166	0.168	0.161	0.133	0.83	0.96	1.02	0.88
T_4	1.05	1.18	1.01	0.71	0.168	0.168	0.159	0.130	0.87	1.00	1.05	0.91
T_5	1.11	1.24	1.09	0.74	0.172	0.169	0.149	0.119	0.92	1.05	1.10	0.95
T_6	1.23	1.39	1.17	0.77	0.200	0.205	0.185	0.162	1.02	1.15	1.19	1.03
T_7	1.15	1.31	1.10	0.75	0.181	0.178	0.159	0.129	0.95	1.08	1.12	0.98
T_8	1.20	1.36	1.14	0.76	0.197	0.202	0.180	0.149	0.99	1.12	1.17	1.00
SE_d	0.039	0.043	0.037	0.026	0.006	0.006	0.006	0.007	0.029	0.036	0.038	0.033
CD (p = 0.05)	0.082	0.091	0.078	0.056	0.014	0.014	0.013	0.014	0.068	0.077	0.082	0.071

Table 5. Effect of integrated Zinc and Iron on micronutrient uptake (mg pot^{-1}) of marigold cv. Local Orange

Treatments	Zn uptake (mg pot^{-1})				Fe uptake (mg pot^{-1})			
	30DAT	45DAT	60DAT	75DAT	30DAT	45DAT	60DAT	75DAT
T_1	1.04	1.92	2.74	2.47	4.18	6.48	8.98	8.72

T_2	1.73	2.78	3.64	3.35	6.67	9.32	11.91	11.70
T_3	2.12	3.21	4.40	3.76	7.85	10.75	13.68	13.33
T_4	2.27	3.45	4.64	3.97	8.43	11.47	14.49	14.20
T_5	2.45	3.72	4.92	4.16	9.01	12.25	15.21	14.79
T_6	2.91	4.33	5.76	4.89	10.51	14.07	17.37	16.94
T_7	2.62	3.92	5.35	4.56	10.30	13.88	16.97	16.57
T_8	2.72	4.16	5.50	4.74	10.37	13.99	17.21	16.79
SEd	0.172	0.261	0.351	0.139	0.484	0.637	0.810	0.368
CD (p = 0.05)	0.364	0.554	0.745	0.221	1.026	1.351	1.720	0.975

Nutrient uptake of Marigold flower

The data pertaining in Table 4, 5 revealed that uptake in flower increased with the application of integrated zinc and iron. Among the treatments, application of RDF + $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.5 % (T_6) reported significantly higher uptake of both macro and micronutrient and it was superior to control. However it was statistically at par with (T_8) RDF + liquid multi micronutrient @ 1.0%.

Table 6. Effect of integrated Zinc and Iron on macronutrient (g pot^{-1}) and micronutrient uptake (mg pot^{-1}) of marigold (cv. Local Orange) flower

Treatments	**N uptake (g pot^{-1})**	**P uptake (g pot^{-1})**	**K uptake (g pot^{-1})**	**Zn uptake (mg pot^{-1})**	**Fe uptake (mg pot^{-1})**	**Cu uptake (mg pot^{-1})**	**Mn uptake (mg pot^{-1})**
T_1	0.43	0.04	0.32	7.96	29.05	1.96	22.08
T_2	0.63	0.06	0.46	11.99	43.47	2.87	33.59
T_3	0.94	0.10	0.67	18.40	68.27	3.94	53.95
T_4	0.99	0.10	0.71	19.94	72.31	4.64	57.35
T_5	1.15	0.13	0.82	23.20	83.22	5.04	66.12
T_6	1.54	0.20	1.09	34.88	109.48	6.80	87.44
T_7	1.29	0.15	0.92	28.50	97.24	5.91	78.29
T_8	1.40	0.17	1.00	31.60	103.66	6.44	83.20
SE_d	0.018	0.005	0.011	0.98	1.25	0.51	1.14
CD (p = 0.05)	0.037	0.011	0.024	2.35	2.98	0.81	2.41

DISCUSSION

Biochemical attributes

The total chlorophyll content increased with the application of zinc and iron. In the present study, zinc and iron fertilizers improved the total chlorophyll content and highest value was obtained with the application of RDF + foliar spray of $ZnSO_4$ @ 0.5 % + $FeSO_4$ @ 0.5 % and showed its superiority over control during vegetative, pre flowering, post flowering. Chlorophyll pigmentation is correlated to the amount of nutrients absorbed by the plant from soil. This increase in chlorophyll content might be attributed to the balanced supply of nutrients at different growth stages of marigold (Karuppaiah *et al.*, 2004). This might also be attributed to the application of iron sulphate in which Fe is necessary for the maintenance of chloroplast structure and function and chlorophyll synthesis, zinc participates in chlorophyll formation by regulating the cytoplasmic concentrations of nutrients and also activates many enzymes, manganese activates some important enzymes involved in chlorophyll formation and copper may have a role in the synthesis and stability of chlorophyll. According to (Singh *et al.*, 2013), applying Zn fertilizers in soil increased the amount of water, protein, transpiration rate, chlorophyll and carbohydrates in crops. The findings of this study also demonstrated that the addition of Zn and Fe improved plant physiological parameter *i.e* total chlorophyll content in leaf. Similar results found by earlier workers (Kumbhar *et al.*, 2017) and (Pirzad and Shokrani, 2012).

Carotenoids are effective quenchers of reactive oxygen species, which are linked to a variety of oxidative stress-mediated illnesses including cardiovascular diseases, and neurological disorders. It primarily serves as antioxidant. Carotenoids are also found inside of cells, may be involved in the regulation of gene expression. Zn helps in the acceleration of cell division and elongation, as well as the translocation of metabolites. Furthermore, it boosts photosynthesis in the plant system by raising the activity of carbonic anhydrase. Cu, on the other hand, altered plant metabolic activity by participating in several metabolic pathways (including ATP generation) and also act as a cofactor for various enzymes (Bai *et al.*, 2009) .It contributes to glucose and nitrogen metabolism. Fe helps in the formation of chlorophyll and the activation of several enzymes involved in the oxidation or reduction processes of photosynthesis and respiration and as a good carbohydrate synthesizer in the plant system, Fe acts as a strong sink (Sohrab *et al.*, 2013), resulting in improved physiological growth prior to the start of the reproductive phase. The findings of the current investigation closely align with those of (Yadegari, 2015), (Yadegari, 2017) and (Pinedo-Espinoza *et al.*, 2020).

Total phenol content increase might be due to the fact that the synthesis of bio-assimilates of iron and zinc and both would have improved the efficiency photosystem II, which ultimately increasing the total phenol content. Additionally, the increased zinc availability accelerated the transformation of phylloxanthin into in flowers and the rates of photochemical reduction, enzyme-mediated carbohydrate transformations and photosynthetic electron transfer are all increased by zinc photosynthetic pigments. Copper is an essential component of proteins found in enzymes that control the rate of biochemical reactions in plants. Similar results was obtained by earlier workers (Siddhu and Saxena, 2017), (Ilangovan *et al.*, 2021) and (Sadique *et al.*, 2021)

Hence, the combined application of Zn, Fe, Mn and Cu significantly increased photosynthetic activities in the plant system, resulting in improved glucose translocation from source to sink.

Nutrient uptake

Nitrogen is an essential component of plants, appearing in the form of proteins, Adenosine Triphosphate, nucleic acids, amino acids, and various plant hormones and it is also a component of chlorophyll, the pigment used in photosynthesis. Leaf N levels was decreased gradually during the growth of marigold, because of N transfer occurs for protein synthesis. The uptake of nutrients might have improved with crop growth period due to higher dry matter production and N content. Similar trend was earlier reported by (Pratap *et al.*, 2005), (Soni *et al.*, 2009). Phosphorus is a component of nucleic acid, phytin, and phospholipids and plays a significant role in energy storage and transfer. It is necessary for cell division and the production of meristem tissue, which promotes accelerated root growth. When the concentration of zinc and iron rise, the phosphorus uptake in plant and flower increase. The increase in P uptake may be attributable to influence of Zn fertilization that induced development of root due to improved synthesis and polar transport of indole acetic acid (IAA), which results in higher absorption of P. Similar results have been reported by (Oseni, 2009). Potassium plays an important role in the ionic strength of liquids inside plant cells. K, the most abundant cellular cation, is involved in enzyme activation, water relations and transpiration-energy relations, assimilate translocation, absorption, and protein synthesis (Wang *et al.*, 2013). K helps in osmoregulation, sustaining turgor pressure in the cell, cell elongation, and growth. Per cent increase in K uptake due to integrated application of zinc and iron and multi micronutrient over control.

Micronutrient uptake

Zinc, one of the eight essential micronutrients, is required by plants in minute quantities but yet critical to plant development. Zinc is an essential component of numerous enzymes and proteins in plants. It is involved in a variety of functions, including growth hormone synthesis and internode elongation (Hänsch and Mendel, 2009). Zn sprayed as a foliar spray is easily absorbed and transmitted through the phloem (Haslett *et al.*, 2001). Although xylem transport of Zn has been shown to be more important for Zn accumulation than re-translocation of Zn from leaves by Palmgren *et al.* (2008) found that phloem transport of Zn from leaf and stem tissue may also play a substantial role in Zn enrichment of plant. Zn fertilizers given to the soil had slight effect on Zn in marigold; however spraying Zn to the foliage caused considerable increases in flower Zn (Phattarakul *et al.*, 2012). It appears that growing conditions have a key influence in xylem (root uptake) and phloem transport (remobilization). Iron is involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function (Rout and Sahoo, 2015). To rise Fe concentration, foliar application of iron might be the only available fertilization practice since soil application is not much effective (Kumar *et al.*, 2017). Fe application might have improved the activity of all enzymes and chlorophyll, as well as plant protein, iron and carbohydrate levels and flower production. Proper iron availability boosts the activity of photosynthesis-related enzymes, resulting in higher yield. Foliar Fe treatments may improve total Fe content while decreasing phytic acid concentration, resulting in higher Fe availability from plant. Appropriate carrier for foliar fertilization should have high solubility and low molecular weight compounds which govern the uptake of nutrients. Foliar-applied iron is transferred from the leaf to the meristemetic area when applied in young leaves. The translocation of iron into the leaf is determined by the plant species, which is important for determining the mobility. As the iron goes through the stomata, it is most likely absorbed by the parenchyma cells surrounding the sub-stomatal chambers and translocated to the phloem via symplastic movement. The amount of micronutrients in grain is determined by nutrient translocation during the plant development stage.

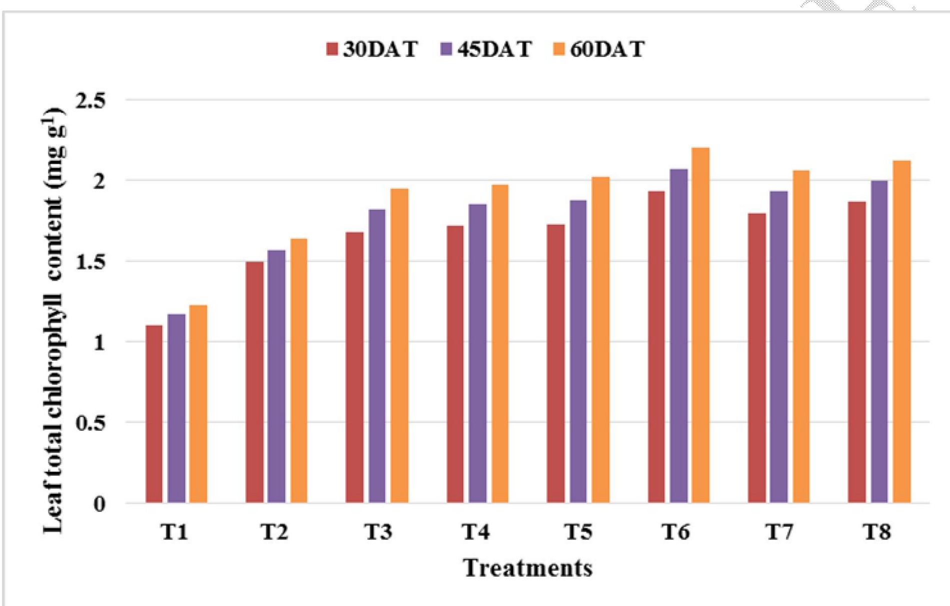

Fig 1. Effect of integrated zinc and iron on leaf total chlorophyll content (mg g^{-1}) at different growth stages of marigold cv. Local Orange

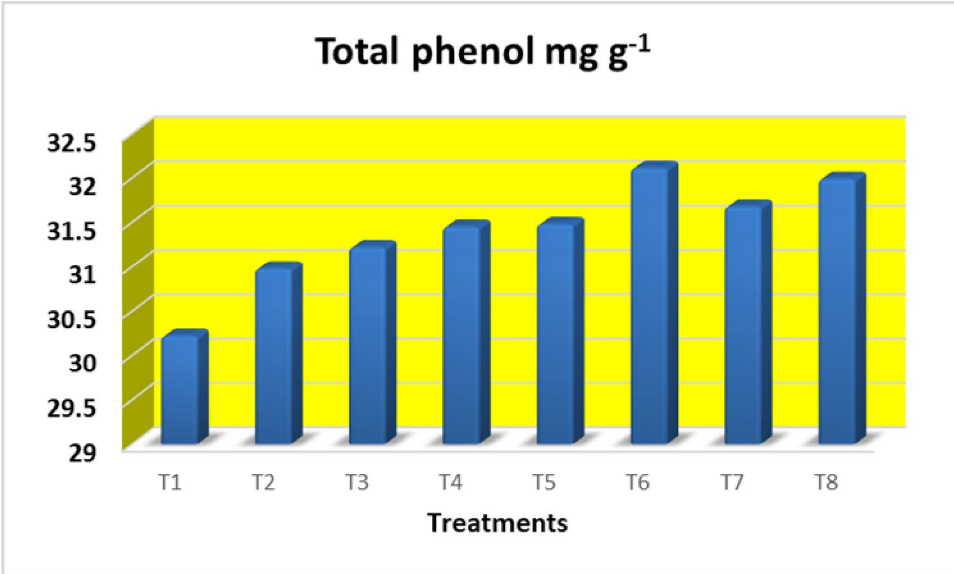

Fig 2. Effect of integrated zinc and iron on total phenol content (mg g^{-1}) of marigold cv. Local Orange

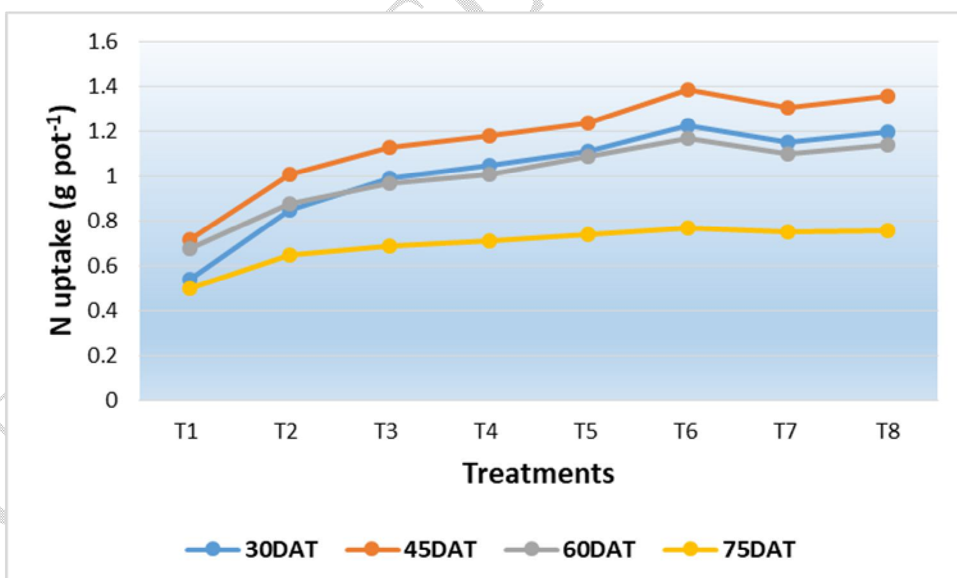

Fig 3. Effect of integrated zinc and iron on nitrogen uptake (g pot^{-1}) at different growth stages of marigold cv. Local Orange

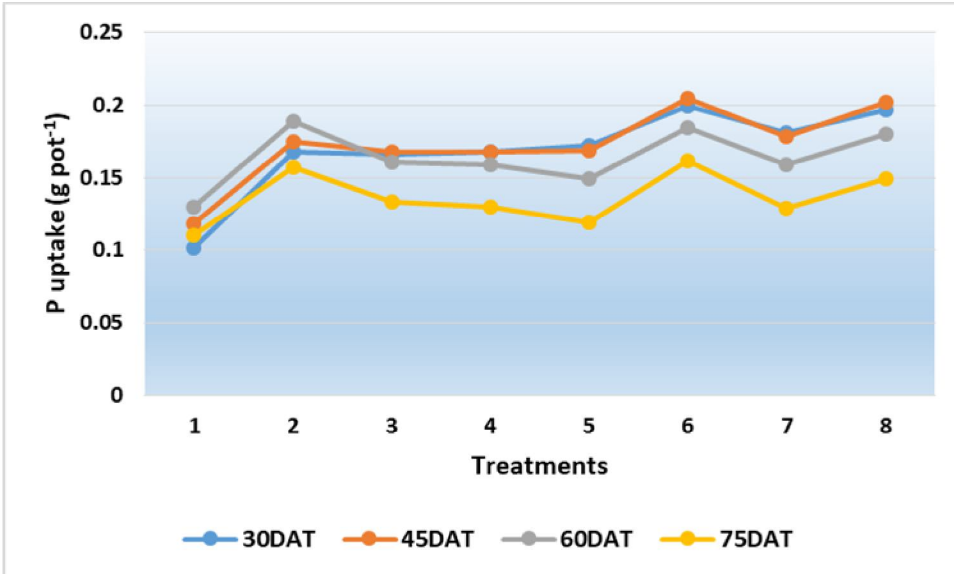

Fig 4. Effect of integrated zinc and iron on phosphorus uptake (g pot^{-1}) at different growth stages of marigold cv. Local Orange

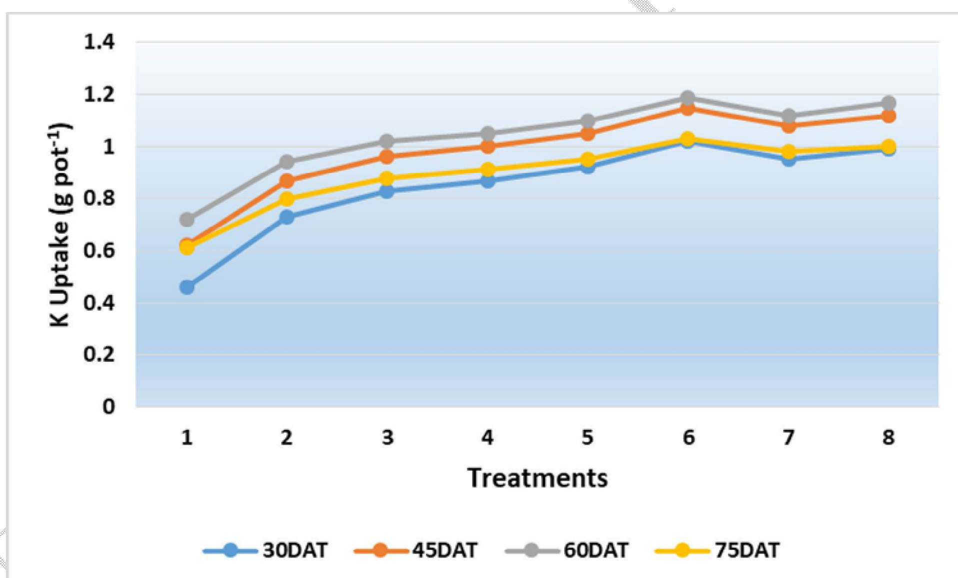

Fig 5. Effect of integrated zinc and iron on potassium uptake (g pot^{-1}) at different growth stages of marigold cv. Local Orange

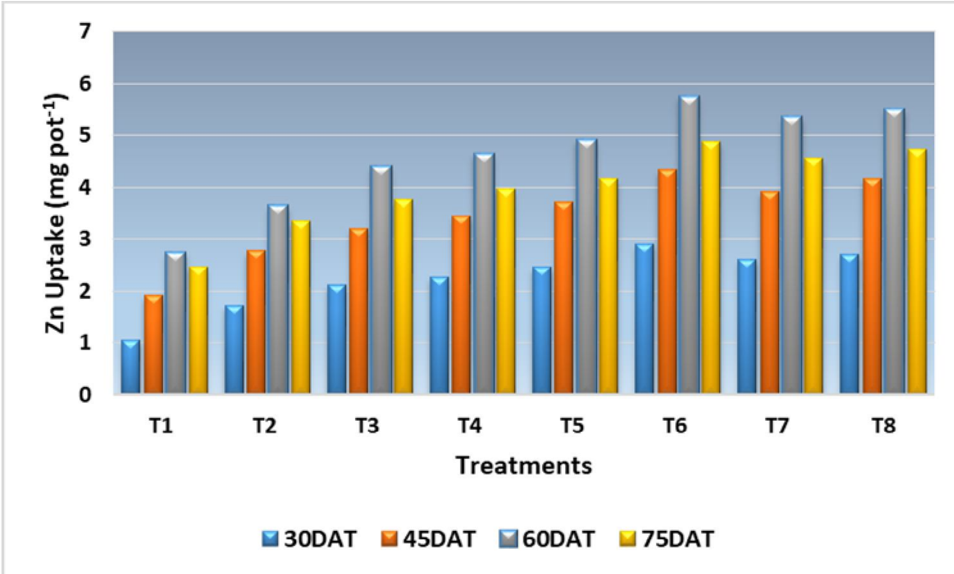

Fig 6. Effect of integrated zinc and iron on zinc uptake (mg pot^{-1}) at different growth stages of marigold cv. Local Orange

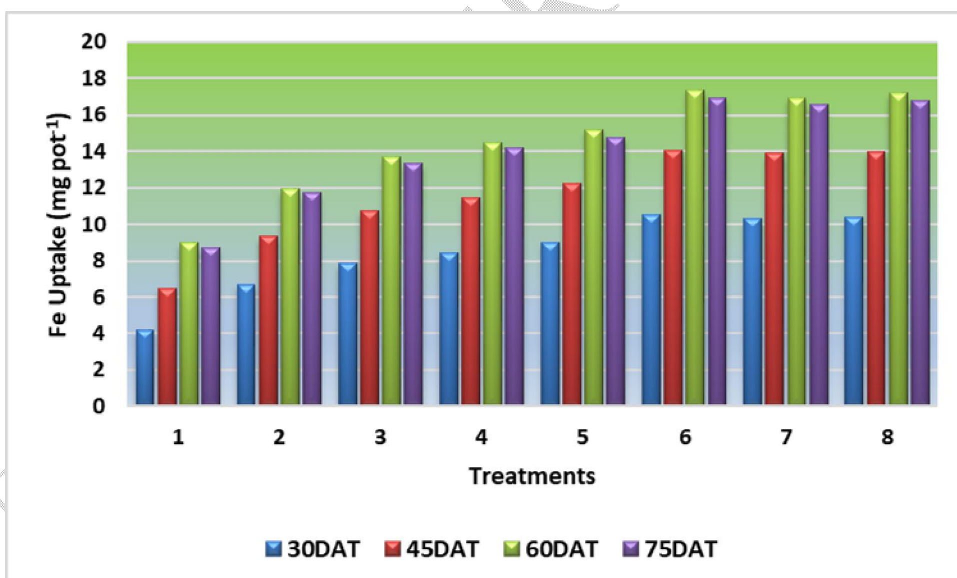

Fig 7. Effect of integrated zinc and iron on iron uptake (mg pot^{-1}) at different growth stages of marigold cv. Local Orange

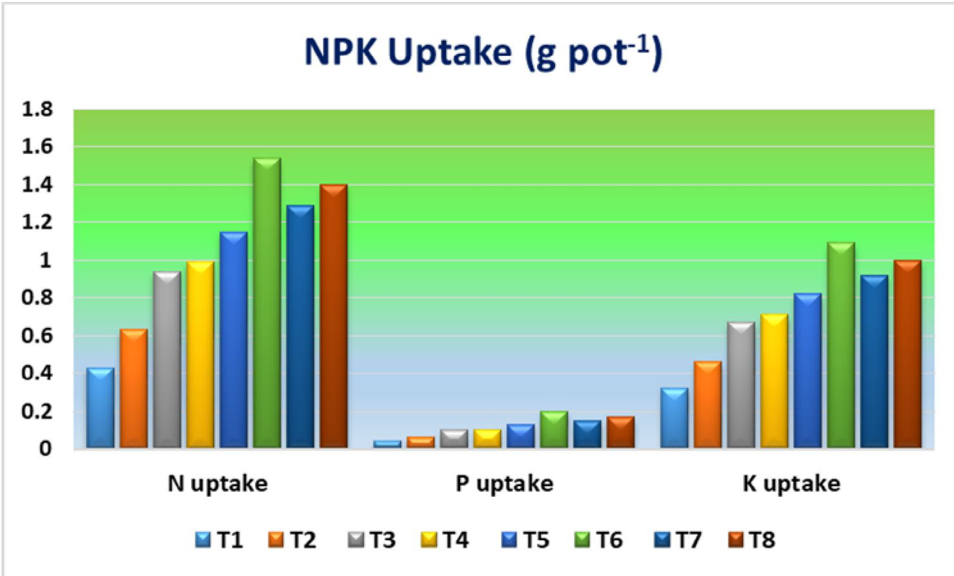

Fig 8. Effect of integrated zinc and iron on macronutrient uptake (g pot^{-1}) of marigold cv. Local Orange flower

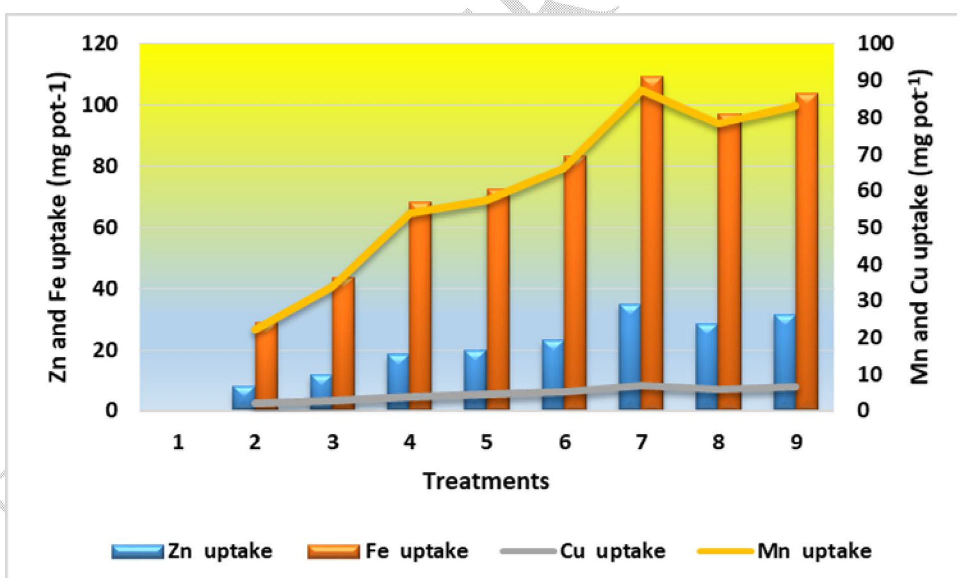

Fig 9. Effect of integrated zinc and iron on micronutrient uptake (mg pot^{-1}) of marigold cv. Local Orange flower

CONCLUSION

The findings notice significance of the present investigation which was especially planned to evaluate the potential of combination of zinc and iron on the important flower crop marigold cv. Local Orange. These findings up to harvesting stage are of relevance that develop insights that additional amount of micronutrients zinc and iron might be beneficial in increasing biochemical attributes and nutrient content of marigold plants for bearing healthy and quality flowers. The study indicated that enriched FYM, foliar application zinc and iron significantly affect the flower quality on biochemical constituents and nutrient uptake of marigold plant and flower. The results revealed that marigold cv. Local Orange responded better to foliar application of ZnSO4 and FeSO4 each @ 0.5% at two stages *viz.* 20 and 35 days after transplanting. Application of liquid multi micronutrient @ 1.0% which contains zinc and iron significantly enhanced the biochemical trait *viz.* total carotenoid content (mg/g) of flowers and total phenols (mg g^{-1}). Application of RDF + $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5 % (T_6) at vegetative and pre flowering stages may be suggested to the farmers for receiving higher marigold flower yield with enhanced nutrient uptake.

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