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Impact of soil and foliar application of $FeSO_4$ and $ZnSO_4$ on growth and yield of curry leaf (*Murraya koenigii* Spreng.)

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Abstract
Curry leaf is grown commercially for its aromatic spicy green leaves. The leaves have good aroma and flavour due to high essential oil content. A field experiment on the influence of soil and foliar application of $FeSO_4$ and $ZnSO_4$ on growth and yield of curry leaf was conducted at College orchard, Department of Spices and Plantation Crops, HC&RI, TNAU, Coimbatore during the year 2018- 2019. The experiment was laid out in RBD with three replications and ten treatments comprising of FYM, soil applications (25 kg/ha and 12.5 kg/ha) and foliar applications (0.5 and 0.25%) of iron and zinc at 30 and 45 days after spraying. Among the ten treatments, foliar feeding of curry leaf with 0.5% of ferrous sulphate showed maximum plant height (236.08 cm), leaf length (4.28 cm), leaf width (3.78 cm), number of rachis per shoot (14.16), number of shoots per plant (15.49), leaf area (8.7 cm^2), chlorophyll index (60.97), leaf yield per plant (1.41 kg) and leaf yield per hectare (4700 kg).

Keywords: Curry leaf, ferrous sulphate, zinc sulphate, growth and yield

Introduction
Curry leaf (*Murraya koenigii*) belongs to the family Rutaceae, is native of SriLanka. In India, it is widely used in Kerala and cultivated mostly in Southern states *viz.*, Tamil Nadu, Kerala and Andhra Pradesh. In Tamil Nadu, it is cultivated on commercial scale in Coimbatore, Erode, Madurai, Salem and Tiruchirappalli districts. Curry leaf is an important spice crop used for flavoring foodstuff in Indian countries due to their slight pungent, bitter and feebly acidic taste, and they also retain their flavor even after drying (Singh 2014) [12]. It is highly demanded for ayurvedic medicinal use and culinary purpose due to its pharmaceutical properties and their aroma (Priyadarshini *et al.*, 2017) [8]. Curry leaves reported to have some medicinal properties such as anti-oxidative, cytotoxic, antimicrobial, antibacterial, anti-ulcer, positive isotropic and cholesterol reducing activities (Saini *et al*., 2015) [11].

Use of the micronutrients which enhance the growth and yield of crops but this is needed in very small quantities. Some of the essential micronutrients are zinc (Zn), iron (Fe), manganese (Mn), boron (B), chlorine (Cl), copper (Cu), molybdenum (Mo), cobalt (Co), vanadium (V), sodium (Na), and silicon (Si). Among them, iron and zinc are essential for plant growth and development because these micronutrients control most of physiological activities of the crop *viz*., leaf chlorophyll content and photosynthetic rate.

Among the micronutrients, iron is an essential element for almost all living organisms because it plays a critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. In plants, iron is involved in the synthesis of chlorophyll, and it is crucial for the maintenance of chloroplast structure and function (Rout *et al.*, 2015) [9].

Zinc acts either as a metal component of enzymes or as a functional, structural, or regulatory cofactor of a large number of enzymes. The accumulation of amino acids and amides in these plants demonstrates the importance of zinc for protein synthesis. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, regulation of Auxin synthesis and pollen formation (Hafeez *et al.*, 2013) [5]. However, there is no research evidence on the soil and foliar application of $FeSO_4$ and $ZnSO_4$ on growth and yield of curry leaf. Hence, the present study was formulated.

Materials and Methods

Field site description

The present study was conducted at College orchard, Department of Spices and Plantation Crops, HC&RI, TNAU, Coimbatore during the year 2018-19. The experiment was conducted at 11° N latitude and 77 ° E longitude with an altitude of 426.7 m above the mean sea level.

Experimental design and treatment

Plants were established with a spacing of 1 x 1m in Randomized block design with 10 treatments involving two micronutrients *viz*., iron (Fe), Zinc (Zn) and FYM along with recommended dose of fertilizers in three replications. Micronutrients are applied through soil application and foliar application individually at 30 and 45 days. FYM applied through soil application. The recommended dose of major nutrients for the curry leaf was applied as 150:25:50 kg / ha /year of N_2O:P_2O_5:K_2O.

Table 1: Treatment details

S. NO	Treatment	Micronutrients	Dose of application	Mode of application
1	T_1	Absolute control	-	-
2	T_2	Farmyard manure	20 t / ha	Soil application
3	T_3	Ferrous sulphate	0.5%	Foliar spray
4	T_4	Ferrous sulphate	0.25%	Foliar spray
5	T_5	Ferrous sulphate	25 kg/ha	Soil application
6	T_6	Ferrous sulphate	12.5 kg/ha	Soil application
7	T_7	Zinc sulphate	0.5%	Foliar spray
8	T_8	Zinc sulphate	0.25%	Foliar spray
9	T_9	Zinc sulphate	25 kg/ha	Soil application
10	T_{10}	Zinc sulphate	12.5 kg/ha	Soil application

* All the treatments were applied with RDF as 150:25:50 kg/ ha/year of N_2O:P_2O_5:K_2O

Observations recorded

The observations were recorded on vegetative growth and yield parameters *viz*., plant height, leaf length and width, number of rachis per shoot, number of shoots per plant, chlorophyll index, leaf area, yield characters kg per plant and kg per hectare.

Statistical analysis

The data were subjected to ANOVA using the statistical computer package of SPSS and treatment means separated using L.S.D and Duncan multiple range test at P<0.05 level.

Result and discussion

Perusal of the data presented in tables 2 & 3 revealed that foliar application of ferrous sulphate significantly increased the growth and yield parameters as compared to soil application.

Growth parameters

The Growth parameters *viz*., plant height, leaf length, leaf width, number of rachis per shoot, number of shoots per plant, Chlorophyll index, leaf area were recorded. The maximum plant height (236.08 cm) was recorded in 0.5% $FeSO_4$foliar spray (T_3) after 30 and 45 days of spraying followed by 12.5 kg/ha$ZnSO_4$soil application(T_{10}) (227.81 cm) after 30 and 45 days of spraying. Whereas the lowest plant height (193.63 cm) was recorded in absolute control (T_1). Our results agrees with those obtained by Amberger (1974**)** who reported that iron is needed for plant growth, photosynthesis and other light process.

Foliar application of 0.5% $FeSO_4$ (T_3) showed the highest leaf length of (4.28 cm) followed by 25 kg/ha $ZnSO_4$ (3.62cm) soil application (T_9). The lowest leaf length (2.63 cm) was observed in T_8 treatment of 0.25% $ZnSO_4$ foliar spray (Table 2).

Table 2: Effect of iron and zinc application on growth parameters in curry leaf

Character/ treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	No. of rachis/ shoots	No. of shoots/plant	Chlorophyll index (SPAD value)	Leaf area (cm^2)
T_1	193.63	2.82	2.01	10.98	2.16	34.82	4.60
T_2	197.99	3.54	2.41	11.84	12.33	44.99	5.60
T_3	236.08	4.28	3.78	14.16	15.49	60.97	8.70
T_4	203.66	3.03	2.09	9.99	8.74	46.07	6.20
T_5	201.97	2.91	2.10	12.65	11.90	46.93	5.50
T_6	217.22	3.20	2.08	12.03	10.41	42.00	3.70
T_7	213.55	3.30	2.03	11.92	7.91	36.87	5.20
T_8	221.56	2.63	1.38	13.18	6.41	45.96	4.90
T_9	224.04	3.62	2.04	12.10	12.55	50.54	4.60
T_{10}	227.81	3.58	2.14	12.32	11.44	45.14	6.40
Mean	213.75	3.29	2.21	12.12	9.93	45.43	5.54
SEd	14.30	0.52	0.20	2.40	1.07	4.67	0.74
CD (0.5%)	30.04	1.11	0.42	2.10	2.20	9.81	1.57

Treatment details: T_1 – Absolute Control; T_2 – RDF +FYM (20 t / ha); T_3 – RDF + 0.5% $FeSO_4$ (Foliar spray); T_4 – RDF + 0.25% $FeSO_4$ (Foliar spray); T_5 – RDF + 25 kg/ha $FeSO_4$ (Soil Application); T_6 – RDF + 12.5 kg/ha $FeSO_4$ (Soil Application);T_7 – RDF + 0.5% $ZnSO_4$ (Foliar spray); T_8 – RDF+ 0.25% $ZnSO_4$ (Foliar spray);T_9 - RDF + 25 kg/ha $ZnSO_4$ (Soil application); T_{10} – RDF + 12.5 kg/ha $ZnSO_4$ (Soil application); *RDF 150:25:50 kg / ha /year.

The maximum leaf width (3.78cm) was recorded in foliar spray of 0.5% ferrous sulphate (T_3) followed by FYM 20 t/ha (2.41 cm) (T_2). The minimum leaf width (1.38 cm) was observed in 0.25% $ZnSO_4$ (T_8) (Table 2).

The highest number of rachis per shoot (14.16) was observed with foliar application (T_3) of iron (as 0.5% $FeSO_4$) which was statistically on par with soil application 0.25% $ZnSO_4$ (T_8) (13.18). The lowest number of rachis per shoot (9.99) was recorded in 0.25% $FeSO_4$ foliar spray (T_4) (Table 2).

The highest number of shoots per plant(15.49) was observed in 0.5% $FeSO_4$foliar spray and the lowest number of shoots per plant (2.16) was recorded in absolute control (T_1) (Table 2).These results are in agreement with those of EL-Fouly *et al.*, (1997) [3] that foliar application of 50 mg/l of iron

increased the growth.

The highest chlorophyll index was recorded as 60.97 when plants were sprayed with 0.5% $FeSO_4$ (T_3), followed by (50.54) T_9treatment of $ZnSO_4$ (25 kg/ha) as soil application. The minimum chlorophyll index (34.82) was recorded in absolute control (T_1).

Foliar application of iron ($FeSO_4$) @ 0.5% (T_3) showed the highest leaf area (8.70 cm^2) followed by soil application of Zinc ($ZnSO_4$) (T_{10})6.40 cm^2@ 12.5 kg/ha. The lowest leaf area (3.70 cm^2) was recorded in the treatment of soil application of iron ($FeSO_4$) (T_6) @ 12.5 kg/ha (Table 2).

Among these treatments, foliar application of iron (as $FeSO_4$) @ 0.5% was the best treatment. These results might be due to iron sprayed at proper concentration which plays role of indispensable element for development of chlorophyll structure due to they had a principal component of chloroplast by the way plants are utilizing the micro-nutritional requirements (Rout *et al.*, 2015) [9]. The positive influences of micronutrients application on curry leaf growth may be due to the improved ability of the crop absorb nutrients to photosynthesize and better sink source relationship. Increase in yield may attribute to increased plant height, leaf length, leaf width, number of rachis per shoot, number of shoots per plant, chlorophyll index and leaf area which are positively affected by the application of iron as foliar spray.

Yield parameters

Among the different treatments, foliar application of iron (as applied $FeSO_4$) @ 0.5% (T_3) gave the highest leaf yield per plant and leaf yield per hectare (1.41 kg/plant and 4700 kg/ha) followed by 0.89 kg/ plant and 2966.67kg/ha recorded in (T_2) FYM 20 t/ha (Table 2). The lowest yield was recorded as 0.60 kg /plant and 2000 kg/ha in absolute controls (T_1) respectively (Table 3). Agarwal *et al.*, (2004) [1] reported similar effect on foliar application of 0.5 per cent iron produce higher yield. In this experiment higher yield compared to all other treatments which might be due to the beneficial effect of iron on curry leaf yield.

Table 3: Effect of iron and zinc application on yield attributing parameters of curry leaf

Treatments	Yield (kg / plant)	Yield (kg / ha)
T_1	0.60	2000.00
T_2	0.89	2966.67
T_3	1.41	4700.00
T_4	0.68	2266.67
T_5	0.66	2200.00
T_6	0.86	2866.67
T_7	0.72	2400.00
T_8	0.43	1433.33
T_9	0.61	2033.33
T_{10}	0.63	2100.00
MEAN	0.75	2496.67
S.Ed	0.09	784.46
CD (%)	0.51	1648.15

Treatment details: T_1 – Absolute Control; T_2 – RDF +FYM (20 t/ha); T_3 – RDF + 0.5% $FeSO_4$ (Foliar spray); T_4 – RDF + 0.25% $FeSO_4$ (Foliar spray); T_5 – RDF + 25 kg/ha $FeSO_4$ (Soil Application); T_6 – RDF + 12.5 kg/ha $FeSO_4$ (Soil Application);T_7 – RDF + 0.5% $ZnSO_4$ (Foliar spray); T_8 – RDF+ 0.25% $ZnSO_4$ (Foliar spray);T_9 - RDF + 25 kg/ha $ZnSO_4$ (Soil application); T_{10} – RDF + 12.5 kg/ha $ZnSO_4$ (Soil application); *RDF 150:25:50 kg / ha /year.

Conclusion

In the present investigation application of iron and zinc had a significant effect on growth and yield parameters. Under adverse condition the nutrient availability in soil to the plant is reduced due to the binding of nutrient to the soil particle. However, application of micronutrient as foliar spray allows plant to come in ready contact with element and thus absorb by leaf pores. It can be concluded that the foliar application of iron (as $FeSO_4$) @ 0.5% at 30 and 45 days after spraying increased the growth and yield parameters. This study provides some useful information about the effect of the iron and zinc in that way broadens our knowledge about the effect of micronutrients on crop production.

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