International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 1360-1363

Received: 04-01-2020
Accepted: 08-02-2020

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Influence of zinc, iron and manganese on growth and yield parameters of V1 mulberry (*Morus alba* L.)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2u.8951

Abstract
A field experiment was conducted to study the effect of soil application of zinc, iron and manganese on mulberry at Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru-65 during 2018-19. Among the different treatments, T_5 (350:140:140 NPK kg/ha/year + FYM 20 t/ha/year + micronutrient formulation of Zn, Fe and Mn @ 6 kg/acre) recorded significantly higher plant height (169.50 and 211.61 cm), shoot height (65.15 and 170.56 cm), number of shoots/plant (30.11 and 30.17), shorter internodal distance (5.13 and 5.14 cm), number of leaves/plant (548.67 and 567.56), leaf area (283.52 and 310.45 cm^2), leaf yield (947.20 and 1040.81 g/plant) and leaf dry matter (359.05 and 552.05 g/plant) on 45th and 75th DAP in V1 mulberry. Compared to other treatments all the above-mentioned parameters found least in the control.

Keywords: Mulberry, micronutrient formulation (Zn, Fe and Mn), growth and yield parameters

Introduction
Mulberry is a robust, perennial deep-rooted high biomass producing foliage crop, being the sole source of nourishment from which the mulberry silkworm (*Bombyx mori* L.) derives nearly 70 per cent of protein for silk synthesis. This plant protein is get converted into silk protein in that silkworm body. The several factors are responsible for successful cocoon crop *viz.*, silkworm egg (3.15%), silkworm race (4.2%), rearing technique (9.3%), local weather (37.0%), mulberry leaf (38.2%), and other factors (6.6%) (Miyashita, 1986) [4]. It is clear that mulberry leaf plays a dominant role in cocoon production as the only source of nutrition to the silkworm. Silkworm larval growth and cocoon yield are mainly influenced by nutritional quality of mulberry leaf (Shankar, 1999) [7].
Micronutrients are involved in several metabolic activities of mulberry plant that are responsible for quality leaf production and stimulate metabolic activity in silkworm which in turn leads to better rearing performance and silk quality. As mulberry is grown for its foliage and harvested for five to six times a year, requirement of nutrients is high and balanced application of required nutrients is essential. Since available literature on the soil application of micronutrients and its effect on quality and quantity of mulberry leaf and development of silkworm and cocoon quality is scanty, the present investigation was taken up with the effect of soil application of Zn, Fe and Mn on growth and yield of mulberry.

Materials and Methods
A field experiment was conducted at Department of Sericulture, UAS, GKVK, Bengaluru-65 during 2018-19 in established mulberry garden with Victory 1 variety planted at a spacing of (90 +150) x 60 cm (paired row system). Physicochemical properties of the experimental site were analysed. The soil was clay loam in texture, having 7.75 pH, EC 0.29 dSm^{-1}, 0.44 percent organic carbon, 220.15 kg ha^{-1} available N, 35.30 kg ha^{-1} available P_2O_5, 175.17 kg ha^{-1} available K_2O. The experiment was laid out in randomized complete block design (RCBD) and replicated thrice with 7 treatments. The treatment details are given below.

T_1 Control (*RDF+*FYM)
T_2 T_1 + Micronutrient formulation @ 2 kg/acre
T_3 T_1 + Micronutrient formulation @ 4 kg/acre
T_4 T_1 + Micronutrient formulation @ 5kg/acre
T_5 T_1 + Micronutrient formulation @ 6 kg/acre
T_6 T_1 + Micronutrient formulation @ 7 kg/acre
T_7 T_1 + Micronutrient formulation @ 8 kg/acre

- *RDF-Recommended dose of fertilizers (350:140:140 kg NPK/ha/year)
- *FYM-Farm yard manure (20 t/ha/year)
- Micronutrient formulation [Zinc (6%), Iron (0.5%) and Manganese (0.5%)]

Micronutrient formulation (Zn, Fe and Mn) was applied to soil as band placement after middle pruning in August, 2018. The observations on growth and yield parameters of V1 mulberry were recorded on 45th and 75th days after pruning.

Result and Discussion

Growth parameters of V1 mulberry

Plant height (cm)

The significant plant height of 169.50 and 211.61 cm was recorded on 45th and 75th days respectively after pruning (DAP) in T_5 (T_1+micronutrient formulation @6 kg/acre), which was on par with T_7 (T_1+micronutrient formulation @ 8 kg/acre) (163.17 and 208.56 cm) and T_6(T_1+micronutrient formulation @ 7 kg/acre respectively) (161.78 and 206.22 cm). The shorter plant height of 129.05 cm (45th DAP) and 172.88cm (75th DAP) was recorded in T1 (100% Recommended dose of NPK + FYM) (control) (Table 1).

Similar results were observed by Patil *et al*. (2001) [6] who reported that the effect of soil application of zinc sulphate at 25 kg/ha significantly increased the plant height (189.95 cm). The results are in conformity with the study of Singhvi *et al.* (2003) [8] who recorded maximum plant height of 196.75 cm as influenced by the application of seriboost at a concentration of 2.5 ml/lit in two sprays.

Highest shoot height (cm)

The significant shoot height of 65.15 and 170.56 cm was recorded on 45th and 75th DAP in T_5, which was on par with T_7 (62.06 and 168.45 cm) and T_6 (59.56 and 164.11 cm). The lowest shoot height of 50.89 cm (45th DAP) and 133.17 cm (75th DAP) was recorded in T1 (control) (Table 1).

In the present investigation T_5 has recorded significant shoot height (65.15 and 170.56 cm) which is on par with Shilpashree and Subbarayappa (2015) [9] who recorded higher shoot height (1.71m) with the application of $ZnSO_4$ at 20 kg ha^{-1}. Similarly, Geetha *et al*. (2016) [3] recorded higher shoot length (153.5cm) in the treatment (T_9:0.5% $ZnSO_4$+ 1.0% $FeSO_4$ + 0.1% Citric acid+ 0.2% Boric acid + 0.5% $MnSO_4$ + 0.01% Na_2MoO_4).

Number of shoots/plant

The number of shoots/plant of V1 mulberry variety was influenced significantly by soil application of micronutrient formulation. Higher number of shoots/plant were noticed in T_5 (30.11 and 30.17) which was on par with T_7 (27.11 and 30.06) and T_6 (26.33 and 29.56) recorded on 45th and 75th DAP. Least number of shoots were recorded in T_1 (20.50 and 21.67) (Table 1).

The current study is in agreement with the results of Sowmya and Narayanaswamy (2015) [10] who recorded higher number of shoots (19.14 @ 30 DAP and 26.99 @ 60 DAP) with the application of zinc sulphate (20kg/ha/year).

Internodal distance (cm)

The significant shortest internodal distance was recorded in T_5 (5.13 and 5.14 cm) which was on par with T_7 (5.16 and 5.17 cm) and T_6 (5.19 and 5.20 cm) compared to other treatments (T_4, T_3 and T_2) recorded on 45th and 75th DAP whereas, longer internodal distance was recorded in T_1 (5.69 and 5.42 cm) (Table 1).

The results are supported by Nithya *et al*. (2018) [5] who recorded that the reduction in the intermodal distance in mulberry apparently is due to the supply of adequate inorganic fertilizers to the plants which increased number of internodes and in turn gave rise to more number of leaves and leaf area per plant. The results of the present study are similar with the findings of Sowmya and Narayanaswamy (2015) [10] who recorded shorter internodal distance (4.43 cm) by application of zinc sulphate at 20kg/ha/year.

Table 1: Effect of soil application of micronutrient formulation (Zn, Fe and Mn) on growth parameters of V1 mulberry at 45th and 75th DAP

Treatments	Plant height (cm)		Highest shoot height (cm)		No. of shoots/plant		Internodal distance (cm)	
	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP
T_1	129.05	172.88	50.89	133.17	20.50	21.67	5.69	5.42
T_2	133.89	182.25	55.11	145.61	21.45	23.72	5.59	5.39
T_3	138.28	182.72	56.00	147.00	23.11	23.95	5.49	5.36
T_4	147.95	184.55	56.50	148.17	24.61	24.39	5.41	5.29
T_5	169.50	211.61	65.15	170.56	30.11	30.17	5.13	5.14
T_6	161.78	206.22	59.56	164.11	26.33	29.56	5.19	5.20
T_7	163.17	208.56	62.06	168.45	27.11	30.06	5.16	5.17
F-test	*	*	*	*	*	*	*	*
S.Em.±	5.91	7.79	1.85	3.27	1.19	1.31	0.125	0.057
CD @ 5%	18.22	24.00	5.71	10.09	3.66	4.05	0.386	0.175

*Significant at 5%

T_1	Control (*RDF + *FYM)
T_2	T_1 + Micronutrient formulation @ 2 kg/acre
T_3	T_1 + Micronutrient formulation @ 4 kg/acre
T_4	T_1 + Micronutrient formulation @ 5kg/acre
T_5	T_1 + Micronutrient formulation @ 6 kg/acre
T_6	T_1 + Micronutrient formulation @ 7 kg/acre
T_7	T_1 + Micronutrient formulation @ 8 kg/acre

- *RDF-Recommended dose of fertilizers (350:140:140 kg NPK/ha/year)
- *FYM- Farm yard manure (20 t/ha/year)
- Micronutrient formulation [Zinc (6%), Iron (0.5%) and Manganese (0.5%)]

Yield parameters of V1 mulberry

Number of leaves/plant

The significant number of leaves/plant of 548.67 and 567.56 was recorded on 45th and 75th DAP in T_5 which was on par with T_7 (533.83 and 556.83) and T_6 (528.95 and 538.33). However, lowest number of leaves/plant was recorded when mulberry was raised without application of micronutrient formulations T_1 (426.72 and 445.56) (Table 2).

The results are in conformity with the study of Shilpashree and Subbarayappa (2015) [9] who noticed that application of $ZnSO_4$ at 20 kg/ha recorded maximum number of leaves (275.2). The results of the present study are also in line with the findings of Sowmya and Narayanaswamy (2015) [10] reported that the application of zinc sulphate (20kg/ha/year) recorded higher number of leaves/plant (141 @ 30 DAP and 219.33 @ 60 DAP).

Leaf area (cm^2)

Mulberry raised with the application of micronutrient formulation at 6 kg/acre (T_5) recorded significant leaf area per plant (283.52 and 310.45 cm^2), which was on par with T_7 (268.50 and 291.97 cm^2) and T_6 (263.83 and 284.45 cm^2) on 45th and 75th DAP, compared to other treatments (T_4, T_3 and T_2). However, the lowest leaf area per plant was recorded in T_1 (205.11 and 242.28 cm^2) (Table 2; Plate 1).

The present investigations are in line with the study of Ahmed *et al*. (2018) [1] who recorded maximum leaf area (545.5 cm^2) by application of Basal + Urea (B+U), Basal + Foliar fertilizer (FF). Similarly, Sowmya and Narayanaswamy (2015) [10] reported that the application of zinc sulphate (20kg/ha/year) recorded maximum leaf area (212.58 dm^2 @ 60 DAP) and Nithya *et al*. (2018) [5] recorded maximum leaf area of 96.90 cm^2 with the foliar application of zinc oxide at 50 ppm.

A) T_1-(RDF + FYM) **B) T_5-(T_1 + micronutrient formulation @ 6 kg/acre)**

Plate 1: Effect of soil application of micronutrient formulation on leaf area of V1 mulberry after 45 days of pruning

Leaf yield per plant (g/plant)

Significant results were noticed with regard to leaf yield per plant of V1 mulberry among the different treatments (Table 2; Fig 1). The leaf yield (947.20 and 1040.81 g/plant) recorded on 45th and 75th DAP was significantly higher in T_5 which was on par with T7 ((883.58 and 1008.17 g/plant) and T6 ((871.15 and 994.03 g/plant). The lowest leaf yield was recorded in T1 (620.45 and 730.67 g/plant).

The results are in conformity with the earlier studies of Yokoyama (1975) [11] who reported that mulberry leaf yield depends on the number and length of the shoots, internodal distance and number and weight of leaves per plant. The results of the present investigations are similar with the findings of Singhvi *et al*. (2003) [8] and Ahmed *et al*. (2018) [1] who recorded leaf yield of 495.50 and 470.8 gm respectively. Similarly, leaf yield of 13,013 kg/ha/harvest in the treatment (0.5% $ZnSO_4$+ 1.0% $FeSO_4$ + 0.1% Citric acid+ 0.2% Boric acid + 0.5% $MnSO_4$ + 0.01% Na_2MoO_4) was recorded by Geetha *et al*. (2016) [5].

Leaf dry matter per plant (g/plant)

Among the different treatments, the soil application of micronutrient formulation at 6 kg/acre (T_5) recorded statistically superior leaf dry matter (359.05 and 552.05 g/plant), which was on par with T7 (336.41 and 538.06 g/plant) and T6 (319.16 and 503.88 g/plant) on 45th and 75th DAP. The lowest was recorded in T1 (216.03 and 326.61 g/plant) (Table 2; Fig. 2).

The present investigation where in T_5 has recorded higher leaf dry matter is in line with the results of Channal (1978) [2] who recorded higher leaf dry matter with foliar application of 0.5 per cent ferric chloride in sunflower.

The growth and yield parameters of V1 mulberry increased due to involvement of micronutrients (Zn, Fe and Mn) in a single formulation in chlorophyll formation which might have helped to influence physiological activity of plants *viz*., cell division, meristematic activity in apical tissue, expansion of cell and formation of cell wall which in turn enhanced the growth and yield parameters.

Table 2: Effect of soil application of micronutrient formulation (Zn, Fe and Mn) on yield parameters of V1 mulberry at 45th and 75th DAP

Treatments	No. of leaves/plant		Leaf area (cm^2)		Leaf yield (g/plant)		Leaf dry matter (g/plant)	
	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP	45 DAP	75 DAP
T_1	426.72	445.56	205.11	242.28	620.45	730.67	216.03	326.61
T_2	445.17	467.22	232.61	242.95	754.99	935.25	246.93	370.35
T_3	465.45	486.72	239.28	262.56	810.67	942.41	260.34	388.23
T_4	487.28	488.89	251.56	263.95	818.67	960.64	274.10	398.56
T_5	548.67	567.56	283.52	310.45	947.20	1040.81	359.05	552.05
T_6	528.95	538.33	263.83	284.45	871.15	994.03	319.16	503.88
T_7	533.83	556.83	268.50	291.97	883.58	1008.17	336.41	538.06
F-test	*	*	*	*	*	*	*	*
S.Em.±	19.39	13.99	10.112	12.396	38.515	46.602	16.517	22.576
CD @ 5%	59.74	43.11	31.158	38.195	118.678	143.595	50.895	69.563

*Significant at 5%

T_1	Control (*RDF+*FYM)
T_2	T_1 + Micronutrient formulation @ 2 kg/acre
T_3	T_1 + Micronutrient formulation @ 4 kg/acre
T_4	T_1 + Micronutrient formulation @ 5kg/acre
T_5	T_1 + Micronutrient formulation @ 6 kg/acre
T_6	T_1 + Micronutrient formulation @ 7 kg/acre
T_7	T_1 + Micronutrient formulation @ 8 kg/acre

- *RDF- Recommended dose of fertilizers (350:140:140 kg NPK/ha/year)
- *FYM- Farm yard manure (20 t/ha/year)
- Micronutrient formulation [Zinc (6%), Iron (0.5%) and Manganese (0.5%)]

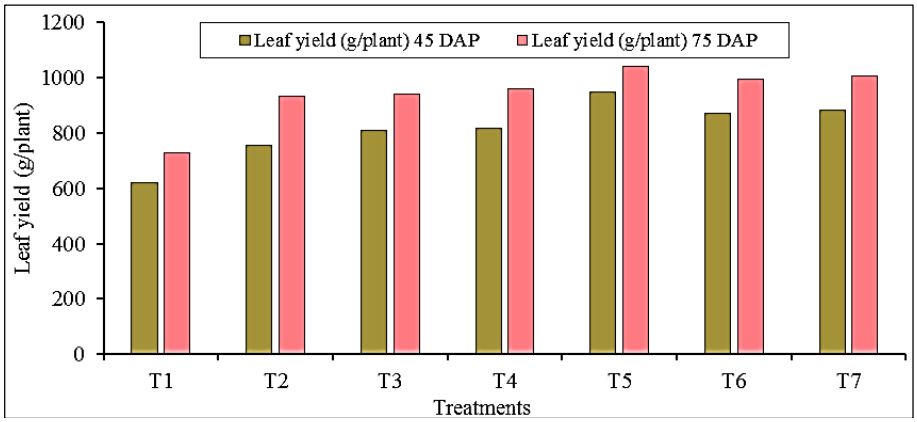

Fig 1: Effect of soil application of micronutrient formulation on leaf yield of V1 mulberry on 45th and 75th DAP

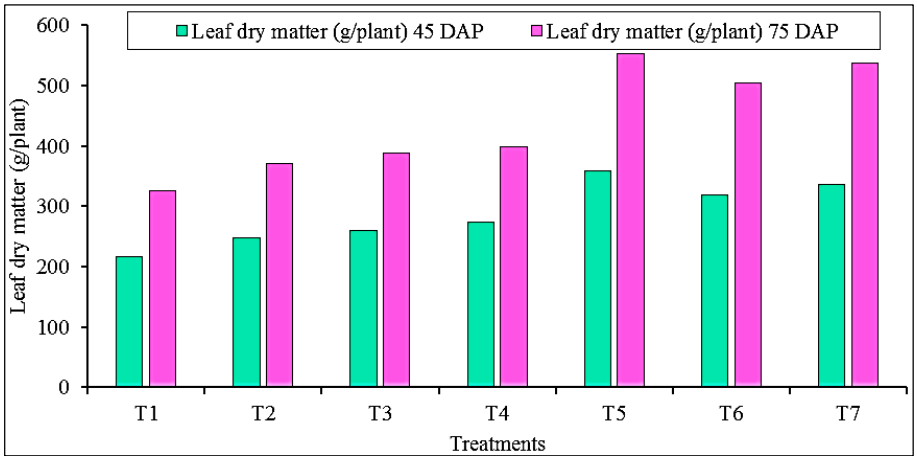

Fig 2: Effect of soil application of micronutrient formulation on leaf dry matter of V1 mulberry on 45th and 75th DAP

Conclusion

The present study has given very encouraging results with micronutrient formulation (Zn, Fe and Mn) at 6 kg/acre on growth and yield of mulberry, there is need to conduct farmers' field trails with (Zn, Fe and Mn) combination and popularize among sericulture farmers.

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