EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS ON MULBERRY (*MORUS ALBA* L.) LEAF YIELD AND SILKWORM (*BOMBYX MORI* L.) ECONOMIC PARAMETERS

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Abstract: Mulberry (*Morus* spp), is a perennial deep rooted high biomass producing foliage crop cultivated as a sole food for silkworm, *Bombyx mori* L. But, due to repeated harvests and soil problems, mulberry is exhibiting nutrient deficiencies in recent years. Besides other measures, foliar application is particularly relevant for timely application of specific nutrients to the foliage during growth and development. Keeping this in view, foliar application of micronutrients was evaluated using V1 variety with respect to mulberry leaf yield and silkworm cocoon yield. The data revealed that treatment T9 (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) recorded significantly higher values of shoot length, number of leaves per plant and mulberry leaf yield and in silkworm, T8 (0.5 % $ZnSO_4$+ (1.0 % $FeSO_4$ + 0.1% Citric acid) + 0.2 % Boric acid + 0.5 % $MnSO_4$) recorded higher values of larval weight, effective rate of rearing, cocoon weight, shell weight, shell ratio and cocoon yield. And gross return, net return and B: C ratio was also higher compared to other treatments.

Keywords: Cocoon yield, Foliar application, Micronutrients, Net return.

Introduction: Mulberry (*Morus alba* L.) is a perennial, deep rooted, fast growing and high biomass producing foliage plant. Mulberry leaf is a sole source of food for silkworm. The quality of mulberry leaf is being considered as the prime factor governing the production of good cocoon. Improved nutrient management coupled with improved agronomic management technologies substantially increased the harvest index of mulberry. However, owing to the increasing demands for silk, stress has to be laid on the further improvement of leaf productivity both in terms of quality and quantity.

Among the various factors contributed for vertical development in the crop production, the contribution by micronutrients is quite remarkable. Micronutrients play a major role in several metabolic activities responsible for protein, sugar and enzyme synthesis leading to better quality mulberry leaf production. In the case of multiple deficiency of micronutrients, the yield may be reduced even upto 50 percent.

Foliar application of micronutrients has improved the yield, quality and micronutrient status of mulberry leaf and the quantitative traits of silkworm, *Bombyx mori* L. (Bose and Majumder, 1996). General improvement in the quality of mulberry leaf with foliar application of micronutrients besides enhanced uptake of major as well as micronutrients by plant was reported earlier by Lokanath and Shivashankar (1986). Foliar application of urea and micronutrients improved the yield and quality of mulberry leaf thereby showed good response to foliar spray (Yeasmin *et al.*,1995).

Micronutrients in general, zinc and iron in particular stimulate the metabolic activity in silkworm leading to improved rearing performance, silk content and higher fecundity rate. The present study was carried out to know the effect of foliar application of micronutrients on mulberry leaf yield, silkworm growth, cocoon yield and economic parameters

Materials and Methods: The study was laid out in a randomized block design with three replications. The study comprised of individual application of Zinc, Iron, Boron, Manganese, Molybdenum in the form of $ZnSO_4$, $FeSO_4$, Boric acid, $MnSO_4$ and Na_2MoO_4 and their combinations along with one untreated control in mulberry variety Victory 1 (V_1). The silkworm race double hybrid ((CSR2 X CSR 27) X (CSR 6 X CSR 26)) were fed with micronutrients treated leaves of mulberry.

The micronutrients were applied as foliar spray at 10^{th} and 20^{th} days after pruning of mulberry. Observations on growth, leaf quality and yield parameters of mulberry and cocoon yield parameters were recorded and subjected to statistical analysis.

Results and Discussions:

Growth parameters of mulberry: The growth parameters of mulberry are presented in Table 1. Maximum average shoot length and number of leaves per plant were registered in the foliar spray of 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 followed by 0.5 % $ZnSO_4$+ (1.0 % $FeSO_4$ + 0.1% Citric acid) + 0.2 % Boric acid + 0.5 % $MnSO_4$ and were found to be statistically superior over all the other treatments. But the average number of shoots per plant was not showed significant difference among the treatments. Increased in shoot length obtained in the foliar application of micronutrients might be due to the involvement of micronutrients 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 inturn enhanced the growth and yield parameters as reported by Lokanath and Shivashankar (1986), Prasannakumar *et al.* (2001), Bose *et al.* (1994) and Misra *et al.* (1995).

Table 1: Growth parameters of mulberry on 45 days after pruning

Treatments	Average shoot length (cm)	Average number of leaves/plant	Average no. of shoots / plant (nos.)
Zinc sulphate (0.5%) [a]	125.0	212.7	9.5
Ferrous sulphate (1.0%) + citric acid (0.1%) [b]	125.2	215.8	9.6
Boric acid (0.2%) [c]	124.8	205.8	9.3
Manganese sulphate (0.5%) [d]	123.3	212.3	9.6
Sodium molybdate (0.01%) [e]	123.3	200.4	9.4
a + b	126.6	211.8	9.4
a + b+ c	127.8	218.3	9.5
a + b + c +d	139.0	221.1	9.6
a + b + c + d + e	153.5	246.4	9.9
Control	116.9	185.2	8.8
SEd	6.20	11.82	0.49
CD(P=0.05)	12.96	24.69	NS

Leaf yield of mulberry: Among the individual and combined foliar application of micronutrients, 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 recorded maximum leaf yield and the least leaf yield was recorded in absolute control (Table 2). This might be due to increased yield attributing characters like shoot length, number of shoots per plant and number of leaves per plant and high balanced application of macro and micronutrients which inturn increased the nutrient uptake in mulberry (Ray and Gupta 1974). Kasiviswanathan and Sitarama Iyengar (1965) have also reported increased leaf and shoot yields as well as fresh weight and dry matter content of leaves due to higher level of Zn which helped in the better uptake of nitrogen and thus indirectly helped in obtaining better yields. Similar responses have also been observed by Dootson (1976). Higher leaf yield in the combined spray of micronutrients was also reported by Vishwanath (1979).

Table 2: Leaf yield of mulberry

Treatments	Yield (kg $ha^{-1}harvest^{-1}$)
Zinc sulphate (0.5%) [a]	10788
Ferrous sulphate (1.0%) + citric acid (0.1%) [b]	11635
Boric acid (0.2%) [c]	10437
Manganese sulphate (0.5%) [d]	11135
Sodium molybdate (0.01%) [e]	10226
a + b	11004
a + b+ c	11407
a + b + c +d	11632
a + b + c + d + e	13013
Control	8411
SEd	563.03
CD(P=0.05)	1176.22

Impact of foliar application on silkworm:

Larvae characters: The combined foliar spray of micronutrients (0.5 per cent $ZnSO_4$ + (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid + 0.5 per cent $MnSO_4$) had significant effect on V instar larvae in silkworm bioassay (Table 3). This might be due to the increased DNA synthesis in the silk gland or may be due to the general growth stimulatory effect of those chemicals on the silk gland, as indicated by Manimala (1995). The importance of these elements were indicated by Ito and Niminura (1966) as well as Horie *et al.*(1967) where they indicated that it accelerated the growth of larvae. But the V instar larvae were highly infected by flacherie disease due to high moisture content in the leaves treated with 0.01 per cent Na_2MoO_4 and 0.5 per cent $ZnSO_4$ + (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid + 0.5 per cent $MnSO_4$ + 0.01 per cent Na_2MoO_4. Bose *et al*. (1995) reported that Mo increased the leaf moisture content.

The effective rate of rearing which indicates the intake efficiency of silkworm in terms of leaves fed by them was found to be significant due to micronutrient application (Table 3). Similar results were reported by Lokanath and Shivashankar (1986). Earlier studies conducted by Horie *et al.* (1967) have also indicated the importance of Zn in better growth of silkworm.

Table 3: Economic characters of silkworm larvae

Treatments	V instar single larval weight (g)	Effective rate of rearing (%)
Zinc sulphate (0.5%) [a]	4.54	83.67
Ferrous sulphate (1.0%) + citric acid (0.1%) [b]	4.48	83.33
Boric acid (0.2%) [c]	4.50	82.67
Manganese sulphate (0.5%) [d]	4.46	83.00
Sodium molybdate (0.01%) [e]	4.17	80.67
a + b	4.56	84.33
a + b+ c	4.59	85.00
a + b + c +d	4.72	87.33
a + b + c + d + e	4.24	82.33
Control	4.06	80.33
SEd	0.05	0.96
CD(P=0.05)	0.11	2.01

Table 4: Economic characters of cocoon

Treatments	Single cocoon weight (g)	Shell weight (g)	Shell ratio	Cocoon yield (kg/100 dfls)
Zinc sulphate (0.5%) [a]	1.88	0.38	20.36	80.15
Ferrous sulphate (1.0%) + citric acid (0.1%) [b]	1.85	0.35	19.41	78.25
Boric acid (0.2%) [c]	1.80	0.32	16.84	76.63
Manganese sulphate (0.5%) [d]	1.82	0.34	19.03	76.82
Sodium molybdate (0.01%) [e]	1.79	0.31	17.13	73.64
a + b	1.91	0.40	20.83	81.99
a + b+ c	1.93	0.43	21.93	83.54
a + b + c +d	2.12	0.53	24.79	93.90
a + b + c + d + e	1.78	0.39	21.52	74.69
Control	1.58	0.29	18.35	69.05
SEd	0.09	0.02	1.30	3.52
CD(P=0.05)	0.19	0.05	2.71	7.35

Cocoon characters: The micronutrients in combination (0.5 per cent $ZnSO_4$ + (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid + 0.5 per cent $MnSO_4$) as foliar spray were significantly influenced the cocoon characteristics like cocoon weight, shell weight and shell ratio of cross breed and double hybrid races (Table 4). Similar results were also reported by Vishwanath (1979). Bose *et al.* (1995) reported that succulent mulberry leaves with less fibre and higher mineral contents presumably stimulated the metabolic activities in silkworm resulting in qualitative improvement of cocoon and silk. The production of cocoons is highly influenced by the quality mulberry leaf as reported by Aruga (1994). The quality of leaf being fortified with additional inputs by application of micronutrients either at soil or at foliar level has an impact on the floss production (Dutta *et al*., 2007).

Among the different micronutrient combinations, foliar spray of micronutrients (0.5 per cent $ZnSO_4$ + (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid+ 0.5 per cent $MnSO_4$) recorded the notable response on silk filament length, filament weight, denier and renditta of both cross breed and double hybrid races. Similar results were reported by Basit and Ashfaq (1999) and Bose and Bindroo (2009). Narayanaswamy and Shankar (2003) revealed that micronutrient foliar spray influenced the quality of cocoons positively. Hence, the use of foliar sprays particularly Zn may be beneficial in sericulture. In the present study, it was evident from the data that 0.5 per cent $ZnSO_4$+ (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid + 0.5 per cent $MnSO_4$ + 0.01 per cent Na_2MoO_4 influenced the cocoon characters like cocoon weight, shell weight and shell ratio.

Influence of foliar spray of micronutrients on economics: Among the different combinations, conflated foliar application of micronutrients (0.5 per cent $ZnSO_4$ + (1.0 per cent $FeSO_4$ + 0.1 per cent citric acid) + 0.2 per cent Boric acid+ 0.5 per cent $MnSO_4$) for cross breed race of silkworm showed a positive increase in the economic returns *viz.,* gross return, net return and benefit: cost ratio (Table 5) even though there was an increase in cost of cultivation which might be due to enhanced cocoon parameters and quality cocoon production. Similar results in economics were also reported by Bose and Bindroo (2009).

Table 5: Effect of foliar spray of micronutrients on economics of cocoon (per harvest)

Treatments	**Total Expenditure**	**Gross Return***	**Net Return**	**B:C ratio**
Zinc sulphate (0.5%) [a]	54581	119368	64788	2.19
Ferrous sulphate (1.0%) + citric acid (0.1%) [b]	54207	116540	62333	2.15
Boric acid (0.2%) [c]	53853	114119	60266	2.12
Manganese sulphate (0.5%) [d]	54049	114411	60362	2.12
Sodium molybdate (0.01%) [e]	53844	109670	55826	2.04
a + b	55405	122101	66696	2.20
a + b+ c	55875	124415	68540	2.23
a + b + c +d	56541	139849	83308	2.47
a + b + c + d + e	57003	111232	54229	1.95
Control	53383	102840	49457	1.93

*Double hybrid cocoon cost @ Rs. 265 per kg

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