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# Efficacy of multinutrient foliar spray on mulberry leaf yield, quality and commercial characters of silkworm (*Bombyx mori* L.)

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**Abstract**
This study, conducted at the College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir in 2021 and 2022, evaluated the "Efficacy of Multinutrient Foliar Spray on Mulberry Leaf Yield, Quality and Commercial Characters of Silkworm (*Bombyx mori* L.)." Various combinations and concentrations of foliar sprays containing magnesium, zinc, sulfur, manganese, and boron were tested on mulberry plants. Significant differences in growth and yield parameters were observed across treatments, with $T_{12}$ (M4C3) showing the best results. The highest leaf yield, specific leaf weight, and specific leaf area were recorded in $T_{12}$ (M4C3), with improved chlorophyll content and photosynthetic rate, especially in spring. When fed to silkworms, these enhanced mulberry leaves improved their commercial traits significantly. The findings suggest that the $T_{12}$ (M4C3) treatment effectively boosts mulberry leaf yield and quality, thereby enhancing sericulture productivity.

**Keywords:** Multinutrient, silkworm, specific leaf weight

## Introduction

Mulberry (M*orus Sp.*) is a typical East Asian plant which can be trained as bush, dwarf or tree. It is widely distributed in varied ecological and geographical zones from intensive cultivation in temperate, subtropical and tropical areas to natural occurrence in forests throughout the world. It is a perennial plant usually cultivated for its leaf which is the only food to silkworm (*Bombyx mori* L). Silkworm is a highly sensitive insect and responds sharply to the changes in feed quality. Quality of mulberry leaf is one of the major factors influencing the healthy growth of silkworm and subsequently the successful cocoon crop. The mulberry leaf yield and quality depend mostly on the soil type, plant variety, availability of plant nutrients and agro-ecological conditions. Leaf quality ultimately has a direct bearing with the improvement in cocoon yield and quality. The nutrients usually given to mulberry are Nitrogen, Phosphorous and Potassium which are usually supplied respectively through Urea, DAP and MOP. Chemical fertilizer (NPK) to mulberry is applied at the rate of 300:120:120 kgs per hectare per year under irrigated conditions and 100:50:50 kgs per hectare per year under rainfed conditions and no other nutrient is applied to the plant, though Boron, Zinc, Magnesium, Manganese and Sulphur are reported to have significantly positive influence on the economic parameters of silkworm (Loknath and Shivshanker, 1986; Chikaswamy *et al*., 1999) [5, 2]. The chemical fertilizers are applied in two splits corresponding to the two silkworm rearings and the plant growth. A good proportion of the applied nutrients is lost through leaching and volatilization. Successful fertilization in the cultivation of mulberry plant in general requires not only proper timing and application rates of fertilizers but adequate use of balanced fertilizers also. Micronutrients like Iron, zinc, copper, manganese, molybdenum, boron, and chlorine are just a few of the key micronutrients. Although these nutrients are only necessary in small levels for plants, they play some key roles in the plant growth and development. As catalysts, micronutrients speed up essential physiological processes in plants. The application of micronutrients to the plants mainly through foliar application can help to improve the leaf yield and quality in the region. Micronutrient foliar spray has been found to increase the leaf yield and commercial silkworm characters like cocoon weight, shell weight, shell ratio and cocoon yield. Keeping in view the promise that foliar nutrition has, in crops especially mulberry, the study entitled. “Efficacy of multinutrient foliar spray on mulberry leaf yield, quality and commercial characters of silkworm (*Bombyx mori* L.)” was conducted.

**Materials and Methods**

The present study was conducted on well-established mulberry plantation of Goshoerami at College of Temperate Sericulture Mirgund, SKUAST-K. Cultural operations was followed as per the recommended package of practices and the study was conducted under following experiments.

Treatment details

| Treatment | Notation | Treatment | Notation |
|---|---|---|---|
| $T_1$ | M1C1 | $T_8$ | M3C2 |
| $T_2$ | M1C2 | $T_9$ | M3C3 |
| $T_3$ | M1C3 | $T_{10}$ | M4C1 |
| $T_4$ | M2C1 | $T_{11}$ | M4C2 |
| $T_5$ | M2C2 | $T_{12}$ | M4C3 |
| $T_6$ | M2C3 | C1 (control-1) | Water |
| $T_7$ | M3C1 | C2 (control-2) | Without spray |

| | |
|---|---|
| $T_1$ (M1C1) Mg (0.299 %) + Zn (0.087%). | $T_2$ (M1C2) Mg (0.599%) + Zn (0.175 %). |
| $T_3$ (M1C3) Mg (0.89%) + Zn (0.262 %). | $T_4$ (M2C1) Mg (0.299 %) + Zn (0.087%). + S (0.149%). |
| $T_5$ (M2C2) Mg (5.99 g) + Zn (1.75 g) + S (2.99 g). | $T_6$ (M2C3) Mg (8.9 g) + Zn (0.262%) + S (0.449%) |
| $T_7$ (M3C1 Mg (0.299 %) + Zn (0.087%) + S (0.149%). + B (0.087%). | $T_8$ (M3C2) Mg (0.599%) + Zn (0.175%) + S (0.299%) + B (0.175%). |
| $T_9$ (M3C3) Mg (0.89%) + Zn (0.262%) + S (0.449%) + B (0.262%) | $T_{10}$(M4C1)Mg(0.299%) + Zn (0.087%) + S (0.014%) + Mn (0.076% |
| $T_{11}$ (M4C2) Mg (0.599%) + Zn (0.175 %) + S (0.029%) + Mn(0.153). | $T_{12}$ (M4C3) Mg (0.89%) + Zn (0.0262%) + S (0.043%) + Mn (0.23%) |

The spray was done one month after sprouting and pruning respectively during spring and summer. It was done twice in each crop at an interval of 15 days.

Observations on various parameters was recorded during spring and autumn crops coinciding with the fifth stage of silkworm rearing except sprouting percentage which was recorded in spring.

**Results**

The growth and yield parameters were recorded during spring and autumn coinciding with the $5^{th}$ stage of silkworm rearings except the sprouting of winter buds which was recorded during spring after the sprouting of dormant winter buds complete (3rd week April). The same are furnished in Table-1 and described below:-

**Nitrogen**. Leaf nitrogen content during spring was the highest (3.878 %) in $T_{12}$ (M4C3) being statistically at par with 3.793 percent recorded in $T_9$ (M3C2) and was significantly higher than the rest of the treatment with the least (2.805 percent) in $T_{14}$ (without any spray).

During autumn, the leaf nitrogen content was in general lower as compared to spring season. However it was the highest (3.327%) in $T_{12}$ (M4C3) being at par with 3.292 per cent again recorded in $T_9$ but significantly higher than the rest of the treatments. It was the least (2.500%) in $T_{14}$ (without any spray).

**Number of Shoot lets/ Branches per plant.**

During spring the number of shoot lets per plant was the highest (146.883) in $T_{12}$ (M4C3) which was statistically at par with 143.21 shoot lets per plant in $T_9$ (M3C3), but significant over the rest of the treatments wherein it ranged from 123.96 in $T_{14}$ to 141.66 in $T_{11}$.

During autumn the number of branches per plant depicted non significant differences among the treatments and ranged from 28 branches per plant in $T_{14}$ to 30.5 branches per plant in $T_{12.}$

**Total shootlet/branch length per plant (m)**

Total shootlet length per plant in spring was the highest (58.44 m) in $T_{12}$ (M4C3) which was statisticantly at par with 58.17 meters total shoot length per plant in $T_9$ (M3C3) and significant over the rest of the treatments. The lowest total shoot let length per plant was found in $T_{14}$ (51.192 meters) involving the plantation without multinutrient foliar sprays.

During autumn total shoot length per plant was again the highest (58.44 m) in $T_{12}$ (M4C3) which was statistically at par with 58.01 7meters total shoot length per plant in $T_9$ (M3C3) The total shoot length per plant was the least (42.783 meters) in $T_{14}$, the treatment involving the plantation without multinutrient foliar spray.

**Leaf yield per plant (kg)**

Leaf yield per plant in spring was the highest (7.517Kg) in $T_{12}$ (M4C3) being statistically at par with 7.450 kilograms recorded in $T_9$ (M3C3) and significantly higher than the rest of the treatments. On the other hand leaf yield per plant was the least 5.850 kilograms in treatment involving the plantation without multinutrient foliar spray. ($T_{14}$)

Leaf yield per plant was in general more during autumn as compared to spring. It was the highest (8.433 Kg) in $T_{12}$ (M4C3) being statistically at par with 8.417 kilograms recorded in $T_9$ (M3C3) and significantly higher than the rest of the treatments. During this season also, leaf yield per plant was the least (5.983 kg) in treatment involving the plantation without multinutrient foliar spray ($T_{14}$) (Table 2).

**Table 1:** Nitrogen percent and shoot growth of mulberry as influenced by multinutrient foliar spray.

| Treatments | Nitrogen (%) spring | Number of shootlets per plant Spring | Nitrogen (%) Autumn | Total shootlet length per plant (m) Spring | Total shoot length per plant (m) Autumn |
|---|---|---|---|---|---|
| $T_1$ (M1C1) | 3.075[e] | 135.67[d] | 2.313 [d] | 51.13[e] | 47.37[e] |
| $T_2$ (M1C2) | 3.072 [e] | 137.66[c] | 2.320 [d] | 52.37[e] | 48.73[d] |
| $T_3$ (M1C3) | 3.160[e] | 139.65[b] | 2.420 [c] | 53.00[d] | 49.51[d] |
| ($T_4$M2C1) | 3.233[d] | 136.66[c] | 2.400 [c] | 52.00[e] | 47.75[e] |
| $T_5$ (M2C2) | 3.217[d] | 137.34[c] | 2.470 [c] | 53.23[d] | 47.85[e] |
| $T_6$ (M2C3) | 3.193[e] | 140.65[b] | 2.470 [c] | 53.33[c] | 48.57[e] |
| $T_7$ (M3C1) | 3.535[c] | 139.61[b] | 3.153 [b] | 52.07[e] | 51.55[b] |
| $T_8$ (M3C2) | 3.560 [b] | 141.55[b] | 3.191[c] | 53.20[d] | 52.51[b] |
| $T_9$ (M3C3) | 3.793[a] | 143.21[a] | 3.292 [a] | 58.17[b] | 54.08[a] |
| $T_{10}$(M4C1) | 3.430[c] | 138.36[c] | 3.100 [b] | 53.07[d] | 50.98[b] |
| $T_{11}$ (M4C2) | 3.555 [b] | 141.66[b] | 3.192[b] | 53.73[c] | 51.70[c] |
| $T_{12}$ (M4C3) | 3.878[a] | 146.68[a] | 3.327 [a] | 58.44[a] | 54.20[a] |
| $T_{13}$ (Water) | 2.938[f] | 127.62[e] | 2.640 [c] | 48.40[f] | 44.06[f] |
| $T_{14}$ (Without spray) | 2.805 [f] | 123.96[e] | 2.500 [c] | 46.40 g | 42.78[f] |
| C.D ($p \leq 0.05$) | 0.114 | 3.78 | 0.134 | 0.394 | 1.535 |

**Table 2:** Leaf yield of mulberry as influenced by multinutrient foliar spray during.

| Treatments | Leaf yield spring | | Leaf yield autumn | |
|---|---|---|---|---|
| | Yield per plant.kgs | Yield(MT)/hectare | Yield per plant.kgs | Yield(MT)/hectare |
| $T_1$ (M1C1) | 6.183[d] | 18.69 | 7.200[c] | 21.6 |
| $T_2$ (M1C2) | 6.317[c] | 19.09 | 7.333[c] | 22.6 |
| $T_3$ (M1C3) | 6.433[c] | 19.44 | 7.383[c] | 22.1 |
| ($T_4$M2C1) | 6.283[c] | 18.99 | 7.033[c] | 21.5 |
| $T_5$ (M2C2) | 6.417[c] | 19.39 | 7.200[c] | 21.6 |
| $T_6$ (M2C3) | 6.500[c] | 19.64 | 7.317[c] | 22.1 |
| $T_7$ (M3C1) | 6.817[b] | 20.60 | 7.683[b] | 23.2 |
| $T_8$ (M3C2) | 6.900[a] | 20.85 | 7.517[b] | 22.2 |
| $T_9$ (M3C3) | 7.450[b] | 22.51 | 8.417[a] | 25.4 |
| $T_{10}$(M4C1) | 6.783[b] | 20.50 | 7.808[b] | 23.6 |
| $T_{11}$ (M4C2) | 6.933[b] | 20.95 | 7.800[b] | 23.7 |
| $T_{12}$ (M4C3) | 7.517[a] | 22.72 | 8.433[a] | 25.8 |
| $T_{13}$ (Water) | 6.150[d] | 18.59 | 6.567[d] | 19.5 |
| $T_{14}$ (Without spray) | 5.850[e] | 17.98 | 5.983[e] | 17.8 |
| C.D (P≤0.05) | 0.258 | | 0.355 | |

**Single cocoon weight (g)**

Single cocoon weight was the highest (2.60 g) in $T_{12}$ (M4C3) being statistically at par with 2.527 grams single cocoon weight recorded in $T_9$ (M3C3) and significantly higher than rest of the treatments. It was the least (2.047 g) in the treatments involving plantation without any multinutrient spray. ($T_{14}$). (Table 15)

**Single shell weight (g)**

Single shell weight was the highest (0.60 g) in $T_{12}$ (M4C3) being statistically at par with 0.57, 0.55 each recorded each in 0.55, 0.55and 0.54 grams recorded respectively in $T_7$ (M3C1)and statistically significant over the rest of the treatments. It was again the least (0.43 g) in the treatments involving no multinutrient foliar spray. ($T_{14}$) (Table 15)

**Shell percentage (%)**

Shell percentage was the highest (22.614%) in $T_{12}$ (M4C3) and was significantly higher than the rest of the treatments. It was the lowest (19.32) in the treatments involving plantation without any spray. ($T_{14}$) (Table 3)

**Table 3:** Cocoon parameters as influenced by multinutrient foliar spray during spring.

| Treatments | Single cocoon weight (g) | Single shell weight (g) | Shell percentage |
|---|---|---|---|
| $T_1$ (M1C1) | 2.287[c] | 0.49[c] | 20.384[h] |
| $T_2$ (M1C2) | 2.337[c] | 0.50[b] | 20.376[h] |
| $T_3$ (M1C3) | 2.397[c] | 0.52[b] | 20.705[g] |
| $T_4$ (M2C1) | 2.357[c] | 0.52[b] | 21.060[e] |
| $T_5$ (M2C2) | 2.397[c] | 0.52[b] | 20.705[g] |
| $T_6$ (M2C3) | 2.457[b] | 0.53[a] | 20.606[g] |
| $T_7$ (M3C1) | 2.407[c] | 0.54[a] | 21.459[d] |
| $T_8$ (M3C2) | 2.447[b] | 0.55[a] | 21.518[d] |
| $T_9$ (M3C3) | 2.527[a] | 0.57[a] | 21.787[b] |
| $T_{10}$(M4C1) | 2.417[b] | 0.55[a] | 21.630[c] |
| $T_{11}$ (M4C2) | 2.467[b] | 0.55[a] | 21.341[e] |
| $T_{12}$ (M4C3) | 2.607[a] | 0.60[a] | 22.123[a] |
| $T_{13}$ (Water) | 2.207[d] | 0.47[c] | 20.213[i] |
| $T_{14}$ (Without spray) | 2.047[d] | 0.43[c] | 19.832[j] |
| C.D (P≤0.05) | 0.091 | 0.061 | 0.102 |

## Discussion

There was improvement in mulberry yield and yield attributing parameters over control by the use of multinutrient foliar spray. Number of shootlets per plant during spring as well as total shoot length per plant during both spring and autumn depicted significant differences among the treatments with the highest (146.883) shootlets per plant in $T_{12}$ (M4C3)and was statistically at par with 143.21 shootlets per plant in $T_9$ (M3C3). The highest total shootlet length of 58.44 and 54.200 meters per plant respectively during spring and autumn was found in $T_{12}$ being again at par with 57.17 and 54.083 meters in $T_9$ (M3C3) and significantly higher than the rest of the treatments. The increase in shootlet number per plant and the total shoot length per plant in the treatments involving multinutrient foliar spray which enhance shootlet length and increases shoot number in mulberry by promoting enzyme activation, enhancing photosynthesis, optimizing nutrient uptake and transport. Because the nutrients when sprayed in combinations resulted in more improvement as compared to when sprayed individually. The shoot length improvement can be because zinc is involved actively in synthesis of tryptophan which is precursor of indole acetic acid a plant hormone responsible for increased tissue growth and development. Likewise magnesium and sulphur are involved in important physiological processes like chlorophyll and protein synthesis. Pathak *et al.* (2011) [8] have also reported that micronutrients can stimulate growth by enhancing photosynthetic and metabolic processes, resulting in an increase in plant metabolites responsible for cell division and elongation. The observations in the present study are supported by the findings of previous studies by Nitinkumar *et al* (2016) [10] who have reported significant increase in shoot height in mulberry by multinutrient foliar sprays. During spring $T_{12}$ (M4C3) had the highest values for yield and yield attributing parameters with the highest fresh weight of hundred leaf (343.92 g), leaf area (263.33 $cm^2$) and leaf yield per plant (7.517 Kg). During autumn also $T_{12}$ (M4C3) measured the highest values for these parameters with 474.167 grams fresh weight of hundred leaves, 371.46$cm^2$ leaf area and 8.433 Kg leaf yield per plant. The values for various growth parameters like leaf area, leaf yield and fresh weight of hundred leaves in $T_{12}$ (M4C3) during both spring and autumn were however, at par with the values recorded in $T_9$ (M3C3) as far as these parameters are concerned. The higher values for these parameters in these two treatments and the general improvement in yield and yield attributing characters as compared to the control can be due to the fact that multinutrient foliar spray offers a holistic strategy for correcting the nutrient shortages in plants including mulberry leading to healthy development and enhanced production thereby necessitating the balanced administration of macro and micronutrients to boost nutrient absorption in mulberry. Similar results have also been reported by Vishwanath (1979) [9], Bose *et al*. (1994) [1]. Leaf nitrogen content during spring was the highest (3.878 %) in $T_{12}$ (M4C3) being statistically at par with 3.793 per cent recorded in $T_9$ (M3C2). During autumn, the leaf nitrogen content was in general lower as compared to spring season. It was the highest (3.327%) again in $T_{12}$ (M4C3) being at par with 3.292 per cent leaf nitrogen recorded in $T_{9.}$

Single cocoon weight was the highest (2.60 g) in $T_{12}$ (M4C3) being statistically at par with 2.527 grams recorded in $T_9$ (M3C3) Single shell weight was the highest (0.60 g) in $T_{12}$ (M4C3) being statistically at par with 0.57, 0.55 and 0.55, 0.55and 0.54 grams recorded respectively in $T_9$ (M3C3) $T_{11}$ (M4C2) and $T_{10}$ (M4C1) $T_8$ (M3C2) $T_7$ (M3C1) Shell percentage was the highest (22.614%) in $T_{12}$ (M4C3) and was significantly higher than the rest of the treatments, Raw silk recovery was the highest (17.34) in $T_{12}$ (M4C3) being statistically at par with 17.08 percent recorded in $T_9$ (M3C3), Cocoon yield per 10,000 larvae by weight was the highest (22.760 kg) in $T_{12}$ (M4C3) being statistically at par with 21.43. Longest filament length of (1140.6m) was found in $T_{12}$ (M4C3) which was at par with 1137.6 meters and 1133.1meters recorded respectively in $T_9$ (M3C3) and $T_{11}$ (M4C2). Raw silk recovery percentage was the highest (17.347%) in $T_{12}$ (M4C3) which was at par with 17.08 per cent and 16.928 per cent recorded respectively in $T_9$ (M3C3) and $T_{11}$ (M4C2) Improvement in cocoon characters may be because mulberry leaves benefit from foliar spraying, which provides important nutrients. Silkworms feed on these leaves throughout their larval stage and the nutritional value of the leaves has a direct impact on their growth and development. By raising the nutrient levels in the leaves we provide silkworms with a more nutritious diet. Nutrients including zinc, magnesium, manganese, and sulphur are essential for many physiological functions, including protein synthesis, enzyme activation, and metabolic pathways. Ensuring adequate amounts of essential elements in mulberry leaves can help silkworms use nutrients more efficiently, resulting in improved development and metabolism.

The results are in conformity with Nazar *et al* (2018) [6] who have registered improvement in cocoon characteristics like cocoon weight, shell weight and shell ratio over the control

## Conclusion

The multinutrient foliar spray has improved growth, yield and quality of mulberry leaf during spring and late summer/autumn crops that ultimately led to better growth and economic parameters of silkworm hybrid, CSR2 × $CSR_4$.

Multinutient foliar spray did not have any significant effect on number of branches per plant during autumn and the moisture content and its retention capacity in mulberry leaf during both the seasons. However number of shootlets per plant during spring and total shoot length during both spring and autumn were significantly higher in $T_{12}$ (M4C3) and $T_9$ (M3C3) as compared to other treatments. Total shoot length per plant respectively during spring and autumn was 58.44 and 54.083 meters in $T_{12}$ (M4C3) and 58.17 and 54.200 meters in $T_9$ (M3C3) as against 46.40 and 42.783 meters in $T_{14}$ Multinutrient foliar spray has resulted in significant increase in the leaf growth parameters consequently leading ton improved yield. Leaf yield of 7.517 and 7.450 Kilograms per plant during spring and 8.433 and 8.417 Kilograms per plant during autumn was recorded respectively in $T_{12}$ and $T_9$ as against 5.850 and 5.983 kilograms leaf per plant in $T_{14}$ during the two seasons. Multinutrient foliar spray generally improved the leaf nutrient status. Significantly higher nitrogen content was found in $T_{12}$ (M4C3) and $T_9$ (M3C3) in both Spring (3.878 & 3.793%) and Autumn (3.327 & 3.292% respectively) as compared to rest of the treatments with the least (2.805% & 2.500%) in $T_{14}$

## Conflict of Interest

Not available


## Financial Support

Not available

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