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Growth and yield parameters of tree mulberry as influenced by different levels of secondary nutrients

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Abstract
The study on "Performance of tree mulberry applied with secondary nutrients and its influence on silkworm (*Bombyx mori* L.)" was carried out in the established V-1 tree mulberry garden at College of Sericulture, Chintamani during 2022-23. The treatments were formulated based on the recommendation for sulphur application in mulberry and proposed the recommendation for calcium, magnesium and sulphur in the ratio of 3:1:0.9, respectively. The results revealed that RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25 to tree mulberry garden recorded highest total shoot length, number of shoots/tree, number of leaves/tree, leaf area (cm^2) and leaf yield, respectively on 45th and 60th days after application of fertilizers which are on par with RDF + soil application of Ca:Mg:S :: 66:22:20. The lowest observations was recorded in control (recommended dose of fertilizer + FYM).

Keywords: *Bombyx mori*, tree mulberry, secondary nutrients, V-1

Introduction
Mulberry is a hardy, perennial plant with deep roots and abundant foliage that grows year- round in tropical climates. In general, mulberry is cultivated in three forms *viz*., bush, low-cut and tree (Qader *et al*., 1991) [7]. However, if grown without proper scientific management, the quality and production of its leaves can decline over time (Rashmi *et al*., 2009) [10]. In recent years, unpredictable rainfall, recurrent droughts, and declining groundwater resources have resulted in insufficient water for irrigation, limiting the potential for mulberry production. Tree mulberry refers to mulberry plants that are allowed to grow tall, with a crown height of 5 to 6 feet above ground level and a stem girth of 4 to 5 inches or more. The plantation is typically arranged in blocks with varying spacing between plants and rows, such as 6' x 6', 8' x 8', or 10' x 10'. The plants are usually pruned once a year during the monsoon season (July-August) at a height of 5-6 feet above ground level, leaving a maximum of 8-10 shoots at the crown (Dandin and Senagupta, 1998) [4].

Nutrients are the vital components needed for the plant growth and development. As plant growth enhances, the nutrient requirement also increases. Plants generally depend on nutrients available in the soil. Also, these vital nutrients are provided by manures and fertilizers, which are important for plant growth. However, it is significant to remember that excess nutrients, as well as deficiency of them, can impact crop production and inhibit growth. There are different elements classified as macro-nutrients and micro-nutrients that contribute to plant growth according to their function and plant requirements. About 17 essential plant nutrients have been recognized (Arnon and Stout, 1939) [1]. Which includes Calcium, Magnesium and Sulphur as secondary nutrient elements. The nutrient uptake and quality parameters of tree mulberry leaves greatly influence silkworm rearing parameters than in the leaves obtained from the bush garden (Raj Narain *et al*., 1995) [8]. The supplementation of inorganic fertilizers improved the yield and quality parameters thereby increasing the cocoon yield (Bose and Mujamder, 1999) [2]. In addition to primary nutrients, the quantity of secondary and micronutrients applied affect the leaf yield parameters. About 57 percent reduction in mulberry leaf yield is attributed to the deficiency of secondary nutrients (Shankar, 1997) [11].

Materials and Methods

The experiment was conducted during 2022-2023, at the Department of Sericulture, University of Agricultural Sciences, Bengaluru and College of Sericulture, Chintamani. The experimental site was geographically located in the Eastern Dry Zone (Zone-5) of Karnataka and lies between 13.3354° N, 78.0824° E at an altitude of 865 m above the mean sea level and it receives average rainfall of 400 to 750 mm annually. The soil of the experimental plot was sandy clay loam in texture and prior to laying out of the experiment, composite soil samples were randomly drawn from 0 to 30 cm depth in the experimental site from each replication before imposing treatments and analyzed for chemical properties. The treatments were formulated based on the recommendation for sulphur application in mulberry and proposed the recommendation for calcium, magnesium and sulphur in the ratio of 3:1:0.9, respectively. The field trial was laid out in a Randomized Complete Block Design (RCBD) with six treatments and four replications each *viz.*, T_1: RDF + Soil application of Ca:Mg:S :: 33:11:10 kg ha^{-1} yr^{-1}, T_2: RDF + Soil application of Ca:Mg:S :: 49.5:16.5:15 kg ha^{-1} yr^{-1}, T_3: RDF + Soil application of Ca:Mg:S :: 66:22:20 kg ha^{-1} yr^{-1}, T_4: RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25 kg ha^{-1} yr^{-1}, T_5: RDF + Soil application of Ca:Mg:S :: 99:33:30 kg ha^{-1} yr^{-1}, T_6: Control (recommended dose of fertilizer + FYM).The net plot size was 144 m^2 with the spacing of 8 ft X 8 ft (between rows and plants). The growth and yield parameters of V-1 tree mulberry were recorded treatment-wise in each replication by harvesting fresh leaves from five randomly selected trees under each treatment at 45th and 60th DAT and the mean yield was calculated as per the standards suggested and analyzed statistically.

Results and Discussion

Application of RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25 (T_4) to tree mulberry garden recorded highest total shoot length (72.15 and 108.65 cm), Number of shoots per tree (40.74 and 45.17), Number of leaves per tree (796.00 and 1279.74), Leaf area (139.09 and 179.30 cm^2) respectively on 45th day after application of fertilizers (Table 1). The leaf yield per tree (2425.81 and 5426.09 g) and leaf yield per hectare per crop (4211.20 and 9419.69 kg) were also recorded highest in the same treatment on 60th day after fertilization (Table 2). However, all these parameters were on par with the treatment which received RDF + Soil application of Ca:Mg:S :: 66:22:20 (T_3) where it recorded total shoot length (69.80 and 100.72 cm), Number of shoots per tree (38.74 and 43.63), Number of leaves per tree (626.50 and 1092.60), Leaf area (136.79 and 167.10 cm^2) repectively on 45th day after application of fertilizers (Table 1). The leaf yield per tree (1719.74 and 4293.91 g) and leaf yield per hectare per crop (2985.46 and 7454.22 kg) were recorded on 60th day after fertilization and are on par with the treatment which received RDF + Soil application of Ca:Mg:S :: 49.5:16.5:15 (T_2) (Table 2). However, the lowest growth and yield parameters of V1 tree mulberry were recorded in control plot (T_6) (Table 1 & 2).

Increase in plant height and number of shoots may be attributed to the addition of major nutrients like nitrogen, phosphorous and potassium and secondary nutrients like calcium, magnesium and Sulphur at different levels through soil application. The difference in number of shoots per tree and the increased number of internodes might have contributed to higher number of leaves. More number of internodes might have resulted in a higher number of leaves. The results of the current study are in agreement with the findings of Shivaprakash *et al*., (2009) [12] who found that there was significant increase in the shoot yield, leaf yield and stem yield due to application of secondary nutrients. Rani *et al*. (2016) [9] noticed varied biomass production in mulberry with different levels of calcium and magnesium fertilizer application and found that combined spray of 0.4% calcium and 0.2% magnesium resulted in significant increase in total shoot length (3000.00 cm), average branch length (82.32 cm) and length of longest branch (100.00 cm). More number of shoots were found in tree mulberry which might be probably due to wider spacing (10'×10') and proper training methods followed for tree mulberry which might have facilitated more number of branches as well shoots per tree. Similar findings were reported by Tewary *et al*. (2008) [13], who found that the number of shoots per tree was more in tree mulberry (20.11).

Increased leaf yield might be due to higher tree height, more number of shoots per tree and number of leaves per tree recorded in the same treatment. Further, adequate availability of nutrients in the root zone because of secondary nutrients might have favoured the absorption of nitrogen and potassium by eliminating the nutrient loss that would normally occur with conventional methods of fertilizer application and thus, allows better availability and uptake of nutrients (N, P and K) which directly helps the plants to register higher yield with high fertilizer use efficiency (Haynes, 1985) [5]. Application of secondary nutrients significantly increased the yield characters over the control among the fertilizer treatments and the application of 40 kg ha^{-1} yr^{-1} ES (elemental sulphur) resulted in enhanced leaf yield of 36.34 t ha^{-1} yr^{-1} over control (32.36 t ha^{-1} yr^{-1}) (Bose *et al*., 2011) [3]. Purohit *et al*. (2013) [6] recommended the use of calcitic limestone, paper mill sludge and basic slag (liming materials) in order of preference every year on their availability and reported that by application of 0.125 LR (Lime Requirement) calcitic limestone powder resulted in increased leaf yield annually by 12356.66 kg/ha over the control.

Table 1: Effect of different levels of secondary nutrients on growth parameters in tree mulberry

Treatments	Total shoot length (cm)			Number of shoots per tree			Number of leaves per tree			Leaf area (cm2)		
	Crop- I	Crop- II	Mean	Crop- I	Crop- II	Mean	Crop- I	Crop- II	Mean	Crop- I	Crop- II	Mean
T_1: RDF + Soil application of Ca:Mg:S :: 33:11:10	59.45	89.13	74.29	35.49	38.32	36.90	450.37	787.44	618.90	97.69	144.30	120.995
T_2: RDF + Soil application of Ca:Mg:S :: 49.5:16.5:15	64.45	98.03	81.24	36.99	39.61	38.30	553.50	980.59	767.04	128.29	147.50	137.895
T_3: RDF + Soil application of Ca:Mg:S :: 66:22:20	69.80	100.72	85.26	38.74	43.63	41.18	626.50	1092.60	859.55	136.79	167.10	151.945
T_4: RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25	72.15	108.65	90.40	40.74	45.17	42.95	796.00	1279.74	1037.87	139.09	179.30	159.195
T_5: RDF + Soil application of Ca:Mg:S :: 99:33:30	61.90	92.57	77.23	43.25	35.34	39.29	548.43	685.78	617.10	145.29	135.80	140.545
T_6: Control (recommended dose of fertilizer + FYM)	57.15	86.98	72.06	35.99	36.65	36.32	442.80	664.96	553.88	102.01	133.70	117.855
F-Test	*	*	*	*	*	*	*	*	*	*	*	*
SE(m)±	1.683	2.543	2.110	1.031	1.071	1.050	13.955	22.163	18.040	3.114	3.968	3.530
CD @ 5%	5.075	7.667	6.370	3.120	3.210	3.160	42.065	66.807	54.370	9.386	11.963	10.650
CV %	5.249	5.298	5.280	5.370	5.360	5.360	4.899	4.843	4.860	4.987	5.246	5.120

Note: *Significant at 5%, RDF- Recommended dose fertilizers, Crop – I (Dec-Feb), Crop – II (March-May)

Table 2: Effect of different levels of secondary nutrients on leaf yield parameters in tree mulberry

Treatments	Leaf yield per plant (g)			Leaf yield per ha (kg)		
	Crop- I	Crop- II	Mean	Crop- I	Crop- II	Mean
T_1: RDF + Soil application of Ca:Mg:S :: 33:11:10	1504.23	2740.29	2122.26	2611.34	4757.14	3684.24
T_2: RDF + Soil application of Ca:Mg:S :: 49.5:16.5:15	1661.88	3500.70	2581.29	2885.02	6076.12	4480.57
T_3: RDF + Soil application of Ca:Mg:S :: 66:22:20	1719.74	4293.91	3006.83	2985.46	7454.22	5219.84
T_4: RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25	2425.81	5426.09	3925.95	4211.2	9419.69	6815.45
T_5: RDF + Soil application of Ca:Mg:S :: 99:33:30	1583.59	2173.92	1878.76	2749.11	3773.92	3261.52
T_6: Control (recommended dose of fertilizer + FYM)	1124.71	2174.41	1649.56	1952.49	3774.77	2863.63
F-Test	*	*	*	*	*	*
SE(m)±	39.766	79.311	59.40	69.03	137.68	103.11
CD @ 5%	119.868	239.07	179.04	208.09	415.02	310.81
CV %	4.762	4.686	4.700	4.760	4.690	4.700

Note: *Significant at 5%, RDF- Recommended dose fertilizers, Crop – I (Dec-Feb), Crop – II (March-May)

Conclusion

The treatments consisted of different levels of secondary nutrients in varied combinations with FYM (20 MT/ha/yr). Significantly higher mean of average shoot length (90.4 cm), number of shoots per tree (42.95), number of leaves per tree (1037.87) and leaf area (159.195 cm2) of both crops were recorded in tree mulberry raised with (T_4) RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25. The pre-eminent treatment was RDF + Soil application of Ca:Mg:S :: 66:22:20 (85.26 cm, 41.18, 859.55 and 151.945 cm2, respectively). Maximum leaf yield per tree (3925.95 g/tree) and leaf yield per hectare (13,630.89 kg/ha) was noticed in mulberry raised with RDF + Soil application of Ca:Mg:S :: 82.5:27.5:25 followed by RDF + Soil application of Ca:Mg:S :: 66:22:20 (3006.83 g/tree and 10,439.68 kg/ha, respectively) and RDF + Soil application of Ca:Mg:S :: 49.5:16.5:15 (2581.29 g/tree and 8961.14 kg/ha, respectively) on 60th day after application of different levels of fertilizers. While, the minimum leaf yield per tree (1649.56 g/tree) and leaf yield per hectare (5727.26 kg/ha) was recorded in the control plot.

Authors' contributions

This work was carried out in collaboration among all authors. Author Harish Reddy C. executed the research, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author Ramakrishna Naika planned the study and arranged for the fertilizer. Author Dukare Pradip Gulabrao, supported in silkworm rearing, managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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