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Enhancing biochemical composition of mulberry (*Morus alba* L.) through foliar nutrient application

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Abstract
A study was conducted to evaluate the impact of foliar nutrition on the biochemical composition of mulberry (V-1 variety) at the College of Sericulture, Chintamani, during the Rabi and Summer seasons of 2023-24. The experiment followed a Randomized Complete Block Design (RCBD) with eleven treatments, each replicated three times. Among the tested treatments, the foliar application of humic acid + fulvic acid (0.25%) at 25 and 40 Days After Pruning (DAP) demonstrated the most significant enhancement in key biochemical parameters compared to other treatments. The results revealed that this treatment led to the highest leaf moisture content (80.02%), ensuring better leaf succulence, which is crucial for silkworm feeding. Additionally, it recorded the maximum total moisture retention capacity (92.20%), indicating improved water-holding ability in leaves. The total chlorophyll content (50.93 SPAD value) was also the highest, suggesting enhanced photosynthetic efficiency and leaf quality. Furthermore, the treatment significantly increased protein content (25.08%) and carbohydrate content (26.68%), both of which are vital for silkworm nutrition and cocoon production. These findings highlight that humic acid and fulvic acid, when applied at critical growth stages, improve the nutritional quality of mulberry leaves by enhancing moisture retention, chlorophyll synthesis, and protein-carbohydrate accumulation. This makes the treatment highly beneficial for sericulture farmers aiming to produce superior-quality mulberry leaves for silkworm rearing. Given these results, it is recommended that farmers adopt foliar sprays of humic + fulvic acid (0.25%) at 25 and 40 DAP to optimize the biochemical composition of mulberry leaves. Further research could explore the long-term effects of this treatment on leaf palatability, silkworm growth, and cocoon yield, ensuring sustainable sericulture practices. This study provides valuable insights into foliar nutrition strategies for improving mulberry leaf quality, supporting enhanced silk production.

Keywords: Foliar nutrient, mulberry, V-1 and biochemical constituent

Introduction

Sericulture, an agro-based cottage industry, employs a large number of people in India. Asia is the world's leading producer of silk, accounting for 95 per cent of global output. Silk isa high-priced agricultural commodity that accounts for around 0.2 per cent of global textile fiber production and is part of India's cultural heritage, providing a flow of money from rich to poor. India is unique in production of all four commercially available varieties of silk *viz*., Mulberry, Eri, Tasar, and Muga. Mulberry silk accounts for the majority of the country's raw (Dandin & Giridhar, 2014) [3].

Mulberry is a resilient plant that has deep roots and plenty of leaves, making it able to grow all year round in tropical regions. Typically, mulberry is grown in three different forms: bush, low-cut, and tree (Quader *et al.*, 1989) [8]. The quality of mulberry leaves is crucial for the healthy growth of silkworms and has a significant impact on their economic traits such as larval development, cocoon production, and grainage parameters. These traits are largely influenced by the nutritional content of the leaves that are fed to the silkworms. Therefore, ensuring proper nutrition for the silkworms, specifically the (*Bombyx mori* L). species, is of utmost importance as it directly affects cocoon production (Rashmi *et al.*, 2009) [9].

The primary objective of using foliar nutrients on mulberry plants is to increase the availability of essential nutrients and biochemical content. These sprays are not only economical but also have a longer lifespan compared to solid biofertilizers and chemical fertilizers (Katiyar *et al.*, 1995) [7]. The plant nutrients which are absorbed through roots can also be absorbed with equal efficacy through foliage and often several times more efficiently than from soil treatments (Sastry and Appajirao, 1958) [10].

Materials and Methods

The experiment was carried out in the established V-1 mulberry garden in 2019 with (90*60 cm) + 150 cm spacing. The cultural practices adopted were as per the recommendation for irrigated mulberry garden (Dandin *et al.* 2014) [3]. Five plants were selected for studying biochemical composition in each plot. The biochemical composition were recorded at 60th days after pruning. The analysis were carried out based on the standard procedure given by (Jackson 1973) [6].

Details of treatments:

T_1: Control
T_2: Seriboost Plus @ 0.7% at 25 DAP
T_3: Seriboost Plus @ 0.7% at 25 DAP & 40 DAP
T_4: Jeevamrutha @ 0.5% at 25 DAP
T_5: Jeevamrutha @ 0.5% at 25 DAP & 40 DAP
T_6: Humic acid + Fulvic acid @ 0.25% at 25 DAP
T_7: Humic acid + Fulvic acid @ 0.25% at 25 DAP & 40 DAP
T_8: Vermiwash @ 10% at 25 DAP
T_9: Vermiwash @ 10% at 25 DAP & 40 DAP
T_{10}: Biodigester liquid @ 10% at 25 DAP
T_{11}: Biodigester liquid @ 10% at 25 DAP & 40 DAP
Note: DAP = Days After Pruning

FYM @ 20 MT+ RDF (Recommended dose of fertilizers): Included for all the treatments

Results and Discussion

Application of different concentration of foliar nutrition to mulberry revealed notable variation concerning quality parameters of mulberry *viz.*, Leaf moisture content (%), Total moisture retention capacity (%), chlorophyll content (SPAD meter value), carbohydrates (%), protein (%), N, P, K, Ca, Mg, S (%) contents in mulberry leaf estimated in both crop-I and crop-II.

Leaf moisture content (%)

The leaf moisture content was found to be significantly influenced by the application of different concentration of foliar nutrition on mulberry (Table 1). The observation revealed that in crop-I, crop-II and mean of both the crops, Significantly higher leaf moisture content was noticed with the application of humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP (79.33, 80.71 and 80.02% respectively, which was on par with jeevamrutha @ 0.5% at 25 DAP & 40 DAP (77.14, 78.16 and 77.65% respectively) followed by biodigester liquid @ 10% at 25 DAP & 40 DAP (74.94, 76.38 and 75.66% respectively), humic acid + fulvic acid @ 0.25% at 25 DAP (74.28, 75.83 and 75.06% respectively) and seriboost plus @ 0.7% at 25 DAP & 40 DAP (73.95, 75.23 and 74.59% respectively) whereas, lowest (66.64, 70.21 and 68.43% respectively) is observed in the control treatment.

Total moisture retention capacity (%)

The data on leaf moisture retention capacity as influenced by foliar nutrition are presented in the table 1. A perusal of data indicates that foliar application humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP had higher moisture retention capacity of 91.66, 92.74 and 92.20% in crop-I, crop-II and mean of both the crops respectively in comparision to other treatments but found statistically at par with jeevamrutha @ 0.5% at 25 DAP & 40 DAP followed by biodigester liquid @ 10% at 25 DAP & 40 DAP and humic acid + fulvic acid @ 0.25% at 25 DAP and seriboost plus @ 0.7% at 25 DAP & 40 DAP.

The increase in moisture content in leaf may be attributed to the enhancement in hydrogen ion concentration of plant sap due to the accumulation of chloride and less moisture loss by evapotranspiration (Eaton *et al.*, 1942) [5] which increasingly supply the moisture and there by increased the moisture in the leaf and fresh leaf weight. Usually, moisture content in mulberry leaves fluctuate from 64-83 percent (Yokoyama, 1974) [14].

The increase in leaf moisture content might be due to foliar spray of amino^{+} which steadily supplied moisture directly to the leaf there by increasing the moisture content and concentration of N was found in mulberry leaves given with foliar spray of humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP this contributed for higher leaf moisture content. Ushioda (1954) [13] reported that nitrogen has the highest influence on leaf quality and moisture content of leaves. Higher nitrogen increased the moisture content of leaves. Similarly, Bongale *et al.* (2000) [2] reported that leaf moisture in mulberry is positively related with levels of nitrogen applied and leaf nitrogen content.

Total chlorophyll (SPAD meter value):

The total chlorophyll content in leaves (Table 2) revealed that the highest chlorophyll content in crop-I, crop-II and mean of both the crops (49.98, 51.87 and 50.93 respectively) was noticed in humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP which was on par with jeevamrutha @ 0.5% at 25 DAP & 40 DAP (48.20, 50.09 and 49.15 respectively) followed by biodigester liquid @ 10% at 25 DAP & 40 DAP (47.63, 49.52 and 48.58 respectively) and humic acid + fulvic acid @ 0.25% at 25 DAP (45.98, 47.78 and 46.84 respectively).

Total protein (%)

The protein content in leaves (Table 2) revealed that the highest protein content in crop-I, crop-II and mean of both the crops (24.91, 25.25 and 25.08% respectively) was noticed in humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP which was on par with jeevamrutha @ 0.5% at 25 DAP & 40 DAP (23.97, 24.72 and 24.34% respectively) followed by biodigester liquid @ 10% at 25 DAP & 40 DAP (23.75, 24.51 and 24.13% respectively), humic acid + fulvic acid @ 0.25% at 25 DAP (23.09, 23.84 and 23.46% respectively) and seriboost plus @ 0.7% at 25 DAP & 40 DAP (22.81, 23.05 and 22.93% respectively).

Table 1: Effect of foliar nutrition on leaf moisture and moisture retention capacity in mulberry

Treatments	Leaf moisture content (%)			Total moisture retention capacity (%)		
	Crop-I	Crop-II	Mean	Crop-I	Crop-II	Mean
T_1 Control (FYM @ 20 MT +RDF)	66.64	70.21	68.43	79.68	81.28	80.48
T_2 Seriboost Plus @ 0.7% at 25 DAP	72.75	73.59	73.17	83.56	84.86	84.21
T_3 Seriboost Plus @ 0.7% at 25 DAP & 40 DAP	73.95	75.23	74.59	84.66	85.67	85.16
T_4 Jeevamrutha @ 0.5% at 25 DAP	71.76	73.56	72.66	82.82	84.66	83.74
T_5 Jeevamrutha @ 0.5% at 25 DAP & 40 DAP	77.14	78.16	77.65	90.48	91.27	90.87
T_6 Humic acid + Fulvic acid @ 0.25% at 25 DAP	74.28	75.83	75.06	84.29	85.78	85.04
T_7 Humic acid + Fulvic acid @ 0.25% at 25 DAP & 40 DAP	79.33	80.71	80.02	91.66	92.74	92.20
T_8 Vermiwash @ 10% at 25 DAP	70.56	71.96	71.26	80.87	82.38	81.63
T_9 Vermiwash @ 10% at 25 DAP & 40 DAP	71.19	72.19	71.69	81.24	82.76	82.00
T_{10} Biodigester liquid @ 10% at 25 DAP	71.88	73.33	72.61	82.74	83.97	83.36
T_{11} Biodigester liquid @ 10% at 25 DAP & 40 DAP	74.94	76.38	75.66	87.79	89.59	88.69
F-Test	*	*	*	*	*	*
SE(m)$\pm$	2.07	2.28	2.16	2.48	2.43	2.45
CD @ 5%	6.10	6.73	6.36	7.31	7.16	7.21

Table 2: Effect of foliar nutrition on biochemical constituents (Total chlorophyll, protein and Total carbohydrates) in mulberry

Treatments	Total chlorophyll (SPAD meter value)			Toal protein (%)			Total carbohydrates (%)		
	Crop-I	Crop-II	Mean	Crop-I	Crop-II	Mean	Crop-I	Crop-II	Mean
T_1 Control (FYM @ 20 MT +RDF)	36.28	37.50	36.89	18.28	18.41	18.35	19.04	21.89	20.46
T_2 Seriboost Plus @ 0.7% at 25 DAP	42.96	44.85	43.91	21.51	22.27	21.89	22.50	24.35	23.43
T_3 Seriboost Plus @ 0.7% at 25 DAP & 40 DAP	44.21	46.10	45.16	22.81	23.05	22.93	23.20	25.05	24.12
T_4 Jeevamrutha @ 0.5% at 25 DAP	41.39	43.28	42.34	20.62	21.37	21.00	22.43	24.28	23.35
T_5 Jeevamrutha @ 0.5% at 25 DAP & 40 DAP	48.20	50.09	49.15	23.97	24.72	24.34	23.93	25.78	24.85
T_6 Humic acid + Fulvic acid @ 0.25% at 25 DAP	45.98	47.78	46.84	23.09	23.84	23.46	23.27	25.12	24.19
T_7 Humic acid + Fulvic acid @ 0.25% at 25 DAP & 40 DAP	49.98	51.87	50.93	24.91	25.25	25.08	25.76	27.61	26.68
T_8 Vermiwash @ 10% at 25 DAP	37.29	39.18	38.24	18.90	19.65	19.27	20.37	22.22	21.29
T_9 Vermiwash @ 10% at 25 DAP & 40 DAP	38.16	40.05	39.11	19.82	20.57	20.19	21.65	23.50	22.57
T_{10} Biodigester liquid @ 10% at 25 DAP	40.16	42.05	41.11	20.04	20.79	20.41	22.32	24.17	23.24
T_{11} Biodigester liquid @ 10% at 25 DAP & 40 DAP	47.63	49.52	48.58	23.75	24.51	24.13	23.31	25.16	24.23
F-Test	*	*	*	*	*	*	*	*	*
SE(m)$\pm$	1.38	1.44	1.41	0.72	0.79	0.75	0.71	0.78	0.73
CD @ 5%	4.08	4.25	4.15	2.13	2.33	2.20	2.11	2.30	2.16

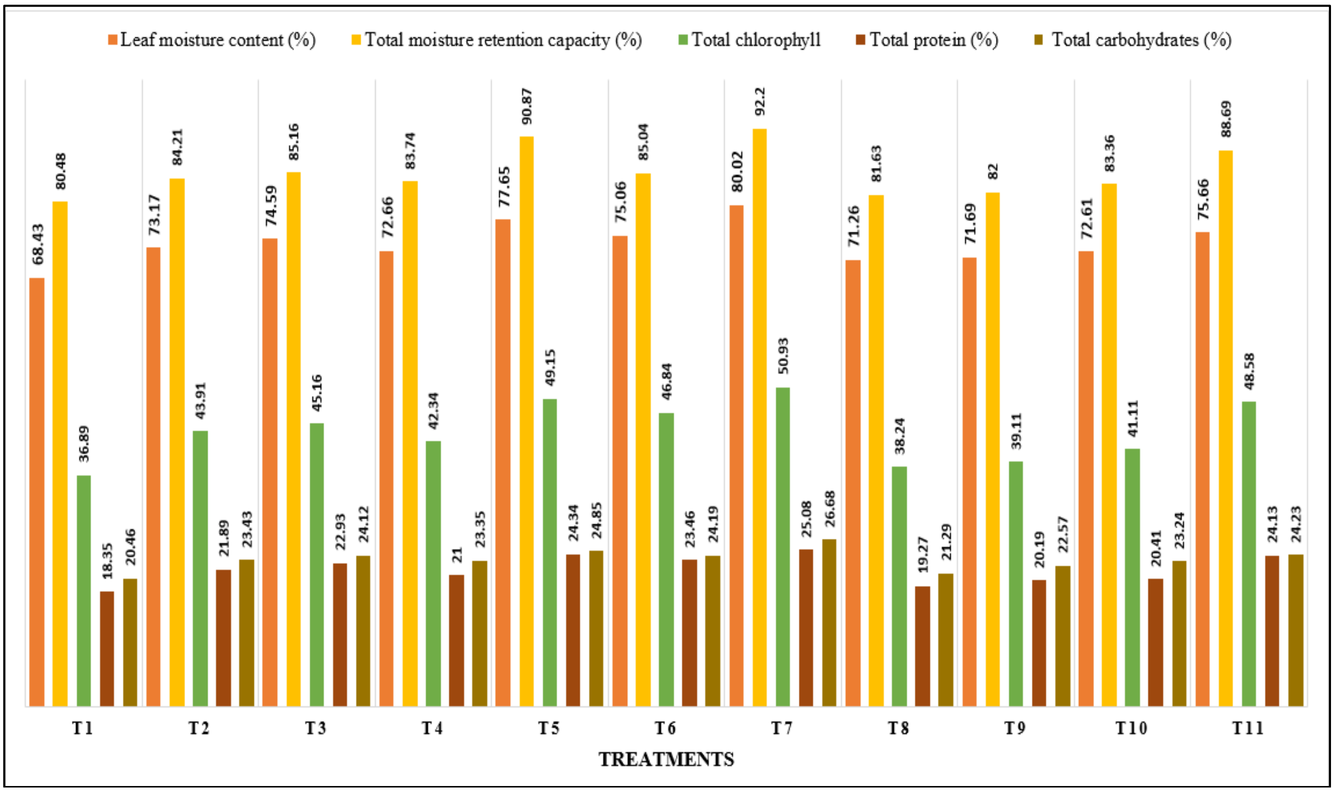

Fig. 1: Comparative Analysis of Leaf Moisture Content, Moisture Retention Capacity, Chlorophyll, Protein, and Carbohydrate Levels in Mulberry under Various Treatments

Total carbohydrates (%)

The carbohydrate content in leaves differed significantly due to application of foliar nutrients the results are presented in the table 2.

Significantly higher carbohydrate content in leaves was recorded in foliar application of humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP (25.76, 27.61 and 26.68%) over all other treatments. But it was found on par with foliar application of jeevamrutha @ 0.5% at 25 DAP & 40 DAP (23.93, 25.78 and 24.85%) in crop-I, crop-II and mean of both crops respectively.

Where higher N content was found in mulberry leaves given with foliar spray of humic acid + fulvic acid @ 0.25% at 25 DAP & 40 DAP this contributed for higher cholorophyll content. The present results are in close proximity with the findings of Singhal *et al.* (1999) who reported that nitrogen is an essential constituent of chlorophyll, nitrogen harvests solar energy and aids in the synthesis of chlorophyll. Photosynthetic efficiency is indicated by the increased amount of chlorophyll content in leaves, thus it can be used as one of the criteria for photosynthetic rate quantification in mulberry (Sujathamma and Dandin, 2000) [12]. Under normal conditions, the treatment of plants with fulvic acid also enhanced the chlorophyll contents in the maize plants (Anjum *et al.*, 2011) [1]. Das *et al.* (2002) [4] found that the use of humic acid enhanced the chlorophyll contents and a foliage feeding of kinetin also increased the chlorophyll contents in mulberry plants.

There was considerable improvement in photosynthetic pigments of maize plants owing to foliar fulvic acid treatment as compared to the untreated plants when grown under water stress conditions, under normal conditions, the treatment of plants with fulvic acid also enhanced the chlorophyll contents in the maize plants (Anjum *et al.*, 2011) [1].

The quality of leaf is dependent on its biochemical contents. Nitrogen is a major component of amino acids, the building blocks of protein, Nitrogen content increases the protein and water content of the leaves, there by increasing the nutritive value of the leaves. Whereas, phosphorus helps in early root development and growth of plants. It is constituent of many compounds in plants such as nucleic acid, phospholipids, coenzymes, NAD, NAPD and ATP. It has close relationship with metabolism of carbohydrates, synthesis of proteins, respiration, photosynthesis and other metabolic activities (Shankar, 1997) [11].

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