International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(8): 517-524
www.biochemjournal.com
Received: 18-05-2025
Accepted: 25-06-2025

Anusha GD
Department of Studies in Sericulture and Seri Biotechnology University of Mysuru, Karnataka, India

Devamani M
Department of Studies in Sericulture and Seri Biotechnology University of Mysuru, Karnataka, India

Basavaiah
Department of Studies in Sericulture and Seri Biotechnology University of Mysuru, Karnataka, India

Corresponding Author:
Devamani M
Department of Studies in Sericulture and Seri Biotechnology University of Mysuru, Karnataka, India

The effect of foliar application of vermiwash enriched with Poshan on the yield and quality of Mulberry (*Morus* sp.) and Silkworm (*Bombyx mori*)

Anusha GD, Devamani M and Basavaiah

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i8g.5245

Abstract
The present investigation evaluated the effects of foliar application of vermiwash with Poshan multi-nutrient formulation on the growth, biochemical composition and productivity of mulberry (*Morus* sp.) leaves and silkworm (*Bombyx mori*). A field experiment was conducted with four treatment conditions, vermiwash + Poshan (3:1), vermiwash only, Poshan only, and an untreated control, in a randomized block design with four replications. We measured growth characteristics (the number of branches, shoot length, number of leaves), and biochemical characteristics (levels of glucose, protein and chlorophyll), and conducted bioassays with silkworm rearing to determine larval weight, cocoon characteristics, filament length and silk yield. According to the findings, applying vermiwash and Poshan together greatly enhanced plant growth, raised biochemical content, and produced larger larval and cocoon weights than other treatments. Overall results suggest that foliar application of vermiwash enriched with Poshan is a promising, eco-friendly method for enhancing mulberry leaf quality and silkworm performance in sericulture, even though cocoon quality traits like shell weight, filament length, and raw silk yield did not differ significantly.

Keywords: Foliar nutrtion, vermiwash, mulberry, poshan, silkworm

Introduction

Sericulture, or the cultivation of silkworms for silk manufacture, is a biologically specialized and economically significant agricultural enterprise. *Bombyx mori*, a domesticated silkworm species that feeds solely on *Morus* spp. (mulberry) leaves, is fundamental to this activity. Mulberry, a deep-rooted, perennial plant, is extremely responsive to nitrogen inputs due to its rapid growth and dense foliage (Altman & Farrell, 2022) [3]. Its productivity directly influences the health and silk-producing ability of silkworms. As a result, the physiological quality of mulberry leaves specifically, their protein, sugar, and moisture content is crucial in regulating larval growth, cocoon weight, shell ratio, and raw silk production (Das *et al.*, 2025) [7].

Environmental factors like soil deterioration, nitrogen fixation, pH imbalances, or unhealthy root zones can often restrict mulberries' capacity to absorb essential nutrients from the soil. Poor leaf quality is the result of these issues, which hinder nitrogen uptake, especially in crops with deep roots (Pahalvi *et al.*, 2021) [16]. In these circumstances, foliar fertilization works well for getting nutrients straight to the parts of the plant that are used for photosynthetic activity. Through stomatal and cuticular absorption, foliar nutrients bypass the root system and are promptly accessible for metabolic processes. This method works particularly well when there is a need for quick nutrient adjustment, during stressful times, or during vigorous vegetative phases (Hossain & Ryu, 2009) [12].

Plant growth, yield, and resistance to abiotic stress are all known to be enhanced by foliar treatment. It has been demonstrated that foliar spraying mulberries with nitrogen (urea), phosphorus, and potassium (NPK) greatly increases leaf yield and raises biochemical components like proteins, starch, reducing sugars, total soluble sugars, and chlorophyll content (Rajendran *et al.*, 2025) [17]. By modifying cocoon formation, silk reeling performance, and larval weight gain, these modifications have a direct impact on silkworm productivity. Growth regulators that enhance leaf development, shape, and photosynthetic rates include GA_3, kinetin, and IAA.

The consistent positive correlation between cocoon production and leaf quality highlights the necessity of prompt and focused nutrient management in mulberry production (D *et al.*, 2024) [6].

Another important argument for using foliar feeding is its economic and operational efficiency. In comparison to soil fertilization, foliar sprays require fewer inputs and provide faster visible results. Furthermore, their compatibility with other agrochemicals (such as insecticides and fungicides) enables farmers to combine treatments, lowering labor costs and operating time. The ability to modify foliar compositions based on the plant's developmental stage and specific deficiency symptoms identified makes it a precise, farmer-friendly approach. (Niu *et al.*, 2021) [15].

Despite the effectiveness of chemical foliar fertilizers, rising environmental and health concerns have led to a global trend toward more sustainable and environmentally friendly agriculture practices. The overuse of synthetic fertilizers and pesticides has resulted in widespread problems such as soil acidification, groundwater contamination, disturbance of soil microbiology, and pesticide resistance (Baweja *et al.*, 2020) [4]. These long-term repercussions necessitate an immediate shift to more balanced farming practices that promote both production and environmental health. As a result, organic and bio-based foliar treatments are being investigated not only as alternatives, but also as strategic enhancers of crop performance in integrated nutrition management systems.

Poshan is one of the commercially available foliar formulations that has drawn a lot of interest because of its tailored formulation and effectiveness. Poshan is an expertly created multi-nutrient solution made especially for mulberries. Applying it topically during the vegetative and leaf maturation phases of mulberry growth is advised since it includes all of the necessary macro-and micronutrients in accessible forms. One application of Poshan is said to improve chlorophyll content, boost plant metabolism, address obvious nutrient deficiencies, and promote consistent and healthy leaf development. Poshan can greatly enhance cocoon weight, shell weight, and silk quality in *B. mori* and produce up to 20% more mulberry leaves under ideal circumstances.

This formulation not only supports healthy plant growth but also reduces the need for frequent chemical fertilizer applications, making it a cost-effective option for farmers practicing intensive sericulture (Alipanah *et al.*, 2020) [2].

The excessive and prolonged use of chemical fertilizers and pesticides has caused health and environmental issues, even while synthetic foliar sprays like Poshan provide quick and noticeable gains in crop performance. These have an adverse effect on long-term soil production and ecological stability and include pesticide residue accumulation, microbial imbalance, water pollution, and soil acidification. As a result, organic and sustainable farming inputs that increase plant yield without sacrificing environmental integrity are gaining popularity worldwide (Aktar *et al.*, 2009) [1]. Among these inputs, vermicompost and vermiwash, which are byproducts of vermiculture, are becoming more and more acknowledged for their capacity to support integrated pest and nutrient management systems, encourage plant development, and restore soil health.

Vermiwash is a liquid biofertilizer that is created by letting water run through a column filled with earthworms, typically Eisenia fetida, and organic debris. Mucus secretions, earthworm excretory products, enzymes (such as urease, phosphatase, and amylase), plant growth hormones (such as auxins and cytokinins), vitamins, and a range of beneficial bacteria are all included in the nutrient-rich extract that is the end result of this process. The resulting liquid is typically clear, slightly alkaline, and pale yellow. When used as a foliar spray, vermiwash has been shown to increase plant growth, photosynthetic activity, nutrient uptake, and resistance to pests and diseases. Because it acts as a natural biopesticide and growth stimulant, it is suitable for organic and eco-friendly farming practices (Gudeta *et al.*, 2021) [10]. Vermiwash has several advantages, but one drawback is that it contains fewer macronutrients than synthetic preparations. Because of this, it is less successful when used alone, especially in crops with high demand, like mulberries, where a steady supply of nutrients is essential for the best possible development of leaves and silk. Recent research has investigated enriching vermiwash with extra nutrients or bio-enhancers to produce fortified foliar compositions in order to overcome this restriction. In order to satisfy the needs of high-yielding cultivars, these enriched versions seek to combine the inherent advantages of vermiwash, such as microbial stimulation and hormone activity, with improved nutritional content ((Nahar *et al.*, 2024) [14] (Che Sulaiman & Mohamad, 2020) [5].

On considering this, the current study aims to study the effect of foliar application of vermiwash supplemented with POSHAN on the growth of mulberry and the biochemical content of its leaves. And assess the nutritive quality of mulberry leaf sprayed with vermiwash supplemented with POSHAN through silkworm rearing.

Materials and Methods

Investigations on the effect of foliar spray of Poshan supplemented vermi-wash on yield, chemical content and cocoon production potential of mulberry (*Morus* sp.) leaves were carried out in the Department of Studies in Sericultural Science. University of Mysore, Manasagangotri, Mysuru, during March-May. Vermiwash was procured from the Bio-waste Management Project of the Department.

In the Department's experimental garden, a high-yielding mulberry cultivar called Victory-1 (V1) was kept under drip irrigation for the foliar spray experiment. 128 mulberry plants were chosen, and they were split up into four treatment groups with four replications each. In order to maintain uniformity and reduce environmental variability, eight plants were used in each replication. A randomized block design was used in the experimental setup to minimize experimental error and enable precise treatment comparisons.

Treatment

Vermiwash was combined with Poshan at a 3:1 ratio and used as the primary therapy. It was tested against vermiwash alone, Poshan alone, and a control (no spray). The four therapies used were:-

T_1: Control(No-Spray)
T_2: Vermiwash+Poshan(3:1).
T_3: Vermiwash alone.
T_4: Poshan-alone.

Each treatment was applied to four randomized replications with a hand sprayer in the cool morning hours. The first spray was applied 40 days after pruning, followed by a second spray 10 days later. Standard cultural procedures, such as irrigation and manure treatment, were followed similarly throughout all plots.

Silkworm rearing

To evaluate the nutritional quality of mulberry leaves under different treatments, a bioassay through silkworm rearing was conducted in the departmental rearing house. Disease-Free Layings (DFLs) of the hybrid silkworm strain PM × CSR2 were obtained from the National Silkworm Seed Organization (NSSO), Mysuru. Prior to rearing, a 2% bleaching powder solution was used to completely clean and disinfect the rearing room and its equipment. Astra/Sanitech was then used for a second disinfection. Using leaves from each treatment group independently, rearing was done from the fourth to the fifth instar. Four replications, each containing 100 larvae, were kept in different trays for every treatment. Throughout the trial, standard silkworm raising procedures were adhered to.

Observations Recorded

After 10 days of the final spray, mulberry growth and leaf yield were observed using the methods listed below:

Growth parameters of the mulberry plant

- **Number of branches per plant:** The total number of healthy branches was determined from 16 randomly selected plants across all replications per treatment. The average number of branches per plant was computed.
- **Average length of shoots (cm):** A measuring tape was used to measure the length of all plant shoots and calculate the average. Sixteen observations from the randomly chosen sixteen
  Plants from all replications of each treatment were counted.
- **Number of leaves per shoot:** Leaves on shoots of average length were counted from 16 plants, and the average number of leaves per shoot was computed.

Silkworm rearing:

Rearing parameters are studied by adopting standard techniques and procedures stated below.

- **Matured larval weight (g):** The Weight of five matured larvae was recorded from each replication of a treatment using a sensitive electronic balance. The mean single mature larval weight of a treatment was calculated.
- **Cocoon weight (g):** Cocoon weight was recorded by weighing twenty cocoons using a sensitive electronic balance, and the single cocoon weight was calculated in each treatment.
- **Pupal weight (g):** Pupal weight was recorded by weighing twenty pupae using asensitive electronic balance, and single pupal weight was calculated in each treatment.
- **Shell weight (g):** Shell weight was recorded by removing pupa and the last larval skin i.e, exuvium, in each treatment.

Reeling parameters

- **Average filament Length (m):** To calculate the average length of filaments, four cocoons were randomly selected from every treatment in every replication and reeled with the help of an éprouvette (a filament measuring device). The number of revolutions was counted and filament length was calculated using the formula below:

Average filament Length (m) = R×1.125

R = Number of revolutions recorded by epprouvette.

1.125 = Circumference of epprouvette in meter.

- **Raw silk percentage:** Raw silk percentage was estimated in each treatment, replication-wise, using the following formula:

$$\text{Raw silk percentage} = \frac{\text{Raw silk weight (g)}}{\text{Cocoon weight (g)}} \text{x}100$$

- **Renditta:** Renditta was estimated in each treatment, using the following formula:

$$\text{Renditta} = \frac{\text{Cocoon weight (g)}}{\text{Raw silk weight (g)}}$$

- **Denier:** Denier was worked out in each treatment, using the formula below.

$$\text{Denier} = \frac{\text{Weight of the filament (g)}}{\text{Length of the filament (m)}} \text{ x } 9000$$

Each parameter was calculated replication-wise for all treatments, and data were statistically analyzed to determine treatment effects.

Estimation of Biochemical parameters

- **Carbohydrate content:** The carbohydrate content in mulberry leaves was determined using the phenol-sulfuric acid method from (DuBois *et al*., 1956) [8]. The leaves collected from the seventh position of the branch were shade dried, ground and extracted in 80% ethanol. A 0.1 mL aliquot of the extract was diluted with 0.9 mL distilled water and added to 1 mL of 5% phenol and then added to 5 mL of concentrated sulfuric acid. The extract was left for 20 minutes and absorbance was assessed at 490 nm using a spectrophotometer. Carbohydrate content was reported in mg/g dry weight with glucose as a standard.
- **Protein content:** The protein content was determined using the Lowry's method (Lowry *et al*., 1951) [13], with Bovine Serum Albumin (BSA) as the standard. The test was performed using shade-dried and powdered mulberry leaves (third or fourth position). One ml of sample was added to 5 ml of protein reagent and incubated for 10 minutes at room temperature, followed by 0.5 ml of Folin-Ciocalteu reagent. After incubation for 30 minutes, absorbance was measured at 660 nm. The protein content was presented as mg/g dry weight.
- **Chlorophyll content:** Chlorophyll content was determined using the method of (Hiscox & Israelstam, 1979) [11] utilizing absorbance (A) measurements at 645 and 663 nm. It used fresh leaf samples. The chlorophyll concentrations were also tentatively calculated using formula given below. The results were converted to mg/g fresh weight. The calculations used the following formulas:

The chlorophyll 'a', 'b', and total chlorophyll were computed using the following formulae.
Chlorophyll 'a'(mg/g fresh weight) = 12.7 (O.D. 663)-2.69 (O.D. 645)×V/1000xW
Where,
O.D=Optical difference
V=Volume made up (ml)
W=Weight of leaf sample (g)

Chlorophyll ‘b'(mg/g fresh weight) = 22.9 (O.D. 645)-4.68 (O.D. 663)x V/1000xW Total Chlorophyll (mg/g fresh weight) = 20.2(O.D. 645)+8.02(O.D. 663)xV/1000 x W

Statistical analysis of data: Statistical analysis of all the experimental data collected during the mulberry and silkworm studies was performed using Fisher's Analysis of Variance (ANOVA) as outlined by Cochran and Cox (2000) and the significance levels of treatments were calculated using the SPSS statistical software tool.

Results and Discussions

Mulberry plants in all four treatments responded favourably to foliar application of vermiwash enhanced with Poshan.

Figures 3-6 show the significant variations in growth parameters that were noted between treatments. Under each treatment, important growth metrics were noted, such as the number of branches per plant, branch length, and leaves per plant. Table 1 displays the analyzed data, and bar diagrams are used to further illustrate how plant performance varies by treatment.

- **Growth parameters of mulberry plants:** The Number of branches, the Length of branches, and the Number of leaves of the mulberry plants were analyzed. The effects of different foliar treatments on mulberry growth characteristics are displayed in Table 1 and indicated in the graph(Figure 1). The most effective growth response was indicated by T_2 (Vermiwash + Poshan), which had the most branches, branch length, and leaf count of any treatment. While T_1 (Control) consistently had the lowest values, treatments T_3 (Vermiwash) and T_4 (Poshan) demonstrated moderate improvements. Significant differences in branch length ($p<0.01$) and branch and leaf number ($p<0.05$) were found by statistical analysis. These results suggest that vermiwash and Poshan applied together have a synergistic effect on the growth of mulberry plants.

Table 1: Data on three growth parameters of mulberry plants

Treatments	No of branches/plants (No.)	Length of branches/plant (cm)	No. of leaves/plant (No)
T_1 (Without spray)	7.065 ± 1.289	175.06±9.33	196.06±1.289
T_2 (Vermiwash+poshan)	8.250±1.52	176.19±17.19	222.75±4.934
T_3 (Vermiwash)	7.563±1.311	165.88±18.22	192.85±1.854
T_4 (Poshan)	7.375±1.20	193.62±11.59	199.12±3.701
Significance	*	**	*

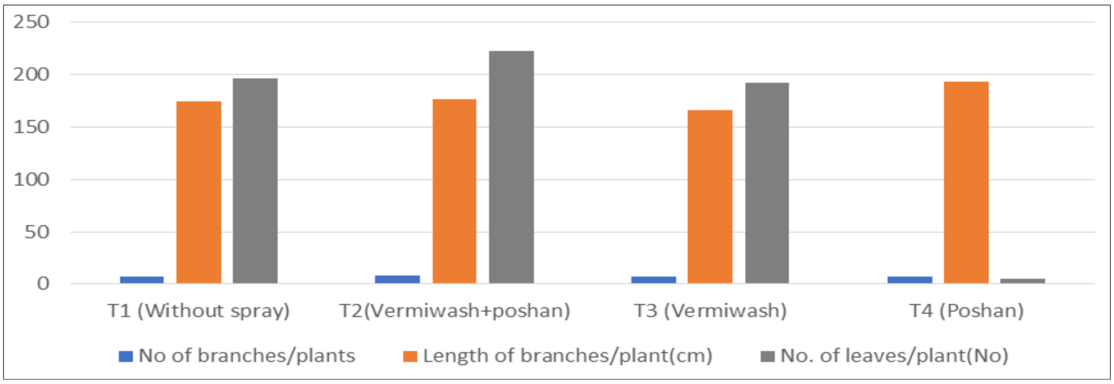

Fig 1: Effects of three growth parameters of mulberry leaves

- **Cocoon parameters:** The impact of various foliar treatments on cocoon characteristics, including single larval weight (g), cocoon weight (g), pupal weight (g), and shell weight(g) is depicted in Table 2 and Figure 2. The highest cocoon weight (1.6438 ± 0.032 g) and larval weight (3.612 ± 0.16 g) were obtained with Vermiwash and Poshan (T_2) combined, suggesting superior cocoon and larval growth. While T_3 (vermiwash alone) had the highest shell weight (0.2575 ± 0.0116 g), T_2 had a slightly lower shell weight (0.2487 ± 0.0112 g) than the other treatments. Larval, cocoon, and shell weight all varied significantly between treatments (**$p<0.01$), but pupal weight did not ($p>0.05$). These findings suggest that although using Vermiwash and Poshan together enhances larval and cocoon development, the formation of shells may be more influenced by the use of either substance alone.

Table 2: Data on Cocoon parameters

Treatments	Single larval weight (g)	Cocoon weight(g)	Pupal weight(g)	Shell weight(g)
T_1 (without treatment)	3.462±0.12	1.6025±0.036	1.262±0.0518	0.2562±0.0140
T_2 (vermiwash + poshan	3.612±0.16	1.6438±0.032	1.262±0.0518	0.2487±0.0112
T_3 (vermiwash)	3.562±0.21	1.5175±0.0604	1.2500±0.0535	0.2575±0.0116
T_4 (POSHAN)	3.481±0.12	1.5425±0.0506	1.2125±0.0354	0.2550±0.0141
Significance	**	**	ns	**

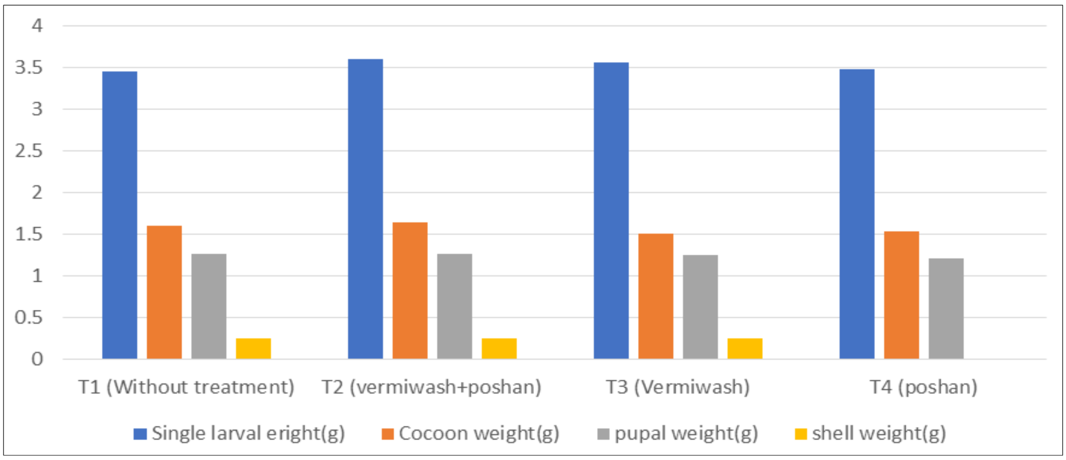

Fig 2: Effects of treatments on cocoon parameters

Cocoon quality parameters

The cocoon quality metrics for each treatment are displayed in Table 3 and Figure 3-6. T_3 (Vermiwash) and T_4 had longer filament lengths, but T_4 (Poshan) had the highest raw silk weight (0.274 g) and denier (2.592). T_2 (Vermiwash + Poshan) showed the lowest renditta, suggesting superior silk recovery. The fact that none of the differences were statistically significant, however, suggests that the foliar treatments had no appreciable impact on the characteristics of cocoon quality.

Table 3: Data on Cocoon Quality Parameters

Treatments	Filament length (m)	Raw Silk Weight (g)	Rendita (kg)	Denier (d)
T_1 (without Treatment)	837.2±54.0	0.218±0.0119	7.370±0.371	2.357±0.244
T_2 (Vermiwash + poshan)	857.2±29.2	0.239±0.012	6.695±0.755	2.4100±0.078
T_3 (Vermiwash)	889.7±41.02	0.2185±0.008	7.0450±0.533	2.200±0.1407
T_4 (Poshan)	891.75±52.18	0.274±0.027	6.807±0.884	2.592±0.267
Significance	N.S	N.S	N.S	N.S

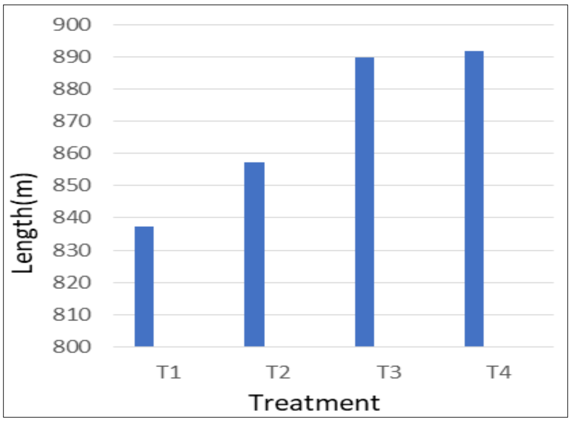

Fig 3: Filament length (m)

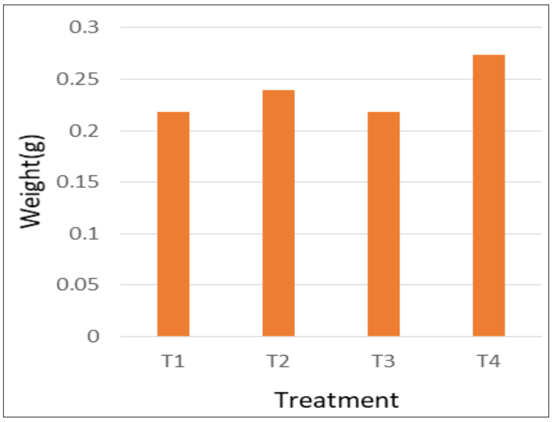

Fig 4: Raw silk weight (g)

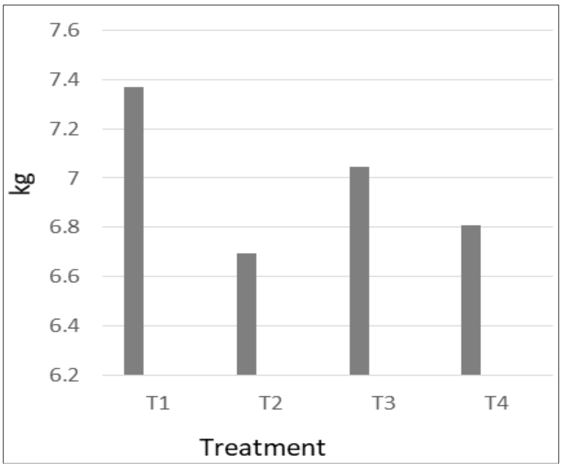

Fig 5: Rendita (kg)

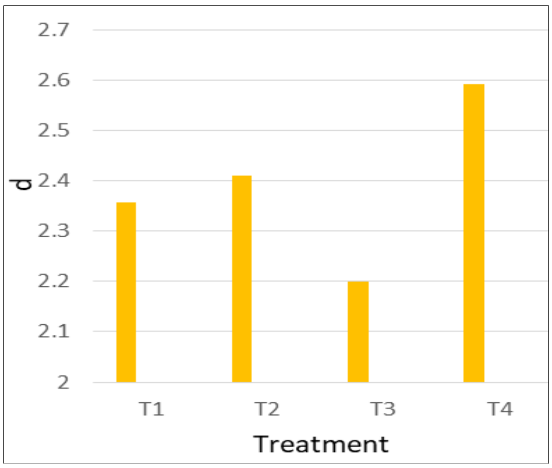

Fig 6: Denier (g)

Data on carbohydrate and protein content

The impact of different treatments on the protein and carbohydrate contents of mulberry leaves is shown in Figure 3. The highest protein (84.93 mg/g) and carbohydrate (123.50 mg/g) contents among the treatments were found in T_2 (Vermiwash + Poshan), indicating a notable improvement in the biochemical composition of the leaves. Additionally, T_4 (Poshan) showed a notable improvement over the control. For both parameters, T_1 (Control) displayed the lowest values. Significant differences were identified using Statistical analysis ($p<0.01$) in protein and glucose content between treatments, demonstrating the effectiveness of foliar supplementation, especially the combination of Poshan and vermiwash.

Table 4: Data on Carbohydrate and protein content (mg/g)

Treatments	Carbohydrate Content (mg/g)	Protein content (mg/g)
T_1 (control)	76.64±11.46	53.164±12.580
T_2 (vermiwash + poshan)	123.50±26.62	84.931±9.090
T_3 (Vermiwash)	83.04±12.20	84.471±8.494
T_4 (poshan)	114.02±26.32	71.670±7.114
Significance	**	**

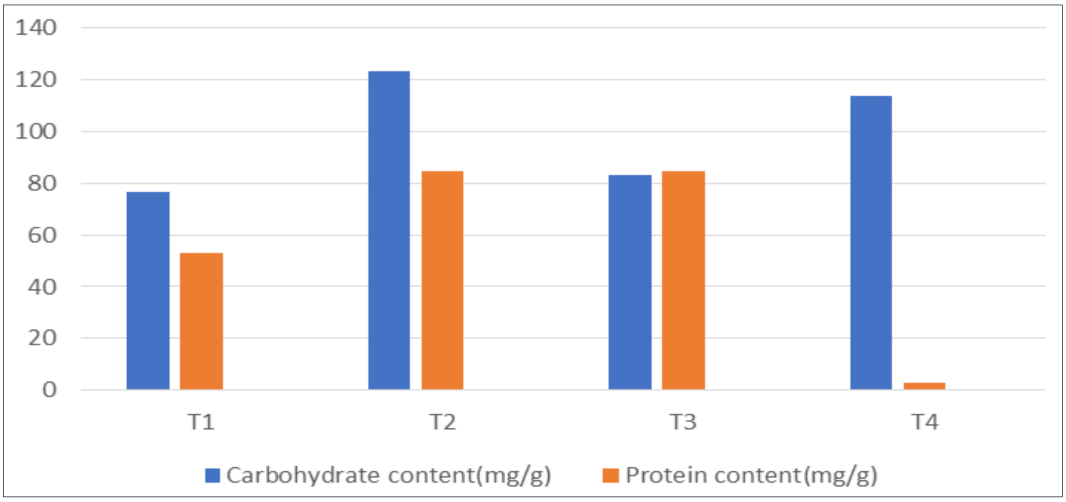

Fig 7: Carbohydrate and protein content

Chlorophyll content

The effects of foliar treatments on the amount of chlorophyll a, chlorophyll b, and total chlorophyll in mulberry leaves are displayed in Table 5 and Figure 9-11. The highest concentrations of all chlorophyll components were produced by the T_2 (Vermiwash + Poshan) treatment; in particular, total chlorophyll (4.856 mg/g) and chlorophyll a (0.027 mg/g) were significantly greater than those of the other treatments. In contrast to the control (T_1), which had the lowest values, T_3 (Vermiwash) and T_4 (Poshan) both had higher chlorophyll contents. Statistical analysis showed significant differences ($p<0.01$) in all measurements of chlorophyll, suggesting that the treatments-particularly the combination of Poshan and vermiwash-effectively raised the levels of photosynthetic pigment.

Table 5: Data on Chlorophyll content of mulberry leaves

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)
T_1(without spray)	0.017±0.002	0.0028±0.0095	3.600±0.6411
T_2 (Vermiwash+poshan)	0.027±0.0026	0.0095±0.0004	4.856±0.137
T_3 (Vermiwash)	0.0197±0.0013	0.0093±0.0037	4.647±0.0286
T_4 (poshan)	0.020±0.0029	0.0757±0.009	4.326±0.3647
Significance	**+	**	**

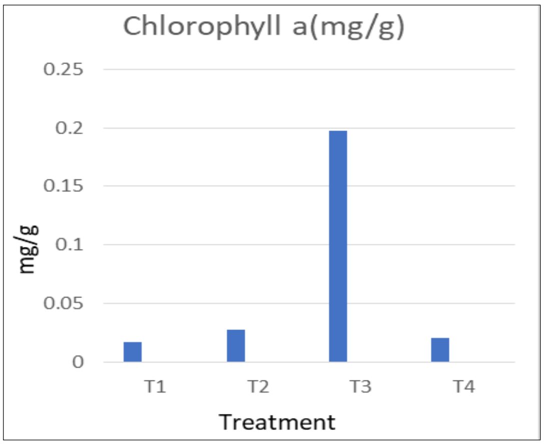

Fig 8: Chlorophyll a

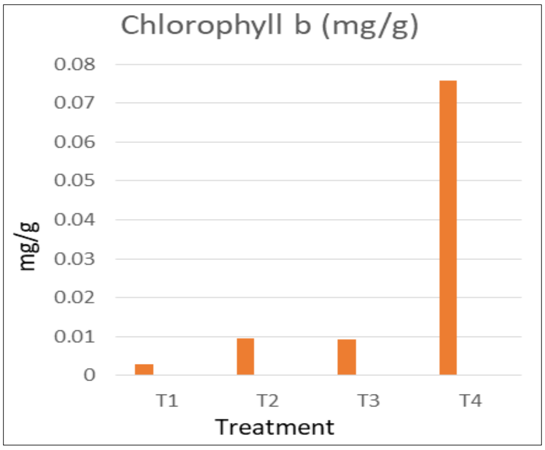

Fig 9: chlorophyll b

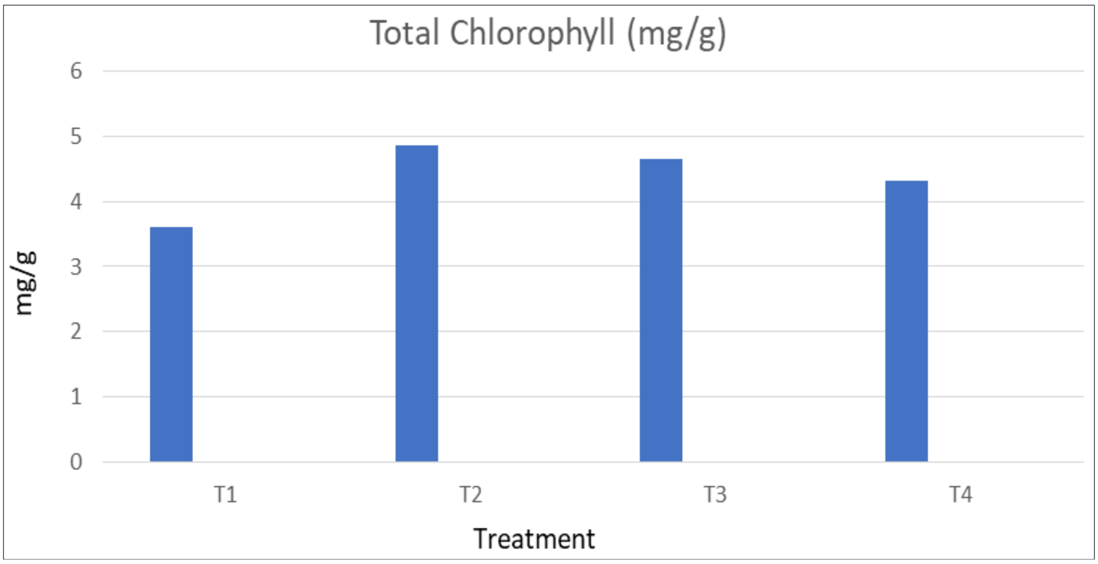

Fig 10: Total chlorophyll

Result and Conclusion

The study looked at how vermiwash mixed with Poshan in a 3:1 ratio affected mulberry (V_1 variety) and silkworm (Kolar Gold hybrid) performance when used as a foliar spray. The treatment was compared to using vermiwash alone, Poshan alone, and a control that received no spray.

The results indicated that the combination of vermiwash and Poshan significantly boosted mulberry growth metrics, including branch number, branch length, and leaf count. Chemo-assay results showed much higher levels of carbohydrates, proteins, and chlorophyll in the leaves treated with the mixture. In the experiment, the combined treatment resulted in significantly greater larval and cocoon weights. However, pupal weight, shell weight, filament length, raw silk weight, renditta, and denier did not show significant differences between treatments.

Overall, vermiwash, along with Poshan, proved to be the most effective method for improving both mulberry leaf quality and silkworm productivity. It offers a cost-effective and environmentally friendly alternative to separate foliar sprays, making it a promising addition for better sericulture practices.

References

1. Aktar W, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: Their benefits and hazards. Interdisciplinary Toxicology. 2009;2(1):1-12. Available from: https://doi.org/10.2478/v10102-009-0001-7
2. Alipanah M, Abedian Z, Nasiri A, Sarjamei F. Nutritional effects of three mulberry varieties on silkworms in Torbat Heydarieh. Psyche: A Journal of Entomology. 2020;2020:1-4. Available from: https://doi.org/10.1155/2020/6483427
3. Altman GH, Farrell BD. Sericulture as a sustainable agroindustry. Cleaner and Circular Bioeconomy. 2022;2:100011. Available from: https://doi.org/10.1016/j.clcb.2022.100011
4. Baweja P, Kumar S, Kumar G. Fertilizers and pesticides: Their impact on soil health and environment. In: Giri B, Varma A, editors. Soil health. Vol. 59. Cham: Springer International Publishing; 2020, p. 265-285. Available from: https://doi.org/10.1007/978-3-030-44364-1_15
5. Che Sulaiman IS, Mohamad A. The use of vermiwash and vermicompost extract in plant disease and pest control. In: Natural remedies for pest, disease and weed control. Amsterdam: Elsevier; 2020, p. 187-201. Available from: https://doi.org/10.1016/B978-0-12-819304-4.00016-6
6. D S, M V, H S, R AR. Improvement of silkworm (*Bombyx mori* L.) growth and cocoon quality using nickel sulfate supplementation. Uttar Pradesh Journal of Zoology. 2024;45(11):182-189. Available from: https://doi.org/10.56557/upjoz/2024/v45i114084
7. Das D, Paul P, Mandal P. Prolonging mulberry leaf longevity with silver-doped copper oxide nanoparticles: A postharvest approach. Discover Plants. 2025;2(1):47. Available from: https://doi.org/10.1007/s44372-025-00130-6
8. DuBois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. Analytical Chemistry. 1956;28(3):350-356. Available from: https://doi.org/10.1021/ac60111a017
9. Ghazy UM, Fouad TA, Ahmed GM. Improving productivity of mulberry trees and silkworm, *Bombyx mori* L., using vermicompost application. International Journal of Industrial Entomology. 2020;40(2):41-50. Available from: https://doi.org/10.7852/IJIE.2020.40.2.41
10. Gudeta K, Julka JM, Kumar A, Bhagat A, Kumari A. Vermiwash: An agent of disease and pest control in soil, a review. Heliyon. 2021;7(3):e06434. Available from: https://doi.org/10.1016/j.heliyon.2021.e06434
11. Hiscox JD, Israelstam GF. A method for the extraction of chlorophyll from leaf tissue without maceration. Canadian Journal of Botany. 1979;57(12):1332-1334. Available from: https://doi.org/10.1139/b79-163
12. Hossain MB, Ryu KS. Effect of foliar applied phosphatic fertilizer on absorption pathways, yield and quality of sweet persimmon. Scientia Horticulturae. 2009;122(4):626-632. Available from: https://doi.org/10.1016/j.scienta.2009.06.035
13. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measurement with the folin phenol reagent. Journal of Biological Chemistry. 1951;193(1):265-275. Available from:

https://doi.org/10.1016/S0021-9258(19)52451-6
14. Nahar K, Ashrafi R, Haque MA. Vermiwash: An effective nutritive blessing to crops. Bangladesh Journal of Nuclear Agriculture. 2024;38(1):21-40. Available from: https://doi.org/10.3329/bjnag.v38i1.76560
15. Niu J, Liu C, Huang M, Liu K, Yan D. Effects of foliar fertilization: A review of current status and future perspectives. Journal of Soil Science and Plant Nutrition. 2021;21(1):104-118. Available from: https://doi.org/10.1007/s42729-020-00346-3
16. Pahalvi HN, Rafiya L, Rashid S, Nisar B, Kamili AN. Chemical fertilizers and their impact on soil health. In: Dar GH, Bhat RA, Mehmood MA, Hakeem KR, editors. Microbiota and biofertilizers. Vol. 2. Cham: Springer International Publishing; 2021, p. 1-20. Available from: https://doi.org/10.1007/978-3-030-61010-4_1
17. Rajendran M, Rahman T, R KK, K S, Hirashmita. Foliar application of multi-nutrient mixture for growth and productivity in mulberry. Asian Journal of Advances in Agricultural Research. 2025;25(3):39-45. Available from: https://doi.org/10.9734/ajaar/2025/v25i3590