

Role of the Sap-Sucking Insect Thrips (*Pseudodendrothrips Mori*) on the Starch, Carbohydrate, and Phenolic Biochemical pigments of *Morus*

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Abstract:

The nutritional and photosynthetic biochemical components of mulberry leaves are significantly degraded by leaf thrips (*Pseudodendrothrips mori*) infestation. As a consequence, there is an average decrease in the concentration of phenolic compounds, carotenoids, starch, carbohydrates, and total chlorophyll. The leaf thrips (*Pseudodendrothrips mori*) is a significant polyphagous pest that attacks mulberry (*Morus*), the sole diet of the silkworm *Bombyx mori* L. These insects cause significant harm by attacking the host plant's fragile leaves, which changes the leaf's texture. Under leaf thrips (*Pseudodendrothrips mori*) infestation, an effort was made to investigate the fluctuations in biochemical components and photosynthetic pigments in six widely grown, high-yielding, and nutritionally important native mulberry kinds, including *Morus indica*, *Morus alba*, *Morus laevigata*, V1 (Victory), S36 (High yielding), and Sahana mulberry. The chosen cultivars were discovered to have a decrease in their biochemical makeup, according to the study. Nevertheless, there was a significant decrease in photosynthetic pigments among all the cultivars of *Morus* leaves. The V1 (Victory) mulberry cultivar, on the other hand, exhibited an increase in some of these colors as a result of pest damage. All the other kinds had less Carotenoid, with the exception of the V1 (Victory) variety. The biochemical makeup of mulberry leaves changes, which can have a detrimental effect on the health, growth, and development of silkworms, resulting in the manufacture of silk of inferior grade. The presence of several insect pests interferes with the production of high-quality mulberry leaves, which in turn affects the quality of silk. The silkworm's health, growth, and development are all adversely affected by these changes in the biochemical makeup of mulberry leaves, which leads to the manufacture of low-quality silk. Thrips (*Pseudodendrothrips mori*), a significant mulberry pest on a sericulture farm, are the subject of the present study, which focuses on their population dynamics. The purpose of the study is to investigate the causes of the quick spread and severity of leaf thrips infestation in mulberry. To safeguard mulberry trees from herbivorous insect pests, rearers are advised to employ appropriate integrated pest management strategies.

Keywords: Biochemical components, thrips (*Pseudodendrothrips mori*), Mulberry, photosynthetic pigments (Starch, Carbohydrate and Phenolic compound).

Introduction:

One of the most significant commercial crops is mulberry, which is widely produced as the only food plant for silkworms (*Bombyx mori*). Mulberry (*Morus* spp.) is a perennial plant that produces a lot of biomass and continues to grow in tropical regions throughout the year. It is a well-known perennial plant that can be found throughout Asia, Europe, Africa,

and Latin America. The only food that silkworms eat in order to grow is mulberry leaves, which are full of protein, carbohydrates, vitamins, and minerals. *Bombyx mori* L., the silkworm that is plagued by a number of insect pest thrips (*Pseudodendrothrips mori*) during cultivation, only feeds on *Morus*. Due to their brief life cycle, the majority of thrips, which are the main pests, are present all year round (Ullal SR,

Narasimhanna MN 1981). Stunted development, malformed leaves, and other signs are among the symptoms. The mulberry leaves' quantity, quality, and yield are all decreased by the pests. Due to its frequent occurrence and significant harm to mulberry trees in recent years, sap sucker is a greater concern. The delicate apical portion of the mulberry shoot is where the early-stage larvae live and consume the soft, young leaves. In general, larvae live on the leaves by creating webs or folding the leaves to create a home. The larval web in which the apical leaves reside rolls and binds the leaf **margins (Umesh, KNN, et al., 1989; Mahadeva, A 2017)**. The web discharged by the larvae sometimes rolls one or two leaves into a cup form, in which the larvae remain. For this reason, mulberry thrips is the common name for the (*Pseudodendrothrips mori*) bug. The silkworm *Bombyx mori* L. relies solely on mulberry (*Morus* spp.) for nutrition in commercial sericulture. Silkworms only eat green mulberry leaves, which provide the nutrients necessary for their healthy development. The mulberry silkworm *Bombyx mori* is an example of this type of feeding on a single host plant, which is known as a monophagous habit. The silkworm's host selectivity is primarily caused by the presence of a yellow pigment attractant known as Morin, which are pentahydroxy flavones. The larval feeding is prevented by the lack of these elements. The physical and chemical characteristics of the leaves determine their quality. Plant leaves' carbohydrates serve as the main output of photosynthesis, functioning as a structural component, an instant energy source, and a storage material (**Siddegowda DK, et al., 1995**). Glucose, the primary source of energy for metabolism and development, is created from carbohydrates, while excess glucose is frequently stored as starch. Additionally, they produce cellulose that gives cell walls their structural strength. Excess glucose produced during daytime photosynthesis is used to create starch in plant leaves, which serves as a short-term energy storage molecule. In chloroplasts, it is kept as granules, which supply a vital and reliable supply of carbon and energy that is used at night to fuel metabolic processes, respiration, and growth. In plant leaves, phenols mainly function as defense mechanisms against biotic stressors

(pathogens, herbivores) and abiotic stressors (UV light, drought, and cold). They serve as sunscreens to shield photosynthetic machinery from UV harm, as antioxidants that scavenge reactive oxygen species (ROS), and as lignin, which gives cell walls structural support. In assessing the nutritional worth of the leaf, the later property is quite important. In the green leaves, the chloroplast pigments are combined with biochemical. There are two varieties of chlorophyll: yellow-green chlorophyll and blue-green chlorophyll A. The cocoons' color, which may be white (Bivoltine), light yellow (multivoltine Pure Mysore), or dark golden yellow (Nistari), is due to these pigments. The pest's sap-sucking behavior has the potential to change the amount of biochemical constituents in the leaves. Changes in the biochemical makeup of mulberry leaves will have a negative impact on the health, growth, and development of silkworms. The end consequence of this is the manufacture of subpar silk. As a result, a study was conducted to ascertain the alterations in the biochemical components and photosynthetic pigments.

MATERIALS AND METHODS:

The healthy and leaf roller infested leaves of six popular indigenous mulberry varieties viz., *Morus indica*, *Morus alba*, *Morus laevigata*, Vi (victory) and Sahana mulberry were collected from plantations in and around India. The leaves were oven dried and processed to analyze the fresh mulberry leaves were utilized to estimate the photosynthetic pigments starch, Carbohydrate and phenolic compound (**Dixon WJ, 1957**). The photosynthetic pigments 100 mg of fresh mulberry leaf tissue was placed in a vial containing 7ml of dimethyl sulphoxide (DMSO) and chlorophyll was extracted into the fluid without grinding at 65°C, incubated for three hours. Liquid was transferred to graduated tube and made up to a total volume of 10ml with DMSO and absorption spectra were recorded at 663 and 645 nm using DU-40 spectrophotometer immediately.

Determination of total carbohydrates: The total carbohydrate was estimated by Anthrone method (**Hedge and Hofreiter, 1962**). Carbohydrate was calculated in relation to fresh weight basis and was

expressed as mg/g tissue; the calculation was done by using following formula

$$\text{Amount of carbohydrate} = \frac{\text{Mg of glucose} \times 100}{\text{Volume of test sample}}$$

Estimation of starch: The starch content was estimated by following the method prescribed by **Hedge and Hofreiter (1962)**. D-glucose was used as **standard** and the value was multiplied by a factor 0.9 to get starch content and it was expressed as mg/g of mulberry leaves.

Estimation of phenols (µg/g): Phenols were estimated following the method of **Malik and Singh (1980)**, by using different concentration of catechol, concentration of phenols was expressed in µg/gm fresh weight material, equivalent to catechol.

Result and Discussions:

The photosynthetic pigments in the mulberry leaves of six native mulberry varieties infested by thrips (*Pseudodendrothrips mori*) (*Morus indica*, *Morus alba*, *Morus laevigata*, Sahana mulberry, and Vi (victory) varieties) displayed almost significant shifts in the photosynthetic pigments (free amino acid, total soluble protein total reducing sugar, and total soluble sugar). The total biochemical components in the *Morus* leaves of all six mulberry kinds that were infested by thrips decreased noticeably mg/g of carbohydrates. The amount of carbohydrates in healthy mulberry leaves from V1 was found to be 65.88 mg/gm, while in mulberry leaves infested with leaf thrips, it was 35.01 mg/gm. additionally, the carbohydrate concentration in healthy S36 high-yielding variety was 65.22 mg/gm, while in thrips-infested plants it was 34.77 mg/gm. The carbohydrate content of Sahana variety of *Morus* varieties was found to be 64.55 mg/gm healthy and 34.55 mg/gm, while in infested it was 33.48 mg/gm, 30.44 mg/gm and 31.55 mg/gm, respectively, lowering the biochemical component. The carbohydrate content of *Morus laevigata*, *Morus alba*, and *Morus indica* was 62.44 mg/gm, 58.22 mg/gm, and 60.44 mg/gm, respectively. mg/g of starch The starch content in healthy V1 was 17.01 mg/gm, but it was found to be 15.01 mg/gm in leaf thrips-infested

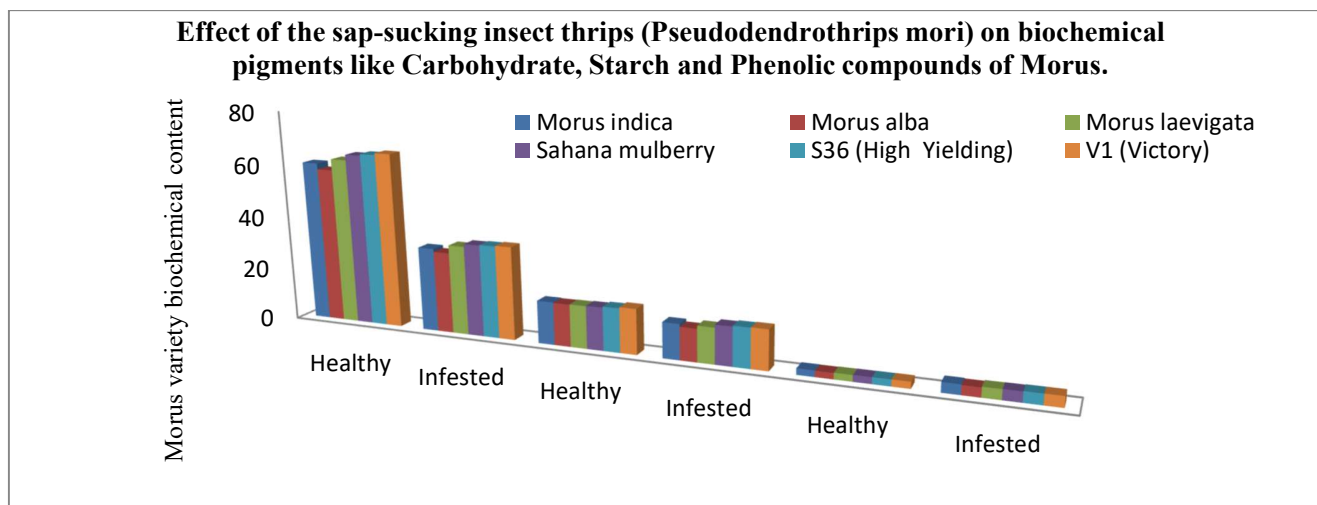
samples. Moreover, the starch level in healthy leaves of the S36 kind was determined to be 16.55 mg/gm, while the starch content in infested leaves was 14.88 mg/gm. The healthy leaves of the Sahana mulberry were discovered to contain 16.17 mg/gm, 15.99 mg/gm, 15.88 mg/gm, 16.02 mg/gm, and 14.55 mg/gm, 13.44 mg/gm, 12.32 mg/gm, and 13.32 mg/gm, respectively, in infested leaves, in relation to *Morus laevigata*, *morus alba*, and *Morus indica*. Phenols (µg/mg): In the mulberry-infested leaves, the amount of phenols was measured to be 2.52 g/mg, while in the healthy mulberry leaves, it was found to be 4.01 g/mg, with the increase in phenols occurring in the V1 variety. In the S36 variety, the phenol level in infested leaves was found to be 2.49 µg/mg, while the control group had 3.99 µg/mg. The infestation rate in the Sahana mulberry cultivar was 2.45 µg/mg, compared to 3.85 µg/mg in the control group. The phenolic content of the other *Morus* species of *Morus laevigata*, *Morus alba*, *Morus indica*, increased from 2.40 to 2.30 to 2.35 µg/mg, while the quantity of infested phenol compound increased from 3.78 to 3.50 to 3.70 µg/mg. In like manner, the same downward trend is seen across all other mulberry varieties, including *Morus Alba*, *Morus laevigata*, Sahana mulberry, and Vi (victory). The results demonstrate that the chlorophyll nitrogenous compounds (free amino acids, total soluble protein, total reducing sugar, and total soluble sugar) are depleted by the thrips sap sucker pest. Despite the higher nutritious values of the variety, a significant proportion of *Morus laevigata* leaves are still lost, emphasizing the necessity for resistant cultivars or prompt thrips (*Pseudodendrothrips mori*) pest management (**Mahadeva, A et al., 2019**). The Victory (V1) *morus* leaves should be highlighted. Due to pest damage, the biochemical components of the photosynthetic pigments were reduced. Similar observations were made in other cases, though, when mulberry leaves were infested by several pests, including mealy bugs (**Anonymous, 1996a; Geethabai M, 1997; Veeranna G 1997**), thrips (**Anonymous, 1996b**), and giant African snails. Consequently, the composition of photosynthetic pigments varied between mulberry cultivars, pest infestation levels, and the amount of damage done.

The changed chlorophyll concentration had a negative impact on photosynthetic activity (Kirk, J. T. O. and Allen, R. L. 1965), which in turn reduced protein synthesis (Arnon, Daniel, I. 1949). The mulberry leaves are therefore nutritionally deficient. Instead of causing a straightforward shift in a single process, pest infestations usually initiate or exacerbate a complex chain of metabolic abnormalities in the host (Ifat B, et al. , 2018; Miyashita Y 1986). Pests can cause leaf malformation, which can impact crop photosynthesis in three ways: by changing light interception, by decreasing the photosynthetic efficiency of biochemicals, or by altering. The quality of cocoon production as well as the growth and development of silkworms are dependent on biochemical factors. The presence of proteins, carbohydrates, and chlorophylls in the leaves determines their quality. Silk production depends on proteins. Because the pathogen used the proteins as a result, the protein levels in the infected leaves must have decreased, and the proteins themselves broke down more quickly than in the healthy leaves (Lowry, O. H., et al., 1951). The health of silkworms and the quantity of cocoons produced are both directly impacted by a carbohydrate found in mulberry leaves. A decrease in carbohydrate metabolic activity might result from a decline in photosynthetic capacity. Plants defend themselves against illness by producing phenols, which are the main component of disease resistance in plants. In our experiment, we discovered that the phenol level in infested plants was much

higher than in healthy plants (Umeshkumar, N. N. 1991). Higher levels of phenols aid in the development of an over-sensitive response to the leaf webber pest infestation. The current study found that silkworm development and cocoon production were greatly affected by feeding mulberry leaves infected with leaf Webbers. The nutritional quality of the leaves is reflected in the lower financial traits seen in these silkworms. Mulberry leaves that were infested with the leaf webber insect and used to raise silkworms yielded cocoons of poor quality that were less compact, had more breaks during reeling, and had a lower filament length. Silk production was severely decreased in the silk worms that were fed infected mulberry plant leaves (Malick, C P. et al., 1980; Shrey, AVMJ, 2014). This study showed that pest infestation causes changes in photosynthetic pigments, nutritional (macro and micro elements), and biochemical components, resulting in lower quality mulberry leaves. These results may be used to pinpoint the causes of mulberry leaf infestations by the Pseudodendrothrips mulberry pest (Narayanaswamy, T K., et al., 2018; Reddy DNR, et al 2003), according to our recommendation. When thinking about the rearing substrates of mulberry larvae utilized for feed, we also advise caution. Additionally, the silkworm larvae are fed such low-quality leaves, which have been shown to impede their healthy growth and development, leading to a low yield and poor quality of natural silk fiber.

Table: Effect of the sap-sucking insect thrips (Pseudodendrothrips mori) on biochemical pigments like Carbohydrate, Starch and Phenolic compounds of Morus.

Biochemical's in Photosynthetic Pigments	Carbohydrate (mg/gm)		Starch (mg/mg)		Phenols(µg/gm)	
	Healthy	Infested	Healthy	Infested	Healthy	Infested
Indian mulberry Variety						
Morus indica	60.44	31.55	16.02	13.32	2.35	3.70
Morus alba	58.22	30.44	15.88	12.32	2.30	3.50
Morus laevigata	62.44	33.48	15.99	13.44	2.40	3.78
Sahana mulberry	64.55	34.55	16.17	14.55	2.45	3.85
S36 (High Yielding)	65.22	34.77	16.55	14.88	2.49	3.99
V1 (Victory)	65.88	35.01	17.01	15.01	2.52	4.01



Two factor ANOVA Factor 2								
	Means:	Healthy	Infested	Healthy	Infested	Healthy	Infested	Means:
	Morus indica	61.217	31.697	16.093	13.367	2.413	3.730	21.419
	Morus alba	58.330	30.550	16.037	12.400	2.357	3.543	20.536
	Morus laevigata	62.623	33.563	16.043	13.550	2.393	3.800	21.996
Factor 1	Sahana mulberry	64.660	34.640	16.240	14.660	2.507	3.877	22.764
	S36 (High Yielding)	65.330	34.880	16.660	14.957	2.503	4.003	23.056
	V1 (Victory)	65.957	35.333	17.187	15.187	2.530	4.130	23.387
		63.019	33.444	16.377	14.020	2.451	3.847	22.193

ANOVA table							
Source	SS	df	MS	F	p-value		
Factor 1	105.8173	5	21.16345	845.60	1.91E-62		
Factor 2	47,166.1273	5	9,433.22545	376910.23	1.54E-157		
Interaction	97.5269	25	3.90108	155.87	5.87E-53		
Error	1.8020	72	0.02503				
Total	47,371.2735	107					

Post hoc analysis for Factor 1							
Tukey simultaneous comparison t-values (d.f. = 72)							
		Morus alba	Morus indica	Morus laevigata	Sahana mulberry	S36 (High Yielding)	V1 (Victory)
		20.536	21.419	21.996	22.764	23.056	23.387
Morus alba	20.536						
Morus indica	21.419	16.75					
Morus laevigata	21.996	27.68	10.92				
Sahana mulberry	22.764	42.25	25.49	14.57			
S36 (High Yielding)	23.056	47.78	31.03	20.10	5.53		

V1 (Victory)	23.387	54.07	37.32	26.39	11.82	6.29		
critical values for experiment wise error rate:								
		0.05	2.93					
		0.01	3.51					
p-values for pair wise t-tests								
		Morus alba	Morus indica	Morus laevigata	Sahana mulberry	S36 (High Yielding)	V1 (Victory)	
		20.536	21.419	21.996	22.764	23.056	23.387	
Morus alba	20.536							
Morus indica	21.419	1.52E-26						
Morus laevigata	21.996	4.16E-40	6.15E-17					
Sahana mulberry	22.764	1.48E-52	8.93E-38	3.65E-23				
S36 (High Yielding)	23.056	2.84E-56	2.09E-43	2.98E-31	4.85E-07			
V1 (Victory)	23.387	4.90E-60	7.63E-49	9.43E-39	1.57E-18	2.19E-08		
Post hoc analysis for Factor 2								
Tukey simultaneous comparison t-values (d.f. = 72)								
		Healthy	Infested	Infested	Healthy	Infested	Healthy	
		2.451	3.847	14.020	16.377	33.444	63.019	
Healthy	2.451							
Infested	3.847	26.49						
Infested	14.020	219.39	192.91					
Healthy	16.377	264.08	237.60	44.69				
Infested	33.444	587.73	561.25	368.34	323.65			
Healthy	63.019	1148.58	1122.09	929.18	884.49	560.85		
critical values for experiment wise error rate:								
		0.05	2.93					
		0.01	3.51					
p-values for pairwise t-tests								
		Healthy	Infested	Infested	Healthy	Infested	Healthy	
		2.451	3.847	14.020	16.377	33.444	63.019	
Healthy	2.451							
Infested	3.847	7.46E-39						
Infested	14.020	1.76E-103	1.82E-99					
Healthy	16.377	2.85E-109	5.69E-106	2.98E-54				
Infested	33.444	2.83E-134	7.82E-133	1.14E-119	1.26E-115			
Healthy	63.019	3.19E-155	1.71E-154	1.35E-148	4.70E-147	8.23E-133		

The statistical table shows a two-factor ANOVA with Factor-1 = mulberry variety (6 levels: Morus indica,

alba, laevigata, Sahana, S36, V1) and Factor-2 = three traits of biochemical like Carbohydrate, Starch

and Phenol (Healthy vs Infested values). It seems that you measured certain parameters under healthy and infested circumstances, maybe leaf nutrients or growth characteristics. The infested varietal Morus leaf is favorably affected by the extremely significant effects of Factor-1 and Factor-2 in the ANOVA table. Varieties are included in the post-hoc (Tukey) for Factor-1. The average summary column on the right, which is around 20–23, reveals that V1 (Victory) has the highest value (23.38), followed by S36 (23.05), Sahana (22.76), laevigata (21.99), indica (21.42), and alba (20.54). Variations include the fact that Morus alba and laevigata have a score of 27.68, among other things. The large t-values imply that almost every pair is likely significant at $\alpha=0.05$. As a result, it can conclude that different Morus varieties react differently to infestation, with V1 and S36 maintaining the highest overall averages. Because interaction is important, they should want to see the difference between healthy and infested Morus types. Lastly, it may conclude that the measured characteristics and mulberry variety infestation status have significant statistical consequences. Data supports selecting V1 or S36 Mulberry kinds since they have the highest overall averages, whereas Morus alba has the lowest. This is the best option for raising silkworm larvae and producing better cocoons and sericulture business for high-yielding cocoons.

Conclusion:

Six varieties of mulberry have been chosen for this study, namely Morus indica, Morus alba, Morus laevigata, V1 (victory), S36 (high yielding), and Sahana mulberry variety. Among the six varieties, the severity of leaf thrips was higher on the Morus indica variety. On biochemical pigments like Carbohydrate, Starch, and Phenolic compounds of Morus in the V1 variety, the sap-sucking insect thrips (Pseudodendrothrips mori) reduced the photosynthetic pigments carbohydrate, starch, and phenol in infested over healthy, as determined by the physiological parameters studied in the six varieties. The mean summary column on the right around shows V1 (Victory) having the highest value (23.38), followed by S36 (23.05), Sahana (22.76), laevigata (21.99), indica (21.42), and alba (20.54). Variations such as Morus alba vs laevigata=27.68, etc. The

selected other cultivars were also severely impacted by sap-sucking thrips (Pseudodendrothrips mori) on biochemical pigments like Carbohydrate, Starch, and Phenolic chemicals of Morus. The current study found that the leaf Pseudodendrothrips mori pest has had a considerable impact on the biochemical makeup of mulberry cultivars, leading to changes in growth parameters, nutritional value, and metabolic processes across all six mulberry species. This infestation resulted in lower leaf yield and quantity, lower leaf quality in mulberry varieties, and its impact on silkworm growth and cocoon production quality, all of which contributed to economic losses for sericulture farmers and the silk industry.

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