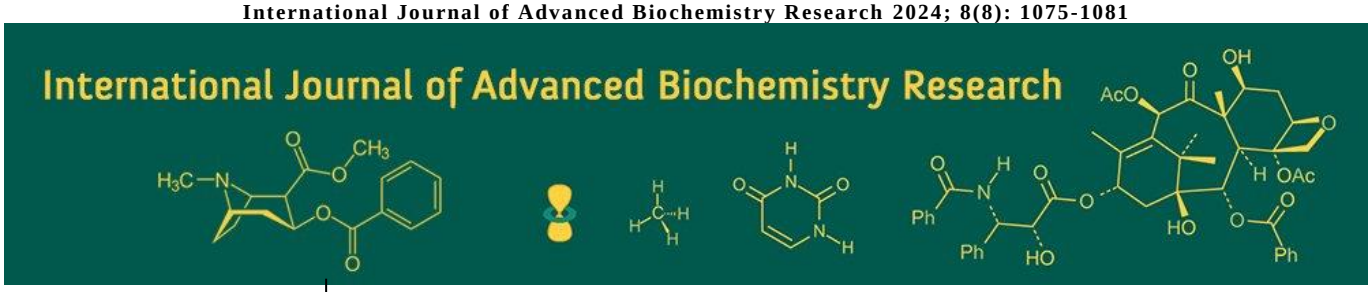

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Omais Bin Ayoub
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Nisar Ahmad Ganie
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Aroos Rauf Rafiqui
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Ovais Ahmad Hajam
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Khursheed Ahmad Dar
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Shakeel Ahmad Mir
Division of Agri-Statistics, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Munazah Yaqoob
Division of Entomology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Corresponding Author:
Omais Bin Ayoub
College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir, India

Impact of *Glyphodes pyloalis* walker infestation on macronutrient and biochemical contents of mulberry (*Morus* spp.)

Omais Bin Ayoub, Nisar Ahmad Ganie, Aroos Rauf Rafiqui, Ovais Ahmad Hajam, Khursheed Ahmad Dar, Shakeel Ahmad Mir and Munazah Yaqoob

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Abstract
The exclusive food source for silkworm (*Bombyx mori* L.) is mulberry leaf and productivity of quality mulberry leaves is crucial for successful sericulture. However, mulberry plants are susceptible to various pests, among which the mulberry pyralid, *Glyphodes pyloalis* Walker (Lepidoptera: Pyralidae) poses a significant threat to mulberry particularly in the temperate region of Jammu & Kashmir, India. The larvae of this pest exhibit voracious feeding behaviour towards mulberry leaf which compromises its nutritional quality and synchronization in the lifecycle of the pest and silkworm rearing ultimately impacts the growth, development and cocoon production of silkworms during the summer and autumn seasons. The present study assessed the impact of *Glyphodes pyloalis* Walker infestation on major nutrients and biochemical compounds of eight mulberry genotypes *viz.*, Goshoerami, KNG, Koksu-21, Koksu-20, Ichinose, Enshutakasuke, Kairiyoroso and Kanva-2. Significant reductions were recorded in nitrogen, phosphorus, potassium, total protein, total carbohydrate and chlorophyll content in infested leaves when compared to healthy leaves. Additionally, a rise in total phenol content was observed in the infested leaves. These results highlight the importance of managing *G. pyloalis* in order to maintain the leaf quality which is essential for the productivity of the sericulture industry.

Keywords: Mulberry, *Glyphodes pyloalis*, infestation, nutrients, productivity

Introduction
The silkworm *Bombyx mori* L. being a highly specialized monophagous insect derives all the nutrients essential for its growth and development from the mulberry leaf (Chauhan and Tayal, 2017) [4]. Therefore, the leaf quality in silkworm rearing decides the prosperity of sericulture as it contributes 38.2 percent to quality cocoon crop (Miyashita, 1986) [22]. Being a perennial crop, mulberry is prone to various pests and diseases which in turn becomes a serious constraint for the production of quality leaf for feeding silkworm. The mulberry pyralid, *Glyphodes pyloalis* Walker (Lepidoptera: Pyralidae) is considered a serious pest of mulberry in India, China, Korea, Japan, Malaysia, Pakistan, Uzbekistan and Burma (Madyarov *et al.*, 2006) [13]. Under Kashmir climatic conditions, *Glyphodes pyloalis* Walker is a major pest of mulberry causing 13.96 percent loss in yield (Ayoub *et al.*, 2023) [2].
The larvae of *Glyphodes pyloalis* exhibit a voracious feeding behaviour on leaves, actively folding them and retaining black faeces, a phenomenon observed to compromise the overall quality of the leaves for silkworm rearing (Khosravi and Jalali Sendi, 2010) [10]. In a related context, the larvae demonstrate a distinct pattern of silk thread formation on the abaxial side of mulberry leaves consuming the mesophyll from beneath these threads leaving a layer of epidermis (Aruga, 1994) [1]. *Glyphodes* through its feeding on leaf mesophyll can lead to a potential shift in the elemental composition thereby impacting the overall quality of the leaves. As per the findings of Narayanaswamy (2003) [24], leaves infested by this pest exhibited a significant reduction in total chlorophyll (Including chlorophyll-a and chlorophyll-b), crude proteins, sugars and inorganic constituents. The decrease in the quality of leaves has a negative effect on silkworm rearing, disrupting the growth and development of silkworms, recognizing the significance of premium feed for silkworms and silk production. The quality of mulberry foliage is greatly determined by the nitrogen, phosphorus and potassium content which is crucial for plant metabolism and growth

(Zhang *et al.*, 2023) [37]. Increased availability of nitrogen, supported by nitrogenous fertilizers, organic manures and beneficial soil microorganisms significantly influence the yield and quality of mulberry leaves (Shankar and Rangaswamy, 1999) [29]. In addition to nitrogen, phosphorus is vital for photosynthesis, protein synthesis and overall plant development while potassium is indispensable for synthesis of sugars, starches, carbohydrates and proteins, and involved in translocation of carbohydrates and protein metabolism in mulberry (Mahadeva, 2016a) [14,]. The collective effects of these nutrients ensure the optimum growth and productivity of mulberry plants.

The importance of mulberry leaf quality for silkworm growth and development and its subsequent influence on cocoon crop has been highlighted by numerous studies (Tazima 1978; Lee and Saho, 1984; Zeya *et al.*, 2003: Hassan and Mir, 2018; Rafiqui *et. al.*, 2023) [32, 12, 36, 7, 5]. Moreover, the synchronization of the life cycles of this insect pest and silkworm poses a potential threat to the second commercial crop. Since the conscious target of moriculture has been quantitative improvement in yield, but for sustained, stable and progressive improvement of sericulture, more attention have to be paid to qualitative increase in leaf productivity as it has a dominant role in the success of cocoon crop. Thus, the present study was aimed at evaluation of macronutrients and biochemical constituents in *Glyphodes* infested leaves of mulberry genotypes as no other research has concentrated on the biochemical evaluation of mulberry leaves in the region of Jammu and Kashmir. Prior researches have only focused on raising silkworms on leaves infested by this pest in order to evaluate its impact on cocoon crop. Through examining this aspect, our research attempts to illuminate the effects of *Glyphodes pyloalis* on the nutritional value of mulberry leaves, a crucial factor for the development of silkworms and the general prosperity of sericulture within Kashmir region.

Materials and Methods

The healthy and *Glyphodes pyloalis* infested leaves of eight mulberry genotypes *viz.*, Enshutakasuke, Goshoerami, Ichinose, Kanva-2, KNG, Koksu-20, Koksu-21 and Kairiyoroso were collected in paper bags from germplasm bank of College of Temperate Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (Jammu and Kashmir, India) during Autumn, 2020. The leaves were washed thoroughly in distilled water and blotted to dry. Later, they were dried in hot air oven at a temperature of 70 °C till constant weight was obtained. The dried leaf materials were ground to fine powder, sieved and subjected to biochemical analysis for recording the following parameters:

Leaf nitrogen (%)

The nitrogen content was determined by Microkjaldal's method as described by Jackson (1973) [9]. 0.5 gm of mulberry leaf sample was taken in a digestion tube to which 4-5 gm of digestion mixture (10 parts of potassium sulphate and 0.5 parts of copper sulphate) was added. Then, 10 ml of sulphuric acid was added to it and digestion unit was allowed to run for 3 hrs. The tube was then left undisturbed overnight and next day tube was fitted in the condensation unit. The contents were collected in a receiving flask which was then titrated against 0.1 N hydrochloric acid and nitrogen content was calculated using the following formula:

$$\text{Nitrogen (\%)} = \frac{\text{(TV-Blank)} \times \text{Normality of acid} \times \text{DF}}{\text{Weight of sample}} \times 100$$

where,
TV= Titration value
DF= Digestion factor

Leaf phosphorus (%)

The phosphorus content was determined by Vandomolybedate phosphoric acid yellow colour method (Jackson, 1973) [9]. 0.5 gm of mulberry leaf sample was taken in a flask and then 10ml of di-acid (Mixture of nitric acid and perchloric acid) in the ratio of 9:4 was added to it. The flask was then kept undisturbed overnight and next day, it was placed on a hot plate at 115-120 °C for digestion till a watery transparent aliquot was obtained. The digested samples were then filtered and diluted with double distilled water to make up final volume to 100 ml, which was then ultimately used for the estimation of phosphorus content in leaf samples.

Leaf potassium (%)

Leaf potassium was determined by Flame photometry method using corning flame photometer, U.K. (Jackson, 1973) [9]. Di-acid digestion of mulberry leaf samples was carried out in the same manner as described for estimation of phosphorus content in leaf. The digest was then used directly for determination of potassium content using flame photometer.

Total protein (%)

The total protein content was determined by Kjeldhal method as described by Ranganna (1997) [26]. The total protein content was determined on the basis of total nitrogen present by multiplying nitrogen content by a factor of 6.25 *i.e.*,

Total protein (%) = Nitrogen (%) × 6.25

Total carbohydrate (%)

Carbohydrate was determined by Anthrone method as per the procedure outlined by Hedge and Hofreiter (1962) [8]. 100mg of the sample was weighed into a boiling tube, hydrolyzed by keeping it in a boiling water bath for 3hrs with 5ml of 2.5 N HCl and cooled to room temperature, it was then neutralized with sodium carbonate until effervescence ceased. Volume was made up to 100ml and centrifuged and supernatant was collected. About 0.2-1ml of the sample was used for analysis. 1ml of water served as blank. Volume was made up to 1ml in all the tubes with distilled water, then 4ml of anthrone reagent was added, heated for 8 min in a boiling water bath, cooled rapidly and the green to dark green color was read at 630 nm. A standard graph was drawn by taking the concentration of glucose on x-axis and spectrometer reading on y-axis. From the graph, the concentration of the glucose in the sample was calculated. Percent carbohydrate was then calculated according to the following equation:

$$\text{Concentration of unknown} = \frac{\text{Absorbance of standard}}{\text{Absorbance of unknown}} \times \text{Concentration of standard}$$

Total phenol (%)

Total phenolic content of the *Glyphodes pyloalis* infested mulberry leaf was determined by modified method reported by Malik and Singh (1980) [21]. Approximately, 500mg of each plant sample was homogenized in ten time volume of 80 percent ethanol and centrifuged at 13000g. Supernatant was collected and the residue again re-extracted with five times the volume of 80 percent ethanol. The supernatants were pooled and evaporated to dryness and finally reconstituted with a known volume of double distilled water. To determine phenol content, 500µl of the reconstituted extract was first combined with 2.5ml of double distilled water and immediately 0.5ml of Folin-Cioucalteau reagent was added. After 3 minutes of incubation period, 20 percent sodium carbonate was added to each sample, vortexed and boiled in a water bath for exactly one minute. The absorbance of each sample was measured at 650 nm against reagent blank. A standard curve was established using catechol as standard and concentration of phenol in sample was determined accordingly.

Total chlorophyll (%)

Total chlorophyll content of the *Glyphodes pyloalis* infested mulberry leaf was determined by Sadasivam and Manickam (1992) [27] method. 1gm of each sample was grinded to a fine pulp in 80 percent acetone followed by centrifugation. The supernatant was transferred to 100ml volumetric flask. The residue was further grinded with 20ml of 80 percent acetone, centrifuged and the supernatant transferred to volumetric flask. The procedure was repeated until the residue became colourless. The volume of pooled supernatant was made up to 100ml with 80 percent acetone. The absorbance of the solution was read at 645 and 663 nm against the solvent (80% acetone) blank.

Calculation

The amount of chlorophyll present in the extract (mg chlorophyll per g tissue) was calculated using the following equations:

$$\text{Percent total chlorophyll} = 20.2\,(A_{645}) + 8.02(A_{663}) \times \frac{V}{10^6 \times W}$$

Where,

A = Absorbance at specific wavelengths

V = Final volume of chlorophyll extract in 80% acetone

W = Fresh weight of the tissue extracted

The change in the biochemical contents of leaf due to pest infestation was calculated by adopting the given formula (Mahadeva, 2011) [17]:

$$\text{Percent increase/decrease} = \frac{\text{Value of healthy leaf - Values of infested leaf}}{\text{Value of healthy leaf}} \times 100$$

Sample collection and processing of mulberry leaves for biochemical analysis

Results and Discussion

Macronutrients (N, P, K) (%)

Among all the eight genotypes studied, the highest nitrogen content of 3.78% was recorded in healthy leaves KNG while as the lowest was recorded in Kanva-2 (2.82%). The nitrogen content in *Glyphodes pyloalis* Walker infested leaves was recorded as highest in KNG (3.62%) and the lowest in Kanva-2 (2.80%). In other genotypes, the nitrogen content was recorded as: Koksu-21 (3.58% and 3.45%), Goshoerami (3.44% and 3.32%), Koksu-20 (3.38% and 3.29%), Ichinose (3.11% and 3.01%), Kairiyoroso (2.98% and 2.94%), Enshutakasuke (2.94% and 2.88%) respectively (Table-1).

Maximum nitrogen content reduction of 4.23% over the healthy leaf was recorded in KNG. The statistical analysis of the data revealed that the nitrogen percentage of both the healthy and infested leaves of Ichinose was statistically different from all other genotypes. The minimum nitrogen reduction percentage of 0.70 was recorded in Kanva-2 (Table-1).

Perusal of data pertaining to phosphorus content in healthy leaves showed significant variations and revealed that the highest phosphorus content of 0.31% was recorded in case of Koksu-21 and lowest in Kairiyoroso (0.14%). The phosphorus content in *Glyphodes pyloalis* Walker infested leaves was recorded to be highest in Koksu-21 (0.27%) and the lowest in Kanva-2 and Kairiyoroso (0.14%). In other genotypes, the phosphorus content in case of healthy and infested leaves was recorded as: Koksu-20 (0.27% and 0.25%), KNG (0.23% and 0.19%), Enshutakasuke (0.22% and 0.21%), Goshoerami (0.20% and 0.18%), Ichinose (0.18% and 0.16%), and Kanva-2 (0.15% and 0.14%) respectively Table-1.

Maximum phosphorus content reduction of 17.39% over the healthy leaf was recorded in KNG and minimum 4.54% in case of Enshutakasuke. Further, no reduction in phosphorus content was recorded in Kairiyoroso (Table-1).

Leaf potassium content in healthy and infested leaves exhibited significant variations. The highest potassium content of 1.50% was recorded in case of KNG while as the lowest was recorded in Kairiyoroso (1.12%). The potassium content in *Glyphodes pyloalis* Walker infested leaves recorded to be highest (1.46%) in KNG and the lowest in Kairiyoroso (1.11%). In other genotypes, the potassium content was recorded as: Koksu-21 (1.48% and 1.45%), Koksu-20 (1.43% and 1.41%), Goshoerami (1.39% and 1.36%), Ichinose (1.16% and 1.14%), and Kanva-2 (1.31% and 1.31%) respectively (Table-1).

Maximum potassium content reduction of 2.66% over the healthy leaf was recorded in KNG and minimum of 0.89% in Kairiyoroso. No reduction was observed in potassium content of Kanva-2 (1.31% and 1.31%) and Enshutakasuke (1.27% and 1.27%) (Table-1).

These findings are well supported by the findings of Etebari and Bizhannia (2006) [5] who reported decrease in nitrogen, phosphorus and potassium contents of leaves by 2.5, 10.8 and 18.7% respectively due to thrip infestation in some mulberry varieties. Similar results have also been reported for various pests of mulberry by Shree and Kumar (2002) [30] and Mahadeva and Nagaveni (2012) [19] and Mahadeva and Shree (2014) [15]. The reduction in the macronutrient content may be attributed to the damage caused by the insect infestation causing numerous wounds which might have quickened the usual transpiration process of leaves leading to loss of nutrients by means of leaching. Similar observations have been made by Venugopalapillai and Krishnaswami (1983) [35] who reported that the damage by pests cause loss of moisture from leaves besides causing appreciable reduction in nutritive value by inducing biochemical changes in leaves.

Table 1: Effect of *Glyphodes pyloalis* Walker infestation on nitrogen, phosphorus and potassium content of different mulberry genotypes

Genotype	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	Healthy	Infested	Reduction (%)	Healthy	Infested	Reduction (%)	Healthy	Infested	Reduction (%)
Goshoerami	3.44	3.32	3.48	0.20	0.18	10.00	1.39	1.36	2.15
Ichinose	3.11	3.01	3.21	0.18	0.16	11.11	1.16	1.14	1.72
Kokso-21	3.58	3.45	3.63	0.31	0.27	12.90	1.48	1.45	2.02
KNG	3.78	3.62	4.23	0.23	0.19	17.39	1.50	1.46	2.66
Enshutakasuke	2.94	2.88	2.04	0.22	0.21	4.54	1.27	1.27	0
Kanva-2	2.82	2.80	0.70	0.15	0.14	6.66	1.31	1.31	0
Kokso-20	3.38	3.29	2.66	0.27	0.25	7.40	1.43	1.41	1.39
Kairiyoroso	2.98	2.94	1.34	0.14	0.14	0	1.12	1.11	0.89
C.D ($p \leq 0.05$)	0.098	0.086		0.04	0.04		0.07	0.06	

Total protein (%)

The total protein content in case of healthy and infested leaves of different mulberry genotypes recorded was: Koksu-21 (22.37% and 21.56%), Goshoerami (21.50% and 20.75%), Koksu-20 (21.13% and 20.56%), Ichinose (19.44% and 18.81%), Kairiyoroso (18.63% and 18.38%), Enshutakasuke (18.37% and 18.00%) and Kanva-2 (17.63% and 17.50%) respectively (Table-2).

The highest total protein content of 23.62% was recorded in case of KNG while as the *Glyphodes pyloalis* Walker infested leaf of the same genotype recorded total protein content of 22.65% thus showing a reduction of 4.23% over the healthy leaf which was maximum among all genotypes. The statistical analysis of the data revealed that the total protein content of both the healthy and infested leaves of KNG was statistically different from all other genotypes. The minimum total protein reduction of 0.73% was recorded in Kanva-2 (Table-2).

The decrease in the total protein content may be attributed to the mechanical damage caused by the insect during infestation which may have altered the physiological activity in the host leading to variation in the synthesis/mobilization of proteins to the damaged tissues in order to resist insect bite. The results fall in line with the findings of Muthuswami *et al.* (2010) [23] who reported reduction in the protein content of thrip-infested mulberry leaves. The prominent decline in nutritional values of mulberry leaves of susceptible genotypes may also be due to heavy population build-up of the *Glyphodes pyloalis* Walker and utilization of nutrients for its multiplication at a faster

rate. At the same time, hydrolysis of proteins by enzymes secreted by the pest at the time of feeding (Sengupta *et al.*, 1999) [28] may have also contributed to the reduction in protein content.

Total carbohydrate (%)

The total carbohydrate content recorded in different genotypes exhibited significant variations and the highest total carbohydrate content of 20.27% was recorded in case of KNG while as the *Glyphodes pyloalis* Walker infested leaf of the same genotype recorded total carbohydrate content of 19.43% resulting in 4.14% reduction over the healthy leaf. However, maximum total carbohydrate reduction of 4.49% over the healthy leaf was recorded in Koksu-21 and minimum (2.07%) in case of Kanva-2 (Table-2).

The total carbohydrate content in case of healthy and infested leaves of other genotypes recorded was: Koksu-21 (19.82% and 18.93%), Goshoerami (19.74% and 18.91%), Koksu-20 (19.12% and 18.33%), Ichinose (17.15% and 16.48%), Enshutakasuke (16.38% and 15.93%), Kairiyoroso (16.04% and 15.67%) and Kanva-2 (15.87% and 15.54%) respectively (Table-2).

The level of chlorophyll content is one of the criteria for quantifying the photosynthetic rate and thus chlorophyll estimates are required to relate other biochemical changes in the plant tissues (Mahadevan and Sridhar, 1982) [20]. In the present study, significant results were obtained for total carbohydrate content of mulberry leaves. The highest total carbohydrate reduction (4.49%) was recorded in Koksu-21 and minimum (2.07%) in Kanva-2. The feeding behaviour of the *Glyphodes pyloalis* Walker results in the reduction of photosynthetic pigments which might have decreased the photosynthetic efficiency resulting in reduction of total carbohydrate level in mulberry leaves. This receives support from the findings of Shree and Kumar (2002) [30], Mahadeva and Nagaveni (2011) [17] and Mahadeva and Shree (2011) [18]. The findings of the present study are also well supported by the findings of Geetha *et al.* (2016) [6] who reported decrease in the carbohydrate content of thrip-infested mulberry leaves.

Total phenols (%)

The total phenols percentage in case of healthy and infested leaves of different mulberry genotypes recorded was: Enshutakasuke (4.09% and 4.12%), Ichinose (3.68% and 3.74%), Kairiyoroso (3.98% and 4.02%), Koksu-20 (3.47% and 3.53%), Goshoerami (3.41% and 3.49%), KNG (3.36% and 3.47%) and Koksu-21 (3.28% and 3.38%) respectively (Table-2).

The highest total phenols content of 4.22% was recorded in case of Kanva-2 while as the *Glyphodes pyloalis* Walker infested leaf of the same genotype recorded total phenols content of 4.25% resulting in 0.71% increase over the healthy leaf. The total phenols content of both the healthy and infested leaves of Kanva-2 was statistically different from all other genotypes. However, maximum total phenol increase of 3.27% over the healthy leaf was recorded in KNG and minimum (0.71%) in Kanva-2 (Table-2).

Umesh *et al.* (1989) [33] reported increased total phenols in the leaves of Vietnam variety due to *Maconellicoccus hirsutus* infestation. Similar results were also noticed by Shree and Mahadeva (2005) [31] in Mysore local and S54 varieties. The accumulation of phenolics in the host may inactivate the enzyme which inhibits the further advance of the pathogenic organism by limiting its source of nutrients (Uritani, 1961) [34].

Total chlorophyll (%)

The total chlorophyll content in case of healthy and infested leaves of different mulberry genotypes recorded was: KNG (0.34% and 0.32%), Goshoerami (0.32% and 0.31%), Koksu-20 (0.31% and 0.30%), Ichinose (0.31% and 0.30%), Enshutakasuke (0.29% and 0.28%) and Kairiyoroso (0.28% and 0.27%) respectively (Table-2).

Among all the mulberry genotypes studied, the highest total chlorophyll content of 0.35% was recorded in case of Koksu-21 while as the *Glyphodes pyloalis* Walker infested leaf of the same genotype recorded total chlorophyll content of 0.32% thus showing a reduction of 8.57 percent over the healthy leaf. The statistical analysis of the data revealed that the total chlorophyll content of the healthy leaves of KNG was statistically different from all other genotypes but that of infested was non-significant. The minimum total chlorophyll reduction of 3.12 percent was recorded in Goshoerami and no reduction was observed in Kanva-2 (0.26% and 0.26%) (Table-2).

These findings are well supported by the findings of Mahadeva (2016b) [14] who reported significant changes in biochemical constituents and photosynthetic pigments in mealy bugs (*Maconellicoccus hirsutus* Green) infested mulberry foliage in six mulberry varieties. Similar results have also been reported by Chandramohan *et al.* (2002) [3], Narayanaswamy (2003) [24] and Shree and Mahadeva (2005) [31]. This alteration in the photosynthetic pigments can be attributed to disruption of host metabolism due to pest damage implicating in loss of chlorophyll synthesis activity.

Table 2: Effect of *Glyphodes pyloalis* Walker infestation on biochemical content of different mulberry genotypes.

Genotype	Total proteins (%)			Total carbohydrate (%)			Total chlorophyll (%)			Total phenols (%)		
	Healthy	Infested	Reduction (%)	Healthy	Infested	Reduction (%)	Healthy	Infested	Reduction (%)	Healthy	Infested	Increase (%)
Goshoerami	21.50	20.75	3.48	19.74	18.91	4.20	0.32	0.31	3.12	3.41	3.49	2.34
Ichinose	19.44	18.81	3.24	17.15	16.48	3.84	0.31	0.30	3.22	3.68	3.74	1.63
Kokso-21	22.37	21.56	3.62	19.82	18.93	4.49	0.35	0.32	8.57	3.28	3.38	3.04
KNG	23.62	22.65	4.23	20.27	19.43	4.14	0.34	0.32	5.88	3.36	3.47	3.27
Enshutakasuke	18.37	18.00	2.01	16.38	15.93	2.74	0.29	0.28	3.44	4.09	4.12	0.73
Kanva-2	17.63	17.50	0.73	15.87	15.54	2.07	0.26	0.26	0	4.22	4.25	0.71
Kokso-20	21.13	20.56	2.69	19.12	18.33	4.13	0.31	0.30	3.22	3.47	3.53	1.72
Kairiyoroso	18.63	18.38	1.34	16.04	15.67	2.30	0.28	0.27	3.57	3.98	4.02	1.00
C.D ($p \leq 0.05$)	0.61	0.54		0.30	0.36		0.02	NS		0.09	0.09	

Conclusion

The findings of this study emphasize the significant impact of *Glyphodes pyloalis* Walker infestation on the nutritional quality of the mulberry leaf across different mulberry genotypes. The results indicate that some genotypes like Kanva-2 show resilience with minimal drop in nutrient content while other genotypes like KNG and Koksu-21 suffer significant declines in leaf nutritional content. This variability in response of mulberry genotypes suggests the need for selective breeding programmes focused on improving pest resistance while maintaining or increasing leaf quality. In conclusion, this study emphasizes the critical importance of managing *Glyphodes pyloalis* Walker infestations in order to ensure the production of superior quality mulberry leaves which directly influences the success of silkworm rearing and cocoon production particularly during summer and autumn rearing. Additionally, continued research into integrated pest management strategies along with the development of more resistant mulberry varieties with better leaf quality, will be essential for sustainable sericulture.

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Competing Interest

The authors declare no conflict of interest in the publication of this manuscript.

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