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MANAGEMENT OF BROAD MITE, *POLYPHAGOTARSONEMUS LATUS* (BANKS) USING BIOLOGICAL CONTROL AGENTS AND THEIR IMPACT ON THE QUANTITATIVE AND QUALITATIVE PARAMETERS OF MULBERRY

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ABSTRACT

The study was conducted during April 2022 to February 2024. The broad mite, *Polyphagotarsonemus latus* occurrence alters the plant growth,leaf yield and quality parameters of mulberry. The study revealed that the damages of broad mite influences greatly on quality and nutritional content of mulberry leaf. Significant differences were observed on plant growth, leaf yield and nutritional content of mulberry leaves. All the growth parameters were highest when the broad mite occurrence was managed by using treatment Pongamia oil @ 3 ml/l *i.e.*, Number of shoots per plant (15.89), number of leaves per shoot (16.61), plant height (183.27cm), number of leaves per plant(168.27), leaf yield per plant (882.07 g). On the other hand the biochemical constituents of the mulberry leaves were also increased in the treatment imposed plots compared untreated control. The treatment Pongamia oil @ 3 ml/l recorded highest amount crude protein (21.46 mg/g), chlorophyll-A (1.535 mg/ml) and total chlorophyll content (1.850 mg/ml) of mulberry leaves. Overall the study revealed that the biological agents including entomopathogenic fungi (*H. thompsonii*(26.46%) & *L. lecanii*(26.12%)) botanicals (Pongamia (32.83)& Neem oil (32.28%)) and predator (*S. punctillum*(21.09%) & *N. indicus* (24.09%)) could be used successfully to manage the broad mite occurrence in mulberry to enhance the leaf yield and quality.

Keywords: Management, Neem, Occurrence, *Polyphagotarsonemus latus*, Pongamia.

INTRODUCTION

Mulberry (Morus spp.) leaf is the sole food plant for the silkworm, Bombyx mori L. it is a deep rooted, perennial and fast growing plant. Yield and quality of mulberry leaf has direct impact on silkworm rearing influencing the cocoon quality and productivity. Throughout the year, mulberry cultivation and silkworm rearing which are the two important farm based activities face challenges from various pests and pathogens. These issues adversely impact cocoon quality and productivity, leading to economic losses for both farmers and the sericulture industry. Among the major insect orders that attack the mulberry crop, the most numerous species are orders Lepidoptera, Hemiptera, Coleoptera, Thysanoptera, Orthoptera and Isoptera.

Additionally, acaridssuch as *Aceria mori* Keifer, *Panonychusulmi* McGr., *Tetramychu-*

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sludeni Zacher, *Tetranychusurticae* Koch and mollusks popularly known as Giant African snail, *Achatinafulica* have also been observed to cause damage (Sengupta *et al*., 1990). The phytophagous mites are devastating many economically important crops worldwide. *Tetranychusurticae* Koch, broad mite, *Polyphagotarsonemus latus* Banks and *Panonychusulmi* Koch(European red mites) are widely known for their extensive damage to many crops. To manage these mites, farmers generally use the pesticides into their crop cultivation. However, chemical control comes with many problems such as insect resistance, detrimental environmental effects and various human health implications. As such biological control is an environmentally friendly alternative that uses bio-control agents such as predators, pathogens and parasitoids to control pests (Daniels Alicia *et al.,* 2023).The broad mite damage has reached alarming levels and is causing significant loss to the mulberry leaf production. As a result, crop losses ranging from 20–70% have been recorded (Prakya Sree ramakumar and Richa Varshney, 2020). Several factors contribute to the severity of the mite menace. These include the availability of mulberry as a preferred host for the mites, changes in climate conditions and elimination of natural enemies due to increase in usage of modern pesticides (Prakya Sree ramakumar and Richa Varshney, 2020). The bioassay results revealed varying resistance ratios of *P. latus* to five acaricides, 26.03 to 81.16-fold for diafenthiuron, 27.35 to 83.47-fold for dicofol, 9.72 to 45.42-fold for fenazaquin, 8.77 to 16.84-fold for propargite, and 48.37 to 163.39-fold for spiromesifen. However, a decline in resistance ranging from 14.11 to 102.53-fold was observed across generations. These findings indicate that applying acaricides at economic threshold levels or adopting a rotational application strategy over one or more seasons can enhance the management of *P. latus* by delaying resistance development. (Neenu *et al*., 2023)

At present, the primary approach for managing mites in mulberry cultivation relies heavily on the use of acaricides namely, Propargite 57% EC, Dicofol 18.5% EC, Fenazaquin 10% EC and Wettable sulphur 80% WP. Broad mite infestation occur during sprouting and leaf harvesting phases of the mulberry cultivation and the use of pesticides especially during harvesting leads to residue problems in the mulberry leaves required for the silkworm rearing. Therefore there is an urgent requirement to develop management strategies using biological control agents, specifically tailored to broad mite management in mulberry ecosystem. The current study aims to promote practical application of biological control agents in managing the broad mite occurring on mulberry. This approach holds great promise for effectively managing broad mite, while considering the socio-economic and environmental well-being of sericulture farmers. Management practices of broad mite, *P. latus* using biological control agents in mulberry cultivation have great impact on plant growth, leaf yield as well as the improvement in biochemical constituents which are the most important factors contributing to quality mulberry leaf, cocoon and silk production.

MATERIAL AND METHODS

Materials used in the study

Mulberry variety: Victory-1(V-1) variety mulberry was used for the field study.This variety was developed and released by Central Silk Board, in the late 1990s. it features erect branches with a greyish stem colour. The leaves are thick, succulent, large entire and ovate with a truncate base, displaying smooth and glossy surface. V-1 mulberry variety is noted for its high rooting ability, rapid growth and substantial yield producing around 60MT/

ha/year under irrigated conditions with recommended practices (Chaitanya and Kishore, 2024).

Predators:

Predator, *Stethoruspunctillum* Weise was collected from mite infested agriculture and horticulture crops at University of Agricultural Sciences, GKVK, Bangalore, Indian Institute of Horticulture Research [IIHR], Bangalore and National Institute of Plant Health Management [NIPHM], Hyderabad and *S. punctillum* was identified through field observation and laboratory studies. The predatory mite, *Neoseiulus indicus* [Narayanan & Kaur] was obtained from the Indian Council of Agricultural Research-National Bureau of Agricultural Insect Resources [ICAR-NBAIR], Bengaluru were used for the study.

Pathogens [Entomopathogenic fungi]:

Entomopathogenic fungi are microorganisms that infect and often kill susceptible insect population through conidia and fungal entomo-pathogens serves as an alternative to insecticides. In the current study, the entomopathogenic fungi, *Leconicilliumlecani* and *Hirsutellathomsonii* were used to know the pathogenesis against broad mite, *P. latus* damaging mulberry. Stock culture of *L. lecanii* obtained from Mulberry Pathology and Microbiology Section of KSSR&DI, Bengaluru and *H. thompsonii*was obtained from NBAIR, Bengaluru and also procured from IPL [International Panaacea Limited] Biologicals Limited, Bengaluru.

Botanicals: Botanicals were found as an effective alternative to conventional pesticides and are environmentally safer with rich source of biologically active compounds. Commercially available Neem oil [Azaneem-10000 ppm] and Pongamia oil [Pure Karanja seed carrier oil] were procured from insecticide retailer shops and used for the study.

Acaricides: Commercially available acaricides or miticides,procured from insecticide retailer shops were used for the field study which includes Propargite[Omite] 57% EC and Fenazaquin [Magister] 10% EC.

Experimental garden and design

The field experimental study was conducted in 15 years old established V-1 mulberry garden maintained with recommended package of practices during 2019-20 to 2021-22. Completely randomised design was followed for experimentation and three replications were maintained for each treatment.

Field evaluation: The field evaluation was conducted for efficacy of predators, *Stethoruspunctillum* and *Neoseiulus indicus*, entomopathogenic fungi, *Lecanicilliumlecanii* and *Hirsutellathompsonii*, botanicals [Neem oil, Pongamia oil] and acaricides [Propargite and Fenazaquin] against broad mite occurrence on mulberry.

Treatment details

T-0: Control ; T-1:*Stethoruspunctillum*@ 200/Plant ; T-2:*Neoseiulus indicus* @ 200/Plant ; T-3:*Lecanicilliumlecanii*(CFU-2x10^8/ml) 3ml/l) ; T-4:*Hirsutellathompsonii*(CFU-2x10^8/ml) 3ml/l) ; T-5: Neem oil @ 3ml/l; T-6: Pongamia oil @ 3ml/l ; T-7: Propargite@ 2ml/l; T-8: Fenazaquin @ 2ml/l

Treatment and observation recorded

Entomopathogenic fungi, botanicals and acaricides were sprayed by using hand sprayers and release of predators was carried out under controlled condition on mulberry after 15 days of pruning and observations were recorded on 60^{th} day after pruning. In each replication five plants were randomly selected and labelled for recording the observations.

Statistical Analysis of the Data

The data from the study has been analyzed using statistical methods to determine the efficacy of biological control agents on managing the broad mite. ONE-WAY Analysis of Variance(ANOVA) was employed using SPSS statistical package (Ver. 21.0) following the methods outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The use of biological agents to manage broad mite, *P. latus* on mulberry significantly enhanced the plant growth, leaf yield and qualitative parameters of the mulberry. The data pertaining to the quantitative and qualitative aspects of mulberry has been presented in Table 1 to 3.

Plant height (cm)

The approaches adopted for the management of broad mite on mulberry, significantly impacted in plant height (F-value=28.747**). The height of the plant was longestin T_6: Pongamiaoil @ 3ml/l(165.83 ±0.255 cm), followed by T_2: *Neoseiulus indicus* @200/ plant (164.94 ± 0.555cm), T_5: Neem oil @ 3ml/l (164.83 ± 0.674 cm),T_8: Fenazaquin @ 2ml/l (164.22 ± 0.642 cm), T_3: *L. lecanii* @ 3ml/l(164.05 ± 0.274 cm), T_1:*Stethoruspunctillum*@200/plant,(162.94 ± 1.583), T_7: Propergite 57%EC @ 2 ml/l (162.78 ± 0.863) andT_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (162.67 ± 1.069 cm)whereas, T_0: Control could register shortest plant height (151.22 ± 0.476cm) (Table 1).

Number of shoots/plant

The number of shoots per plant varied significantly (F-value=16.597**)in adopted practices for the management of broad mite on mulberry. Notably, more number of shoots per plant was observed in T_6: Pongamia oil @ 3ml/l (12.33 ± 0.003shoots/plant) and the other treatments namely T_5: Neem oil @ 3ml/l (12.28± 0.110shoots/plant),T_4: *Hirsutellathompsonii* (CFU- 2x10^8/ml) @ 3ml/l(12.28± 0.053shoots/plant),T_3: *L. lecanii* @ 3ml/l(12.22 ± 0.147),T_8: Fenazaquin@ 2ml/l(12.22 ± 0.053shoots/plant), T_7: Propergite 57%EC @ 2 ml/l (11.89 ± 0.241shoots/plant), T_1-*Stethorus punctillum* @ 200/plant,(11.44 ± 0.391shoots/plant) in T_2: *Neoseiulus indicus* @ 200/plant,(11.39 ± 0.220shoots/plant) found next best with respect to number of shoots per plant. However, less number of shoots per plant was observed in T_0: Control (10.00 ± 0.098shoots/plant).

Number of leaves/plant

Number of leaves per plant is a cumulative effect of number of shoots per plant and number of leaves/shoot. Number of leaves per plant varied significantly (F-value=27.763**) with management practices followed against broad mite occurrence on mulberry. Considerably, more number of leaves per plant (343.75± 0.500leaves/plant) was observed in T_6: Pongamia oil @ 3ml/l. The treatments T_5: Neemoil @ 3ml/l (340.14± 0.220leaves/plant), T_8: Fenazaquin 10% EC @2ml/l(337.15± 2.698leaves/plant), T_3: *Lecanicilliumlecanii*(CFU = 2x10^8/ml)@3ml/l(336.74± 4.315leaves/plant), T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (335.69± 1.361leaves/plant), T_7: Propargite 57% EC @2ml/l(324.80± 5.446leaves/plant), T_2:*Neoseiulus indicus* @ 200/plant(315.93± 5.044leaves/plant) and T_1: *Stethoruspunctillum* @ 200/plant(313.14± 12.27 leaves/plant) stood next in the order with respect to number of leaves per plant. On contrast, T_0: Control could register less number of leaves per plant (253.81 ± 3.175leaves/plant).

Leaf yield (g/plant)

Statistically significant (F-value=26.193**) variations registered due to imposition of biological agents against broad mite on mulberry. Leaf yield per plant was highest with T_6: Pongamia oil @ 3ml/l (973.50± 2.024 g/plant), followed by T_5: Neem oil @ 3ml/l (963.74± 4.394 g/plant), T_8: Fenazaquin 10% EC @2ml/l(954.44 ± 7.748 g/plant), T_3: *Lecanicilliumlecanii*(CFU = 2x10^8/ml)@3ml/l(952.85± 13.22 g/plant), T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (950.91± 4.459 g/plant), T_7: Propargite 57% EC @2ml/l(918.59± 16.00 g/plant), T_2:*Neoseiulus indicus* @ 200/plant(896.48± 15.49 g/plant) and T_1:*Stethorus punctillum* @ 200/plant(889.12± 34.89 g/plant). However, leaf yield per plant was considerably less in T_0: Control (719.74± 9.150 g/plant) (Table 1).

There is relatively no information available on managing the broad mite on mulberry through biological control agents. However, for comparison insights from studies on the management of mite infestations on other crops which are severely affected by broad mite, *P. latus* are utilized for discussion. Islam *et al.* (2019) reveal that the neem seed kernel extracts efficacy in managing the jute yellow mite, suggesting its potential for mulberry cultivation. Sarkar *et al*. (2018) demonstrated the feasibility of integrating cost-effective and safer inputs, such as *L.lecanii* and spiromesifen, for yellow mite management in jute. Adopting this approach in mulberry cultivation could minimize mite infestation with minimal environmental impact. Chemical management in mulberry poses significant challenges due to the sensitivity of silkworms to most pesticides. Broad mite occurrence in mulberry affects the plant growth, leaf yield, and nutritional parameters. This study aims to fill this gap by evaluating the impact of bio-intensive management approaches to manage broad mite occurrence and maintaining mulberry leaf production, considering various quantitative and qualitative parameters.

control Leaf moisture (%)

Leaf moisture content in mulberry differed significantly (F-value=4.725**) among the management approaches when adopted broad miteon mulberry. Highest leaf moisture content was recorded in treatment T_3: *Lecanicilliumlecanii*(CFU- 2x10^8/ml) @ 3ml/l(66.47 ± 0.478%) when compared to other treatments such as T_6: Pongamia oil @ 3ml/l (66.41 ± 0.488 %),T_5: Neem oil @ 3ml/l (66.35 ± 0.992%), T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (65.42 ± 2.115%), T_8: Fenazaquin 10% EC @2ml/l(65.40 ± 0.366%), T_2: *Neoseiulus indicus*@200/plant(65.09 ± 0.289%),T_1:*Stethorus punctillum* @200/plant(65.08 ± 1.574%)and T_7: Propargite 57% EC @2ml/l(64.89 ± 1.140%). Lowest leaf moisture content of mulberry was recorded in T_0: Control (63.41 ± 0.577%)(Table 2).

Mite occurrence in mulberry alters the moisture content of the leaf as mites suck the sap from leaf and becomes unpalatable to silkworms. In the present experiment the leaf moisture content in mulberry varies from 63.41% in untreated control and 66.47% in the treated leaves. The present results are conformity with the findings of Abou-Awad *et al*. (2014) studied the effect of broad mite feeding on apical leaves of sweet pepper (*Capsicum annuum* L.) and reported that increase in the population of mites (from 5.2 to 14.9 /leaf) was accompanied with 56.3% decrease in fresh weight and 49.2% decrease in dry weight of apical leaves.

Carbohydrates (mg/g)

Carbohydrate content in mulberry leaf did not vary statistically (F-value=0.727^{NS}) among the biological control agent management practices when followed for broad mite on mulberry. However, carbohydrate content was marginally more in T_5: Neem oil @ 3ml/l (18.56 ± 0.064mg/g) and the treatments followed next in the order were T_6:Pongamia

Table 1: Impact biological control agents on growth and yield of mulberry

Treatment	Plant height (cm)	Number of Shoots/plant	Number of leaves/plant	Leaf yield (g/plant)
T_0: Control	137.97 ± 3.407	10.11 ± 0.110	136.63 ± 0.441	657.73 ± 9.374
T_1: *Stethoruspunctillum* @200/plant	173.70 ± 5.008 (21.99)	12.33 ± 0.095 (12.39)	153.53 ± 1.105 (12.37)	751.67 ± 20.30 (14.28)
T_2: *Neoseiulus indicus*@200/plant	171.20 ± 2.001 (24.09)	12.11 ± 0.147 (19.78)	151.93 ± 0.470 (11.28)	743.17 ± 23.71 (12.99)
T_3: *Lecanicilliumlecanii*(CFU = 2x10^8/ml)@3ml/l	174.00 ± 2.065 (26.12)	13.95 ± 0.147 (37.95)	156.50 ± 0.929 (14.54)	810.27 ± 37.49 (23.19)
T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l	174.47 ± 5.610 (26.46)	14.00 ± 0.254 (38.48)	154.17 ± 0.273 (12.83)	806.60 ± 49.78 (22.63)
T_5:Neem oil @3ml/l	182.50 ± 20.25 (32.28)	14.83± 0.839 (46.72)	161.43 ± 1.438 (18.15)	875.33 ± 11.03 (33.08)
T_6: Pongamia oil @3ml/l	183.27 ± 2.601 (32.83)	15.89± 0.910 (57.17)	168.27 ± 0.649 (23.15)	882.07 ±17.49 (34.11)
T_7: Propargite 57% EC @2ml/l	173.50 ± 4.519 (25.75)	12.78± 0.147 (26.38)	154.73 ± 0.578 (13.25)	774.50 ± 26.02 (17.75)
T_8: Fenazaquin 10% EC @2ml/l	162.53 ± 4.519 (17.81)	12.44± 0.241 (23.18)	158.57 ± 0.593 (16.05)	795.13 ± 17.55 (20.90)
Mean	170.35± 2.772	13.16 ± 0.338	154.54 ± 1.663	788.56 ± 14.70
F-value	10.315**	15.070**	124.399**	6.697**

oil @ 3ml/l (18.36 ± 0.675 mg/g),T_5: Neem oil @ 3ml/l (66.35 ± 0.992%), T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (18.34 ± 0.376 mg/g), T_3: *Lecanicilliumlecanii*(CFU- 2x10^8/ml) @ 3ml/l(18.22 ± 0.252mg/g), T_7: Propargite 57% EC @2ml/l(17.94 ± 0.311mg/g),T_2: *Neoseiulusindicus*@200/plant(17.92 ± 0.215mg/g),T_1:*Stethorus punctillum* @200/plant(17.86 ± 0.127mg/g)andT_8: Fenazaquin 10% EC @2ml/l(17.85± 0.162mg/g). On the other hand, relatively less carbohydrate content in mulberry leaf was recorded in treatment T_0: Control (17.75± 0.390mg/g)(Table 2). The present results are agreement with the findings of earlier reports of Mohd Yaqoob Dar *et al*. (2011) who reported the carbohydrate content in the mite damaged leaves was 73.1 mg/g dry wt. ranging between 65.8 to 87.5 mg/g dwt. While the mean value of carbohydrate content in healthy leaves were 98.72 and varied between 92.1 to 110.0 mg/g dry weight. The carbohydrate content in mite damaged leaves was reduced compared to healthy mulberry leaves.

Crude protein (mg/g)

Crude protein varied significantly (F-value=4.790**) among the management practices when imposed against broad mite management on mulberry. The mulberry leaves which are harvested from T_6: Pongamia oil @ 3ml/l recorded highest protein content (21.46 ± 0.131mg/g), followed by T_5: Neem oil @ 3ml/l (21.23 ± 0.115mg/g), T_3: *Lecanicilliumlecanii* (CFU- 2x10^8/ml) @ 3ml/l(20.68 ± 0.100mg/g),T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l (20.64 ± 0.313 mg/g),T_2: *Neoseiulus indicus* @200/plant (20.39 ± 0.343mg/g), T_1: *Stethoruspunctillum* Weise @200/plant (20.38 ± 0.123mg/g),T_8: Fenazaquin 10% EC @2ml/l (20.15 ± 0.101mg/g)and T_7: Propargite 57% EC @2ml/l (17.94 ± 0.311mg/g). Notably, lowest crude protein content (19.88 ± 0.363mg/g) was found in T_0: Control (Table 2). The present results are agreement with the findings of earlier reports. Mohd Yaqoob Dar *et al*. (2011) recorded the protein content of the mite damaged leaves was 23.72 mg/gram dry weight compared to 36.50 in the healthy leaves. It ranged from 20.1 to 27.5 and 32.4 to 40.0 in the damaged and healthy leaves respectively.

Chlorophyll ‘a’ (mg/g)

Chlorophyll‘a’ content in mulberry leaf differed significantly (F-value=5.474**) among the management practices adopted against broad mite on mulberry. Higher chlorophyll ‘a’ content in mulberry leaf(1.535± 0.039mg/g) was recorded in T_6: Pongamia oil @ 3ml/l, followed by T_5:Neem oil @ 3ml/l (1.532 ± 0.022mg/g), T_4: *Hirsutellathompsonii*(CFU-2x10^8/ml) *3ml/l* (1.520± 0.079mg/g), T_7: Propargite 57% EC @2ml/l (1.512 ± 0.021mg/g), T_3: *Lecanicilliumlecanii* (CFU- 2x10^8/ml) @ 3ml/l(1.500± 0.024mg/g),T_8: Fenazaquin 10% EC @2ml/l (1.495 ± 0.030mg/g), T_1:*Stethorus punctillum*@200/plant (1.488 ± 0.028mg/g)and T_2: *Neoseiulus indicus* @200/plant (1.480 ± 0.026mg/g). Whereas, lowest chlorophyll‘a’ content (1.397mg/g± 0.047mg/g) was recorded in T_0: Control (Table 3).

Chlorophyll ‘b’ (mg/g)

Chlorophyll ‘b’ content in mulberry leaf did not vary significantly(F-value=1.284^{NS}) when biological control agents management practices imposed on broad mite in mulberry.However, relatively highest chlorophyll ‘b’ content in mulberry leaf (0.250 ± 0..35 mg/g) was recorded in treatment T_8: Fenazaquin 10 % EC @ **2ml/l,over** other treatments namely T_6:Pongamia oil @ 3ml/l (0.247 ± 0.033 mg/g), T_5:Neem oil @ 3ml/l (0.247 ± 0.027 mg/g), T_3: *Lecanicilliumlecanii* (CFU- 2x10^8/ml) @ 3ml/l (0.243± 0.034 mg/ml),T_4: *Hirsutellathompsonii* (CFU- 2x10^8/ml) *3ml/l* (0.241 ± 0.032mg/g),T_2: *Neoseiulus indicus* @200/plant (1.480 ± 0.026mg/g), T_7:

Table 2: Impact of biological control agents on biochemical composition of mulberry

Treatment	Leaf moisture (%)	Carbohyd-rates (mg/g)	Crude protein (mg/g)
T_0: Control	63.41 ± 0.577	17.75 ± 0.390	19.88 ± 0.363
T_1: *Stethoruspunctillum* Weise @200/plant	65.08 ± 1.574 (2.644)	17.86 ±0.127 (0.620)	20.38 ±0.123 (2.532)
T_2: *Neoseiulus indicus* @ 200/plant	65.09 ± 0.289 (2.649)	17.92 ± 0.215 (0.977)	20.39 ± 0.343 (2.582)
T_3: *Lecanicilliumlecanii*(CFU = 2x10^8/ml)@ 3ml/l	66.47 ± 0.478 (4.826)	18.22 ± 0.252 (2.648)	20.68 ± 0.100 (4.007)
T_4: *Hirsutellathompsonii*(CFU = 2x10^8/ml) @3ml/l	65.42 ± 2.115 (3.180)	18.34 ± 0.376 (3.324)	20.64 ± 0.313 (3.823)
T_5:Neem oil @3ml/l	66.35 ± 0.992 (4.642)	18.56 ± 0.064 (4.563)	21.23 ± 0.115 (6.791)
T_6: Pongamia oil @3ml/l	66.41 ± 0.488 (4.736)	18.36 ± 0.675 (3.437)	21.46 ± 0.131 (7.964)
T_7: Propargite 57% EC @2ml/l	64.89 ± 1.140 (2.339)	17.94 ± 0.311 (1.070)	20.14 ± 0.302 (1.325)
T_8: Fenazaquin 10% EC @2ml/l	65.40 ± 0.366 (3.149)	17.85 ± 0.162 (0.582)	20.15 ± 0.101 (1.375)
Mean	66.05±0.521	18.09±0.106	20.55±0.116
F-value	4.725**	0.727**	4.790**

CFU: Colony forming unit   ***pd"0.01*   (   ): Per cent change over control

Propargite 57% EC @2ml/l (0.240 ± 0.073mg/g) and T_1:*Stethorus punctillum* @200/plant (0.232 ± 0.039mg/g). On the other hand, T_0: Control recorded lowest chlorophyll 'b'content of 0.206 ± 0.035mg/g (Table 3).

Total Chlorophyll (mg/g)

The total chlorophyll content in mulberry leaf differed significantly (F-value=9.444**) among the management practices when adopted against broad mite on mulberry. Considerably, highest total chlorophyll content (1.850 ± 0.031 mg/g) was recorded in T_6:Pongamia oil @ 3ml/l and the treatmentsT_5:Neem oil @ 3ml/l (1.848± 0.011 mg/g), T_4:*Hirsutella thompsonii*(CFU- 2x10^8/ml) *3ml/l* (1.837 ± 0.051mg/g),T_1:*Stethorus punctillum* @200/plant(1.794 ± 0.012mg/g), T_2:*Neoseiulus indicus*@200/plant(1.786 ± 0.013mg/g),T_3:*Lecanicillium lecanii*(CFU-2x10^8/ml/l) @ 3ml/l (1.821 ± 0.015 mg/g),T_8: Fenazaquin 10 % EC @ 2ml/l(1.780 ± 0.013 mg/g) andT_7: Propargite 57% EC @2ml/l(1.750± 0.052mg/g) stood next in the rank with respect to total chlorophyll content. However, lowest total chlorophyll content (1.603± 0.028mg/g) was recorded in T_0: Control (Table 3). In the present experiment total chlorophyll content is the addition of Chlorophyll A and Chlorophyll B. This chlorophyll content in mite

Table 3: Impact of biological control agents on chlorophyll content of mulberry

Treatment	Leaf moisture (%)	Carbohyd-rates (mg/g)	Crude protein (mg/g)
T_0: Control	1.397 ± 0.047	0.206 ± 0.035	1.603 ± 0.028
T_1: *Stethoruspunctillum* Weise @200/plant	1.488 ± 0.028 (6.500)	0.232 ± 0.039 (12.39)	1.794 ±0.012 (11.96)
T_2: *Neoseiulus indicus*@ 200/plant	1.480 ± 0.026 (5.905)	0.241 ± 0.026 (16.92)	1.786 ± 0.013 (13.09)
T_3:*Lecanicilliumlecanii* (CFU=2x10^8/ml)@ 3ml/l	1.500 ± 0.024 (7.333)	0.243 ± 0.034 (17.83)	1.821 ± 0.015 (15.59)
T_4:*Hirsutellathompsonii*(CFU= 2x10^8/ml) @3ml/l	1.520 ± 0.079 (8.762)	0.241 ± 0.032 (16.87)	1.837 ± 0.051 (16.74)
T_5:Neem oil @3ml/l	1.532 ± 0.022 (9.648)	0.247 ± 0.027 (19.68)	1.848 ± 0.011 (17.51)
T_6: Pongamia oil @3ml/l	1.535 ± 0.039 (9.798)	0.247 ± 0.033 (19.78)	1.850 ± 0.031 (17.62)
T_7: Propargite 57% EC2ml/l	1.512 ± 0.021 (8.190)	0.240 ± 0.073 (16.39)	1.750 ± 0.052 (10.50)
T_8: Fenazaquin 10% EC@2ml/l	1.495 ± 0.0.030 (6.998)	0.250 ± 0.035 (21.11)	1.780 ± 0.013 (12.64)
Mean	1.514±0.020	0.239±0.106	1.796±0.019
F-value	5.474*	1.284	9.444**

CFU: Colony forming unit ****pd”0.01**(): Per cent change over control

infested plants altered significantly (pd”0.01; F-value=9.444**) among the different management practices followed to manage the broad mite incidence in mulberry. In contrast, Malakah and Elsadany, (2018) also studied the influence of host plants and some leaf contents on biological aspects of *Tetranychusurticae* Koch and reported that the total chlorophyll content in mulberry is reduced on the other hand the chlorophyll content in castor leaves has been increased when the mites were infested to these host plants.

CONCLUSIONS

The present study revealed that the use of biological control agents and plant-derived oils significantly enhanced the growth and leaf yield of mulberry while effectively managing the broad mite, *Polyphagotarsonemus latus*. The application of *Pongamia oil* at 3 ml/l (T6) yielded the best results, with the highest plant height (165.83 cm), number of shoots (12.33), leaves per plant (343.75), and leaf yield (973.50 g/ plant), followed closely by *Neem oil* and other treatments like *Lecanicilliumlecanii* and *Hirsutellathompsonii*. Notably, the leaf moisture content, crude protein, and total chlorophyll levels were significantly higher in treatments with biological agents, particularly *Lecanicilliumlecanii* and *Pongamia oil*. The control treatment (T0) showed the lowest values across all parameters, indicating the negative impact of broad mite infestation. These approaches not only mitigate the impact of the pest but also improve the overall quality and yield of mulberry leaves, contributing to more sustainable agricultural practices in sericulture.

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