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Sustainable Management of *Aphis craccivora* Infesting Som Plant (*Machilus bombycina*) for Quality Muga Silk Production

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ABSTRACT

Som plant (*Machilus bombycina* King) is an important plant in agroforestry system in the warm and humid climate of north-eastern India. It is extensively cultivated to support the sericulture industry, particularly for the rearing of the muga silkworm, which produces the highly valued muga silk. The Leaves of the som plants are the primary food source of muga silk worm, and the timber of the plant is also valuable. Som plant is being attacked by number of insect pests which actually hampers the successful silkworm rearing. Among these pests Aphid (*Aphis craccivora*) is a major one causing heavy damage to the tender leaves resulting in production of poor quality leaves which affects the silkworm health. Higher infestation of *A. craccivora* are generally seen during January–February, followed by a decline, with another peak during the second week of September to the first week of October. Highest average population (24.98 aphids/leaf) was recorded during last week of September (39th standard week). Aphid incidence showed positive correlation (p= 0.05) with temperature and relative humidity indicating increased activity of this pest under worm and humid condition. Population had a significant negative correlation (p= 0.01) with the average total rainfall which indicated that population declined during the period of heavy rainfall. Studies were made to evaluate efficacy of extracts from plants such as *Pongamia pinnata* L., *Nicotiana tabacum* L., *Polygonum hydropiper* L., *Spilanthes paniculata* Wall. and *Allium sativum* L as well as botanical insecticide such as azadirachtin against aphids infesting som leaves. Methanol and water were used as solvent for extraction. Imidacloprid 17.8 SL (Confidor) was used as check. Imidacloprid was the most effective treatment providing more than 80% aphid suppression followed by azadirachtin. *Polygonum* extract was very effective against the aphid (>60% suppression). As som plant leaves are the major food component of muga silk worm rearing, toxic synthetic insecticide should not be used. Silk worm may be prone to diseases by the use of microbial pesticides. Plant extracts (bio-pesticides) having less or no hazardous effects on muga silk worm and environment can be incorporated in pest management of som plant.

Keywords : Incidence, *Aphis craccivora*, Abiotic factors, Bio-pesticides, Organic cultivation

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Introduction

Muga Silk Worm (*Antheraea assamensis* Helfer) is a sericigenous insect belonging to the family saturniidae under the order lepidoptera. Its cultivation is restricted to the north-eastern India mainly in the Brahmaputra valley of Assam and adjoining foothills and is the sole producer of the globally renowned muga silk. The northern districts of West Bengal particularly Coochbehar and Jalpaiguri district have immense potential of muga silkworm cultivation for eco-climatological similarity with lower Assam. Cultivation of the muga silkworm gives substantial economic returns to farmers and plays an important role in rural livelihood improvement by providing a regular income throughout the year (Lakshmannan *et al.*, 1998). However, the pace of development of Muga culture in West Bengal is comparatively slow due to lack of technology transfer and limited research support. The worms are raised on soalu (*Litsaea polyantha)* and som (*Machilus bombycina).* Som plant *(Machilus bombycina* King) is an important medium sized tree cultivated by the farmers on small scale for rearing of muga silk worm (*Antheraea assamensis* West wood). It is polyvoltine in nature having five to six generations in a year and seasonal variations significantly influence its commercial characteristics. Females of *A. assamensis* that had been reared on soalu produced significantly higher pupal weight and higher oviposition rates compare to those reared on som and other host plants. The number of eggs laid was significantly positively correlated with pupal weight which was the better estimator for fecundity (Barah *et al.*, 1991). Nutritional value of host plants plays an important role in the larval growth and silk productivity. Krishnaswami (1978) observed that mulberry leaves containing water, protein, total sugars, soluble carbohydrates, along with lower minerals and crude fiber content is the best relished and utilized by silkworm larvae. In addition to its importance in sericulture som plant also has some timber value.

Though som plant (*Machilus bombycina* King) is not cultivated in West Bengal, but the northern parts of West Bengal particularly Cooch Behar and Jalpaiguri district have immense potentiality of its cultivation for eco-climatological similarity with lower Assam. This agro-climatic situation stimulates muga culture in Cooch Behar district of West Bengal (Debnath, 1995). However, som cultivation faces lot of problems due to attack of insect-pests. chemical pesticide should not be used for pest control due to their toxic effects on silkworm and microbial pesticide is not recommended as these may induce disease susceptibility in silkworm population. Thus botanical pesticide is advisable for pest management in silkworm production.

With a view to improvement of quality leaf production and silk production it is essential to apply safe pesticide particularly plant product / phytopesticide for safe management of insect pests of host plant (Som, *Machilus bombycina* King). Extensive and indiscriminate use of synthetic insecticides on silkworm host plants has led to pest resurgence and resistance development in both mulberry and non-mulberry systems. Development of resistance to synthetic insecticides against major pests viz. Tussock moth, gall midges, leaf roller and stem borer has forced the entomologist to switch over to plant originated insecticides in sericulture. More

commonly used plants in pest control, are Neem, Pongamia, Indian privet, Adathoda, Chrysanthemum, Turmeric, Onion, Garlic, Tobacco, Ocimum, Custard apple, Zinger and some other plants (Singh and Sarat Chandra, 2002).

Table 1. Insect pest complex of som plant (*Machilus bombycina* King)

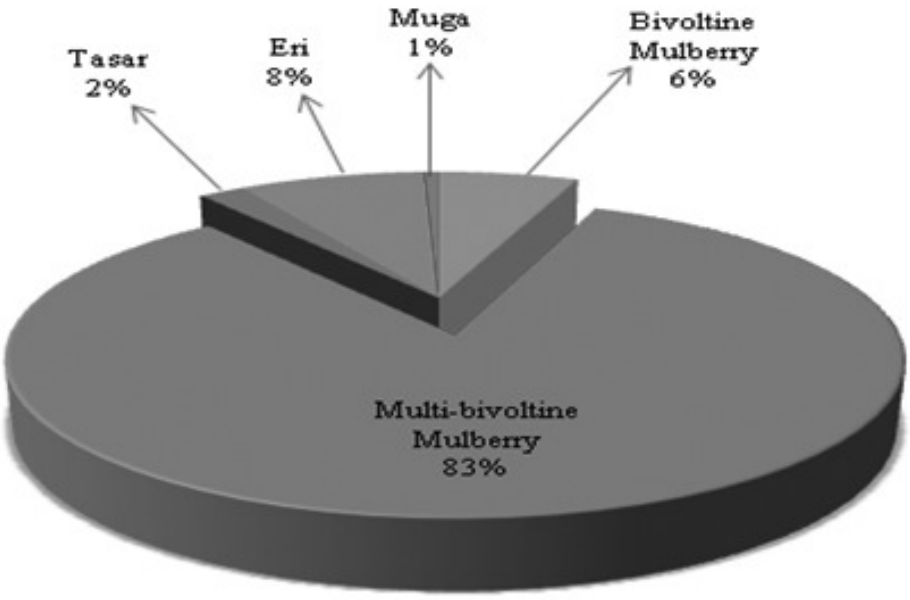
Sl. No.	Common name	Scientific name	Systematic position	Plant parts infested	Pest status
01	Aphid	*Aphis craccivora*	Hemiptera: Aphididae	Tender leaves	Regular, Heavy
02	Thrips	*Thrips tabaci*	Thysanoptera: Thripidae	Tender leaves	Regular, Heavy
03	White scale	*Ceroplastes destructor*	Hemiptera: Coccidae	Tender leaves	Regular, Heavy
04	Mite	*Tetranychus sp.*	Acarina: Tetranychidae	Tender leaves	Regular, Heavy
05	Leaf miner	*Phytomyza sp.*	Diptera: Agromyzidae	Tender leaves	Regular, Heavy
06	Flea beetle	*Phyllotreta sp.*	Coleoptera: Chrysomellidae	Tender leaves	Regular, Moderate
07	Stem borer	*Indarbela tetraonis*	Lepidoptera: Arbelidae	Stem	Regular, Heavy
08	Hairy caterpillar	*Euproctis lunata*	Lepidoptera: Lymanteriidae	Tender leaves	Occasional, Mild
09	Semilooper	*Plusia sp.*	Lepidoptera: Plutellidae	Tender leaves	Occasional, Mild
10	Gall insect	*Aspondylia sp.*	Diptera: Cecidomyidae	Tender leaves	Occasional, Mild
11	Jassid	*Empoasca binotata*	Hemiptera: Jassidae	Tender leaves	Occasional, Mild
12	Mealy bug	*Maconellicoccus hirsutus*	Hemiptera: Coccidae	Tender leaves	Occasional, Mild

Muga Silk Industry

Sericulture, the technique of silk production, is an agro-industry, playing an eminent role in the rural economy of India. The worms (*Antheraea assamensis* West wood) are raised on soalu (*Litsaea polyantha)* and som (*Machilus bombycina)*. Benchamin and Giridhar (2005) reported that India is the second largest producer of both the mulberry and tasar varieties of

silk in the world with a share of 18% and 10% respectively of the total silk production, while the golden yellow muga silk is produced only in India. Muga silk production solely depends on proper growth and development of larva which in turn depends on the leaf quality of the host plant. Silk production in Cooch Behar is low as compared to Assam mainly due to low nutritional status in the leaves of the som plant. To produce good quality leaves of host (som) plant bio fertilizers and organic manures may play an important role as these inputs are eco-friendly and useful as well to maintain good soil health for longer period of time. The muga-based ecological farming system is a concept and approach for transforming the idea of conservation of biological resource and environmental protection to optimize integrated economic, ecological and social benefits to ensure sustainable rural development.

The species of silkworm is considered semi-domesticated as the worms crawl down of the host plant at the end of their larval period and are collected by the rearers. They are allowed to spin cocoons in the rearer's houses. The worms are raised on soalu (*Litsaea polyantha)* and som (*Machilus bombycina)*. A single female moth of muga lays 150-200 eggs after copulating with the male for 6-8 hrs. Usually, the female is tied to a 'kharika' for laying eggs. The larvae are reared, outdoors on trees of som or soalu. They have the habit of crawling down the trees in groups when no leaves are left. During this time, the rearer transfers the worms to another tree. At the end of the larval period, when the worms are ready to spin the cocoons, they crawl down the tree in search of a suitable place for the construction of cocoons. Such worms are collected by the rearer and are allowed to spin the cocoons in 'jali', made of dried twigs.



Silk production in India (Source: www.nistads.res.in)

Pest Status of Aphid on Som Plant

Som plant (*Machilus bombycina*) cultivation faces lots of challenges due to infestation of insect-pests. Due to attack of the pests, it becomes difficult for the farmers to conduct rearing (Singh *et al.*, 2000; Mandal and Ghosh, 2020). *Aphis craccivora* Koch (Hemiptera: Aphididae) has emerged as a serious pest which badly affects muga culture in different ways – they suck the cell sap from newly emerged central twigs and arrest the growth of the plant, secret honeydew which leads to the development of black 'Sooty Mould' on the tender leaves resulting in reduced photosynthetic area which ultimately hampering the general physiology of the plant (Mathur and Upadhyay, 2002) and the larvae of silkworm also avoid this type of leaves. The pest multiplies most rapidly in late spring and with the increase in temperature, its population increases (Singh *et al.*, 2000). Severe aphid infestation causes stunting, crinkling and curling of leaves, resulting in low quality leaves.

Incidence of Aphid

Ghosh *et al.* (2016) reported that low level of population (0.03 to 3.39/leaf) was recorded on 24th standard week to 27th standard week that is during 3rd week of June to 1st week of July when average temperature, relative humidity and weekly rainfall ranged from 28.88^0 C-30.00^0 C, 78.60%-89.71% and 77.60 mm-201.95 mm respectively. During the rainy season pest population is low due to heavy rains. At this period no control measure against aphid should be adopted. Higher level of population (17.45 to 24.98/leaf) was maintained on 36th standard week to 40th standard week that is during 2nd week September to 1st week of October when average temperature, relative humidity and weekly rainfall ranged from 28.30^0 C-30.48^0 C, 77.02%-88.85% and 6.20 mm-194.60 mm respectively. In 39th standard week that is last week of September, highest population (24.98/leaf) was recorded when average temperature, relative humidity and weekly rainfall were 29.57^0 C, 83.85% and 41.90 mm respectively. They also reported that the aphid population had significantly positive correlation with temperature, relative humidity and weekly rainfall. Result also revealed that the aphid population had significantly negative correlation with temperature difference. It indicates that aphid population in terai region increases with the rise of temperature, humidity and rainfall and decrease when difference between maximum and minimum temperature is higher. The pest caused more damage under worm humid condition and thus this pest can be designated as the pest of monsoon crop.

Harmful Effect of Chemical Insecticides

Since the discovery of DDT as an insecticide in 1939 by Dr. Paul Muller, there has been a great expansion in the use of chemicals for the pest control. During manufacturing, transportation, storage and application pesticides enter in the abiotic and biotic components of the environment through air, water and soil and disturb the ecosystem, causing sometimes a great disaster. Miss Rachel Carson published an epoch-making book "Silent Spring" in the year 1962 awakened the people referring the forceful account of the danger of indiscriminate use of

pesticides. These days the pollution of the environment is a problem of great importance and is of everybody's concern. The pesticides may accumulate in the environment and contaminate all the systems i.e. air, water, soil, plants animals etc. by being transported from one system to another. Although they are protecting the crops from pests for boosting up the agricultural produce but bring out ecological disturbance and environmental pollution. It is found that the pesticides disrupt the microbial activity of the soil, adversely affect the earth worm population in the soil and may also harm the predatory mites and carabid beetles. They may have adverse effect on some invertebrates that were responsible soil fertility. The uptake of insecticide residues by some crops adversely affects our health. Water has been found contaminated with pesticides by different ways. Many great rivers of the world have been found to contain large amount of insecticide residues which killed the fishes and other aquatic animals living there (Srivastava and Saxena, 1989).

Management of Aphid by Using Bio-Pesticides (Phyto-Chemicals)

Farmers become increasingly dependent on chemical pesticides to which pests have developed resistance (Osteen and Szmedra, 1989). *A. craccivora* is known to develop resistance to several pesticides (Mokbel and Mohamed 2009). Most of the conventional chemicals viz. organochlorines and organophosphates are broad spectrum, persistent in nature and having long residual action (Subba *et al.*, 2017). The indiscriminate use of these pesticides has lead to the problems of pesticide resistance, resurgence and contamination of different components of the environment (Dhaliwal and Kour, 2010). Consequently, there is an urgent need to identify alternative insect control strategies involving application of insecticides at appropriate doses and time of application that can address the problem of resistance, are less persistent, are having minimal residual effects, and are non-toxic to non-target organisms (Ghosh, 2020). Plant extracts act through different mechanisms viz. insect growth regulators (IGR), feeding detterence, repellency and behavioral disruption (Schmutterer, 1990). Neem seed oil, either alone or in combination with biopesticides are useful for controlling aphid (El-Hawary and Abd El-Salam, 2008). Azadirachtin is considered an excellent botanical pesticide because of its biodegradability, demonstrated low toxicity to vertebrates, environmental safety, and safety to non-target organisms (Jacobson, 1989). The botanical insecticide azadirachtin was found effective against aphid, achieving 59.23% suppression at three days after spraying (Ghosh *et al.,* 2004). Generally, the nicotine contain of the tobacco plant (*Nicotiana tabacum* L.) varies from 5-10 % in the leaves (Thacker, 2002) and nicotine is effective against a wide range of pests. Use of synthetic pesticides along with tobacco-based product was more economically beneficial than using synthetics alone (Opolot *et al.,* 2006). Ghosh (2015) reported that *Polygonum hydropiper* flower extract at 5 % concentration and tobacco leaf extract at 10 % concentration gave more than 70 % and 65 % aphid suppression respectively. *In-vivo* studies in brinjal also indicated the maximum reduction of aphids (67.3–72.3%) within 5–14 days after application of *Annona squamosa* 40 EC formulation at 1.0% dose

followed by *Pongamia pinnata* 40 EC (Purkait *et al.,* 2019). Imidacloprid 30.5 SC @ 160ml/ha and Spinosad 45 SC @100ml/ha gave significant population reduction of aphid over control, providing 88.73% and 63.04% control respectively (Thakoor *et al.,* 2019). Acetamiprid was found highly efficacious against aphid and found to suppress 85.11% aphids closely followed by *neem* + *Spilanthes* (73.29% control) (Ghosh, 2017). Immidacloprid, was the most effective in providing more than 80% aphid suppression on som plant followed by azadirachtin (>70% suppression) and *Polygonum* extract (>60% suppression) (Ghosh *et al.,* 2016).

Ghosh and Chakraborty (2012) reported that pest control by using bio-control agent is an important component of Integrated Pest Management (IPM) and organic farming. The ladybird beetles (*Menochilus sexmaculatus, Brumus suturalis, Harmonia dimidiate, Coccinella septempunctata*) and green lacewing bug (*Chrysoperla carnea*) are efficient predators of aphids (Muniappan *et al.,* 2012).

Extracts of *Polygonum* plant gave better aphids control, recording more than 60% suppression (Ghosh *et al.*, 2009) in lady's finger field. Polygonum floral parts are extracted in methanol following the standard methodology developed by Mandal *et al.,* 2016 and Mandal and Ghosh, 2020. Imidacloprid and other chemical pesticides are highly toxic synthetic insecticide, so there is every possibility to contaminate som plant leaf with the toxic chemicals, as som leaf is the major food component of muga silk worm rearing. Mixed formulation of bio-pesticides like Azadirachtin+tobacco and Azadiractin+ polygonum or mixed formulation of small amount imidacloprid with polygonum provided higher aphid control at par with the imidacloprid in its recommended doses. So, we can avoid the use of highly toxic insecticides like imidacloprid and other chemical insecticides. Das *et al.* (2010) and Ghosh *et al.* (2012, 2013) reported rapid degradation of residues in imidacloprid and neem oil compared to other pesticides. Plant based insecticides or plant extract cannot give higher control when it is used individually but when it is mixed with other formulations it provides higher control. Plant-based insecticides could be mixed with very small dose of chemical insecticides like imidacloprid with azadiractin/polygonam/tobacco extracts which will be eco-friendly. Plant extracts and neem (azadiractin) insecticide are of biological origin having low or no hazardous effect on health and environment and so can be incorporated in Integrated Pest Management (IPM) programme against aphids on som plant.

Problem of Pest Control and Right Path of Control Strategy

The quality of som leaves is significantly degraded due to infestation by various insect pests. Fresh and healthy leaves are essential for proper growth and development of muga silk worm. Synthetic organic chemicals should not be used for pest management programme as because they may adversely affect the development of muga silk worm. Microbial pesticides are not suitable for insect-pest control to som plant as because muga silk worm may prone to attack of different diseases. Pest control by using botanical extracts is the right path to formulate an environmentally sound, toxic free pest management programme. A wide range of botanical products remains available for

inclusion in future pest management strategies. Due to rapid advancement of science and technology with constant changing dynamic nature of agriculture, pest management strategy should be adopted in changing form from time to time.

Adoption of Integrated Pest Management programmes is essential to minimize indiscriminate pesticide use and to ensure sustainable muga silk production.

Conclusion

Muga silk production largely depends on proper growth and development of silkworm larva and the larval development mainly depends on the leaf quality of som plant. Silk production in Cooch Behar is low as compared to Assam due to low nutritional status in the leaves of the som plant. Improvement in leaf quality through the application of biofertilizers and organic manures can play a crucial role, while simultaneously maintaining long-term soil health in an eco-friendly manner.

Several vegetable crops may be taken under consideration as intercrop for extra earning for the farmers. Hence high value crop like medicinal and aromatic plant etc. may be intercropped to boost up the economy of the farmers and to minimize the risk of cultivation. Nitrogen requirement of som plant is generally high and proper dose of nitrogenous increase the leaf quality of som plant. In view of this, legume crops with special reference to pulse legume may be intercropped to add nitrogenous nutrients to the soil as well as extra earning for the farmers.

Quality of leaf of som plant is degraded due to attack of different insect-pest. Fresh and healthy leaves are required for proper development of muga silk worm. Synthetic organic chemicals should not be used for pest management programme as because they may adversely affect the development of muga silk worm. Pest control by using botanical extracts is the right path to formulate an environmentally sound, toxic free pest management programme. A number of botanicals may be taken for consideration for pest management programme. Incorporation of botanical insecticides into Integrated Pest Management programmes offers a viable pathway to reduce reliance on chemical pesticides, protect silkworm health, and ensure sustainable muga silk production.

Aphid (*Aphis craccivora*) incidence on som plant (*Machilus bombycina*)




Muga silk worm Larva rearing on Som plant and formation of cocoon

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