ISSN: 2582-6980

AUGUST 2021

AGRI MIRROR FUTURE INDIA

AIASA Agriculture Magazine

A Voice for Agriculture

Volume 02 | Issue 08

aiasanewdelhi aiasa5 AIASA https://aiasa.org.in/?page_id=2851

A Voice for Agriculture

AGRI MIRROR : FUTURE INDIA

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GLOBAL SILK PRODUCTION – GENESIS AND HISTORY

R. Aruna*[1], K.A. Murugesh[1] and S. Ranjithkumar[1]
[1]Department of Sericulture, Forest College and Research Institute, TNAU, Mettupalayam – 641 301.
* Corresponding author: arunaramaiah07@gmail.com

Silk is the most elegant textile in the world with unparalleled grandeur, natural sheen and inherent affinity for dyes, high absorbance, light weight, soft touch and high in durability. Due to the presence of many unique features, silk is often referred as the 'Queen of Textiles" in the world. No other fibre is comparable with the silk in the case of its quality, softness, royal look, etc.

Genesis of silk production

Silk was discovered in China by the Empress, Xi- Ling, the wife of Emepror Huang-Di and later spread to other parts of the world. The first authentic reference to silk is found in the Chronicles of the Chou- King of China (2,200 BC). The king is reported to have pointed out to the Empress Xi-Ling the worms destroying the mulberry trees in his garden. One day as she sat under her favorite mulberry tree in the garden sipping tea and admiring the beautiful spring flowers, cocoons fell into a bowl of hot tea. While trying to recover the cocoon from the hot liquid with a spoon, she discovered that a very fine and very long lustrous thread unwound itself from the cocoon. She discovered silk and the process of obtaining it from the cocoons. The silk industry came into being.

The discovery of silk was celebrated with great feasting and rejoicing throughout the land. In the beginning, silk was worn only by the royal family in the 'Chang –Tong' Province. For more than two thousand years the Chinese kept the secret of silk making themselves. It was the most zealously guarded secret in history. Later when commercial relations were established between China, and the rest of the world. Knowledge of silk spread far and wide.

From China, the secret of silk making spread first to Korea through Chinese immigrants in 1,200 BC. From there it spread to Japan, when Semiramus, the Japanese General conquered Korea and took as slaves the prisoners-of-war farmers and artisans dealing with the cultivation, rearing and weaving of mulberry silk.

From China, the secret of sericulture spread to Tibet in AD 440, when a Chinese Princess, who married the King of Khotan, carried mulberry and silkworm seeds in her head apparel. Then around AD 550, two Nestorian monks appeared at the Byzantine Emperor Justinian's court with silkworm eggs hid in their hollow bamboo staves. Under their supervision the eggs hatched into worms, and the worms spun cocoons. This allowed a silk industry to be established in the Middle East. By the sixth century the Persians, too, had mastered the art of silk weaving, developing their own rich patterns and techniques. It was only in the 13th century; Italy began silk production with the introduction of 2000 skilled silk weavers from Constantinople. Eventually silk production became widespread in Europe.

History of silk production

Various documents indicate that the silk was originated in China during 2800 BC. In the Vedic period, dating back to about 5000 BC, the silk and silk garments were known to

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the Indian people. In Mahabharatha (5480 BC), there is vivid description about silk and silk garments. Lord Krishna was described as always clad in Kashi Pitambara (Silk of Banaras). There are sporadic references to Kashmir silk and Bengal silk. The survey of Indian Silk Industry in India was carried out by Prof. H M Lefroy during 1915-16, and Later by Mr. R C Rawlley (1919). Lefroy describes that, “Silk was produced in India before Christian era. During this period the silkworm was referred to as Indian worm, indicates the presence of silk producing industry in India”.

The silk trade flourished in India during the medieval period. Under the Moughals, silks from Kashmir and Bengal were exported mainly by the Moors, who during the 14^{th} and 15^{th} centuries transmitted it to Europe. The British had identified the qualitative shortcoming with Indian silk and tried to improve it by bringing experts to modernize the rearing and reeling techniques. In 1771, the ‘China worm’ was introduced with the idea of improving cocoon quality.

Sericulture flourished in Mysore during the 18^{th} century under Tipu Sultan. The technology was transferred from Bengal. Japanese and Italian silkworm strains were imported and experts hired from these countries. Spread of diseases during 1866 and the world depression in 1929 along with competition from imported silk and Rayon lead to downfall of Indian silk industry on the eve of World War II. British East India company exploited silk industry and exported large quantities from West Bengal to England. Denied on privatization, sericulture was developed in Mysore and Jammu and Kasmir.

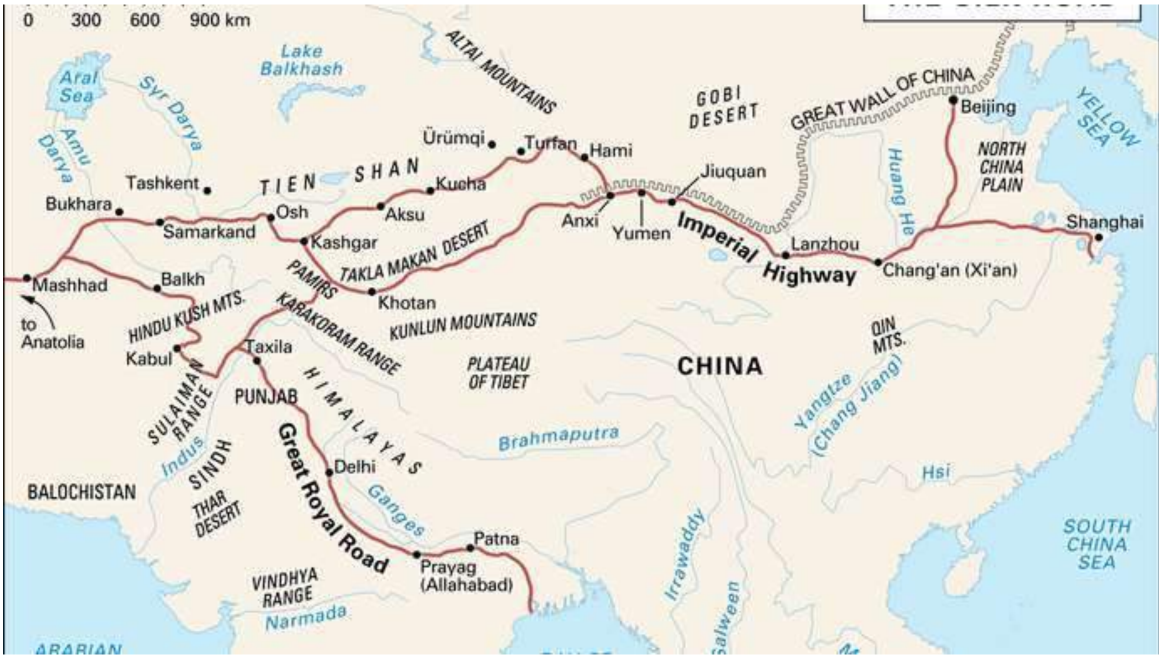
Recommendations by a Silk Panel in 1946 lead to the formation of the Central Silk Board in 1949, an apex body expanding Research and Development activities in sericulture. Currently in India about 98 % of the total mulberry silk produced in five states viz., Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir.

Silk Road

For many centuries Chinese kept the art of silk making a close guarded secret and tantalised the whole world with the ‘heavenly fabric’. By 1000 BC the Chinese silk products became so popular that they started export, mainly through caravans on foot and camel back. Later this caravan tract came to be known as Silk Road. Through Silk Road, silk travelled from China to almost every part of the world. In return wools, gold and silver went to China.

The road started from Shanghai on the Pacific Ocean and traversed along the Great wall through ‘Sian’. At the mouth of the ‘Taklimakan desert’, the road split into two, each branch binding the sides of the desert. The two branches re united at Kashagar - the last great oasis within China. From Kashagar the road rose into the Russian Pamir, again splitting into two. One branch leads to Samarkand and the other to Afghanistan. Once again they reunited near the frontiers of Iran. After travelling through Baghdad, Damascus and Istanbul, the road broke on the shores of Adriatic ocean. The goods were then shipped across to Rome. Subway followed from Rome to Genoa and Cadiz in Spain, where the road ended. From Shanghai to Cadiz the Silk Road measured nearly 12,800 km. It remained the longest man-made road on earth during the 2000 years of its use.

Apart from its role in international trade, the Silk Road has tremendous historic significance. Silk road was a prestigious network of trade routes linking the civilization of the East represented by China with the civilization of the West represented by Rome. It was the route used by Buddhist priests and also the traders who exchanged goods as well as ideas of the two great civilizations of the time. Chinese silk was exchanged for gold, wool, horses, jade and glass of the west and ideas from Buddhism was exchanged for those from Christianity.



Silk production in India

Silk has been intermingled with the life and culture of the Indian. India has a rich and complex history in silk production and its silk trade which dates back to 15th century. Sericulture industry provides employment opportunity for more than 9.20 million persons in rural and semi-urban areas in our country. Among the people involved in silkworm rearing and silk production, a sizeable number of workers belong to the economically weaker sections of society. India's traditional and culture bound domestic market and an amazing diversity of silk garments that reflect geographic specificity has helped the country to achieve a leading position in silk industry.

India is the only country which has all the four kinds of silk namely, domesticated Mulberry silk (*Bombyx mori*), semi domesticated Eri silk (*Philosomia ricini*), wild Tasar silk (*Antheraea mylitta*) and golden Muga silk (*Antheraea assamensis*). Each sericultural state in India has a traditional reputation for a particular kind of silk goods from ancient times. Eg. Banaras silk, Kashmir silk, Bengal silk, Mysore silk and Kanchipuram silk. The muga silk is produced only in our country with its golden yellow glitter is a prerogative of India. Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal and Jammu & Kashmir are the prominent states where the sericulture is extensively practiced and large quantity of raw silk is produced.

The protection of silk stands for livelihood opportunity for millions, owing to its high employment opportunity, low capital requirement and remunerative potential. The nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of the policy makers to recognize the sericulture industry among one of the most appropriate avenues for socio-economic development of a largely agrarian economy of India.

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DIAGNOSIS OF ZINC DEFICIENCY AND ITS MANAGEMENT IN CROP PLANTS

Duddukur Rajasekhar*[1] and Muddana Sri Sai Charan Satya[2]
[1]School of Crop Improvement, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, India.
[2]School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, India.
*Corresponding author: drnaidu.agri@gmail.com

Introduction

Zinc is the one of the essential micronutrients and an important constituent of several enzymes and proteins, required in in small quantities for crop plants. Though, it is a key role in growth, development, and defense (Cabot *et al.*, 2019).

The normal range for zinc in plant tissue is 15-60 ppm and in the growing medium between 0.10-2.0 ppm. Zinc deficiency or toxicity does not occur often; however, they both negatively impact crop growth and quality. Any deficiency or toxicity has to be addressed before crop damage is irreversible.

Functions of Zinc

Zinc involved in many reactions of the cellular metabolism, including biological processes, such as antioxidative defense, protein synthesis, carbohydrate metabolism, auxin metabolism, and stability of genetic materials (Clemens, 2006). It is used in the formation of chlorophyll and some carbohydrates, conversion of starches to sugars and its presence in plant tissue helps the plant to withstand cold temperatures.

When does the Zinc deficiency occurs?

Zinc deficiency is linked with Sulphur deficiency. It can occur in neutral and calcareous soils, intensively cropped soils, paddy soils and very poorly drained soils, sodic and saline soils, peat soils, soils with high available Phosphorus (P) and Silicon (Si) status, sandy soils, highly weathered, acid, and coarse-textured soils, soils derived from serpentine and laterite, and leached, old acid sulfate soils with a small concentration of Potassium (K), Magnesium (Mg), and Calcium (Ca) (Knowledgebank.irri.org. 2021)

- Little amount of available Zn in the soil.
- Growing varieties are susceptible to Zn deficiency
- High pH (close to seven or alkaline under anaerobic conditions).
- Reduction in Zn uptake due to an increase in Iron (Fe), Ca, Mg, Copper (Cu), Manganese (Mn), and P after flooding.
- Large applications of P fertilizer.
- Precipitation of Zn as ZnS when pH decreases in alkaline soil following flooding.
- Excessive liming.

Some of the crops with their diagnosis and management of zinc deficiency is given below

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Rice

Dead and dying leaves have an oily appearance when wet

Common deficiency symptoms:
Little leaf, Chlorosis, Necrotic spots

Zinc

Dusty brown spots on upper leaves of stunted plants, Chlorotic midribs, particularly near the leaf base of younger leaves

Management

Grow Zn-efficient varieties,
Broadcast $ZnSO_4$ in nursery seedbed,
Dip seedlings or presoak seeds in a 2–4% ZnO suspension

Maize

Deficiency symptoms:
White to pale yellow bands in the lower half of the leaf which advance to pale brown or grey necrosis (White bud)

Zinc deficiency made worse by Organic soils, High pH soils, Soils rich in phosphorus, Soils receiving high phosphorus application, Cold wet conditions

Management :

Soil application: Zinc can be applied broadcast at a rate of 5-10 lb Zn/acre as chelate or at 15-30 lb Zn/acre as zinc sulfate

Wheat

Lesions form on middle leaves, pale lines develop on new growth

Necrosis half way along middle and older leaves causes them to droop

Parallel necrotic ‘tramlines’ on leaves

Management

Foliar spray (effective only in current season) or drilled soil fertilizer, zinc seed treatment

Sorghum

 . 

Deficiency symptoms

Emerging leaves uniformly pale green.

Bleached white patches on the leaves. Older leaves have yellow streaks or chlorotic striping between veins.

Prevents internode elongation and result in crowding of the top most leaves producing a fan shaped appearance. Lack vigour and poor yield

Management

Zinc sulphate application @ 25- 30 kg ha^{-1} or zinc chelates @10 kg ha^{-1}

On standing crop, spray 3 kg $ZnSO_4$ + 1.5 kg un-slaked lime in 500 litres water on 2 or 3 weeks after seedling emergence

Soybean

Deficiency symptoms

Chlorosis in the interveinal areas of new leaves producing a banding or striping appearance.

Under severe conditions necrosis develops and plant growth become stunted

Management

Foliar spray of Zinc sulphate 1 % at fortnightly intervals , soil application of $ZnSO_4$ @ 20-25 kg ha-1.

Blackgram

Deficiency symptoms

Interveinal areas of leaves become yellow and die prematurely.

Reduction of growth in plants.

Yellowish smaller leaves, veins remain green in colour.

Management

Application of basal dose $ZnSO_4$ at the rate of 25 kg per ha. Spraying of 0.5% $ZnSO_4$ during 20, 30, 40th day after sowing.

Bengal gram

Deficiency symptoms
Leaves chlorotic and then turn to rusty brown colour. Veins remain green. Leaves and shoots smaller than normal. Yellowing in interveinal areas.
Management
Foliar spray of $ZnSO_4$ @ 0.5%

Red gram

Deficiency symptoms
Stunted growth narrowing of leaves with pale green or yellow.
Inter-veinal chlorosis starting from tip of leaflets and spreading to the remaining area leaving only the midrib green.
Management
Foliar spray of $ZnSO_4$ at 0.5% at fortnightly interval
Soil application of $ZnSO_4$ 10-15 kg/ha.

Groundnut

Deficiency symptoms
Stunted growth while young leaves are smaller than normal. Leaf lamina will be uneven on both sides. Leaf become chlorotic
Management
Soil application of 25 kg $ZnSO_4$
Foliar spray of 0.5% $ZnSO_4$

Conclusion

The Zinc deficiency is managed by following the steps given in the next sentence irrespective of all crops. Growing Zn-efficient varieties. Contact your local agriculture office for an up-to-date list of available varieties. Using fertilizers that generate acidity (e.g., replace some urea with ammonium sulphate). Appling organic manure before seeding or transplanting or applied to the nursery seedbed a few days before transplanting. Allowing

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permanently flooded fields (e.g., where three crops per year are grown) to drain and dry out periodically. Monitoring irrigation water quality. Where possible, Broadcast $ZnSO_4$ in field.

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EFFECT OF CHITOSAN ON NEMATODES

Mouniga.R* and Lekha Priyanka Saravanan
Department of Agricultural Entomology and Nematology, Tamilnadu Agricultural University, Coimbatore, Tamilnadu-641003.
* Corresponding author: mounigasmile@gmail.com

Chitosan

Fungi are abundant sources of chitosan and it exists naturally in fungi like zygomycetes and mucorales such as *Gongronella butleri, Aspergillus niger ,Rhizopus* sp., *Asperigullus niger* with the highest amount of extractable chitosan obtained at the late exponential phase. Chitosan is prepared by chitin deacetylation and its production. It acts as a very good bio control agent and also enhances plant growth parameters.

Plant parasitic nematodes

Plant parasitic nematodes are very microscopic organisms. The average size is about 1mm long. It is also called as eel worm, round worm and belongs to the phylum Nematoda. There are three classification of nematodes based on their parasitism :- 1. Endo parasitic nematodes, 2. Semi-endo parasitic nematodes, 3. Ecto- parasitic nematodes. Among these, the endoparasitic nematodes are known to cause a major yield loss in crops. Endoparsasitic nematodes are root knot nematode (*Meloidogyne* spp.) and cyst nematode (*Globodera* spp.)

Plant parasitic nematodes

Protocol for preparation of chitosan

Mode of action of chitosan on nematodes

The suggested mechanisms include:

(1) Increased microbial chitinase activity which may damage chitin-containing egg shell.

(2) The nematocidal activity of increased ammonia concentration due to chitin hydrolysis.

(3) Stimulated growth of bacteria, actinomycetes, and a limited number of fungal species with chitinolytic properties as antagonistic microorganisms.

Examples

- ✓ Chitosan combined with onion waste effectively controlled root-knot nematode disease and improved plant growth as well as the yield of eggplant. This may be due to the release of various phytochemicals after the decomposition of onion waste which may disturb the life cycle and thereby reduce the rate of reproduction (Asif *et al.*, 2017).
- ✓ Chitosan as an elicitor induced plant mediated systemic resistance against *M. incognita* in eggplant. The eliciting activity of chitosan, causing systemic resistance in the plant and the release of various toxic chemical compounds during decomposition which have lethal effects against the second stage juveniles of *M. incognita* and nematode multiplication.
- ✓ The low-molecular-weight chitosan (5 kDa) was shown to display an elicitor activity by inducing the local and systemic resistance of *L. esculentum* tomato to the root-knot nematode *M. incognita*.
- ✓ Pinewood nematode (*Bursaphelenchus xylophilus*) a stem nematode is controlled by chitosan as it causes alteration in bacterial community which support nematode colony to prosper, i.e. gram negative to gram positive bacteria altering its reproduction capacity and increase its mortality (Da silva *et al*., 2021).
- ✓ Chitosan enhances parasitism of *Meloidogyne javanica* eggs by the nematophagous fungus *Pochonia chlamydosporia* increases appressorium differentiation in *Pochonia chlamydosporia*.

Conclusion

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In conclude that, application of chitosan in soil will also suppress the population of pathogenic oraganisms and plant parasitic nematodes.

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ROLE OF BIO-CONTROL AGENT IN SERICULTURE

G. Swathiga and P. Priyadharshini
Department of Sericulture, Forest College and Research Institute, Mettupalayam-641 301

Introduction

Sericulture is an agro based cottage industry, having tremendous employment potential and providing direct and indirect employment through on - farm as well as off- farm activities. The silkworm (*Bombyx mori* L.*)* being a monophagous insect derives complete nutrient supply including water required for its growth from the mulberry leaves. Mulberry which belongs to genus *Morus* comprising of 68 species, is a perennial woody plant which after proper establishment can come to full yielding capability during the second year and last for over 17 years without any significant deterioration in leaf yield.

Bio-control

Bio-control is the action of the parasitoids, predators and pathogens against target Pathogens and pests to keep their populations below the level of economic damage by keeping environment harmonized. Bio control is an environmentally sound and effective means of reducing or mitigating pests and pest effects through the use of natural enemies. Bio-control is economic method. The term biological control was first used in the index of economic entomology in 1930. The bio-control can be applied for the pests of agriculture, forest, medical, household etc.

Need of bio-control

Chemical control pose serious unwanted problems like air, soil and water pollution , health hazards, killing of beneficial insects, secondary pest out- break , pest resurgence , pest – resistance etc. Therefore, biological control serves as a potential weapon in avoiding these problems. Manipulation of native natural enemies which bring about the reduction in pest population is a desirable method of controlling insect pest in sericulture (Thangavelu and Singh 1991; Singh et al., 1992). As compared to chemical control we are spreading very less amount on biological control in India. DeBach (1964) reported that during (1923-1953), California industry saved 115 million dollars by spending only 4-5 million dollars on biological control.

Biological Control of insect pests in Sericulture

Biological control is the utilization of one living organism to control another. This is an age old practice and since the time immemorial, man is using cats to control rats. Similarly, to control insect pests also, biological method is being successfully implemented almost since three decades. This method is safe, eco-friendly, cheap and long lasting.

The bio control of the pest in sericulture is much more effective, selective and safe for humanity (Singh et al., 1992; 1993 and 1994). Mulberry is the only food plant for the silkworm, *Bombyx mori* L. which is an economically important insect for sericulture industry.

Mulberry is reported to be attacked by more than 200 species of insects belonging to various orders. According to an estimate, the pests and diseases cause about 25% loss in foliage production of mulberry (Gupta et al. 2000). Pest management with special reference to biological consideration is one of the best solutions for pest management in sericulture. For this we have to think over the regulation of biotic agents in the field, because biotic agents possess tremendous potential for keeping the population of harmful insects below the damaging level. The micro–organisms that adversely affect the target pathogens growing in association with them are termed as *antagonists*. The mechanism of actions of an antagonist is called *antagonism*. In biological control of plant diseases, the antagonists are called *biological control or bio-control agents,* which have the potential to interfere in the life processes of plant pathogens. The efficacy of bio control agent is dependent on ecological factors.

Mulberry, like most of the other crops, is attacked by a vast pest complex. Important among them are pink mealy bug, papaya mealy bug, leaf roller and Bihar hairy caterpillar. Similarly uzifly is a serious pest on the silkworm. It is estimated that mealy bug infestation contributes in bringing down the leaf yield by about 1,800 kg/ acre and uzi fly causes cocoon yield loss of about 10-15%. In Mulberry, the first evidence of bio-control of diseases has been reported long back in 1935 when Adam and Pugsley observed a yellow bacterium, isolated from mulberry leaves itself, inhibited the infection of bacterial leaf blight in mulberry caused *by Pseudomonas mori.* To suppress these pests, few effective insect predators and parasitoids are available. They are as follows:

Mulberry Pest management using Bio-control agent

Lady bird beetles for tukra mealy bug

Two species of ladybird beetles namely *Scymnus cocciaora* and *Cryptolaemus montrouzieri* feed voraciously on all the stages of pink mealy bug which causes tukra symptom in mulberry.

Besides feeding, they also lay their eggs in the midst of mealy bug colony. The grubs which hatch out from these eggs also devour various stages of the mealy bug which feed for nearly 20 days after which they pupate. In about 7-9 days, adult beetles emerge from these pupae and the total life cycle is completed in about 30-35 days. Adults live for about 2 months.

Recommendation: 2 units/ acre/ year (in two equal splits at an interval of 6 months). (1 unit= 250 adults of *Scymnus* or 125 adults of *Cryptolaemus*)

Method of release: Release adult beetles near mulberry plants having tukra symptom, covering the entire garden.



Mealy bug infestation ***Cryptolaemus montrouzieri*** ***Scymnus cocciaora***

Acerophagus papaya for papaya mealy bug

These are tiny exotic hymenopteran parasitoids which are very effective against papaya mealy bug. They actively search the mealy bug nymphs and parasitize them by laying eggs inside their host body. They are host specific, early nymphal parasitoids and complete life cycle in 15-16 days, with a fecundity of 50-60 eggs and adult longevity of 5 to 6 days.

Recommendation: On noticing the pest, release the parasitoids@ 100 parasitoids or 1 Vial/ acre.

Method of release: The lid of the parasitoid container should be removed and walked throughout the papaya mealy bug infested garden so that they will come out of the container and go in search of the hosts for parasitization. One time inoculative release is sufficient and repeated releases are not required.


Papaya mealy bug infestation ***Acerophagus papayae***

Trichogramma chilonis for leaf roller

This is a very minute hymenopteran egg parasitoid which parasitizes the eggs of leaf roller as well as Bihar hairy caterpillar by laying their eggs inside the host eggs. They complete their life cycle in bout 8-10 days. They are so small that 10-15 individuals can sit on a pinhead.

Recommendation: 4 tricho-cards / acre / crop @ 1 card/week starting from 5-6 days after spraying insecticide (July to December).

Method of release: Each card may be teared into small pieces and stapled on the underside of mulberry leaf at random, during cooler hours.

Leaf roller infestation

Trichogramma parasite

Fixing Tricho card

Other pest management using Biocontrol agent

- Ladybird beetles, *Menochilus sexmaculatus and Scymnus coccivora, Anthocorid orius sp.* and Neuropterans were observed to feed on thrips (major pest of mulberry) in the field and laboratory.
- *Reduvid* and *pentatomid* predators are observed to feed on both nymphs and adults of jassid.
- *Menochilus sexmaculatus* @ 200 adults/acre, *Cryptolaemus montrouzieri* @ 300 adults/acre and *Scymus coccivora* @ 500 adults/acre are released against spiraling whitefly pest of mulberry.
- Use of predators such as the *green lacewing* and *parasitic encirtid wasps* against scale insect.
- Predation by *Eocanthecona furcellata* was observed in the field against cutworm pest of mulberry.

Silkworm pest management using Bio-control agent

Nesolynx thymus for uzifly

Nesolynx thymus is a hymenopteran ecto-pupal parasitoid of the uzifly which is a serious pest of silkworms.

Each female *N. thymus* lays about 250 eggs at the rate of 50-70 eggs per pupa ie., each female can destroy about 4 to 6 uzi pupae from which uzi flies never emerge, instead, the adults of N.T. emerges.

Schedule of release: 2 pouches/100 dfls on 3rd day of 5th instar. From each pouch about 10,000 to 12,000 parasitoids emerge.

Method of release: Two pouches of *N. thymus* are kept in rearing house 3-4 days after IV moult. After the completion of rearing, same pouches are shifted to mounting/harvesting place and finally to litter pit. From each pouch, N. thymus adult emergence continues for 7-10 days.

N. thymus pouch | **Egg laying by N.thymus** | **N.thymus developing inside uzi pupae**

Mulberry Disease management using Biocontrol agents

- *Trichoderma harzianum, T. viride, Pseudomonas maltophila, Clasdosporium cladosporioides, Curvularia lunata, Corynebacterium sp., Staphylococcus sp.* and *Streptomyces sp.* have been evaluated for their antagonistic potential against *C. moricola* pathogen of leaf spot disease of mulberry.
- Yellow ladybird beetles, *Illeis cincta Fab.* and *I .indica Timb.* reported as biological control agents of powdery mildew fungus of mulberry.
- The fresh extracts of *Azadirachta indica* was found most effective in controlling powdery mildew of mulberry followed by *Chromolaena odorata* and *Allium sativum.*
- *Trichoderma harzianum, T.viride* and *Gliocladium virens* are reported to be antagonistic to *A. alternata* and *F. pallidoroseum* causing fungal leaf blight in mulberry.

Antagonistic microorganism for Root rots

Use of antagonistic microorganisms like *Trichoderma harzianum +Trichoderma viride* in combination with effective microorganisms for their bio control potential against *Fusarium spp*. of mulberry causing root rot disease. Antifungal activity of the extract of root epidermis of mulberry (*Morus alba* L.) in–vitro against *Rosellinia necatrix* (mulberry root rot) and many other phytogenic fungi.

Silkworm Disease management using Bio-control agent

Exploitation of naturally occurring plant materials and avoidance of synthetic chemicals has achieved paramount importance in present day strategy silkworm disease management system in order to avoid environmental pollution and its hazardous effects on humans, animals and plants. In Jammu and Kashmir, white muscardine disease inflicts heavy damage to silkworm population/silk industry year after year and sometimes up to 80-90 per cent cocoon crop loss is registered in severely affected areas.

An annual crop loss up to 23.5 per cent has been estimated due to this disease. *Trichoderma viride* and *Chaetomium uridicum* possesses antagonistic potentialities against the pathogen of white muscardine and could be used as bio- control agent for the management of the disease. *Trichoderma viride, Trichoderma harzianum* and *Trichoderma spp.* were used against *Beauveria bassiana* and *Metarhizium anisopliae* pathogens of white muscardine and green muscardine disease respectively in silkworm.

Use of fresh plant extract has been top priority during last three decades for the plant disease control. Extract of garlic was found to inhibit growth of *Beauveria bassiana*. Various botanicals like pudina, walnut, and pambachalan were also found to be effective against *Beauveria bassiana*.

Extracts of garlic and datura each at 30 and 50 per cent concentrations and formalin chaff at 0.8 per cent have been found effective against muscardine disease without deleterious effect on commercial characters. Plant products *viz*., heena leaf, garlic bulb, tomato leaf, mango bark, cotton leaf, turmeric powder, onion, tulsi leaf, neem leaf and ginger at 1.0 , 2.0, 3.0 per cent concentrations were screened against *Aspergillus flavus* and *A. tamari* both in –vitro as well as in – vivo for the control of fungal disease (Aspergillosis) in silkworm. Among these heena leaf, garlic and mango bark inhibited the growth of both *Aspergillus* spp. at all concentrations tested in culture medium and were also found to be effective in controlling the infection of the disease in silkworms after dusting with these plant products.

Advantages of Biological control

- Bio-control agents search and kill the target pests
- Biological control is safe to environment
- It can be integrated well with other methods of pest control
- It is self-propagating and self-perpetuating
- Problem of pest resistance is not there
- No harmful effects on humans, livestock and other organisms
- It is virtually permanent

Precautions

- No insecticide should be sprayed after releasing bio-control agents

Conclusion

Since bio control agents are ecofriendly, economical, feasible and long–term effective, they hold greater promise for the safer and effective management of diseases and pests in sericulture. Though use of Bio control agents for disease and pest management can not completely help us in replacement of chemical pesticides but can help us to curtail non judicious use of these chemicals.

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