

ORGANIC FARMING IN MULBERRY

Recent breakthrough



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GOVERNMENT OF INDIA, SALEM – 636 003

TAMIL NADU, INDIA

CITATION

TECHNICAL BULLETIN:

ORGANIC FARMING IN MULBERRY: RECENT BREAKTHROUGH

YEAR OF PUBLICATION: July 2014

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PUBLISHED BY :

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PREFACE

Tamil Nadu leads in production as well as productivity of Bivoltine silk in India. This is achieved through technological advancements and dedicated extension support to the sericulturists as well as keen interests of sericulture farmers in adoption of advanced package of practices.

The organic farming system followed by Indian farmers with traditional knowledge since the time immemorial has lost its importance due to advent of green revolution. Since few decades, consumption of inorganic inputs like chemical fertilizers, insecticides, fungicides, weedicides etc., reached its own height because of short term results and cost effectiveness.

Off late, the researchers and farming community understood the un-sustainability of chemicals in crop production besides their deleterious effect on the environment and human beings and in recent past the term of “organic farming” is often spelled. However in present trend, organic farming could only be achieved when the organic inputs will be an effective alternate to chemicals.

The efforts of the scientists of Central Silk Board on successful innovations of various organic inputs alternate to the chemicals laid stepping stone for organic farming revolution in sericulture. The effective, economic and eco-friendly packages of practices especially the “Water Jetting Technology” for management of sucking pests of mulberry, “Field Bio-cage” for mass multiplication of parasitoids of papaya mealybug, Thermal Weeding and Black Polythene Mulching brought out by the Scientists of Tamil Nadu helps to eliminate use of hazardous insecticides and weedicides in mulberry ecosystem to a greater extent and deserves all the appreciation.

I confident that the comprehensive advanced organic farming strategies illustrated in this technical bulletin will help the farmers to improve their cocoon productivity and profit through sustainable production of quality mulberry leaf organically. I hope the book will be highly useful to the field functionaries / sericulture extension workers to understand the advanced organic farming system and effective implementation in field. I suggest this book to be translated into Tamil and other regional languages for better utility by sericulture farmers in different states. I appreciate the authors for bringing out this valuable publication which is need of the hour to sustain the sericulture industry.

(Dr. S. Prabhakaran, I.A.S.)

ECO - FRIENDLY TECHNOLOGIES FOR PEST AND WEED MANAGEMENT IN MULBERRY



WATER JETTING



THERMAL WEEDING



BLACK POLYTHENE MULCHING

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FOREWORD

Mulberry, the sole food plant of silkworm, *Bombyx mori* L. which is perennial in nature, cultivated over 2 lakh hectares in India and exploited largely for silk production. Under tropical conditions the plants are pruned 5-6 times annually to take up silkworm rearing and the routine agronomical practices viz., application of fertilizers, weeding, pest and disease management etc., after each harvest is an integral part of moriculture to ensure production of quality leaves in order to optimize the cocoon production.

Long-term applications of chemical inputs like inorganic fertilizers, weedicides, insecticides, fungicides etc., in bimonthly interval in mulberry gardens not only pollute the ecosystem but also cause adverse impact on the soil health and hazardous effect on human beings and beneficial organisms including silkworms. Therefore in place of chemical based sericulture, the possibilities of exploring appropriate eco-friendly alternatives are thought-out in recent past.

The efforts of scientists are immense in innovating organic inputs alternate to chemicals and effective eco-friendly packages of practices in sericulture and their field implementations through sound extension system. It is a timely step to bring out an illustrated technical bulletin on “organic farming in mulberry” with comprehensive information about the organic inputs for mulberry garden and advanced eco-friendly package of practices with special reference to integrated organic nutrient management and effective non-chemical pest, disease and weed management.

I hope that the bulletin will be very useful to the sericulture farming communities, field functionaries/ extension workers, students and researchers.


(Dr. B.B. BINDROO)

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INTRODUCTION

Sericulture is an agro-based industry offers employment and livelihood security to about 7 million people in India. Mulberry (*Morus alba* L.), the food plant of silkworm (*Bombyx mori* L.) is a perennial tree cultivated (moriculture) over 2 lakh hectares in the country and maintained years together as plants or bush by regular pruning to exploit the leaves for rearing of silkworms and silk production.

AGRONOMICAL PRACTICES

Silk productivity and profit of the farmers mainly depends upon the quantum as well as quality of mulberry leaves produced as the former influences on rearing capacity of silkworms *i.e.*, the quantum of larvae to be reared and the later play vital role on their growth and development and economic parameters like effective rate of rearing, cocoon yield and silk ratio. Therefore, like agricultural crops, the agronomical practices *viz.*, manuring, irrigation, weeding, pest and disease management *etc.*, are imperative in moriculture.



Mulberry garden with quality leaves

OVERUSE OF CHEMICALS IN MULBERRY GARDEN AND ITS IMPACTS

(A) Fertilizers

Under advanced package of practices of silkworm rearing with mulberry shoots, approximately 3-4 MT of foliage is removed from one acre of mulberry garden at each harvest. However under irrigated conditions, the plants are capable to rejuvenate the foliage shortly by devouring soil nutrients and become ready for subsequent harvests a month after each pruning. It causes depletion of about 28 kg of nitrogen (N), 11 kg of phosphorous (P) and 11 kg of potash (K). Therefore, the farmers need to replenish the soil nutrients with recommended dosage of 140 kg of ammonium sulphate, 70 kg of single super phosphate and 18 kg of muriate of potash / acre / crop for sustainable production of quality mulberry leaves.

Farmers could harvest shoots from mulberry garden 5-6 times in a year at bimonthly interval to take up silkworm rearing. Hence, an annual input of 1.40 MT of chemical fertilizers is applied in one acre of plantation. Such continuous overuse of chemical fertilizers pollutes the soil and ground water, alters physical and chemical properties of soil, depletes the naturally available essential nutrients besides deleterious effect on beneficial micro and macro organisms which play vital role on soil health and plants growth.



Application of chemical fertilizer in mulberry garden

(B) Weedicides

Wider spacing of mulberry plants under irrigated condition and maintenance of enriched soil fertility in order to optimize the leaf quality and yield also encourage the growth of number of weeds which become menace to mulberry and cause economic loss to the farmers. Weeds in mulberry garden compete with the plants for water, soil nutrients, light and space, thus hamper the growth and adversely affect the leaf productivity resulted with proportionate depletion in cocoon production.



Chemical weed management in mulberry

Farmers prefer to use weedicides in mulberry garden for management of weeds due to their effectiveness and economy under the prevailing situation of scarce of agriculture labours and hike in wage rates. The drift of herbicides sprayed in the garden directly affects the physiological parameters of mulberry plants and leaf yield. Adverse effect of weedicides on mulberry is often visible in many gardens. The residues of weedicides applied in the mulberry garden pollutes the soil as well as ground water, affects beneficial organisms and soil health.



Phytotoxicity of weedicide

(C) Insecticides & Fungicides

Mulberry plants are prone to attack by number of insect species as well as infection of various diseases which also cause abrupt reduction in leaf quality and yield. Feeding such pest and disease affected leaves to silkworms resulted to adverse effect on the cocoon yield and silk quality. Therefore, it is essential to maintain the mulberry gardens free from pest and diseases.

Among various IPM tools, chemical control measure is the most preferred and invariably adopted by farmers. Insecticides generally applied twice per crop *i.e.*, once at 10-12th day after pruning and second at an interval of 10 days and fungicides are used only when foliar diseases are noticed. Therefore, a mulberry garden receives minimum 10-12 sprays per annum.

Application of insecticides with high toxicity and prolonged residual effects in mulberry gardens is restricted because of their hazardous effect on silkworms. However, repeated applications of selective low persistent chemicals like DDVP turned ineffective due to development of resistance in the pests. Therefore, indiscriminate use of various broad spectrum insecticides is being practiced by many farmers to contain the pests.



Pesticides most used in the mulberry garden



Healthy silkworms

Under such condition, the farmers often experience mortality of silkworms due to direct residual toxicity of insecticides / fungicides either sprayed in their own mulberry garden or in the vicinity. The sub-lethal concentrations of these chemicals indirectly cause adverse effect on growth of silkworm and its economic traits which resulted with poor cocoon yield and monetary loss. Further, use of toxic chemicals by the farmers in long term cause health hazards including nervous disorders, diabetes, infertility, cancer *etc.*,

Greater issue of insecticides in relation to pest management is the development of resistance in the pests while the natural enemies of the pests are wiped out due to their high sensitivity to the chemicals. Therefore, repeated chemical applications often resulted in outbreak of pests in mulberry ecosystem besides pollution and hazardous effects to the human beings and beneficial organisms.



Insecticide affected silkworms

WHY ORGANIC FARMING IN MULBERRY ?

Once planted, mulberry is being maintained for several years with continuous agronomical practices in bimonthly intervals. Chemical based inputs are much preferred by the farmers because of short term results and economy. Residues of the chemicals (fertilizers / weedicides / insecticides / fungicides) used in the mulberry garden pose a potential risk of environmental pollution besides adverse effects on the users, silkworms, natural enemy complex, beneficial micro-organisms *etc.*

Though chemical farming initially yields good results, the sericulture farmers certainly experience its negative impacts on leaf yield as well as quality and cocoon productivity, few years after mulberry cultivation. Therefore, promotion of organic farming is need of the hour in sericulture to avoid indiscriminate use of chemicals in mulberry garden. In this context, this bulletin enumerates possible organic inputs and their utility in mulberry farming as well as recent advancements in eco-friendly agronomical package of practices developed for sustainable sericulture.

I. INTEGRATED ORGANIC NUTRIENT MANAGEMENT PRACTICES

Organic manures play vital role on soil health by improving its physical, chemical and biological properties. It enhances water holding capacity in sandy soils, facilitates aeration and infiltration in heavy soils, increases nutrient supply power of alkaline soil by reducing its pH, promotes the activities of beneficial microorganisms to make the soil more fertile besides its own nutrient values. The buffering nature of the organic matter is considered to be advantageous to overcome the problem of residues of pesticides, fungicides, herbicide and other heavy metals in agro-ecosystem. The important organic manures and their utility for mulberry leaf production are illustrated below.

1.1. FARMYARD MANURE (FYM)

FYM is bulky organic manure prepared simply by storing cow / buffalo dung, droppings of sheep, goat, poultry *etc.*, along with leftover fodders (available from own source of livestock culture of farmers) in pits for few months for decomposition. The well decomposed FYM contains approximately 0.5 % N, 0.2 % P_2O_5 and 0.5 % K_2O . However to realize the full nutrient potential of livestock wastes, they must be properly decomposed, through suitable method of composting.



Close-up view of FYM



FYM ready for application in mulberry garden

Being bulky and cheap source of organic manure, FYM is an integral part of soil health and integrated nutrient management (INM) strategies in India. In sericulture, soil test based FYM application is highly appreciable. The dosage of FYM varies with soil organic carbon content as given below.

Soil organic carbon (%)	Dosage (MT/ ac / year)	No. of splits
<0.35	12	3
0.35 - 0.65	10	2
0.65 – 1.00	8	2

1.2. COMPOST

Compost is a product of biodegradation of organic wastes available from different sources like crop residues, weeds, green and dry leaves, cow dung, poultry wastes, urban wastes, wastes from agro based industries (pressmud, sericulture wastes *etc.*) which is carried out by diverse group of heterotrophic microorganisms such as bacteria,

fungi, actinomycetes and protozoa. The principles behind composting are narrowing down of C: N ratio, the total destruction of harmful pathogens and weed seeds by high temperature evolved during decomposition and stabilization.

When the organic materials broken down in the presence of oxygen the process is called aerobic decomposition and end product formed are carbon dioxide, humic substances and release of available plant nutrients. The quality of compost is depending upon the availability of organic wastes and their composition besides the judicious mixing and preparation. However it holds rich nutrient value than FYM. The nutrient value of compost can further be increased by application of superphosphate or rock phosphate @ 10 to 15 kg / MT of raw material at the initial stage of filling the compost pit.



Compost for mulberry garden

1.3. VERMI-COMPOST



Earth worms

Earthworms as friends of farming community, renders help in soil improvement, organic matter decomposition and in enhancing the quality of agricultural produce. Vermicomposting is a bio-oxidation process of organic wastes involving a joint action of earthworms and micro-organisms. In this process earthworms act as versatile bioreactors converting organic materials into fine granules called vermicast (excreta of earthworms). Vermicompost is rich in plant nutrients, enzymes, antibiotics, plant growth hormones and large beneficial microbial populations which help to increase the quality and yield of mulberry leaves suitable for higher productivity of silk. Application of 10 MT of vermicompost with 50% reduction in the application of recommended dose of chemical fertilizers (NPK) / ha/ year could produce leaf yield at par with application of 20 MT of FYM /ha/year with full recommended dose of chemical fertilizers.

1.4. POULTRY MANURE

Poultry manure is good source of organic nutrients and used after decomposition. Poultry droppings have nitrogen (4.55 to 5.46 %), phosphorus (2.46 to 2.82 %), potassium (2.02 to 2.32 %), calcium (4.52 to 8.15 %), magnesium (0.52 to 0.73 %) and appreciable quantities of micronutrients like Cu, Zn, Fe, Mn etc., besides cellulose (2.26 to 3.62%), hemicellulose (1.89 to 2.77 %) and lignin (1.07 to 2.16 %). This can be decomposed with suitable organic amendment like chopped paddy straw or coir pith by adding fungal inoculums of *Pleurotus sajor-caju* (1.25 kg and 0.5 kg respectively).



Poultry manure for mulberry garden

1.5. SHEEP AND GOAT MANURE

The sheep and goat droppings have more nutrients than farmyard manure and compost. This manure consists of 3 % N, 1 % P_2O_5 and 2 % K_2O . There are two methods of application of droppings of sheep or goat. In first method, the decomposed droppings of sheep or goat in pits applied later to the field where in the nutrients present in the urine are wasted. In the second method, sheep and goats are kept overnight in the field by which urine and faecal matter incorporated to the soil in shallow depth by using working blade harrow or cultivator.



Goat manure for mulberry garden

1.6. GREEN MANURES

Green manuring can be defined as a practice of incorporating the soil with the undecomposed green plant tissues for improving its physical structure as well as fertility. It is a best alternative to FYM in the prevailing situation of its scarcity and high cost due to decline in livestock farming in recent past. Green manure crop is grown in inter rows of mulberry plants and incorporated in soil at pre flowering stage because they are grown only for their biomass which is high in organic matter and nutrients. The green-manure crop also supplies additional nitrogen due to its ability to fix nitrogen from the air with the help of its root nodule bacteria.



Green manuring in mulberry with sunnhemp and a view of root nodules

Further *in-situ* composting of green manure promotes the build-up of beneficial rhizosphere micro-flora in the garden which enhance the availability and mobilization of soil nutrients to the plants. Green manures will break down in to the soil gradually and add some nutrients to the soil for the next crop too. Green manuring in mulberry with dhaincha (*Sesbania aculeata*) and sunn hemp (*Crotalaria juncea*) @ 15 kg seeds / acre is recommended for alkaline and neutral soil conditions respectively.

The seeds are treated with *Rhizobium* (200g) with sufficient quantity (300 ml) of rice gruel in room temperature and shade dried for 30 minutes. After sowing, it is better to give splash irrigation for 2-3 times followed by flood irrigation. The green manure crop is incorporated in the soil before flowering (approximately 40-45 days after sowing) either by trampling method or by power tiller. About 15-17 tonnes of green biomass per hectare per year can be incorporated to soil by green manuring with dhaincha or sunnhemp in mulberry garden annually for soil fertility improvement. The additional benefit of green manuring is that it prevents weed growth and saves the weeding cost.

1.7. BIO-FERTILIZERS

A bio-fertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the plant. In present scenario, bio-fertilizers are the one of the inevitable alternative to chemical fertilizers.

Certain common bacteria like *Azotobacter chroococcum*, *Azospirillum* spp. (*A. brasilense*, *A. lipoferum*, *A. amazonense*, *A. halopraeferens* and *A. irakense*) are capable of fixing atmospheric nitrogen (biological nitrogen fixation). However, the *Azospirillum* plays additional role that it secretes growth promoting substance (Indole Acetic Acid) in the soil, induces disease resistance and drought tolerance in the plants. Similarly, another bacterium, *Bacillus megaterium* called as phosphorus solubilizing bacteria (PSB) which is capable of solubilizing insoluble phosphorus and making available to the plants.

How to apply

- It is recommended to apply *Azotobacter* or *Azospirillum* @ 8kg / acre/ year and PSB @ 10 kg / acre /year along with 500 kgs of well powdered FYM in 5 splits which curtails use of 25 % of N & P chemical fertilizers respectively.
 - Bio-fertilizers are applied on 6th – 7th day after pruning .
 - Bio-fertilizer should be applied near to root zone, covered with soil and irrigated immediately.
 - A minimum of 15 days required between chemical and bio-fertilizer application.
- The bio-fertilizers should be stored in cool place and used before expiry date.

Vesicular- arbuscular mycorrhizae (VAM)

Vesicular-arbuscular mycorrhizae is a symbiotic fungus also called endomycorrhizae having harmonious relationship with mulberry root. The benefit of mycorrhizae to plants is mainly attributed to increased uptake of nutrients, especially phosphorus while in exchange of sugars provided by the plants. The fungus

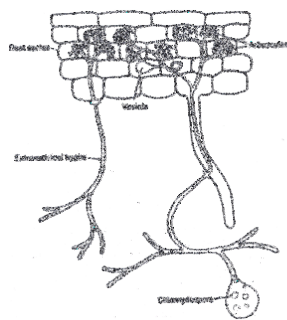
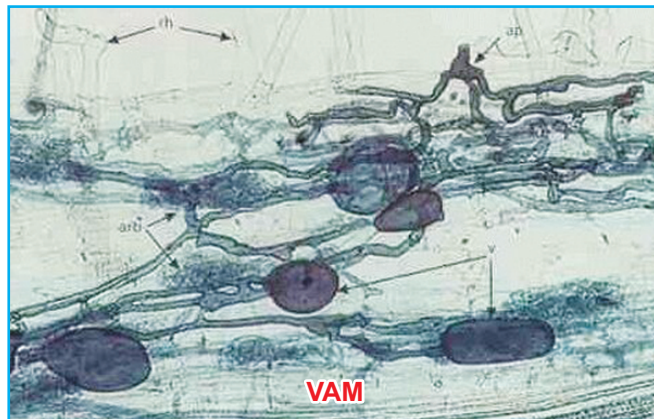


Diagram of V-A mycorrhizae (Toussoun, Henson, 1994)

colonizes the root cortex of mulberry plants forming a mycelia net work and characteristic vesicles (bladder like structures) and arbuscules (branched finger like hyphae). The vesicles are the terminal swellings of hyphae. The VAM hyphae grow several centimeters out of the roots with huge surface area than the root hairs of the plant. Hence, they absorb more nutrients and mobilize quickly to the plants than the root system does not have VAM association. The rate of inflow of phosphorus into mycorrhizae can be up to six times that of the root hairs. Further, the VAM also make available of insoluble rock phosphate to the plants.

VAM inoculation for new mulberry plantation

Soil based inoculum of VA- mycorrhizae containing mixed culture of *Glomus mosseae* and *G. fasciculatum* is used for raising mycorrhizal mulberry saplings in nursery beds. About 5-6 months old mycorrhizal saplings are transplanted to the main field along with nursery soil containing VAM spores. Phosphorus can be used @ 60 kg / ha / yr instead of 120 kg / ha/ yr after one year of establishment. The VAM inoculation ensures 50% curtailment of chemical phosphorus application in mulberry cultivation without any loss in leaf yield and quality.

VAM Inoculation in established mulberry garden

To inoculate an established mulberry garden (more than 2 years old) with VAMycorrhizae, at first the garden is pruned and intercultural operations are completed. Soil based VAM inoculum is applied @ 1000 kg / ha making furrows to a depth of 7.5 - 10 cm in between mulberry rows. After the application of VAM inoculum, maize seeds (local variety) @ 20 kg/ha are sown in furrows at a distance of approximately 5-10 cm from each other for multiplication of VAM in the roots of maize plants. After 40-45 days of growth, the plants are cut at the height of 20-30 cm and allowed to grow for another 30-40 days. After 80-85 days, the maize plants are cut to the ground level and the roots colonized by VAM are incorporated in the soil by ploughing. From the next crop onwards, phosphorus is to be applied @ 60 kg/ ha/ yr in place of 120 kg / ha / yr.

1.8. NEEM OIL CAKE(NOC)

Among the different organic sources, the non-edible oilcakes in general and NOC in particular contain high amount of plant nutrients and alkaloids which induces immunity against pests and diseases in mulberry besides its higher nutrient content than other oil cakes. The alkaloid contents (nimbin and nimbidine) which inhibit the nitrification process of N transformation in soil while applying nitrogenous fertilizers and makes N available slowly. The NOC @ 60 kg/ac/crop combined with N fertilizer significantly increased the mulberry leaf yield. However, the application of 800 kg /ac in 4 split doses at an interval of 3 months during inter-cultural operations is recommended to control root-knot disease.

1.9. PRESSMUD

Pressmud plays important role in alkaline soil amelioration. The fresh material as such is not advisable due to generation of heat at thermophilic stage of decomposition in the soil. Hence, decomposition of the pressmud is inevitable before its application in the soil. The composting is done by spreading fresh pressmud to 1 metre width and 3 metre length (depending upon the quantity) to



Composted pressmud

about 15 cm thicknesses. Then microbial culture of *Pleurotus* or *Trichoderma viride* (1 kg / MT of pressmud), urea (5 kg / MT) and cow dung as a starter (50 kg/MT) are sprinkled over this layer by mixing them in water. Then another layer of pressmud to a thickness of 30 cm is added and again the microbial culture, urea and cow dung are sprinkled. This process is repeated until reach a height about one metre. The top layer is covered with soil. Water is sprinkled to moisten it to 50% water holding capacity. This moisture level is to be maintained throughout. Decomposition will be over within 6 to 8 weeks. Rock phosphate, ferrous sulphate, zinc sulphate etc., can also be added to improve the nutrient contents. The pressmud thus composted is dark in colour with narrow C: N ratio (about 12:1). It contains about 2.08 % N, 3.63 % P₂O₅, 1.40 % K and 22.38 % organic carbon.

1.10. FOLIAR FERTIGATION

1.10.1. VERMI-WASH

Vermi-wash is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules and used as foliar spray. It contains plant growth hormones like auxins and cytokinins apart from nitrogen, phosphorus, potash and other micro-nutrients. Adult worms measuring 100g of same species are collected, released into a container having 50ml of lukewarm water (37°- 40°C) and agitated for two minutes. Then earthworms are taken out and washed in another 50ml of water at room temperature for two minutes and released back into tanks. Dilute 1 litre of vermi-wash with 4-5 liters of water and spray as foliar spray during the late evening hours. A mixture of vermi-wash (1 liter) with cow urine (1 liter) in 10 liters of water acts as bio-pesticide cum liquid manure.

1.10.2. PANCHAGAVYA

Panchagavya is a well known organic product which plays major role in promoting growth and immunity in plant system. Panchagavya is prepared using five cow products viz., cow dung (7kg), cow urine (10 liters), milk (3 liters), curd (2 liters), ghee (1kg) and other ingredients viz., jaggery (3kg), well ripened poovan banana (1 dozen), tender coconut water (3 liters) and plain water (10 liters). Initially, cow dung and ghee are mixed thoroughly in a plastic container and stirred once at morning and evening hours for 3 days. Then it is added with cow urine & water and allowed for 15 days with regular stirring as above. After 15 days, milk, curd, tender coconut water, jaggery and banana are mixed. Panchagavya will be ready after 30 days. The container should be kept under shade and covered with a wire mesh or mosquito net to prevent development of housefly maggots in the solution



Preparation of panchagavya

Panchagavya has all macro and micro nutrients apart from the growth hormones (IAA and GA) essential for production of quality mulberry leaves. It holds low pH value due to the production of organic acids by the fermentative microbes. *Lactobacillus* present in the panchagavya produces various beneficial metabolites such as organic acids, hydrogen peroxide and antibiotics, which are effective against pathogenic microorganisms.

1.11.RECYCLING AND UTILITY OF SERI-WASTES

About 12-15 MT of sericulture waste comprising silkworm litter, leftover mulberry leaves, soft twigs, farm weeds *etc.*, are being obtained from one hectare of mulberry garden annually which have tremendous manorial value of nitrogen (280-300kg), phosphorus (90-100 kg) and potash (150-200 kg) as well as micronutrients like iron, zinc, copper *etc.*, when properly composted and it is found to be much superior compared to farmyard manure.

1.11.1 Composting

Composting is a microbial conversion of biodegradable organic wastes into a stable product called humus by indigenous micro-flora found in nature using a simple technique. All sericulture wastes can be converted into compost rich in nutrient value as well as the load of beneficial micro organisms.

Two pits, size of 3x1x1m are adequate to receive sericulture wastes from 1 acre of mulberry plantation. Sericulture wastes like silkworm litter, left over mulberry leaves weeds *etc.*, are collected in the pit and fresh cow dung or biogas slurry mixed in a bucket of water is sprinkled over the layer after each collection. At the end of rearing, all left over leaves from the garden along with the pruned mulberry twigs are added to the pit and compacted with mud. A consortium of lignocelluloses decomposing fungi like *Aspergillus* sp., *Trichoderma* sp., and *Belaromyces* sp., be added @ 1kg / MT of sericulture waste to speed up the decomposing process. Super phosphate may also be mixed to enrich the compost. When the pit is filled to a height of 30-40 cm above the ground level, it is plastered with 2.5 cm layer of a mixture of mud and cow dung and allowed for composting. Thatch the shed to protect the compost pit from rain and direct sunlight.

1.11.2 Vermi-composting

A thatched shed of approximately 7.5 x 6.0 meters size on a slightly elevated ground is sufficient for utilizing sericultural waste from one hectare mulberry area. All around the shed stone bund is to be prepared to prevent infestation of predators. In the shed, eight trenches measuring 2.4 x 0.6 x 0.45 meters in two rows of four trenches each side are made and lined with polythene sheet. For every tone of waste mix 5 kg cow dung / biogas slurry in 100 liters of water in an open pit and allow for about 7-10 days for partial decomposition. Later, fill each trench with 200-300 kg of semi-decomposed sericultural waste having 30-40% moisture. Introduce a mixed culture of earthworms into the feed @ 1.5 kg/MT of waste and leave for 6-7 weeks. Sprinkle water regularly to maintain moisture around 30-40%. After 6-7 weeks, the casts appear as loose granules. Harvest the vermi-compost and sieve through wire mesh to separate earthworms.



Vermi-composting of seri-residues

II. EFFECTIVE NON-CHEMICAL PEST, DISEASE AND WEED MANAGEMENT PRACTICES

2.1 PEST MANAGEMENT

2.1.1. PHYSICAL METHOD

WATER JETTING

Spray of strong jet of water is one of the components of IPM which is generally recommended to manage the sucking pests like thrips, aphids, mites *etc.*, in agricultural and horticultural crops. In this method the pests are dislodged and washed-out from the plants and hence the pest population is kept below economic injury level. Though this practice is effective and eco-friendly, could not become popular as it is laborious to fetch bulk quantity of water and the process is time consuming and costly.



Water Jetting in mulberry garden

Hence, a simplified and user-friendly water jetting system is developed for mulberry garden in which a portion of irrigation water is diverted in order to get uninterrupted supply of adequate water for effective jetting. This technology is highly effective against all major sucking pests of mulberry *viz.*, pink mealybug, *Maconellicoccus hirsutus* (Green), papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink, mulberry thrips, *Pseudodendrothrips mori* Niwa, spiralling whitefly, *Aleurodicus dispersus* Russell, mulberry whitefly, *Dialeuropora decempuncta* (Quaintance & Baker) and jassid, *Empoasca flavescens* Fabricius, causing severe damage on leaf yield and quality.

A new and user friendly water jetting system

Mulberry is normally irrigated at the interval of 7-10 days depending upon the soil condition. Hence every garden is provided with pipeline (generally 2 or 2.5" diameter PVC pipes) from a water source *i.e.*, either from open well or bore-well connected to a water pumping system. Water jetting system is developed by simple modification in existing irrigation system of the mulberry garden with an additional attachment and the jetting is done by splitting a portion of irrigation water. Water jetting system is established using following procedures.

- Arrange 2" diameter PVC pipes as main pipe lines across the mulberry garden at a distance of 200 feet and connect all pipes using PVC solvent cement.
- The pipe line should be arranged in opposite direction to parallel rows of mulberry plants. Approximately 10-12 lengths of pipes (1 length = 20 feet) required to cover one hectare of mulberry garden.

- Connect one end of the main pipe line to the outlet of irrigation system using a 'T' joint providing a gate valve opening to the irrigation channel and close another end with a threaded end cap after fixing 2" male threaded adaptor (MTA) or a gate valve.
- Create water outlets from the main pipeline at the distance of 40 feet, fitting 2 feet length of 1" PVC pipes with the help of suitable (2"/1") PVC reducers / saddles enable to connect 1" garden hose for jetting water on mulberry plants. All outlets should be provide with the provision of gate valves.



Arrangement of pipe line



Steps involved in establishment of water jetting system in mulberry garden

- The entire system is concealed under earth keeping all 1" pipe outlets along with the gate valves above ground level.

How to spray strong jet of water ?

- Insert a 1" garden hose firmly to the 1" PVC outlet pipe and open the gate valve. Garden hose with 100 feet length is ideal.
- Attach a jet gun with another end of the hose.
- Open the gate valve of main pipeline for flow of water into the irrigation channel and switch on the pump-set.



Water jetting system for management of sucking pests in mulberry

- After flow of water in the outlet of main pipeline, adjust the gate valve by closing slowly to get adequate water pressure in the hose. Allow partial flow of water into the irrigation channel after adjusting adequate water pressure in the hose. This is essential to avoid bursting of PVC pipes due to high pressure.
- Spray the strong jet of water on the mulberry plants covering 5-6 paired rows in each side of main pipeline. Then shift the hose to the next outlet and so on to cover entire mulberry garden.

- Blocking of hose tip (outlet) with the help of thump instead of using jet gun was found effective and easy to adjust the out flow pressure and jetting range depending upon the intensity of the pest population and distance of jetting.
- Avoid jetting of polluted water or the water having high concentration of injurious salts.

Advantages

- This water jetting system is highly efficient and eliminates the draw backs and drudgery of conventional water spray through hand / power operated sprayers and hence it is effective and user - friendly.
- Uninterrupted supply of adequate water through hose for jetting makes convenient to cover larger area in shorter time. Therefore this system saves time and manpower.
- Adequate water pressure hits the pests lethally, dislodge and washout them from plant surface successfully and helps to keep their population below economic injury level without application of any harmful chemical.
- This system recorded high efficacy against all sucking pests of mulberry (> 90% control) as well as successfully washouts egg masses, tiny larvae / grubs *etc.*, of other pests.



Water jetting in papaya mealybug affected mulberry garden

- The farmers could maintain their mulberry garden free from pests through routine water jetting at the time of each irrigation starting from 10 days after pruning (DAP) till harvest of leaves (approximately 4-5 jetting per crop).
- This is an eco-friendly approach as it helps to avoid use of harmful insecticides and does not cause any health hazard to the users, silkworms and other beneficial organisms and hence it also does not pollute the environment.
- Helps to maintain toxic free environment for proliferation of natural enemies of the pests and is compatible with bio-control programme.
- Symbiotic association of ants with the sucking pests protects them from natural enemies. Water jetting drives out the ant population encourage the activities of natural enemies to feed / parasitize efficiently.
- Silkworm rearing can only be taken up 15-20 days after spray of chemical insecticide in mulberry garden due to its residual toxic effect. Further, chemical measure to control pests in mulberry garden is not possible after initiation of rearing. But water jetting can be done at any moment if pest incidence is noticed *i.e.*, even after initiation of silkworm rearing.
- Many sericulture farmers often face mortality of silkworms due to deposit of insecticide drifts on mulberry leaves when the crops in the vicinity are sprayed. Under such condition, the farmers can spray water in the mulberry garden using this water jetting system to washout the drifts before feeding to the silkworms to avoid the toxic effect.
- Water jetting not only eliminates the pest population but also removes the dusts from the leaves which increase the efficiency of photosynthetic activities followed by increase in leaf quality. The silkworms prefer this dust free quality leaves, with resultant increase in silk productivity and income to the farmers. In chemical measures the dusts and sooty moulds left as such.
- The technology is highly economic as the cost of establishment of the system is lesser than the purchase of one standard power sprayer and also can conveniently be used for many years. Water jetting can be done at the time of routine irrigation without using additional man power and any revolving expenditures.
- This system is suitable for large scale application and could also conveniently be adopted in agricultural and horticultural crops.
- It is estimated that approximately 2-3 hours required covering 1 acre mulberry plantation depending upon the plants age. As the jetted water flew into the root zone of the plants it is simultaneously irrigated and hence water is not wasted.



Water jetting removes the dusts

2.1.2. BIOLOGICAL METHOD

Mulberry ecosystem is ideal to implement biological control of pests because of its perennial nature. Moreover, the usage of high potent insecticides on a crop like mulberry is practically impossible due to their sensitivity to silkworms. Therefore, the biological method plays a significant and indispensable role in managing key pests of mulberry. Some of the effective predators and parasitoids for successful management of important insect pests of mulberry is given below.

Sl. No.	Name of the insect pest	Name of the biocontrol agent	Numbers to be released / ac/ crop
1.	Pink mealybug <i>Maconellicoccus hirsutus</i>	Predators A) <i>Cryptolaemus montrouzieri</i> (or) B) <i>Scymnus coccivora</i>	250 adults 500 adults
2.	Papaya mealy bug <i>Paracoccus marginatus</i>	Parasitoids A) <i>Acerophagus papayae</i> (or) B) <i>Pseudleptomastix mexicana</i> (or) C) <i>Anagyrus loecki</i>	50-100 adults
3.	Thrips <i>Pseudodendrothrips mori</i>	Predator <i>Chrysoperla</i> spp	4000-8000 eggs
4.	Spiralling whitefly <i>Aleurodicus dispersus</i>	Predators A) <i>Axinoscymnus puttardriaahi</i> B) <i>Scymnus coccivora</i>	250 adults 250 adults
5.	Leaf webber <i>Diaphania pulverulentalis</i>	Parasitoids A) <i>Trichogramma chilonis</i> - egg B) <i>Bracon brevicornis</i> - larval C) <i>Tetrastichus howardii</i> - pupal	3 cc of eggs 200 adults 1lakh adults in 3 splits



2.1.3. BOTANICALS

2.1.3.1 Neem Oil

Neem oil besides its repellent effect forms a coating on the insect's body, blocking the breathing openings (spiracles) and suffocating the insect. The azadirachtin present in the neem oil known to possess antifeedant activity as well as disturbs insect moulting by antagonizing the insect hormone ecdysone. Therefore, neem oil is used widely as a biological pesticide under organic farming at 2% and 3% concentrations along with wetting

agent (5% soap oil) and effective against the pink mealy bug, papaya mealy bug, whiteflies, thrips and leaf webber in mulberry.

During mixing, the turbid fatty material should be removed to avoid phyto toxicity in mulberry. The neem oil is not having any deleterious effect on young and late age silkworm after 10th day and 5th days after spraying respectively and safer to environment. The efficacy of neem oil (3%) is increased when applied in combination with fish oil rosin soap (2%) against sucking pests of mulberry than its sole application.

2.1.3.2. Amalgamated plant extracts (APE)

Amalgamated extracts of the following plant materials specific against Spiralling whitefly, *Aleurodicus dispersus*, papaya mealybug, *Paracoccus marginatus* and mulberry thrips, *Pseudodendrothrips mori*, as mentioned below (table) known to have good insecticidal properties and found effective when sprayed @ 6 %. Further, all these APEs are eco-friendly and safer to silkworms and natural enemy complex in the mulberry ecosystem. The mulberry leaves could be used for feeding silkworms 7-10 days after spray.

Name of the plants	Parts	Quantity (g)		
		<i>A. dispersus</i>	<i>P. marginatus</i>	<i>P. mori</i>
<i>Azadirachta indica</i> (L)	Leaf	500	500	--
<i>Aloe vera</i> (L)	Leaf	500	500	--
<i>Cassia auriculata</i> (L.),	Leaf	500	500	--
<i>Zingiber officinale</i> (Roscoe)	Rhizome	50	50	50
<i>Curcuma longa</i> (L.),	Rhizome	50	50	50
<i>Allium sativum</i> (L.)	Bulb	50	50	50
<i>Capsicum annuum</i> (L.)	Green Chilly	50	50	50
<i>Acorus calamus</i> (L.)	Rhizome	50	50	50
<i>Ocimum sanctum</i>	Leaf	--	500	--
<i>Nerium indicum</i>	Leaf	--	500	--
<i>Calotropis gigantea</i> L.	Leaf	--	--	500
<i>Annona squamosa</i> L.	Leaf	--	--	500
<i>Leucas aspera</i> Willd.,	Leaf	--	--	500
Cow urine		4.5 l	6.5 l	6.5 l

The above mentioned leaf materials in specified quantity were soaked in of fresh cow urine in a sterile plastic container and mixed with the paste of *Z. officinale*, *C. longa*, *A. sativum*, *C. annuum* and *A. calamus*. The mixture was allowed for fermentation up to 13 days. The mouth of the container was covered with a clean cloth to avoid contact with the house flies. During the process of fermentation, mixture was stirred every day thoroughly. After fermentation, the mixture was filtered and collected in a separate container.

2.2. DISEASE MANAGEMENT

2.2.1. ROOT ROT

This disease is caused by *Rhizoctonia bataticola* (Taub.) Butl. [=*Macrophomina phaseolina* (Tassi.) Goid]. Infected mulberry plant suddenly withers followed by decaying of roots and death. The disease initially appears sporadically in few plants as isolated patches, which act as infective centers for spread of the disease, leading to the mortality of well established plants within a short span.

Control measures

Navinya is an eco-friendly formulation, the innovation of CSR&TI, CSB, Mysore for effective management of root rot disease in mulberry. Control measures to be adopted is given below

- Prune the dried / wilted plant to 15-30 cm above the ground level. Make a shallow ring basin all around the plant stump to avoid overflow of the solution.
- Prepare *Navinya* solution by adding 10 g / liter of water and stir well (1 kg *Navinya* /100 liter sufficient for 100 plants).
- Pour 1liter solution over the pruned stump to drench completely up to the ground level.
- Treat the surrounding plants also to prevent spread of the disease.

Precautions

- Remove the dead mulberry plants, burn and expose the soil to sunlight.
- Do not irrigate the treated mulberry plants during the first 4-5 days.
- Re-plant with new saplings after dipping their roots in 0.4 % *Navinya* solution over 15 minutes before planting.
- Treat the plants, which show symptoms such as blackening of leaf margin and withering immediately to avoid disease, spread.

The optimum organic carbon content should be improved by applying compost / manure to the level >0.5% in soils. Keep the soil moisture level above 40% through irrigation to prevent the disease.

2.2.2. POWDERY MILDEW

Powdery mildew caused by *Phyllactinia corylea* (Pers.) Karst is a serious disease of mulberry inflicting considerable qualitative as well as quantitative losses. *Trichoderma viride* and *T. harzianum* @ 50.0% were highly effective and inhibited the conidial germination by 75.08% and 72.23%, respectively. The *in vitro* treatments exhibiting conidial germination inhibition of more than 50.0% were also tested *in vivo* for the management of the disease. Culture filtrates of *T. viride* and *T. harzianum* both at 50.0% concentration



Illeis cincta feeding on powdery mildew

were equally effective (65% - 68% disease control) and were at par with carbendazim 50 WP @ 0.05%. The population of potential mycophagous coccinellids like *Illeis cincta* associated with powdery mildew need to be encouraged in mulberry ecosystem.

2.2.3. ROOT KNOT DISEASE

It is caused by Meloidogyne incognita (Kofoid & White), a nematode which shows the symptom of stunted growth with marginal chlorosis and necrosis of leaves. Knots / galls formed on the roots are spherical with varying size; young galls are too small and yellowish white, while old are big and blackish brown in colour.

Control Measure

For effective management of the disease, an eco-friendly product, Nemahari (75% plant components: 25% chemicals) is developed at CSR&TI, Mysore.

Method of Application

- (i) Moderate infection of root knot disease (< 50galls/plant):
Two applications / year
- (ii) Severe infection of root knot disease (> 50galls/plant): Three applications / year

First Application:

Apply Nemahari @ 40 kg / ha after mixing with 400 kg FYM/compost during intercultural operation by making the trenches up to 15 cm deep near the root zone of plant and cover with soil followed by irrigation.

Second Application:

70-80 days after first application following the aforesaid method.

Third Application:

140 - 150 days after second application following the aforesaid method.

Precautions:

- Irrigate the treated mulberry plants immediately.
- Maintain optimum organic content in soil by applying compost manure to rise the organic carbon level >0.5% in soils.
- Keep soil moisture level above 40% throughout crop period.

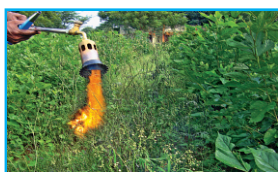
2.3. WEED MANAGEMENT

There are many drawbacks in the existing weed management practices in mulberry garden. Hand-weeding is the most efficient method, but it is back-breaking, time-consuming and costly. At the same time, scarce of agriculture labours and hike in wage rates are greater issues in the recent past. Tillage is a useful method to control annual weeds and easier than hand weeding. Using bullock power is a traditional practice but became rare due difficulties in maintaining bullocks and widespread use of hired tractor / power tillers in agricultural sector. However, hiring of above machineries is also costly as well as ploughing is not viable in many mulberry gardens due to varied spacing system and improper maintenance plants as bushy type. Mechanical weeding unavoidably injures

both the roots and above ground parts of the mulberry plants and the weeds in intra-row space and which grown near mulberry stem are not controlled. Besides, sometimes due to unfavourable weather and soil conditions, mechanical weeding may not be possible.

Chemical control is rather less popular because of its adverse effects to mulberry plants and higher cost. In addition application of single herbicide may not be effective in controlling the weeds in mulberry because of a great diversity in weed flora and a longer duration required to suppress the weeds which come in several flushes. Further indiscriminate use of herbicides deteriorates the soil health, texture and the residual toxicity cause adverse effects on beneficial micro-organisms and silkworms. In this context, two effective, economic and eco-friendly packages of practices *viz.*, Thermal Weeding and Black Polythene Mulching were developed and standardized for management of weed menace in mulberry gardens.

2.3.1. THERMAL WEEDING



Thermal weed control involves the use of flaming equipment to create direct contact between the flame and the plant. In some developed countries tractor mounted propane-fuelled flammers, diesel or gas powered flammers are commonly used to control weeds in agriculture field but the flaming is mainly done prior to crop emergence. For mulberry garden in situ flame weeding package was standardized with LPG operated “Gas Flame Gun” (Seritorch).

Thermal weeding is exposing weeds and its seeds to temperatures higher than that they can survive. Flaming involves out-right burning down of weeds on sufficient exposure to fire. However, short term exposure for few seconds was found sufficient to kill the weeds. This technique works by rupturing plant cells when the sap rapidly expands due to heat and coagulation of proteins. It is sufficient to heat parts of the plants especially leaves up to 70° C to damage the protein. If a plant heated up to 100° C all the cellular structures are destroyed. In both cases vesicular breathing ceases and the weeds die.



“Gas Flame Gun” (Seritorch)

THERMAL WEEDING PROCESS

The LPG operated “Gas Flame Gun” (Seritorch) developed for the purpose of cleaning and sterilizing mountages in sericulture was used to control weeds through flame in mulberry garden. The thermal weeding could be taken up using following procedure:

- The “Gas Flame Gun” comprises a burner fitted with a lance, LPG hose and pressure regulator to connect with the cylinder.
- LPG cylinders with the capacity of 2 or 5 kg was found suitable for thermal weeding which may easily be lifted while weeding or the big cylinder can be lifted using a suitable trolley.
- Connect the LPG pressure regulator with a commercial gas cylinder and put on.
- Screw the control tap for flow of gas to the burner initially at minimum level and ignite the gas emitting from the burner.
- Adjust the gas flow to get desired flame output based on the population and biomass of weeds in the mulberry garden.
- Make short term exposure of flame on weeds by fast horizontal swing of lance (burner) instead of outright burning (i.e. the exposure is adjusted depending upon the weed type and intensity which sufficient to kill the weeds).
- The weeds wilt immediately after exposure to flame and dry completely 2-3 days after flaming.

LPG REQUIREMENT & ECONOMICS

- Weeds are more susceptible to flame when they are young seedlings 1-2 inch tall or in 3-5 leaf stage, hence flaming at this stage found easy and economical.
- Approximately 10-20 kg of LPG is required to cover one acre of mulberry garden for weeding when the weed intensity is low and moderate. Weeds with heavy biomass consume about 30 kg / acre.



Flaming of parthenium in mulberry garden

- Thermal weeding was highly economical than manual weeding when the weed density is low.
- Increase in density narrow down cost reduction over manual weeding because of increased consumption of fuel and manpower to treat vast foliage.
- Flaming in addition to destroying the weeds, burns their seeds making unviable for germination. Hence, establishment of weeds takes longer time in the flamed plots than hand weeded plots.
- Therefore 2-3 flaming in a year assured weed free environment in the mulberry garden which curtailed more than 50% cost over manual weeding.

OBSERVATIONS OF THERMAL WEEDING

- All dicotyledonous weeds including *Parthenium* were controlled successfully by short term exposure. Monocotyledonous weeds needed slight higher exposure than dicots.
- Among menacing perennial grasses *Cynodon dactylon* found highly susceptible to flame *i.e.*, the recovery of plants was very low and it took more than 60 days where as *Cyperus rotundus* emerged quickly within a week which required repeated flaming for effective control.
- Mulberry stem found resistant to heat and hence flaming of weeds grown near to them and in the intra rows was shown no adverse effect to the plants.



Thermal weeding in mulberry garden

- Best result was noticed under windless condition or flaming towards the wind direction was effective. Early morning or evening are the best time for flaming to observe the flame patterns and adjust the equipment.
- The flame is not intact with soil directly at the time of flame weeding, since it covers only the green mass of the weeds as well as fast swing movement of flame. Hence, there is no chance of adverse effect on soil texture and beneficial micro flora.

ADVANTAGES

- Thermal weeding is effective, easy to apply (user friendly), economic compared to other weed management practices, eco-friendly and helps to avoid use of harmful weedicides in mulberry ecosystem.
- The problem in hand weeding due to scarce in agriculture labour may easily be managed by adopting thermal weeding in mulberry garden.
- Thermal weeding also feasible to suppress the weed population by *in situ* flaming in grown-up garden. This practice under certain circumstances was found essentials to avoid the seed setting in weeds and its dispersal.
- Flaming also helps to check the spread of harmful pests like leaf roller (*Diaphania pulverulentalis*), spiralling whitefly (*Aleurodicus dispersus*), papaya mealy bug (*Paracoccus marginatus*) *etc.*, by destroying the pest's population in fallen mulberry leaves, weed hosts and soil.

- During hand / mechanical weeding processes the matured seed was dropped into the soil which led to continuous growth of weeds throughout the year. But flaming burns the seeds or makes them unviable for germination which prevents repeated growth of weeds and assures great reduction in weed population.
- Further, thermal weeding curtails >90% man power compared to manual weeding. Hence thermal weeding reduces weeding cost in a greater way as well as cost of cocoon production and increases the net profit to the sericulture farmers.

2.3.2 BLACK POLYTHENE MULCHING FOR WEED CONTROL AS WELL AS WATER ECONOMY



Mulching with scrap black polythene sheet

Being a widely spaced crop, mulberry suffers heavy yield loss due to growth of number of weed species especially under irrigated condition which reflect adversely on silk worm cocoon productivity and profit of the farmers. But under the prevailing situation of shortage of agriculture labour and hike in wage rate, the weed management becomes cumbersome

and the expenditure on weeding attributes significant increase in cost of cocoon production.

Concurrently, another greatest threat in maintaining sustainable sericulture is availability of irrigation water as the water table is going down year by year and the cocoon productivity is getting reduced mainly in summer season due to shortage of water in many areas. Hence water management is also equally important to sustain the sericulture activities. A major portion of the irrigated water in mulberry garden is wasted due to evaporation and consumption by competitive weeds.

Mulching in agricultural crops especially in vegetable gardens is an age-old practice in many countries. Though number of organic and synthetic materials suggested for mulching, black polythene sheet found predominant. It prevents the weed growth due to its opaqueness, conserves the soil moisture, enhances the temperature of root zone and hence renders fast crop development and higher yield.

Black polythene sheet

Numbers of mulch materials like green manures, straw, coconut leaves, saw dust, coir dust, dry weed, papers, hay, water hyacinth, polythene sheets *etc.*, are generally recommended for agricultural and horticultural crops. In mulberry garden mulching with green manure crops and pruned mulberry twigs are commonly practiced. In recent past, mulching with black polythene sheets become popular as it is found very effective in control of weeds and conservation of soil moisture in vegetable gardens. Woven polythene fabric is commercially available for mulching in developed countries.



A view of mulched row free from weeds after growth of mulberry

How to mulch?

A) In mulberry garden

Black Low Density Poly Ethylene (LDPE) sheets of 200 gauges were used as mulch material. The scrap polythene sheets can be purchased @ Rs. 20/- per kg and used. However fresh material is available in whole sale market as roll @ Rs. 40-50/. It is estimated about 200 kg of sheet is required for one acre of mulberry garden costing about Rs. 4,000 to 8,000 depending upon the quality. The mulching was applied after pruning of mulberry plants and application of fertilizers, by spreading the black polythene sheets between the rows of the plants even over the grown up weeds. The sheet should be adequately suppressed to the ground with little soil or mud so that it should not get displaced due to wind.

The mulch between wider rows (5'gap) were kept without disturbance permanently in subsequent crops where as the polythene sheets spread over the narrow space (3' gap) were opened temporarily after each pruning for application of fertilizers but again covered before irrigation. The irrigated water percolates in the open soil of entire row near stem area of the plants. The mulch is also compatible with drip irrigation system.



A view of weeds suppressed under black polythene mulch



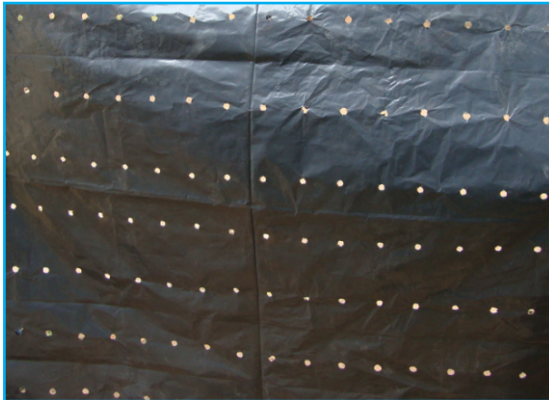
Comparative view of weed growth in mulched and non-mulched portion

B) In nursery

The land will be prepared using the routine agronomic practices recommended for raising the nursery. Pre-punching of black polythene sheets according to the spacing between the rows and cuttings will facilitate easy operation. The sheets are spread over the plots after irrigation and the cuttings are inserted into the soil through the holes.



Preparation of nursery bed



Pre-holed black polythene sheet & Spreading the sheet over the plot after irrigation



Planting the cuttings



View of un-mulched plots



Weed growth one month after plantation in mulched & un mulched plots

IMPACT OF BLACK POLYTHENE MULCHING

A) In mulberry garden

Black polythene mulch showed high efficiency in controlling weed population in mulberry garden as well as in conservation of soil moisture compared to unmulched and hand weeded plots which reflected positively on plant growth and leaf yield.

Black polythene mulch plays vital role in suppression of the weed population due to its quality of opaqueness and the expenditure on weeding is reduced more than 90% compared to hand weeding method. Further the problem in hand weeding due to scarce in agriculture labour may easily be managed by adopting this technology in mulberry garden.

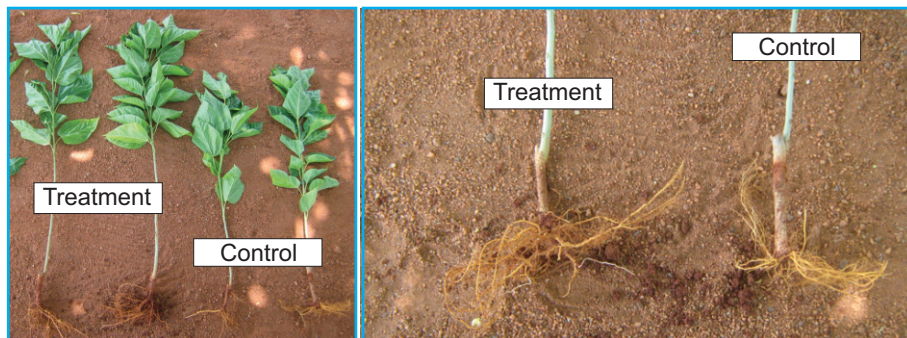
About 25-50 % of irrigated water is wasted due to its evaporation from soil surface. The polythene mulch prevents soil water evaporation and thus helps to retain soil moisture. The moisture conservation in summer helps the farmers to harvest quality mulberry leaves even after postponing the irrigation to some extent due to scarcity of irrigation water. This technology also helps to improve the mulberry productivity under rain fed condition by conserving available soil moisture.

It is reported that the black sheet mulching enhances the root-zone temperature by absorbing the radiation. Such modification in soil micro - climate *i.e.*, increases in soil temperature and moisture, promotes faster crop development and higher yield.

B) In nursery

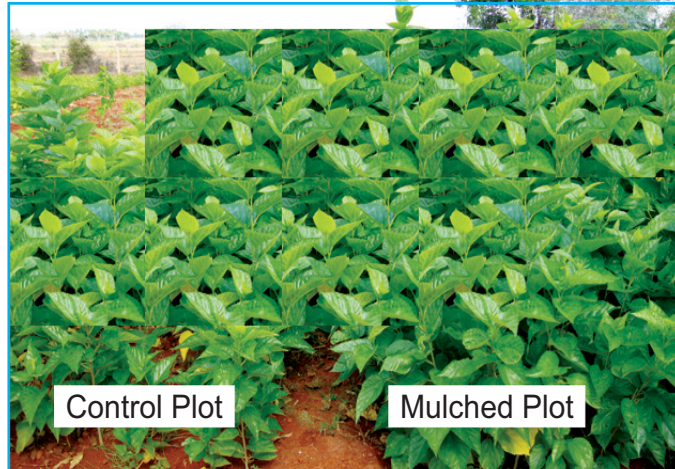
Nurseries often suffer in initial stage due to predominant growth of weeds. In many cases the growth of weeds overwhelms before sprouting of cuttings. In this stage weeding is cumbersome and needs much care because disturbance of cuttings before rooting resulted with failure of sprouting. The weeds in nursery compete with the saplings for water, space and nutrition which drastically affect the rooting and growth.

Black polythene mulching in nursery resolves above problems as the growth of weeds is more or less nil in the mulched plots. The beneficiary effect of this technology *viz.*, arrest of weed growth, retention of soil moisture, increase of root zone temperature is attributed to increase in sprouting percentage, rooting and growth of saplings in the mulched plots than un-mulched one. The establishment of transplanted saplings obtained from the mulched plot is found recorded higher (98.67%) than the saplings of un-mulched plots (80.53%) due to their increased vigour.



Comparative height and root mass of saplings in mulched and control plots & Comparative stem girth and root formation of saplings in mulched and control plots

Black polythene mulching is effective and economic and plays vital role in control of weed population as well as conservation of soil moisture in mulberry garden and nursery. Therefore this technology helps the sericulture farmers to manage the prevailing situation of scarce in agriculture labour, to reduce weeding expenditure as well as to economize the irrigation water. Further this technique also improves the leaf productivity in mulberry garden and sapling production in nursery as it alters soil micro-climate favourably for growth of plants.



Comparative growth of saplings in control and mulched plots

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Designed and Printed by :

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Water Jetting



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NEW VISTA OF ORGANIC FARMING IN MULBERRY

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