

Bridging the Gap: Agronomical Constraints and Extension Needs in Mulberry Farming - A Case Study

Chandrashekharaiyah, M^{1*}; Prashant Natikar²; Sahana KP³; Tulsi Naik KS⁴; Aruna AS⁵; Manthira Moorthy S⁶

^{1,4,5}Silkworm Seed Production Center, NSSO, Central Silk Board, Mysore

²Silkworm Seed Production Center, NSSO, Central Silk Board, Bangalore

³Basic Seed Farm, NSSO, Central Silk Board, Dharmapura

⁶National Silkworm Seed Organization, Central Silk Board, Bangalore

*Corresponding Author

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Abstract— Mulberry cultivation is essential for successful sericulture, as the quality of leaves directly impacts the growth of silkworms, cocoon yield and silk quality. However, various agronomic challenges such as poor soil fertility, waterlogging, improper nutrient management, pest and disease outbreaks, continuous cropping and inadequate residue handling can lead to reduced leaf quality and plant vigour. Improper practices like mulching of mulberry twigs, indiscriminate disposal of pruning residues, and neglect of pruning or canopy management further compound these issues. This case study documents these prevalent constraints through systematic field observation and interaction with sericulture farmers in Karnataka. Implementing sustainable practices such as soil testing, balanced fertilization, organic matter incorporation, moisture conservation, proper pruning, pollarding and residue management in a scientific manner can enhance leaf nutrient composition, improve photosynthetic efficiency, reduce pest and disease incidence, and boost overall productivity. Bridging the knowledge gap through extension services, training and field demonstrations is essential to promote these practices, ensuring high-quality mulberry leaf production, sustainable sericulture, and enhanced livelihoods for farmers.

Keywords— Mulberry, Sericulture, Silkworms, Knowledge gap, Agronomic constraints, Extension services.

I. INTRODUCTION

Mulberry plants require optimal soil, climate, nutrients, water, and their management practices to produce high-quality leaves suitable for silkworm rearing. Healthy silkworm growth and cocoon productivity depend on leaf moisture, protein content, sugars, vitamins and mineral composition. Mulberry thrives in deep, well-drained loamy soils with a slightly acidic pH and high organic matter, supporting strong root development and nutrient uptake. Moderate temperatures of 24–28°C, 70–80% relative humidity and adequate sunlight with protection from extreme heat promote tender, succulent leaves preferred by silkworms (Dandin et al., 2003). Consistent soil moisture without waterlogging enhances leaf moisture and protein levels. Balanced nutrient management with nitrogen, phosphorus, potassium, secondary nutrients (calcium, magnesium, sulphur) and micronutrients (zinc, iron, manganese, boron, copper) maintains high chlorophyll content and biochemical composition. Proper pruning, timely harvesting of chawki leaves, efficient irrigation at critical stages, organic amendments and integrated pest and disease management ensure continuous production of nutritious foliage. Selecting high-yielding, high-nutrition mulberry varieties improves leaf quality and productivity, benefiting larval growth, cocoon weight, silk filament length and sericultural profitability.

Mulberry plants will become weak and produce low-quality, poor nutritious leaves when exposed to a combination of soil, climate, nutrient, water, pest, and management stresses that disrupt their physiological processes. Factors such as poor soil fertility, imbalanced nutrient supply and low organic matter can reduce root development and limit the uptake of essential nutrients crucial for leaf protein, chlorophyll and moisture content. Water stress from irregular rainfall, inadequate irrigation or prolonged drought can decrease photosynthesis and lead to coarser leaves, while waterlogging can damage roots and reduce nutrient availability. Extreme temperatures, low humidity and high solar radiation can further impact leaf tenderness and biochemical quality required for silkworm digestion. Soil acidity, salinity and compaction can restrict root growth and nutrient absorption, while continuous monocropping without soil amendments can deplete nutrients and decrease microbial activity. Pest and disease attacks, such as nematode infestation, leaf spot, rust, powdery mildew, rot, borers, whitefly, thrips, jassids, leaf roller, mites and tukra etc., can cause leaf damage, chlorophyll loss and reduced photosynthetic area, directly affecting leaf nutrient composition. Inadequate pruning, poor canopy management and improper harvesting intervals can result in aged, fibrous leaves with reduced protein and moisture content. Additionally, using unsuitable or low-yield varieties not adapted to local agro-climatic conditions can contribute to weak growth and inferior leaf quality. These biotic and abiotic stresses collectively weaken the plant's physiological vigor, disrupt nutrient metabolism and ultimately lead to poor-quality mulberry leaves that do not meet the nutritional needs of silkworms.

Mulberry cultivation and silkworm rearing are highly skilful and proper management practices essential for achieving crop success. Many farmers who are being engaged in sericulture for the past three decades have acquired practical knowledge through experience and learning from fellow farmers. Skilled farmers are able to assess mulberry crop stages and implement timely pruning, nutrient application, irrigation, weed management and pest and disease control to ensure the production of high-quality leaves. They also rely on visual observations of leaf quality to determine suitability for silkworm feeding, thereby safeguarding crop productivity. However, the majority of farmers fail to recognize several non-productive practices that reduce silkworm productivity, either immediately or over the long term.

This case study documents these critical agronomic constraints observed during field engagements with sericulture farmers in Karnataka and provides scientific analysis to bridge the knowledge-practice gap through targeted extension.

II. METHODOLOGY AND CASE STUDY CONTEXT

This study is based on systematic field observations and interactions conducted by the authors from the Central Silk Board's National Silkworm Seed Organization (NSSO) during regular extension and monitoring activities in sericulture zones of Karnataka during 2024. The methodology involved direct field assessment of mulberry gardens, photographic documentation of prevalent practices, and discussions with sericulture farmers to understand their rationale and challenges. The observations are compiled from more than 50 farmer interactions and field visits, focusing on identifying gaps between recommended scientific practices and on-ground implementation. This case-based, observational approach provides a diagnostic overview of key agronomic constraints requiring extension intervention.

III. DOCUMENTED AGRONOMIC CONSTRAINTS AND SCIENTIFIC ANALYSIS

Through field engagement, the following key agronomic constraints were consistently observed and documented:

3.1 Mulberry Twigs Mulching:

Mulberry twigs are generally woody in nature with high carbon and low nitrogen content. Therefore, they are not suitable for mulching in the mulberry gardens as such, because they require very high nutrients for regrowth immediately after pruning. Spreading and incorporation of mulberry twigs after pruning will not decompose and release nutrients immediately. However, dry twigs provide some benefits in mulberry gardens by conserving moisture and suppressing weeds. Scientific composting requires a suitable carbon-to-nitrogen (C:N) ratio and a suitable microenvironment for microbial growth and multiplication. It is a thumb rule that a ratio of 25:1 to 30:1 (carbon:nitrogen) should be maintained during composting. Mulberry twigs are generally rich in carbon and require a higher nitrogen substrate to balance the nutrient status.



FIGURE 1: Pruned mulberry twigs are evenly spread in the field to act as mulch

During the regular crop production process, the application of nutrients to the mulberry gardens implemented with twig-mulching will cause the diversion of nutrients. Mulberry twigs with a high C:N ratio (similar to wood) invariably cause nitrogen immobilization (Dandin et al., 2003). During the decomposition process of the dry twigs, the microorganisms involved in decomposition depend on available nitrogen, which is supplemented through external application, for their growth. They will scavenge nitrogen from the soil, making it temporarily unavailable to the mulberry plants. The nutrients applied will be fully utilized by the microorganisms instead of the growing mulberry plants and the microflora multiplies adequately to break down the organic matter efficiently. Therefore, dry mulberry twig mulching does not significantly contribute to soil nutrient cycling or moisture conservation, making it an unsuitable practice for commercial mulberry production.

3.2 Improper Utilization of Farm Wastes:

Composting of sericulture wastes promotes a circular economy by transforming waste into a valuable resource. One hectare sericulture farm generated approximately 15-20 MT of waste per year, which is very rich in macronutrients N, P, K as well as micronutrients like Fe, Zn, and Cu etc. Dry twigs obtained after pruning/pollarding, leftover mulberry leaves and leftover bedding materials after silkworm rearing including larval excrement, droppings and residual leaves can be utilized for composting. Seri wastes are also utilized for vermicomposting. The Vermicomposting process requires about 50-60 days while anaerobic composting takes about 120-150 days (Subbulakshmi Ganesan et al., 2022). Composting mulberry twigs requires mixing of chopped mulberry twigs (to increase surface area), dry leaves (to balance C:N ratio), sawdust / chopped woody materials, cow dung and other degradable farm wastes in the composter along with little quantity of urea as source of nitrogen for microorganism. Maintaining 45-60 per cent moistures in the mixture is essential for better growth and multiplication of microorganisms. Sudhakar et al., (2018) reported that about 8 MT compost can be generated from the seri-wastes. Burning mulberry twigs in certain places creates air pollution. Instead, preparing biochar from the leftover mulberry twigs can be a useful technique for carbon sequestration to mitigate greenhouse gas emissions. Soil application of biochar increases beneficial soil organisms, improves nutrient recycling, and helps to remove heavy metals and organic contaminants from the soil.



FIGURE 2: Mulberry twigs removed during pruning are dumped outside the field or burnt

Improperly disposing of mulberry twigs by dumping them outside the fields creates ideal microhabitats for several insect pests and disease-carrying organisms. The decomposing twigs provide shelter, breeding sites and resting places for pests such as stem borers, mealybugs, grasshoppers, Mollusca's, mites, and other field-dwelling insects. These organisms can survive unfavorable conditions inside the discarded plant material and later migrate into healthy mulberry fields, causing new infestations. This movement poses a continuous threat to existing crops, reducing plant vigor, leaf yield and overall mulberry garden productivity. Therefore, implementing scientific waste management practices—such as shredding, composting, or controlled incineration—is essential to prevent pest buildup and safeguard crop health.

3.3 Water Logging Conditions:

Mulberry plants susceptible for water stagnation and affects oxygen supply to root system. Water stagnation in the mulberry gardens due to continuous raining creates both hypoxia and anoxia conditions. Leading to yellowing of leaves resulting in reduced chlorophyll and carotenoid contents. Therefore, shortage of quality leaf is the major constraints during continuous raining and waterlogging situations. Constructions of drainage system across slopes can effectively drain out the excess water from the fields. The following effects are observed in mulberry crop under waterlogging conditions:

- Insufficient oxygen inhibits ATP production in roots, impacting nutrient and water uptake.
- Waterlogged soils hinder nutrient absorption, particularly nitrogen, potassium, and magnesium. Toxic ions like Fe^{2+} and Mn^{2+} can accumulate, leading to nutrient toxicity.
- Impaired root function slows shoot growth and leaf expansion, resulting in premature leaf yellowing and shedding due to disrupted nutrient transport.
- Oxygen-deprived conditions stimulate ethylene production, causing leaf epinasty, abscission, and growth inhibition.
- Excess water in soil encourages fungal / bacterial pathogens like Phytophthora and Pythium, Fusarium leading to root rot and plant vulnerability to diseases.
- Chlorosis and stomatal dysfunction reduce photosynthesis, diminishing leaf yield and silk production potential.



FIGURE 3: Mulberry garden in the waterlogged condition

3.4 Neglect of Side Branch Clipping and Canopy Management:

Clipping of unproductive branches redirects nutrients and resources to productive branches, enhancing the quality of mulberry leaves by boosting photosynthetic activity. Non-productive side branches, being less vigorous, consume vital resources that could otherwise support the growth of productive branches. It enhances better light penetration and air circulation in the canopy, reducing pest and disease incidence by creating a less favourable environment for their development (E.g. Infestation of sucking pests, Powdery mildew disease).



FIGURE 4: Mulberry plants, with well-developed main and side branches ready for harvesting

Opening up the canopy structure through pruning improves air circulation and reduces humidity, modifying the microclimate to deter fungal diseases that thrive in damp conditions. Additionally, removing dense growth and eliminating dead, diseased, or damaged branches reduces hiding spots for pests and prevents the spread of diseases / pest inoculants.

3.5 Lack of Rejuvenation through Pollarding/Pruning:

It is a pruning technique followed after each crop to maintain specific height of the plant with fresh growth for commercial sericulture activities. It helps new branches grow luxuriously by utilization of sunlight and nutrients. The process also encourages dormant buds to sprout by rejuvenating old trees. Pollarding in mulberry plantation breaks the lifecycle of pests' attack and wind damage.



FIGURE 5: Old mulberry plants with poor vigour are prone to termite infestation, whereas rejuvenated plants demonstrate enhanced growth and vitality

3.6 Continuous Cropping Practices:

Continuous cropping pattern within the locality supports dispersal of crop pests and diseases propagules from old plantations to new plantations. Hence, discrete cropping pattern in a locality discontinues / breaks the life cycle of pest / diseases from a crop to the subsequent crops and avoid its spread.



FIGURE 6: Coexistence of early and late age mulberry plantations, where mature and fresh leaves are simultaneously available, create a conducive environment for pests, diseases to spread from late to early stage garden

3.7 Leaving Crop Residues after Every Harvest:

Leaving crop residues (such as pruned shoots, fallen leaves, and harvest remains) in the mulberry field after each harvest is a common practice among farmers. However, when it is being practice without scientific management, it can pose significant agronomic challenges in mulberry seed crop farming.



FIGURE 7: The emergence of new shoots from leftover twigs after leaf harvesting for silkworm rearing using existing soil nutrients - A costly practice

- Residues serve as shelters and breeding grounds for pests like stem borers, mealybugs, mites, thrips, jassid, grasshoppers and Snails
- Disease-causing organisms (fungi, bacteria) survive in the infected residues and act as primary sources of infection for the next crop.
- The continuous presence of residues facilitates the carry-over and rapid spread of pests and diseases within and between fields.
- Accumulated residues hinder field operations such as irrigation, fertilizer application and intercultural practices.
- Residue piles create humid microclimates conducive for pests / disease fungal diseases.
- Weed growth is more under partially decomposed residues.
- Natural decomposition of residues is slow under field conditions.
- Nutrients trapped in residues are not readily available during critical growth stages, reducing fertilizer efficiency.

IV. RECOMMENDATIONS FOR EXTENSION AND SUSTAINABLE PRACTICES

Based on the documented constraints, the following practices should be promoted through extension services to ensure soil and crop health and attain sustainability:

1. **Soil testing** at least once in two year before applying fertilizer to check levels of macro-nutrients (N, P, K), pH, organic carbon and available micronutrients. Use the test results to customize your fertilizer application instead of relying on general guidelines. Seek assistance from local agricultural extension services or soil laboratories / KVKs / Institutes for accurate testing. By avoiding both poor and over-fertilization, one can save costs, preserve soil health, and improve leaf quality and yield.
2. **Balanced fertilizer application:** Apply the recommended NPK rates (e.g. 350:140:140 kg/ha/yr) (Dandin et al., 2003) divided throughout the crop cycles. Adjust based on soil test results. Supplement with secondary nutrients and micronutrients if deficient. Utilize a combination of organic sources and chemical fertilizers for optimal results. This approach promotes sustained yields, improves nutrient use efficiency and minimizes environmental impact.
3. **Organic matter management:** Involves regular application of farmyard manure (FYM), compost, green leaf manuring or green manures. Intercropping or cover cropping with legumes can also be beneficial. Composting crop residues helps to improve soil structure, water retention capacity, microbial activity, and erosion control.
4. **Adjust pH and soil chemistry:** Apply lime in acidic soil (pH <6.2) and gypsum in alkaline soil. Correct pH to unlock nutrients like phosphorus (P) and zinc (Zn) for improved nutrient availability, reduced wastage and healthier plants.
5. **Moisture Conservation and Efficient Irrigation:** Utilize mulches, create basins or furrows, capture runoff, consider drip or enhanced irrigation methods and adjust irrigation timing to align with crop growth stages. These practices can lead to decreased water stress, improved nutrient absorption and reduced leaching.
6. **Reduced tillage and proper soil management practices:** Involves limited deep tillage, avoiding excessive disturbance, promoting root health and rotating or resting areas when possible. These practices help prevent compaction, preserve soil structure and reduce erosion.
7. **Education/Extension Support:** Training farmers on fertilizer application based on soil test results, demonstrating more efficient practices through plots and conducting cost-benefit analyses to illustrate long-term profitability of sustainable methods. This approach aims to enhance adoption rates, promote peer learning and improve overall uptake of sustainable farming practices.

V. CONCLUSION

The sericulture farmers do possess rich experiential knowledge, still gaps persist in recognizing the long-term impacts of sub-optimal agronomic practices. Bridging these gaps requires strong extension support, field demonstrations, soil-based advisory services, and promotion of scientific residue and water management. Adoption of these practices will enhance mulberry leaf quality, improve silkworm performance, and ensure sustainability in yield and livelihoods.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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