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Integrated Soil Nutrient Management in Mulberry under Temperate Conditions

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Abstract: The State of Jammu and Kashmir represents the traditional mulberry sericulture under the temperate belt. Sericulture involves agriculture, art, culture, civilization and reflects the industry. Mulberry is grown in varied climatic conditions ranging from temperate to tropics. In past sericulture was domain of temperate regions. Majority of Sericulturist in these traditional areas have taken up mulberry cultivation on small land holdings as a life sustaining occupation. As a result of financial constraints and ignorance on the part of majority of stakeholders and many others, mulberry is largely cultivated in nutrient deficient systems. Sericulture in the region however, sustains on tree type of plants which are available on road side, bund side, river side and borders of agricultural fields etc. Also not much importance is given to available nutrients in the soil. Due to the above constraints, the yield of mulberry is low in the conventional areas. Also, the leaf quality gets affected especially without application of any inputs. Thus, intern affecting the production and quality of silk. The analysis of soil samples at CSR&TI, Pampore, had shown wide variation in pH and EC in different seasons. Macro and micro-nutrients status in soil plays important role in the life cycle of plant as major physiological process sustains on proper concentrations of these nutrients. Therefore, refinement is needed in package and practice for propagation of these plant materials. Attempts are also required to be made plant, to define ways for improvement and proper management of leaf quality and soil health.

Key words: Mulberry · Nutrients · Sericulture · Soil · Temperate

INTRODUCTION

Jammu and Kashmir is a traditional sericulture state. Mulberry silk contributes to the major production among other types of silks. Kashmir valley represents the temperate climatic conditions and is well suited for the bivoltine sericulture. Mulberry is a hardy, perennial, deep rooted plant capable of thriving under diverse agro-climatic conditions [1-2]. The sericulture in the region however, sustains on tree type of plants which is available on road side, bund side, river side and borders of agricultural fields etc. As a result, mulberry is largely cultivated in nutrient deficient systems. Due to the above constraints, the quality and yields of mulberry are low in the conventional areas. Owing to the limited cropping pattern intensive plantation is not taken up at the commercial level. Beside this, leaf quality plays an important role in successful rearing and production. So, attempts are also required to be made to define greener ways to improve leaf quality.

Majority of rearers in the traditional areas have taken up mulberry cultivation on small land holdings as a life sustaining occupation. Other farmers with more land have taken up mulberry sericulture only as an additional occupation since they cultivate a wide variety of other crops (Apple, Almond, Saffron and Peach) in the major portion of their land. The genotypes which have over the years, became popular in the region are of Japanese origin are poor rooters, when propagated through stem cuttings the survivability is very poor. Therefore, refinement is needed in package and practice for propagation of these plant materials at nursery stage. Fertilizer application is not followed by majority as mulberry survives over unfavorable climatic conditions and continuous to produce the leaf (though of poor quality) even under nutrient deficiency and moisture stress; mulberry is only an intermediate product (not directly sold for cash returns) and hence does not attract immediate attention of farmers; added to the climate unpredictability, an uncertainty regarding the success of silkworm crop does not persuade heavy investments with risks;

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as a result many farmers are happy with poor returns without investments. Moreover no seriousness is seen towards the availability of nutrients in the soil. Mulberry growers pay more attention towards the rearing but not towards the soil health. Soil is very important factor which has to be analyzed before the rearing as the nutrient status of the soil will determine the quality of leaf produced. Thus intern affecting the production of good quality of silk.

Lot of work has already been done on the yield attributing characters of the mulberry plantations available here in this region. Biochemical analysis of various types of plantations available in this region will help in better characterization and utilization of plant material. It will also help in improving present knowledge, understanding various seasonal biochemical changes and developing ways to prevent/ developing abiotic and biotic stress tolerance in this species. The paper focuses on different ways to sustain soil health status in temperate ecosystems.

Plant Nutrients: Seventeen chemical elements are known to be important to a plant's growth and survival. These chemical elements are divided into two main groups: non-mineral and mineral.

Non-Mineral Nutrients: The Non-Mineral Nutrients are hydrogen (H), oxygen (O) & carbon (C). These nutrients are found in the air and water. In a process called photosynthesis, plants use energy from the sun to change carbon dioxide (CO_2-carbon and oxygen) and water (H_2O- hydrogen and oxygen) into starches and sugars. These starches and sugars are the plant's food. Plants get carbon, hydrogen and oxygen from the air and water.

Mineral Nutrients: The nutrients, which are up taken from the soil, are dissolved in water and absorbed through a plant's roots. There are not always enough of these nutrients in the soil for a plant to grow healthy. This is why mostly we use fertilizers to add the nutrients to the soil. The mineral nutrients are divided into two groups:

Macronutrients: Macronutrients can be broken into two more groups: primary and secondary nutrients. The primary nutrients are nitrogen (N), phosphorus (P) and potassium (K). These major nutrients usually are lacking from the soil first because plants use large amounts for their growth and survival. The secondary nutrients are calcium (Ca), magnesium (Mg) and sulphur (S). There are usually enough of these nutrients in the soil so application of fertilizer is not always needed. Also, large amounts of Calcium and Magnesium are added when lime is applied to acidic soils. Sulphur is usually found in sufficient amounts from the slow decomposition of soil organic matter, an important reason for not throwing out grass clippings and leaves.

Micronutrients: Micronutrients are those elements essential for plant growth which are needed in only very small (micro) quantities. These elements are sometimes called minor elements or trace elements, The micronutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn). Recycling organic matter such as grass clippings and tree leaves is an excellent way of providing micronutrients (as well as macronutrients) to growing plants.

The terms essential plant nutrient or essential mineral element were formed to describe the minerals needed by plants to grow and complete life cycles. Essential plant nutrients must be directly involved in some aspect of the plant metabolism such as structural material, enzymes or hormones and they must not be totally replaceable by another mineral element. Plant nutrition is the study of the chemical elements that are necessary for plant growth. A nutrient that is able to limit plant growth according to Liebig's law of the minimum is considered an essential plant nutrient if the plant can not complete its full life cycle without it. There are 17 essential plant nutrients. Carbon and oxygen are absorbed from the air, while other nutrients including water are obtained from the soil. Nutrients are recycled in nature through the process of nutrient cycle (Fig.1).

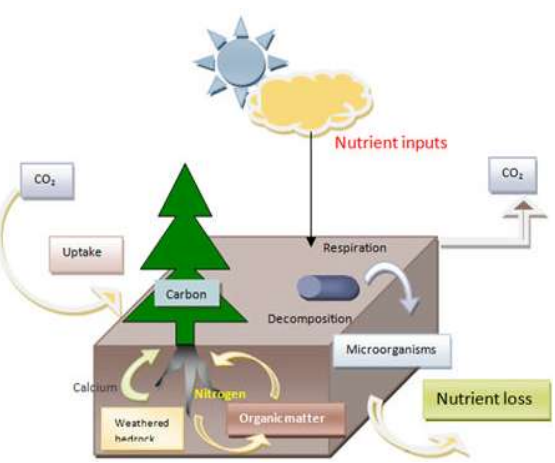

Fig. 1: Diagram showing nutrient cycling in nature

Soil Health: In general, most plants grow by absorbing nutrients from the soil. Their ability to do this depends on the nature of the soil. Depending on its location, a soil contains some combination of sand, silt, clay and organic matter. The makeup of a soil (soil texture) and its acidity (pH) determine the extent to which nutrients are available to plants. Soil Texture (the amount of sand, silt, clay and organic matter in the soil) affects how well nutrients and water are retained in the soil. Clays and organic soils hold nutrients and water much better than sandy soils. As water drains from sandy soils, it often carries nutrients along with it. This condition is called leaching. When nutrients leach into the soil, they are not available for plants to use.

An ideal soil contains equivalent portions of sand, silt, clay and organic matter. Soils across the valley diverge in texture and nutrient content, which makes some soils more productive than others. Sometimes, the nutrients that plants need occur naturally in the soil. Other times, they must be added to the soil as lime or fertilizer. Soil pH (a measure of the acidity or alkalinity of the soil) is one of the most important soil properties that affect the availability of nutrients to the plants [3]. Macronutrients tend to be less available in soils with low pH. Micronutrients tend to be less available in soils with high pH. Valley soil exhibits great variability in soil pH and macronutrients status during different seasons of the year and at different locations (Tables 1&2). Lime can be added to the soil to make it less sour (acid) and also supplies calcium and magnesium for plants to use. Lime also raises the pH to the desired range of 6.2 to 6.8. If the pH is highly alkaline gypsum can be used for reclamation. In some places ammonium sulphate in place of urea has also been used for reclamation alkaline soils. Another problem created by an imbalance of pH is the buildup of toxic salts, which prevents roots from absorbing water. In pH range 6.2-6.8, nutrients are more readily available to mulberry plants and microbial populations in the soil increases. Microbes convert nitrogen and sulphur to forms that plants can use. It is a good to have soil tested, will get a report about the status of Micro and macro nutrient status in the soil and depicts how much amendments and fertilizer the crop needs to get quality yield [4-5].

Green and Organic Manure application: Green manuring is an age-old practice of growing leguminous plants and incorporating the same in the soil. Green manuring plants can fix atmospheric nitrogen in the soil by the action of root nodule bacteria (*Rhizobium)*. In mulberry garden green manuring is done by growing short duration green manuring crops like pea (*pisum sativum*) and masoora (*Phaseolus aureus*) in November-December. Before flowering, the green plants are cut into small bits and incorporated into the soil by digging or ploughing. This helps in increasing soil organic matter and also supplies additional nitrogen besides improving soil structure and water holding capacity of the soil.

Organic manures are obtained from decaying plant and animal material. It plays an important role in building up soil fertility and increasing moisture holding capacity and growth of micro-organisms in the soil [6-7]. It also improves micro-nutrient levels and the physical condition of the soil. Hence, application of adequate quantity of organic manure to maintain the fertility status of the soil is very essential. The common organic manure used in mulberry garden is farmyard manure (FYM).

Table 1: Variation in soil pH at different CSR&TI units in autumn and spring seasons

SITE	pH (Autumn)	EC (Autumn) dS/m	pH (Spring)	EC (Spring) dS/m
REC TRAL	5.98-6.67	0.15-0.21	5.23 -7.93	0.11-0.29
CSR&TI, PAMPORE	8.03-8.69	0.27-0.47	6.62-8.37	0.14-0.27
REC Y. K. PORA	7.10-7.53	0.14-0.30	6.46-6.94	0.13-0.24
REC BANDIPORA	8.21-8.94	0.11-0.14	6.09 -7.83	0.12-0.18
P4 MANASBAL	7.03-7.71	0.20-0.25	6.37-8.45	0.14-0.22

Table 2: Variation in macronutrients status at different CSR&TI units in autumn season

Site	Available N Kg/ha	Available P Kg/ha	Available K Kg/ha
CSR&TI, PAMPORE	341.33	31.2	236.3
REC TRAL	393.25	49.3	282.2
REC Y. K. PORA	234.52	21.6	155.7
REC BANDIPORA	271.41	37.8	289.0
P4 MANASBAL	389.82	41.2	294.6

The compost or vermicompost is very useful in increasing the nutrient availability to the plants. Under irrigated conditions, farmyard manure is applied at the rate of 20 tones per hectare per year, whereas, under rainfed conditions, 10 tones farmyard manure is applied per year hectare of mulberry plantation during November-December. The farmyard manure should be fully decomposed in a pit prior to its application and should be thoroughly mixed with the soil. As the availability of good farmyard manure is becoming difficult day by day, it is highly beneficial for the farmers to prepare compost or vermicompost using sericultural farm residues like silkworm litter, rearing bed refuses, leftover mulberry twigs and other decomposable organic materials like weeds, leaves, green twigs etc.

Biofertilizers: Biofertilizers (microbial manures) are live preparations containing nitrogen fixing or phosphate solubilising micro-organisms used as field inputs to improve soil fertility, plant growth, crop production and protection [8-10]. Being cost effective and eco-friendly, use of biofertilizers is gaining momentum with mulberry being no exception. Researches carried out at C. S. R. & T. I. Pampore have revealed that the use of biofertilizers can lead to the curtailment of chemical nitrogen and phosphorus up to the extent of 50%, thereby helping check the environmental pollution, besides, being cost effective.

The two products easily available in the market are Nitrofert (*Azotobacter chrocosum*) and Phosphofert (*G. mosseae*). These can be handled very easily. Nitrofert biofertilizer is a bacterial preparation of live *Azotobacter chrocosum* cells blended with peat soil, charcoal, FYM in powdered form as carrier containing 10^{8-9} cells per gram applied in soil as a partial substitute to nitrogenous fertilizer. Phosphofert (Arbuscular Mycorrhizal Fungi) biofertilizer is of fungal origin, symbiotic in nature, containing mycelia and spores of AMF in rhizosphere soil which enhances mobilization, diffusion, absorption and uptake by plants especially in phosphate deficient soils [11].

Application of Chemical Fertilizer: Mulberry is a nutrient hungry plant. The requirement of major nutrients especially nitrogen is very high compared to other crops as it is fast growing and grown mainly for its leaf which is harvested two times in a year. Hence, application of recommended dose if of chemical fertilizers is essential as fertilizers break down quickly and the nutrients are readily available to the plants for quick and luxuriant growth. The readily available chemical fertilizers available in Kashmir are: Urea, DAP and MOP. In temperate regions, the recommended dose of fertilizer for dwarf and bush type of plantation under irrigated conditions after fourth year of establishment is 300kg 'N': 120kg 'P': 120kg 'K' per year per hectare and 100kg 'N': 50kg 'P': 50kg 'K' per year per hectare under rainfed conditions [12]. The quantity of fertilizer application also depends on the system of cultivation (Tables 3 & 4).

As mulberry is mainly cultivated as tree in temperate region like Kashmir, the schedule of application of chemical fertilizer for such type of plantation is also region

Table 3: Recommendations for macro and micro nutrients enrichment in mulberry plantation

Nitrogen (N):	Application of 300 kg N/ha/yr in two equal splits @ 150 kg N/ha/crop, about 20 days before silkworm brushing.
Phosphorus (P):	Application of 120 kg P_2O_5/ha/yr. It should be applied near root zone at the depth 30-50 cm from soil surface. During the month of December (Soil application).
Potassium (K):	Application of 120 kg K_2O/ha/yr. During the month of December (Soil application).
Calcium (Ca):	Soil pH should be determined and if the soil is acidic, apply lime @ 1.0 MT/ha every 4-5 years.
Magnesium (Mg):	Aqueous solution of 0.2 -0.5% Magnesium Sulphate/ha/crop should be sprayed over the leaves of deficient plants.
Sulphur (S):	Application of 0.1-0.2% aqueous solution of potassium sulphate, sprayed on deficient plant.
Boron (B):	Aqueous solution of 1.0 kg Boric acid/ha/crop should be sprayed over the leaves of deficient plants.
Copper (Cu):	Aqueous solution of 1.0 kg Copper Sulphate/ha/crop should be sprayed over the leaves of deficient plants.
Iron (Fe):	Aqueous solution of 1kg Ferrous Sulphate/ha/crop should be sprayed over the leaves of infected plants.
Manganese (Mn):	Aqueous solution of 1.0 kg Manganese Sulphate/ha/crop should be sprayed over the leaves of deficient plants.
Zinc (Zn):	Aqueous solution of 2.0 kg Zinc sulphate/ha/crop should be sprayed over the leaves of deficient plants.

Table 4: Fertilizer application requirement per year per hectare (kg) in tree type of Mulberry Plantation

	Year of plantation			
Fertilizer	I Year	II Year	III Year	IV Year onwards
Nitrogen (N)	50	100	200	300
Phosphorus(P)	25	50	75	120
Potash (K)	25	50	75	120

Fig. 2: Sprouting nature of winter Buds of promising mulberry genotypes as on 28 March, 2011 at CSR&TI, Pampore

specific. The chemical fertilizer should be applied in two doses, the first dose comprising of half of 'N' and full of 'P' & 'K' in the first fortnight of April and the remaining half of 'N' in the first week of July. The fertilizer should be applied immediately after digging and placed at a depth of 8" – 12" round the plants. Irrigation should be provided immediately after the application of fertilizers for better uptake of nutrients by the plants. In case of rainfed mulberry it is advisable to apply the fertilizers immediately after rains. Fertilizer application dates may also be scheduled according to the variety; for early sprouting varieties the application dates should be early for late sprouters the application may be delayed for some days (Fig. 2). However, to reduce the cost of cultivation and soil pollution, chemical fertilizers can also be supplemented through the use of bio-fertilizers.

Soil Moisture Conservation: The availability of irrigation or rain water in agriculture or in mulberry cultivation is becoming very much limited day by day due to gradual reduction in the ground water table. Hence, it is highly essential to conserve the soil moisture through different methods as described below for productive growth of mulberry plants:

- Fall ploughing: This is done by repeated ploughing of the land before irrigation or the onset of rainy season for maximum per collation of rain water.
- Compartmental bunding: Small sub-plots are made within the main plots with raised bunds to hold water in the sub-plots.
- Dead furrows with tide ridges: This can be adopted in relatively sloppy lands. The furrows should be intercepted with small bunds to stop run-off water.
- Growing green manure crops: Application of sufficient organic matter, tank slit and farmyard manures can be added to improve water- holding capacity of the soil. However, in the scarcity of these inputs, one can practice green manuring with leguminous plants like pea (*pisum sativum*) and masoora (*Phaseolus aureus*) etc. to improve organic matter content of the soil which in turn can conserve soil moisture effectively.
- Mulching: Covering the surface of the soil with dry leaves, weeds etc. to check the loss soil moisture through evaporation is called mulching. This can also be done economically by growing green manure crops and using the as mulch material. The soil surface should be covered with dry weed mulch to check the soil moisture loss through evaporation. The mulching is especially more important to the plants which are entirely dependent on rain water to conserve soil moisture by avoiding run-off loss of rainwater from the land.
- Growing varieties tolerant to drought: Mulberry varieties like Goshoerami. KNG, Ichinose, Tr-10 can are recommended to be cultivated under rainfed conditions of Kashmir as they have ability to withstand drought conditions and can produce reasonably high yield.

Leaf Transportation and Preservation: You know that shoots once harvested are to be carried to the rearing rooms. The existing situation in the temperate region reveals that these shoots are to be carried over long distances. Mostly, silkworm rearers do not have their mulberry plantation near their rearing places. The leaf bearing shoots are transported to long distances for which tangas, trucks, tractors and load carriers are being employed (Fig. 3).

The mulberry shoots are also being carried out as head load involving a lot of time. The branches/ shoots while being transported are generally carried without covering and are exposed directly to sunlight thereby affecting the leaf quality. So, precautions have to be taken for retaining the maximum moisture in the leaf. For quick and efficient transportation of shoots, the following measures are very useful:

Fig. 3: Transportation of leaves by rearers without proper care

- Ensure availability of mulberry leaf close to the rearing places by growing more plants around, which will reduce transportation distance and time.
- While transporting, cover the shoots with moist gunny cloth.

The quality of the leaf gets affected not only due to long distance transportation, but also, due to improper preservation of mulberry shoots. The leaf quality is primarily affected by loss of leaf moisture from the time it is harvested till it is actually fed to the worms [13]. So, to prevent the loss of moisture from the leaves the shoots can be preserved by covering them with wet gunny cloth in the rearing room. However, better method of shoot preservation is by keeping harvested mulberry shoots in bundles and placing them in an upright position, keeping their cut ends dipped in water (20-25cm), under wet gunny cloth coverage (giving some support to the cloth so that it does not touch the leaf).

CONCLUSION

Leaves of mulberry plants provide all the nutritional requirements for the growing of silkworms. Mulberry can be grown well in all climatic zones i.e., Tropical, Sub-tropical and temperate. To achieve high yield of good quality leaf, we have to adopt suitable cultivation practices like preparation of land, selection of host plant (mulberry) varieties, planting system, raising of nursery, methods of propagation, maintenance of host plants and plant protection measures. Beside these factors one should not forget the role of soil for the successful crop. Soil health status has to be taken in account always to produce high quality leaf and for sustaining yield. By adopting integrated nutrient management system we can easily sustain the productivity and sericulture in Kashmir regions. The policy makers have to consider this type of system in the package and practices for temperate sericulture.

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