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Role of foliar sprays in sericulture industry

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Abstract
Foliar spray is a type of feeding technique to the plants by applying liquid fertilizers directly to their leaves. The absorption of essential nutrients takes place largely through the stomata of leaves and through the epidermis. Mulberry (*Morus sp.*) is a deep rooted high biomass producing foliage crop cultivated as a sole food for silkworm, *Bombyx mori* L. But due to repeated harvests and soil problems, mulberry is exhibiting nutrient deficiencies in recent years. Although crops need low amounts of micronutrients (Monreal *et al.*, 2015) but still half of the cultivated world's soils are deficient in plant bioavailable micronutrients due to their slow replenishment from the weathering of soil minerals, soil cultivation for thousands of years and insufficient crop fertilization. Thus, there is a need to correct their deficiencies through use of foliar sprays. Furthermore, foliar sprays on mulberry plants help in disease management, enhance biochemical constituents of mulberry leaf, silkworm growth as well as cocoon parameters. Hence a model needs to be framed for maintaining continuous supply of micronutrients to obtain desired quantity and quality of mulberry leaf for successful silkworm cocoon crop and increasing overall silk productivity.

Keywords: Foliar spray, Stomata, Silkworm, micronutrients, mulberry leaf and cocoon

Introduction
Foliar fertilization is an important tool for the sustainable and productive management. It is theoretically more environmentally friendly, immediate and target oriented than soil fertilization since nutrients can be directly delivered to plant tissues during critical stages of plant growth. The process by which a nutrient solution applied to the foliage is ultimately utilized by the plant include foliar adsorption, cuticular penetration, uptake and absorption into the metabolically active cellular compartments in the leaf, then translocation and utilization of the absorbed nutrient by the plant. Aerial plant surfaces are covered by a hydrophobic cuticle and very often possess modified epidermal cells such as trichomes or stomata. The outer surface of cuticle is covered by waxes that may confer a hydrophobic character to the plants surface. The degree of hydrophobicity and polarity of the plant surface is determined by the species, chemistry and topography which are also influenced by the epidermal cell structure at a microscopic level. Nutrients present in the soil are not well absorbed in deep rooted plants and translocation of nutrients to shoot is sluggish under adverse soil conditions which favour soil fixation of nutrients. Mulberry (*Morus spp.*) is a deep rooted high biomass producing foliage crop cultivated as a sole food for silkworm, *Bombyx mori.* Mulberry (*Morus spp.*) is a deep rooted high biomass producing foliage crop cultivated as a sole food for silkworm, *Bombyx mori* L. But due to repeated harvests and soil problems, mulberry is exhibiting nutrient deficiencies in recent years. Foliar application in right time increases the level of absorption to the leaf in a stage of growth and development. Foliar application is an admirable way of supplying instant nutrient to the plants for quick boost or if it shows any symptoms of nutrient deficiency. Therefore, it is an effective method for correcting the soil deficiencies and overcome soils inability to mobilize nutrients to the plants. It is found very effective in improving the leaf yield quality and quantity of mulberry which is an important factor for optimum growth and development of silkworm, *Bombyx mori* (Bose *et al*., 1994) [14].

The leaf yield and quality of mulberry depends on the soil type, plant variety, and availability of plant nutrients and agroecological conditions which reflects on the quality of silk production. In India mulberry is largely cultivated for leaf production and contributes to an extent of 38.20% for successful cocoon crop production (Miyashita, 1986) [12]. Hence silkworms should have fed with good quality mulberry leaves for the successful cocoon crop production (Vijaya *et al*., 2009) [15]. Lokanath and Shivashanlsnr, 1986 [21] showed the positive effect like improved yield and increased number of branches and herbage in mulberry due to Foliar application of micronutrients (Boron, Iron and Manganese) along with magnesium.

Several workers have reported the improved nutritive parameters like increased moisture, protein, sugars and chlorophyll contents in mulberry through foliar application of micronutrients.

Importance of foliar sprays to Mulberry

Nutrition plays an important role in improving the and development of the silkworm, *Bombyx mori* L. and the silk production is dependent on the larval nutrition and nutritive value of mulberry leaves and in producing good quality cocoons (Etebari, 2002) [16]. Zinc is the only metal that shows amphoteric character and is freely soluble in water and alkalies to form zincates. It has multiple biological functions and is integral component of more than 20 different enzymes including DNA and RNA polymerases. It confers protection to cells against toxins, helps in structural and functional maturation of neurons and homeostasis under different conditions (Willot and Tran, 2002) [17]. Zinc helps in synthesis of lipids, proteins, carbohydrates and helps in reducing the duration of larval and pupal stages (Bhattacharya and Medda, 1981) [18]. Fortification of mulberry leaves with supplementary nutrient and feeding silkworms is a useful technique to increase economic value of cocoon. The modulatory effect of zinc chloride enriched mulberry leaves on various aspects of silkworm such as, Proteins in various tissues like silk gland, haemolymph and in muscles of the 5th instar silk worm larvae and on the economic parameters of the cocoon (Devi *et al.,* 2013). Feeding of zinc enriched mulberry leaves to the silkworms enhances their fecundity.

Mulberry as a foliage crop responds well to foliar sprays (Qadri, 2011) [2]. Timely and immediate application of specific nutrient (Kannan, 1990) [4]. Foliar spray of Zn as ($ZnSO_4$) increases the moisture content in mulberry leaves (Lokanath 1981) [3]. The moisture content determines the nutritive quality of leaves and plays an important role in the production of quality cocoons (Dandin and Kumar, 1989) [5]. Foliar spray of Zinc helps in retaining the leaf freshness for longer periods. When iron (as Fe_2SO_4 (0.5%) Ferrous Sulphate solution) is sprayed 20 – 25 days after pruning to the mulberry garden under irrigated conditions augments leaf yield of mulberry by 12-15%. Inclusion of sticker-spreader agents in the spray is suggested to improve adherence of the micronutrient source to the foliage. Caution should be used because of leaf burn due to high salt concentrations or inclusion of certain compounds in foliar sprays.

Feeding of foliar sprayed mulberry leaves to the silkworm larvae increases their weight and finally the cocoon weight. The foliar sprays also increase the moisture content of mulberry leaves and such type of leaves determines the nutritive quality of leaves and plays an important role in the production of quality cocoons (Dandin and Kumar 1989) [5]. Effects of foliar spray of urea along with different doses of NPK fertilizers significantly increases the leaf yield and nutrients, leaf freshness, moisture retention capacity, proteins, sugar and starch in both tender and mature mulberry leaves (Quader *et al*., 1989) [20]. Foliar sprays help in retaining the leaf freshness for longer periods. The most important application of foliar sprays is that plants show quick response and is advantageous compared to the soil application which is slow and further the applied nutrients are oxidized and becomes unavailable to the plants. Micronutrients play a significant role in Plant growth, Photosynthesis, Chlorophyll formation, cell wall development, resistance to plant diseases and nitrogen fixation (Vitti *et al*. 2014) [7]. They also play an important role in enzymatic reactions and important for activities of soil microorganisms (Noor-Ul-Din 2012) [6]. Micronutrients play an important role in ROS detoxification because they activate the enzymes which act as ROS scavengers like Ascorbate peroxidase (APX), Superoxide dismutase (SOD), Catalase (CAT), Peroxidase (POD) (Kumar *et al.,* 2008) [8].

Commercially available foliar formulations for mulberry under irrigated conditions are mentioned in table 1.

Posan

It is a multinutrient formulation for correcting the nutrient deficiencies in mulberry. Posan is a multinutrient formulation for foliar spray. It contains all the essential nutrients in a balanced and easily available form for healthy growth of the mulberry thereby catering the complete nutritional requirement of the silkworms. It also enhances the mulberry leaf yield upto 20%. (1 Lt. of Posan: 140Lt. Water).

Seriboost

It is a liquid fertilizer of micronutrients for increasing mulberry productivity. Seriboost (a product of SERICARE) was tested for mulberry, is a multinutrient formulation used as foliar spray containing all necessary nutrients in a balanced proportion and in easily available form for healthy growth of mulberry thereby producing good quality cocoons. Seriboost is sprayed at 0.25% in two sprays per crop after pruning/leaf picking (1st spray 23-25 days after pruning and 2nd spray 3-25 days after pruning).

Role of foliar sprays on mulberry and silkworm disease management

Many diseases of mulberry affect the leaf yield and nutritive quality. The ecofriendly control of different diseases of mulberry was developed by Maji *et al*., 2006 [22] using two botanicals viz., botanical-I and botanical-II and one biocontrol agent. Biocontrol-II and biocontrol agent reduced powdery mildew disease which is caused by *Phyllactinia corylea*. The findings indicated that foliar spray of botanicals is safe and ecofriendly for management of major foliar diseases of mulberry. Further, foliar spray of medicinal plant extract of neem, parthenium and bulb extract of garlic were tested to assess their effect on conidial germination of *Phyllactinia corylea* and powdery mildew disease development on mulberry leaves and these were found to reduce drastically Percent Disease Index. Furthermore, foliar sprays on mulberry plants help in disease management, enhance biochemical constituents of mulberry leaf, silkworm growth as well as cocoon parameters. Thus, foliar sprays have wider impact on sericulture productivity. Administration of seed extract of *Plectranthes corylifolia* and leaf extract of *P. ambonicus* to third instar silkworms resulted into reduction of mortality due to grasserie disease (Manimegalai and Chandramohan, 2006) [23]. Development of defense mechanisms to resist several mulberry and silkworm diseases and improved the drought tolerance, enhance silkworm growth and cocoon productivity without affecting flora and fauna.

Conclusions

Foliar feeding is a technique of feeding plants by applying nutrients directly to their leaves. Foliar spray has been used as supplemental doses of minor, major nutrients and botanicals. Micronutrients play an important role in crop production. They are equally important like macronutrients so their application is necessary. There is very narrow difference

between deficiency and toxicity levels, so micronutrients should be applied carefully only when crop needs them and after soil test. Development of defense mechanisms to resist several mulberry and silkworm diseases and improved the drought tolerance, enhance silkworm growth and cocoon productivity without affecting flora and fauna.

Table 1: Commonly used foliar nutrients in mulberry (Dhiraj and Kumar, 2011).

Foliar nutrients	Improvement in plant
Phalda	Leaf yield
Harith	Leaf yield and quantity
Plantonik	Proteins, sugars and amino acids
Plantoflex and Microflex	Growth, quality and yield of mulberry leaves
Multizyme	Leaf moisture and chlorophyll
Tracel-2	Leaf spot disease
PGPR	Leaf rust disease
B-nine	Leaf moisture and chlorophyll
Biozyme	Chlorophyll, sugar content and photosynthetic rate
Seri-Azo and Seri- phos	Mulberry leaf yield and quality
Navaras, Micron, S20, Amruth, Paras and Plantovit	Growth, quality and yield of mulberry leaves
Seriboost	NPK contents of mulberry leaf

Table 2: Effect of foliar micro nutrient sprays on the biochemical parameters of mulberry leaves

Zn	Aqueous solution of 2.0 kg Zinc sulphate/ha/crop should be sprayed over the leaves of deficient plants.
Mn	Aqueous solution of 1.0 kg Manganese Sulphate/ha/crop should be sprayed over the leaves of deficient plants.
Fe	Aqueous solution of 1kg Ferrous Sulphate/ha/crop should be sprayed over the leaves of infected plants
Cu	Aqueous solution of 1.0 kg Copper Sulphate/ha/crop should be sprayed over the leaves of deficient plants.
B	Aqueous solution of 1.0 kg Boric acid/ha/crop should be sprayed over the leaves of deficient plants.

Table 3: Recommendations for micronutrient enrichment in mulberry (Rathore *et al*., 2011) [10]

Treatments	Moisture content (%)	Moisture retention capacity (%)	Chl.a (mg/g)	Chl.b (mg/g)	Crude protein (%)	Caroteinoid (mg g^{-1})
Zinc sulphate (0.5%)	72.68	78.44	1.52	0.30	18.63	0.36
Ferrous sulphate (1.0%) + citric acid (0.1%)	70.57	77.76	1.56	0.35	19.09	0.29
Boric acid (0.2%)	72.22	77.43	1.50	0.30	17.40	0.34
Manganese sulphate (0.5%)	71.38	77.50	1.51	0.29	17.16	0.32
Sodium molybdate (0. 01%)	76.01	80.41	1.54	0.34	16.91	0.31
Control	69.36	77.33	1.35	0.27	15.78	0.30

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