International Journal of Agriculture Innovations and Research
Volume 6, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 23/10/2017 | Accepted on: 30/10/2017 | Published: 25/12/2017

Response of Mulberry (*Morus alba* L.) to Foliar Supplementation of Nutrient-composite

R. Kar[1], R.L. Ram[1*], M.K. Ghosh[2] and Kanika Trivedi[3]
[1]Regional Sericultural Research Station, Central Silk Board, Kalimpong-734 301, West Bengal.
[2]Central Sericultural Research and Training Institute, Central Silk Board, Pampore, Srinagar-190 001, Jammu and Kashmir.
[3]Central Sericultural Research and Training Institute, Central Silk Board, Berhampore-742 101, Murshidabad district, West Bengal.
*Corresponding author email id: ramlakhanram08@gmail.com

***Abstract* – A pilot study was conducted at research farm of Central Sericultural Research and Training Institute, Berhampore, Murshidabad district, West Bengal, with four treatments each comprising five replications, to study the effect of nutrient-composite on growth attributing characters, yield and quality of mulberry (*Morus alba* L.) variety C-2038. Based on the data analyzed, it was found that foliar application of treatment combination T_2 (nutrient-composite) - [$(NH_4)_2SO_4$ (5.0 mM) + KH_2PO_4 (5.0 mM) + KCl (5.0 mM) + $MgSO_4.7H_2O$ (2.5 mM) + $ZnSO_4.7H_2O$ (2.5 mM), + $(NH_4)_6Mo_7O_{24}.4H_2O$ (0.01 mM)] performed better than rest of the treatment e.g. T_1-control [water spray]; T_3 (Hormone-composite) - [GA_3 (5.0 mg l^{-1}) + Kinetin (10.0 mg l^{-1}) + IAA (10.0 mg l^{-1})] and T_4 (Nutrient-hormone-composite)- [$(NH_4)_2SO_4$ (5.0 mM) + KH_2PO_4 (5.0 mM) + KCl (5.0 mM) + $MgSO_4.7H_2O$ (2.5 mM) + $ZnSO_4.7H_2O$ (2.5 mM) + $(NH_4)_6Mo_7O_{24}.4H_2O$ (0.01 mM) + GA_3 (5.0 mg l^{-1}) + Kinetin (10.0 mg l^{-1}) + IAA (10.0 mg l^{-1})], respectively. Growth attributing characters like height of plant (133.4 cm), number of shoots plant^{-1} (12.0), number of leaves plant^{-1} (288.4) and total length of leaf bearing shoots plant^{-1} (1287.0 cm) were recorded maximum with the foliar application of nutrient-composite (T_2). In case of treatment combinations T_3 and T_4, the above parameters were improved over control but registered lesser values than T_2. Barring control, the impact of other three treatments were found at par in terms of leaf area of 1.61 m^2/100 leaves. Control (T_1) recorded 102.8 cm height of plant, 8.0 number of shoots plant^{-1}, 124.6 number of leaves plant^{-1}, 641.2 cm total length of leaf bearing shoots plant^{-1} and leaf area of 1.19 m^2/100 leaves. Similarly, leaf yield (14.38 t ha^{-1}) was also recorded maximum in the same treatment combination (T_2) computing 36.4% leaf yield gain over control. The leaf yield in control was 10.54 t ha^{-1}. Assimilation of C, N, P and K by mulberry leaf was also found significantly higher in T_2 (nutrient-composite) in comparison to rest of the treatments.**

***Key words* – Mulberry, Nutrient-composite, Silkworm, Nutrients assimilation.**

I. Introduction

Sericulture is an agro based industry and well known heritage of Indian culture and tradition. Both economically and traditionally, this industry plays lead role to nurture the rural economy by providing the opportunity for better livelihood among millions of people through pre and post cocoon technology. Mulberry sericulture is the back bone of this industry as it occupies nearly 72% of total raw silk production in India. Mulberry leaf is basic food material of silkworm (*Bombyx mori* L) and also major source of silk protein. Nutritional qualities of mulberry leaves supplied as food material of silkworm have great influence for production of quality cocoon [1], because, the silk produced by the above silkworms are directly derived from protein of mulberry leaves. Besides, feeding of nutritious mulberry leaves to silkworm larvae also lowers the mortality rate of silkworm [2]. Various researchers across the world have also reported that the nutritional quality of mulberry leaves have significant effect on silkworm for production of quality cocoon. Juyal *et al.*, [3] reported that the quality mulberry leaves alone have 38.3% influence on production of quality cocoons. Singhal *et al.*, [4] have also opined that quality mulberry leaves have great influence for production of quality cocoon.

There are various factors responsible for production of quality mulberry leaves. These factors are soil health, nature of mulberry variety, integrated nutrient management, agronomic practices, environmental condition and protection measures for disease and pest. Among these, soil health, environmental condition and nutrient management have greater influence on the same. The soil application of fertilizers is a common practice in various crop plants as well as in timber plants in forests, but, such application has certain disadvantages including their high cost and less nutrient uptake in rainfed conditions. Besides, excess use of these fertilizers in soil alongwith other insecticides and pesticides pose a serious threat not only to mulberry crop but also to the environment. Hence, an alternative approach is necessary for the purpose of enhancing mulberry production without causing the substantial damage to the ecosystem.

Foliar application in the form of composite formulation of different nutritional resources is an efficient approach in terms of reducing quantity of nutrient-inputs along with enhancing the nutrient assimilation by plant. Besides, it is also much effective for physiological growth and development of mulberry plants. Plant nutrients like magnesium, manganese, iron, zinc, and boron are also provided to mulberry as foliar nutrients for enhancing its growth, yield as well as quality of leaf [5] and ultimately cocoon weight and cocoon yield [6]. Foliar applications of several plant growth regulators in combination with inorganic fertilizers have significant influence on growth and development of several crops including mulberry [7; 8]. Considering the importance of the foliar application, a pilot study was conducted during July-September, 2015 to study the effect of nutrient-composite through foliar application on yield and quality of high yielding mulberry, variety C-2038, in alluvial plains of Murshidabad district, West Bengal, India.

II. Materials and Methods

A pilot study was conducted at research farm of Central Sericultural Research and Training Institute, Berhampore, Murshidabad district, West Bengal, during July-September, 2015. The high yielding mulberry variety C-2038 was chosen as the test crop. The variety was planted at 60 cm x 60 cm spacing in a randomized block design with four treatments each comprising five replications under irrigated condition. The treatments comprised the foliar application of different combinations of nutrients and hormones are given in Table 1.

Table 1: Treatment combination

Treatment	Nature of treatment	Nutrient composition
T_1	Control	Water spray
T_2	Nutrient composite	$(NH_4)_2SO_4$ (5.0 mM) + KH_2PO_4 (5.0 mM) + KCl (5.0 mM) + $MgSO_4.7H_2O$ (2.5 mM) + $ZnSO_4.7H_2O$ (2.5 mM), + $(NH_4)_6Mo_7O_{24}.4H_2O$ (0.01 mM)
T_3	Hormone composite	GA_3 (5.0 mg l^{-1}) + Kinetin (10.0 mg l^{-1}) + IAA (10.0 mg l^{-1})
T_4	Nutrient-hormone composite	$(NH_4)_2SO_4$ (5.0 mM) + KH_2PO_4 (5.0 mM) + KCl (5.0 mM) + $MgSO_4.7H_2O$ (2.5 mM) + $ZnSO_4.7H_2O$ (2.5 mM) + $(NH_4)_6Mo_7O_{24}.4H_2O$ (0.01 mM) + GA_3 (5.0 mg l^{-1}) + Kinetin (10.0 mg l^{-1}) + IAA (10.0 mg l^{-1})

The treatments were sprayed twice, one at 20 days after pruning of the mulberry plant and another after an interval of 10 days through a spray volume of 500 l ha^{-1}. All the treatments including control (water spray) received other inorganic and organic inputs for the crop as mentioned through soil application computed on the basis of recommended doses of N, P_2O_5 and K_2O @ 336: 180: 112 kg ha^{-1} $year^{-1}$ along with 20 t FYM ha^{-1} $year^{-1}$. The NPK were applied in the form of urea, single super phosphate and muriate of potash. Growth attributes, namely, plant height, number of shoots $plant^{-1}$, number of leaves $plant^{-1}$, total length of leaf bearing shoot $plant^{-1}$, leaf fall (%) and leaf area along with leaf and shoot yields were recorded.

For estimation of carbon contents of leaf samples, the samples were oven dried at 70 ^{O}C and dry weights of the same were calculated using moisture content. The ash contents of the oven-dried leaf samples were determined by igniting 1 g of powdered sample at 550 ^{O}C for 6 hours in a muffle furnace. A total of 50% of the ash-free mass was taken as the carbon content [9]. Carbon capturing efficiency (CCE) by mulberry was calculated on hectare basis utilizing the dry weight of mulberry leaf.

Nitrogen contents of the oven dried (70 ^{O}C) leaf samples of the experimental plants were extracted by digesting the same with concentrated sulphuric acid in presence of catalyst mixture and thereby estimated nitrogen contents of the digested material following the standard Kjeldahl method [10]. On the other hand, phosphorus and potassium contents of the oven dried (70 ^{O}C) leaf samples were extracted by digesting the same with tri-acid mixture (HNO_3: $HClO_4$: H_2SO_4 :: 10: 4: 1) and thereby estimated phosphorus and potassium contents of the digested material with the help of visible spectrophotometer (λ: 470 nm) and flame photometer (using K-filter), respectively following the standard analytical protocol [10].

Assimilation of carbon, nitrogen, phosphorus and potassium by mulberry leaf samples were computed on hectare basis utilizing the dry weight of mulberry leaf. Besides, the ratios of nitrogen, phosphorus and potassium in comparison to carbon content of mulberry leaf were also computed on the basis of respective titre to have an idea about the relative abundance of those three primary nutrients under different sources of foliar application.

III. Result and Discussion

3.1 *Soil Fertility Status of the Experimental Plots*

Soil fertility status of the experimental plots as furnished in the Table 2 indicated that the experiment was initiated in a sandy clay loam soil texture developed over the eco-geographic region, *“Assam and Bengal Plain, hot sub-humid eco-region with alluvium derived soil”*. The bulk density of the soil was in the proximity with the optimum value for commercial mulberry production [11] and water holding capacity was also substantially high. The soil reaction was slightly alkaline and electrical conductivity was much below the critical value with respect to safe growth of mulberry. Organic carbon content was at medium range while available nitrogen content was at lower side. Phosphorus and potassium contents are at high level of availability.

Table 2: Soil fertility status of the experimental plots

Sl. No.	Soil parameters	Nutrient status
1.	Soil Texture	scl
2.	BD (Mg m^{-3})	1.32
3.	WHC (kg kg^{-1})	0.42
4.	Soil pH (1:2.5 soil-water suspension)	7.54
5.	EC (dS m^{-1})	0.15
6.	OC (g kg^{-1})	6.65
7.	$KMnO_4$-N (kg ha^{-1})	224
8.	Olsen’s P (kg ha^{-1})	32
9.	NH_4OAc-K (kg ha^{-1})	354

3.2 *Effect of foliar application of nutrient-composite on growth attributes of mulberry var. C-2038*

Effect of foliar application of different formulations on growth attributes of mulberry, var. C-2038 are given in Table 3. Based on the data analyzed, it has been revealed that, the growth attributing characters like plant height, number of shoots $plant^{-1}$, number of leaves $plant^{-1}$, length of leaf bearing shoots $plant^{-1}$ and leaf area were increased significantly due to foliar application of nutrient-composite (T_2) followed by T_3 and T_4 over control.

Growth attributing characters like height of plant (133.4 cm), number of shoots plant^{-1} (12.0), number of leaves plant^{-1} (288.4) and total length of leaf bearing shoots plant^{-1} (1287.0 cm) were recorded maximum with the foliar application of nutrient-composite (T_2). In case of treatment combinations T_3 and T_4, the above parameters were improved over control but registered lesser values than T_2. Barring control, the impact of other three treatments were found at par in terms of leaf area of 1.61 m^2/100 leaves. Control (T_1) recorded 102.8 cm height of plant, 8.0 number of shoots plant^{-1}, 124.6 number of leaves plant^{-1}, 641.2 cm total length of leaf bearing shoots plant^{-1} and leaf area of 1.19 m^2/100 leaves.

Table 3: Effect of foliar application of nutrient-composite on growth attributes of mulberry var. C-2038

Treatment	Height of the plant (cm)	Number of shoots plant^{-1}	Number of leaves plant^{-1}	Total length of leaf bearing shoots (cm) plant^{-1}	Leaf area (m^2/100 leaves)
T_1	102.8	8.0	124.6	641.2	1.19
T_2	133.4	12.0	288.4	1287.0	1.61
T_3	123.8	11.0	236.0	1077.6	1.61
T_4	117.0	11.4	237.8	1065.8	1.61
CD (P=0.05)	7.89	2.28	42.94	200.2	0.11

During the last two decades, studies on foliar nutrition have received considerable attention especially in agriculture, horticulture and other foliage crops and beneficial effects of foliar spray of nutrients were well established [12]. Mulberry is of no exception in this regard. Improvement in the growth and leaf yield of mulberry through foliar application of different nutrients were also reported by various workers throughout the country [3; 13; 5; 14]. Positive effect of foliar application of micronutrients on growth attributes, yield and quality of mulberry was also reported by various workers [15; 16; 17]. The physiological, biochemical and commercial traits of mulberry silkworm is directly influenced by quantity and quality of biochemical constituents like proteins, carbohydrates, minerals etc in mulberry leaves. Several attempts on the similar line of works have been made by many workers [18; 5; 7; 19].

3.3 *Effect of foliar application of nutrient-composite on yield and quality of mulberry var. C-2038*

Effect of foliar application of nutrient-composite on yield and quality of mulberry var. C-2038 is furnished in the Table 4. The data furnished in the table revealed that yield and quality of mulberry leaves increased significantly due to foliar supplementation through different sources over control. The maximum leaf yield 14.38 t ha^{-1} was recorded with the treatment combination T_2 followed by 13.26 t ha^{-1} with T_4 and 12.05 t ha^{-1} with T_3. The leaf yield in control was 10.54 t ha^{-1}. The leaf yield gain due to foliar spray of nutrient-composite (T_2) was 36.4% over control. Though leaf shoot ratio was not increasing significantly due to foliar spray of different sources, the lowest leaf fall% due to spray of nutrient-composite (T_2) appeared to be the major contributing factor for maximum number of leaves/ plant (table 3) and, in turn, the highest leaf yield at that particular treatment. The moisture and crude protein content of leaf sprayed with treatment combination T_2 was also significantly increased over control.

Table 4: Effect of foliar application of nutrient-composite on yield and quality of mulberry var. C-2038

Treatment	Leaf yield (t ha^{-1})	Leaf yield gain (%)	Leaf: shoot ratio	Leaf fall (%)	Leaf moisture (%)	Crude protein content of leaf (%)
T_1	10.54	-	1.54	11.91	76.61	21.88
T_2	14.38	36.4	1.62	9.92	78.27	26.25
T_3	12.05	14.3	1.60	10.06	78.12	21.00
T_4	13.26	25.8	1.61	10.94	78.31	22.75
CD (P=0.05)	2.06	-	NS	1.33	0.68	1.84

The increase in growth and yield of mulberry might be attributed to the involvement of extra addition of primary nutrients like NPK along with the spray of secondary nutrients like Mg as well as S and micronutrients like Zn and Mo. The improved nutritional environment as a result of enhanced supply of different nutrient elements as mentioned above might have favourably influenced the carbohydrate metabolism. The increase in leaf yield was due to increase in the photosynthesis, which resulted into the accumulation of higher amount of carbohydrates in the vegetative portion of the plant and ultimately enhancing the growth and leaf yield [20]. The additional impact of different elements in terms of chlorophyll formation, activation of enzymes, protein synthesis, carbohydrate metabolism, mobilization and activation of one element by other etc. is the principal cause of such enhancement in growth and yield of mulberry. Again, maximum crude protein content of the nutrient-composite (T_2) treated leaves might be correlated with the additional synthesis of sulphur containing amino acids [20] due to incorporation of sulphur along with molybdenum and extra incorporation of nitrogen containing compounds in the particular treatment composition.

3.4 *Effect of foliar application of nutrient-composite on nutrients assimilation by mulberry leaf, var. C-2038*

Assimilation of carbon, nitrogen, phosphorus and potassium by mulberry leaf was also found maximum in case of nutrient-composite (T_2) and the same was significantly higher over control (Table 5).

Table 5: Effect of foliar application of nutrient-composite on nutrients assimilation by mulberry leaf, var. C-2038

Treatment	Nutrients assimilation (kg ha^{-1})			
	Carbon	Nitrogen	Phosphorus	Potassium
T_1	1059.36	86.43	7.93	66.67
T_2	1321.94	131.26	13.63	90.63
T_3	1106.66	88.64	9.81	70.17
T_4	1238.88	104.75	12.17	77.70
CD (P=0.05)	174.11	17.81	1.88	13.47

On the other hand, ratio of nitrogen, phosphorus and potassium with respect to carbon as furnished in the Table 6 were noted minimum at the same treatment. It is interesting to note that leaf of C-2038 mulberry variety can capture 1.32 t carbon from one hectare of land during the particular season while sprayed with nutrient composite (T_2). Thus, the treatment is having an extra carbon capturing efficiency (CCE) of 260 kg ha^{-1} in comparison to existing package of practices and the same has a meaningful bearing with the current agenda of "Global Warming".

Table 6: Effect of foliar application of nutrient-composite on nutrient ratios of mulberry leaf, var. C-2038

Treatment	Nutrients ratios		
	Carbon : Nitrogen	Carbon : Phosphorus	Carbon : Potassium
T_1	12.26	133.64	15.89
T_2	10.07	97.02	14.59
T_3	12.49	112.77	15.77
T_4	11.83	101.77	15.84

The increase in assimilation of carbon, nitrogen, phosphorus and potassium might be due to the influence of different nutrient elements through foliar spray on enhanced biomass production of mulberry, which, in turn sensitized the plant to draw higher amount of nutrients (NPK) from soil and in addition to capture higher amount of carbon from atmosphere. As dilute concentrations of different elements were sprayed, nutrient use efficiency was enhanced and the same might be explained in terms of greater competition of plant for nutrients assimilation at lower doses [21; 22]. Further, lower values of C: N, C: P and C: K ratios in mulberry leaf sprayed with nutrient-composite (T_2) in comparison to others revealed proportional increment of primary nutrients like NPK in the system of mulberry.

Based on the data analysed, it has been concluded that foliar supplementation of different inputs exerted positive impact on mulberry in terms of growth, yield and quality aspects along with efficient mobilization of nutrients within the plant system. Among the treatments, nutrient composite comprising of combination of soluble compounds containing essential nutrient elements appeared superior to others in terms of above mentioned aspects. Thus, the treatment, nutrient composite promises to sustain high mulberry productivity of the variety C-2038 over the years without addition of any extra fertilizer elements to soil over the existing recommendation. Not only depletion of soil nutrients associated with higher productivity but disturbance to the soil ecology may also be averted in the course of such foliar spray.

References

[1] Economic and Social Commission for Asia and the Pacific. ESCAP, 1993. Techniques of silkworm rearing in the tropics. United Nations, New York, USA.

[2] Food and Agricultural Organization (FAO) 1990. Sericulture Training Manual. FAO Agricultural Services Bulletin 80, Rome, pp 117.

[3] Juyal, AC, Singh, BD, Rajat, M, Ramakant, M and Gonashyam, M, 2003. S-146 - A suitable mulberry genotype for north-western India. *Indian Silk*, 41: 9-10.

[4] Singhal, BK, Malav, R, Sarkar, A & Datta, RK, 1999. Nutritional disorders of mulberry (*Morus* spp.): III. Leaf nutrient guide for secondary nutrients. *Sericologia*, 39 (40): 599-609.

[5] Lokanath, R and Shivashankar, K, 1986, Effect of foliar application of micronutrients and magnesium on growth, yield and quality of mulberry (*Morus alba* L.). Indian *J. Seric.,* 25(1): 1-5.

[6] Vishwanath, AD and Krishnamurthy, K, 1982. Effect of foliar spray of micronutrients on the larval development and cocoon characters of silkworm (*Bombyx mori* L.). *Indian J. Seri*., 21(1): 1-6.

[7] Qaiyyum, MH and Bari, MA, 1990. Foliar nutrition in mulberry. *Indian Silk*, 28(1): 26.

[8] Dixon, RK, Carrett, HE and Cox, CS, 1984. Response of white oak seedlings to foliar application of fertilizers and plant growth regulators. *Hort. Sci*., 19 (4): 523-524.

[9] Nath, AJ and Das, AK, 2011. Carbon storage and sequestration in bamboo-based smallholder home gardens of Barak Valley, Assam. *Curr. Sci*., 100 (2): 229-233.

[10] Jackson, ML, 1973. *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi.

[11] Kar, R, Bose, PC, Majumder, SK and Dutta, RN, 2008. Physical characterization of mulberry (*Morus sp.*) growing soils in four states of Eastern India in relation to their organic carbon and available nutrient contents. *Indian J. Seric*., 47: 126-129.

[12] Narahari Rao, BV, Bongale, UD, Chaluvachari and Krishna, M, 2001. Response of mulberry to the application of commercial foliar sprays. *Proc. Nation. Sem. Mulb. Seri. Res. India*, Karnataka State. Seric. Res. Dev. Inst., Bangalore, pp.233-236.

[13] Bose, PC, Sen, R and Dutta, RK, 1994. Effect of foliar application of micronutrients to mulberry on rearing performance of silkworm Bombyx mori L. *Indian J. Seric*, 3:1-5.

[14] Subbarao, G, Chakravarthy, SB and Fotdar, RK, 1983. A comparative study of soil and foliar application of nitrogen on the yield of mulberry. Paper presented In: *Nation Sem. Silk Res. Dev.,* Cntrl. Silk Board, Bangalore, March, 10-13, pp.61.

[15] Rajegowda and Raju, M, 2011. Effect of micronutrients foliar spray on mulberry growth, silk production and cost benefit. *J. Ecobiol*., 28(1): 49-53.

[16] Singhvi, NR, Kodandarmiah, J, Rekha, M, Sarkar, A and Datta, RK, 2001. Effect of salicylic acid on leaf yield and pigment content in mulberry (*Morus alba* L.). *Indian J. Seric.,* 40: 100-102.

[17] Patil, VC, Angadi, SA, Roodagi, LI, Angadi, SS and Patil, RR, 2001. Effect of soil and foliar application of micronutrients on growth, yield and quality of mulberry. *Proc. Nation. Sem. Mulb. Seri. Res.,* India, Karnataka State Seri. Res. Dev. Inst. Bangalore, pp.127-131.

[18] Fotedar, RK and Chakrabarty, S, 1986. Comparative studies on foliar and soil application of nitrogen on the leaf yield and mulberry. *Indian J. Seric*., 25(2): 58-63.

[19] Ankalagi, RF and Ansari, MF, 1992. Effect of 1-Triacontanal and 'Fasal' on the growth and yield of mulberry, *Morus alba* and *Bombyx mori*. *Sericologia*, 32(3): 405-410.

[20] Kar, R, Majumder, SK, Ghosh, MK. and Bindroo, BB, 2012. Prospect of foliar sulphur supplementation for escalation of productivity of aged mulberry (*Morus alba* L.) plant on a sulphur deficient soil. *Proc. UGC sponsored State Level Seminar on Adv. Biol. Sci. towards Sustn. Dev*., Berhampore Girl's College, Berhampore, West Bengal, 29-30 March, pp. 169-175.

[21] Rajkhowa, DJ and Baroova, SR, 1996. *J. Indian Soc. Soil Sci*., 44 (2): 259.

[22] Yadav, BL and Vyas, KK, 2006. *J. Indian Soc. Soil Sci*., 54 (2): 158.