Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7362

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (1):** 346-352 (2019)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Combined Effect of Biofertilizers and Micronutrients on Growth and Yield Attributes of Mulberry (*Morus indica* L.)

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Received: 22.12.2018 | Revised: 28.01.2019 | Accepted: 6.02.2019

ABSTRACT

The combined effect of micronutrient and biofertilizers was studied under existing mulberry garden. Different combination of micronutrients and biofertilizers were used in this study to assess the growth and yield of mulberry. Treatments were imposed on five continuous crops and the observations recorded for all crops. The pooled data revealed that among the twelve different combinations of ,the treatment combination of 100 % RDF + Soil application of $ZnSO_4$, Fe SO_4, $MnSO_4$ and $MgSO_4$ @ 25 kg ha^{-1} each + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer each @ 1500 ml ha^{-1}) recorded superior growth and yield attributes viz., plant height (198 cm), number of shoots (14 $plant^{-1}$), number of leaves (646 $plant^{-1}$), leaf area (101146 cm^2 $plant^{-1}$) and leaf yield (1218.369 g $plant^{-1}$) with high leaf moisture retention percentage of 93.94.

Key words: *Mulberry, Micronutrients, Biofertilizers, Growth attributes, Yield*

INTRODUCTION

Micronutrients are involved in several metabolic activity of mulberry plant that are responsible for quality leaf production and stimulate metabolic activity in silkworm which in turn leads to better rearing performance and silk quality. As mulberry is grown for its foliage and harvested 5-6 times a year, nutrient requirement is high and balanced application of nutrients is essential. Currently emphasis is being given to major nutrients with less focus on micronutrients. Even though foliar application of micro nutrients is in practice now, soil application of micronutrient is known to have residual effect.

Cite this article: Nazar, A., Kalarani, M.K., Jeyakumar, P., Kalaiselvi, T., Arulmozhiselvan, K. and Manimekalai, S., Combined effect of Biofertilizers and Micronutrients on Growth and Yield Attributes of Mulberry (*Morus indica* L.), *Int. J. Pure App. Biosci.* **7(1):** 346-352 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7362

Mulberry plant cultivated for several years to its perennial nature and harvesting of shoot along with foliage at periodical interval increases need of the plant nutrients for its regeneration. Due to periodical pruning this crop removes the soil nutrient reserves and need the proper nutrient management for a successful crop. Plant life cycle depends on the supply of essential elements at optimum quantity and in a proper stage of plant growth. All essential elements have specific impact on the plant growth. Regular use of high value micronutrient free macronutrient fertilizers coupled with enhanced removal of micronutrient by mulberry crop due to intensive cropping with high yield varieties have resulted in causing multiple micronutrient deficiencies in the fields of mulberry garden[1]. The deficiency of essential nutrients in the soil has been found to cause nutritional, anatomical and histological disorders in mulberry[2].

Biofertilizers or microbial inoculants are the preparation of live microorganisms used to improve plant nourishment and soil fertility there by achieving more and sustainable crop production. Biofertilizers are cheaper, low capital intensive, non-bulk and eco-friendly source to boost productivity. Having their dependency on renewable energy, the biofertilizers offer an attractive source of nutrients for sustaining crop productivity[3]. Sori *et al.*[4] reported that, the application of microbial inoculation in conjunction with organic manure has significantly increased the productivity of mulberry leaf. With the increasing cost of chemical fertilizers and concern about environmental pollution, the role of biologically active organism to fix, solubilise and release of NPK which can make agriculture more productive and sustainable without harming the environment has to be harnessed efficiently. Literature on soil application of micronutrients with biofertilizers to mulberry is scanty and hence the study on the combined effect of micronutrients on growth and yield of mulberry and silkworm was carried out.

MATERIAL AND METHODS

A field experiment was conducted at D. Perumapalayam village of Salem district, Tamil Nadu during 2016-17 in an established mulberry garden with mulberry variety Victory 1 (V1) planted at a spacing of (5+3) x 2 feet in paired row system. The experiment was laid out in Randomised Block Design and replicated thrice with 12 treatments comprising of T_1- Control (100% RDF), T_2-100 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ @ 25 kg ha^{-1} each, T_3-100 % RDF + Soil application of $ZnSO_4$, Fe SO_4, $MnSO_4$ and $MgSO_4$ @ 25 kg ha^{-1} each + Recommended dose of Biofertilizers (Azos, Phospho and Potash mobilizer), T_4-75 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ @ 25 kg ha^{-1} + Recommended dose of Biofertilizers (Azos, Phospho and Potash Mobilizer), T_5-100 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$@15 kg ha^{-1}, T_6-100 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ @ 15 kg ha^{-1} + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer), T_7-75 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ @ 15 kg ha^{-1} + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer), T_8-100 % RDF + 0.5 % Foliar spray of $ZnSO_4$, Fe SO_4, $MnSO_4$ & $MgSO_4$, T_9-100 % RDF + 0.2 % Foliar Spray of $ZnSO_4$, $FeSO_4$, $MnSO_4$ & $MgSO_4$, T_{10}-100 % RDF + 0.5 % Foliar spray of $ZnSO_4$, Fe SO_4, $MnSO_4$ and $MgSO_4$ + Recommended dose of biofertilizers (Azos, Phospho & Potash mobilizer), T_{11}-100 % RDF + 0.2 % Foliar Spray of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer) and T_{12}-75 % RDF + 0.2 % Foliar spray of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and $MgSO_4$ + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer).

The bio-fertilizer inoculants Azos: *Azospirillum lipoferum*, Phospho: *Bacillus megaterium* var. *Phosphaticum* and Potash mobilizer: *Frateuria aurantia* used in this study were mass multiplied on the respective medium and the bacterial inoculants cells were

separated and concentrated by tangential flow filtration system (PALL Life Sciences Inc.) and formulated in a liquid based cell encapsulation medium with declared cell count of 1 x 10^{8} CFU ml^{-1} in Bio-fertilizer Production Unit, Department of Agriculture, Salem and given as soil application at recommended dosage of 1500 ml ha^{-1}.

Micronutrients as foliar application were sprayed on 25 days after pruning (DAPR). The observations on growth and yield attributes were recorded on 65 DAPR. Leaf area per plant was measured using a Leaf Area Meter (LICOR, Model LI 3000) and expressed as cm^2 $plant^{-1}$. For recording growth and yield attributes five crops were selected at random and the mean was recorded . The moisture retention of leaf samples were calculated using the formula and expressed in percentage.

$$\text{Leaf moisture retention (\%)} = \frac{\text{Fresh wt. of leaf after 10 h – Dry wt.}}{\text{Fresh wt. of leaf after 10 h}} \times 100$$

RESULTS AND DISCUSSION

The present field study was planned to find out combined effect of soil and foliar application of micronutrients along with soil application of biofertilizers on mulberry growth, yield attributes.

Combined application of micronutrients and biofertilizers resulted in better growth and yield of mulberry. Higher plant height (198 cm), number of shoots (14 plant $^{-1}$) number of leaves (646 plant $^{-1}$) and leaf area (101146 cm^2 $Plant^{-1}$) was observed in T_3 followed by T_4 (Table 1). However higher total dry matter production (69.77 g) was observed in T_4 compared to T_3 and other treatments. The increase in plant height, number of leaves per plant, leaf area and total fresh leaf yield per plant in T_3 might be due to balanced nutrition, with biofertilizers and micronutrients role in various physiological processes, favorable nutrient interaction[5] and changing the root morphology *via* producing plant growth promoting substances[6].

Micronutrients often act as co factors in enzyme activation and participate in redox reactions, photosynthesis and respiration besides play an essential role in carbohydrate metabolism and sugar translocation[7]. Better response of mulberry to application of micronutrients and biofertilizers on fresh leaf yield (218.369 g $plant^{-1}$) was also observed in T_3 as compared to other treatments which might be due to the micronutrients like Zn, Mn, Fe have aided in better uptake of nitrogen and indirectly helped in obtaining better yields. These results are in conformity with findings of Kasiviswanathan *et al*[8]. Biofertilizers application increases the number of lateral roots and enhances root hair formation to provide more surface area to absorb sufficient nutrients[9]. This improves the water status of the plant and aids the nutrient profile in the advancement of plant growth and development[10,11].

Similarly combined application also influenced the moisture retention status of mulberry leaves and this may be due to the influence of nutrients and biofertilizer, which had mediated the moisture availability in the soil rhizosphere, thereby maintaining normal growth, water uptake and other metabolism in plants and also due to water retention capacity of organic manures which steadily supply the moisture and there by moisture content in leaf and fresh leaf weight were increased. Similar findings were reported by Rashmi[12], Sunil[13], Murali[14], Shashidhar[15] in S-36 and M-5 mulberry varieties. Mary *et al.*[16] reported that the application of different biofertilizers plays a significant role in enhancing the soil fertility in terms of macronutrients, secondary nutrients and microbial populations there by it facilitate the mulberry crop for its luxuriant crop growth.

The increase in the availability of micronutrients in the rhizosphere zone of

mulberry resulted in higher uptake of these minerals in to the plant. This is due to organic acid produced by biofertilizers (Azos, Phospho and Potash Mobilizer) which led to the altering of soil pH, chelating the minerals to bring the ion to available form there by enabling the easy uptake of all macro and micro nutrient. Dutta *et al.*[17] also opined that application of biofertilizer increased the uptake of macro-nutrients such as N, P, K as well as micro-nutrients such as Fe and Mn in mulberry which is in accordance with the present investigation. This is an indication for uptake of plant nutrients due to synergistic effect of various beneficial microorganisms flourishing in soil due to addition of organic manures[18].

Table 1: Effect of micronutrients and biofertilizers on growth and yield of mulberry

Treatments	Plant height (cm)	No. of shoots plant^{-1}	No. of leaves plant^{-1}	Leaf area (cm^{-2})	Fresh leaf yield plant^{-1} (g)	TDMP (g plant^{-1})	Leaf moisture retention After 10 h (%)
T_1	164	9	328	34717	597.77	313.63	90.87
T_2	185	10	396	47269	840.88	434.03	91.77
T_3	198	14	646	101146	1218.36	636.00	93.94
T_4	196	13	571	84312	1183.87	695.77	93.17
T_5	170	10	360	38487	741.43	386.51	91.08
T_6	192	13	550	75939	1194.66	610.54	92.49
T_7	194	13	551	74381	1082.94	604.69	92.78
T_8	175	10	373	40585	732.38	418.48	91.43
T_9	170	10	376	41253	769.97	421.47	91.21
T_{10}	191	12	487	65989	1100.11	583.67	92.18
T_{11}	186	12	455	57857	1020.89	552.12	92.06
T_{12}	184	11	443	53604	977.41	509.49	92.04
Mean	184	11	461	59628	955.06	513.87	92.09
SEd	5.89	0.365	7.61	2449.92	31.92	17.41	1.189
CD(0.05%)	11.08	0.742	15.48	4124.50	64.95	35.42	2.418

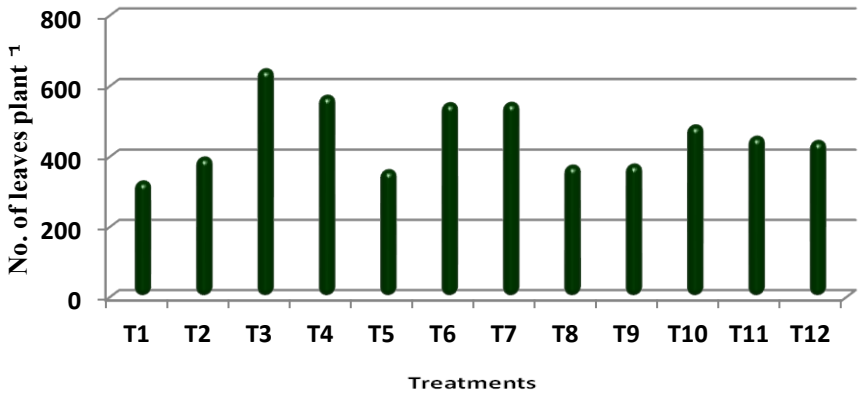

Fig. 1: Effect of micronutrients and biofertilizers on No. of leaves plant $^{-1}$

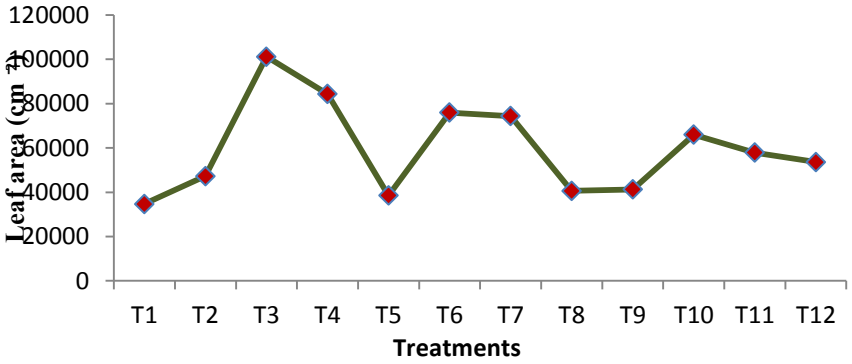

Fig. 2: Effect of micronutrients and biofertilizers on leaf area plant $^{-1}$ (cm^{-2})

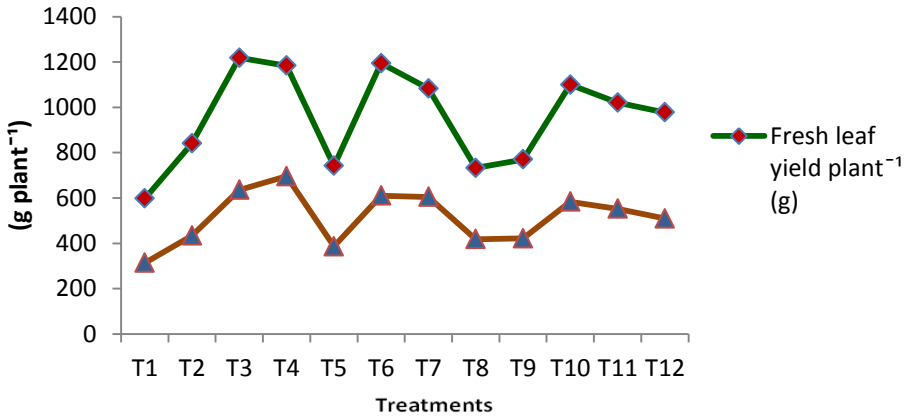

Fig. 3: Effect of micronutrients and biofertilizers on Fresh leaf yield plant $^{-1}$ (g) and TDMP (g plant $^{-1}$)

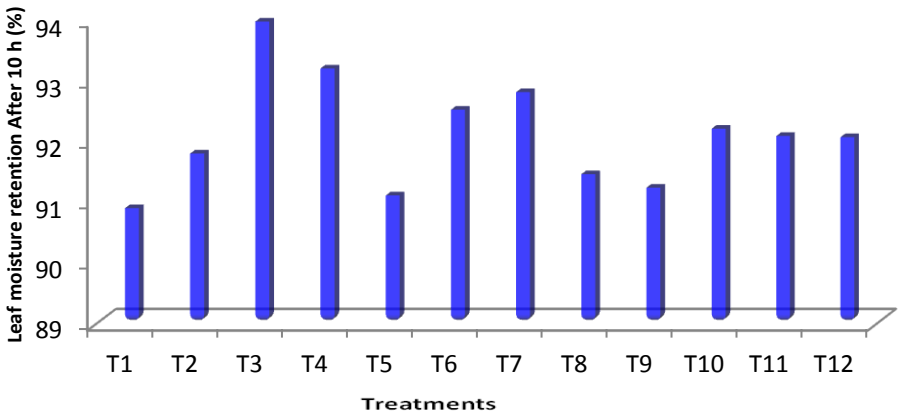

Fig. 4: Effect of micronutrients and biofertilizers on Leaf moisture retention after 10 h (%)

CONCLUSION

The present investigation revealed that the combined application of micronutrient and biofertilizers along with recommended dose of major nutrients increases the availability of the essential nutrients in the rhizosphere zone. Particularly, the biofertilizers maintain the availability of these nutrients by fixing from atmosphere, chelating and releasing from the clay minerals so as to avoid conversion to non available form resulted in increase in the growth and yield of mulberry. It is concluded that, treatment T_3 (100 % RDF + Soil application of $ZnSO_4$, $FeSO_4$, $MnSO_4$ and

$MgSO_4$ @ 25 kg ha^{-1} each + Recommended dose of biofertilizers (Azos, Phospho and Potash mobilizer) imposed plants performed better in growth parameters *viz*., plant height, number of branches, leaves, leaf area and leaf yield and yield attributes

Acknowledgement

The authors are thankful to Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India.

Author Contributions: This is the part of Ph.D student's thesis work (first author A. Nazar) and all the authors participates in the work in a substantive way and contributed equally.

Conflict of Interest: None declared

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