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Influence of application of microbial consortium on established mulberry plantation under temperate climatic conditions

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Abstract
Bio-fertilizers or microbial inoculants are now being increasingly and effectively used in various agriculture crops with reduced synthetic fertilizer input. The idea is not only to reduce the cost of production but also a step in raising crops organically. Field experiment conducted consecutively for two years at College of Temperate Sericulture SKUAST-K on the use of microbial consortium on established mulberry plantation of Goshoerami variety indicated significant differences among various treatments. The experiment was laid out with 13 different treatments with different levels of nitrogen and phosphorus in combination with different biofertilisers. From the pooled data of two years it was observed that treatment T_9 where only ¾ of phosphorus and nitrogen was applied registered shootlet number to the extent of 60 which was however at par with T_8 and T_{10} recording values of 59.33 and 58.66 respectively. Longest shootlet length was also found to be highest in T_{10} (recommended dose) *viz*., 39.33 which was however at par with T_7, T_8 and T_9. Total shootlet length was highest in T_8 recording a value of 2382.16 cm which was in turn at par with T_9 registering value of 2370.33 cm. Moisture percentage was highest in T_9 with a value of 74.90% being at par with T_{10} receiving recommended dose of synthetic fertilizers without inoculation. Similar observation was recorded in moisture content after six hours being highest in T_9 *viz*., 55.03% but at par with T_{10} recording value of 54.01%. The results indicate that nitrogen and phosphorus application in mulberry under temperate conditions can be reduced to 3/4 and 1/2 percent without any deleterious effect on yield.

Keywords: Biofertilisers, mulberry, temperate, azotobacter, PSB

Introduction
The sustainability of crop production is directly related to kind and cost of inputs being pumped into cultivation of such crops as the economic viability of inputs decide the amount of revenue which a farmer can generate. Lesser the input cost, more will be the benefit. With the advancement of science and more awareness among the beneficiaries various innovations have been arrived at to make the agricultural sector cost effective (Ajmal *et al*., 2018) [10] and safe. Famers always find it difficult to apply the synthetic fertilizers to their crops as per the recommended package of practices which cannot only be attributed to the soaring cost of fertilizers but also because of health hazards which application of synthetic fertilizer results in. Further the inaccessibility of the essential plant nutrients due to lack of sufficient quantity and type of fertilizer **x** also hinders smooth application of fertilizers. Continuous use of chemical fertilizers also results in the deterioration of soil quality and gradual loss of soil fertility which might further lead to the accumulation of heavy metals in plant tissue, affecting the nutritional contents of the yield and edibility (Farnia and Hasanpoor, 2015) [2]. Biofertilizer or the microbial inoculants that contain the culture of dormant or live cells of the effective strains of N-fixing, P-solubilizing/mobilizing, K-solubilizing (Itelima *et al*., 2018; De Vives-Peris *et al*., 2020; Fasusi *et al*., 2021) [9, 7, 12]. The use of bio-fertilizers, therefore, supplies and enhances the productivity per area in a comparatively short time, consume smaller amounts of energy, reduces contamination of soil and water, increases soil fertility, and encourages antagonism and biological control of phytopathogenic organisms (Sneha *et al*., 2018) [13].

Sori *et al.* (2008) [14] while studying the influence of bio-inoculants on available N, P and K content of M_5 mulberry garden under rainfed conditions stated that the mulberry gardens treated with bio-inoculants at 20 kg/ha of *Azotobacter* + 25 kg/ha of *Aspergillus awamori* + 20 kg/ha of *Trichoderma harzianum* + 75 percent recommended nitrogen and phosphorus each through chemical fertilizer with full recommended dose of farm yard manure and potassium have recorded maximum available NPK.

Chandrashekar *et al*. (1996) [15] while studying the effect of inoculation with *Acaulospora laevis, Bacillus megaterium* var. *phosphaticum* and *Azospirillum brasillense* using two sources of phosphorus on the growth and leaf yield of mulberry reported that synergistic interaction of *Azospirillum* with phosphate solublising bacteria and vesicular arbuscular mycorrhiza fungi resulted in maximum leaf yield of mulberry.

Gabhiye *et al*. (2003) [5] recorded the effect of biofertilizers on growth and yield parameters of tomato. According to their opinion, *Azotobacter* gave best results in terms of plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size. Biofertilizers in combination with chemical fertilizers was found to be the best treatment and significantly influenced all yield contributing characters.

Rather *et al*. (2018) [1] evaluated the response of lettuce to biofertiliser inoculation and FYM and observed that biofertiliser enhanced growth, yield and quality attributes of lettuce significantly. Hoshang Naserirad *et al.* (2011) [6] while studying the effect of integrated application of bio-fertilizer on grain yield, yield components and associated traits of maize cultivars reported that inoculation with biofertilizers containing *Azotobacter* and *Azospirillum* increased plant height, leaf number per plant, fruit mean weight and yield as compared to control (without biofertilizer).

Materials and Methods

The present investigation was carried out at the experimental farm of College of Temperate Sericulture SKUAST-K (Located at 34 0 1.17'N Latitude, 74 0.17'E Longitude and at an altitude of 1585 m above MSL. Established 20 years old mulberry plantation of Goshoerami an exotic variety of mulberry which is the most popular variety of mulberry used for commercial rearing in the region with uniform growth and vigour was used for the study. The plantation was maintained as dwarf at 6ft x6ft spacing. The experimental was laid in RBD with 13 treatments whose details are here under:

Treatment details

T_1	=	PSM+¼P
T_2	=	PSM+½ P
T_3	=	PSM+¾P
T_4	=	NFB+¼N
T_5	=	NFB+½ N
T_6	=	NFB+¾N
T7	=	PSM+NFB+¼ P+¼ N
T_8	=	PSM+NFB+½ P+½ N
T_9	=	PSM+NFB+¾P+¾ N
T_{10}	=	RD
T_{11}	=	PSM
T_{12}	=	NFB
T_{13}	=	Absolute control

The data on various growth parameters was recorded at the time coinciding with 5th age silkworm rearing in field.

Results and Discussions

Two year pooled data indicated that treatment T_9 where only ¾ of phosphorus and nitrogen was applied registered shootlet number to the extent of 60 which was however at par with T_8 and T_{10} recording values of 59.33 and 58.66 respectively. Longest shootlet length was also found to be highest in T_{10} (recommended dose) *viz*., 39.33 which was however at par with T7, T_8 and T_9. Total shootlet length was highest in T_8 recording a value of 2382.16 cm which was in turn at par with T_9 registering value of 2370.33 cm (Table-1). Chikkaswamy (2015) [4] while working on the effect of *cyanobacterial* biofertilizer on soil nutrients and mulberry leaf quality and its impact on silkworm crops reported that *cyano bacterial* biofertilizer can be recommended to the sericulture farmers with an intension to improve the soil fertility condition and leaf quality traits besides saving 50% cost of chemical fertilizers. Irfan *et al.* (2010) [8] also while studying the effect of nitrogen fixing bacteria on plant growth and yield of *Brassica juncea* reported that application of both the bacteria recorded higher plant growth and yield in *Brassica juncea*. Also it was reported that *Azospirillum* inoculation resulted in higher growth and yield parameters in comparison to *Azotobacter* inoculation.

Moisture percentage was highest in T_9 with a value of 74.90% being at par with T_{10} receiving recommended dose of synthetic fertilizers without inoculation. Similar observation was recorded in moisture content after six hours being highest in T_9 *viz*., 55.03% but at par with T_{10} recording value of 54.01%. The results indicate that nitrogen and phosphorus application in mulberry under temperate conditions can be reduced to 3/4 and 1/2 percent without any deleterious effect on yield (Table-2). Baqual (2013) [11] while working on the economics of using biofertilizers and their influence on certain quantitative traits of mulberry reported that it is possible to curtail the application of N and P in mulberry cultivation to an extent of 25-50% without any adverse effect on leaf yield and quality by supplementing N & P through use of *Azotobacter* and PSB. Baqual and Das (2012) [3] while working on the effect of inoculation with *Azotobacter* and PSM on mulberry reported that the dual inoculation of mulberry with PSM like *Bacillus megaterium*, *Aspergillus awamori* and nitrogen fixing bacteria like *Azotobacter chroococcum* under varying levels and sources of P and N revealed significant beneficial effect on fresh root biomass, total above ground biomass etc. of the saplings of V_1 and S_{36} mulberry varieties.

Table 1: Influence of inoculation of growth parameters of established mulberry

Treatment	Number of shoot lets/plant			Longest shootlet length (cm)			Total shoot let length (cm)		
	Spring 2018	Spring 2019	Pool	Spring 2018	Spring 2019	Pool	Spring 2018	Spring 2019	Pool
T_1	48.00	49.33	48.66	32.66	33.00	32.83	1533	1629.33	1591.16
T_2	46.66	49.00	47.83	32.66	29.00	30.83	1515	1389.33	1452.16
T_3	48.33	49.66	49.00	29.66	29.67	29.66	1436.66	1449.00	1442.83
T_4	46.00	49.00	47.50	29.33	31.00	30.16	1345.66	1478.00	1411.83
T_5	48.00	42.66	45.33	30.33	30.66	30.50	1453.33	1282.66	1368.00
T_6	46.66	47.33	47.00	27.66	31.66	29.66	1290.00	1352.66	1321.33
T7	43.33	45.66	44.50	39.00	39.66	39.33	1692.00	1806.66	1749.33
T_8	59.00	59.66	59.33	40.00	37.00	38.50	2361.00	2403.33	2382.16
T_9	59.33	60.66	60.00	39.00	40.00	39.50	2315.00	2425.66	2370.33
T_{10}	58.33	59.00	58.66	40.33	39.33	39.83	2023.33	2302.66	2163.00
T_{11}	47.00	45.33	46.16	34.00	34.33	34.16	1674.00	1516.66	1595.33
T_{12}	45.66	43.00	44.33	31.33	32.66	32.00	1427.33	1380.00	1398.66
T_{13}	43.33	45.00	44.16	32.33	35.00	33.66	1367.00	1533.33	1450.16
Cd 5%	5.98	4.51	4.14	3.80	4.26	3.20	337.20	252.81	177.54

Table 2: Various moisture related parameters of established mulberry as influenced by the application of microbial consortium

Treatment	Moisture content (%)			Moisture content after six hours (%)			Moisture retention capacity after six hours (%)		
	Spring 2018	Spring 2019	Pool	Spring 2019	Spring 2018	Pool	Spring 2018	Spring 2019	Pool
T_1	72.40	72.36	72.38	52.66	52.66	52.66	92.93	92.26	92.60
T_2	72.96	72.76	72.86	52.10	52.03	52.06	92.73	92.46	92.60
T_3	73.63	73.26	73.45	53.60	53.56	53.58	91.73	91.53	91.63
T_4	72.76	72.20	72.48	52.33	52.20	52.26	92.26	92.60	92.43
T_5	73.33	72.70	73.01	52.60	52.60	52.60	92.76	92.60	92.68
T_6	73.26	73.26	73.26	53.26	53.00	53.13	92.13	92.06	92.10
T7	73.53	73.30	73.41	53.56	53.40	53.48	93.36	93.30	93.33
T_8	73.03	73.73	72.88	53.26	52.63	52.76	95.06	94.96	95.01
T_9	75.13	74.66	74.90	53.56	52.00	55.03	94.96	94.70	94.83
T_{10}	74.40	73.63	74.01	52.90	54.00	54.01	95.30	95.33	95.21
T_{11}	72.50	72.50	72.50	52.63	52.43	52.53	91.66	91.43	91.55
T_{12}	72.36	72.06	72.21	52.43	51.93	52.18	91.50	91.36	91.43
T_{13}	72.70	T_2.63	72.66	52.76	52.66	52.71	91.36	91.00	91.18
Cd 5%	1.02	1.07	0.93	1.05	1.24	1.08	1.03	1.00	0.99

Conclusion

On the basis of current findings it may been concluded that, the scope for the application of microbial consortium in mulberry cultivation is more as it helps in reducing the demand for the chemical fertilizers, increases the nutrient use efficiency and improves leaf quality.

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