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Mulberry Leaf Productivity, Profitability and Soil Fertility as Influenced by Inorganic Fertilizers and Biofertilizers Under Intercropping System

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A field experiment was conducted during kharif (I) and rabi (II) 2009-10 and 2010-11 at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu to study the effect of biofertilizers and inorganics applied to mulberry under intercropping system with green gram. Green gram intercropping significantly increased the mulberry leaf yield (8348 and 8464 kg/ha) in the first and second seasons, respectively and soil nutrient status (N, P and K) with the values of N (287 kg/ha), P (13.5 kg/ha), K (457 kg/ha) and organic carbon (0.76 per cent) and decreased pH (7.9) and electric conductivity (0.36 mmhos/m) of the soil with higher B/C ratio (2.07) as compared to pure crop of mulberry. Application of 100 per cent NPK (300:120:120 kg/ha/year) recorded higher leaf yield, soil fertility status and economics which was on par with application of Azophos 15 kg /ha/year with 50 per cent recommended N and P fertilizers.

Key words: Inorganic fertilizers, biofertilizers, azophos, intercropping, soil health, mulberry leaf yield.

Mulberry (*Morus alba* L.) (Family: Moraceae) is a perennial, deep rooted, fast growing and high biomass producing foliage plant. Mulberry leaf is the sole source of food for silkworm *Bombyx mori*. L. India continues to be the second largest producer of silk in the world after China contributing about 13.14 per cent to the world silk production (CSB, 2010). The standing area under mulberry in India is around 2.82 lakh hectares producing 20,410 tonnes of raw silk. Over 98 per cent of mulberry raw silk production is contributed by the five traditional states of sericulture namely Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir.

In Tamil Nadu, the area under mulberry cultivation is 10,389 ha (Datta, 2008). So efforts are being made to develop new varieties and agronomic practices to increase the leaf productivity to sustain profitability in sericulture. Maintenance of soil fertility is highly essential for the sustainable production of mulberry leaf. The requirement of macro nutrients such as nitrogen, phosphorus and potassium is very high (300: 120: 120 NPK kg/ha/year) under irrigated condition when compared to any other agricultural crops.

The biofertilizers enriched with bacteria and fungi have proven to be of great importance in improving the yield and quality of mulberry (Chandrashekar *et al.,* 1996; Baqual *et al.,* 2005). Intercropping of short duration pulses is one of the means by which the risk of crop failures in mulberry can be partially minimized (Shankar and Rangaswamy, 2000). They fix atmospheric nitrogen in the soil, thereby making the soil more fertile. Hence, the present has taken to study the performance of different inorganics individually and in combination with biofertilizers on growth, leaf yield and quality of mulberry and work out the economics for various treatment combinations

Materials and Methods

A field investigation was carried out during *kharif* (I) and *rabi* (II) 2009-10 and 2010-2011 at Tamil Nadu Agricultural University, Coimbatore which is located at 11° N latitude and 77°E longitude. The mean altitude is 426.7m above mean sea level. The experiment was laid out in split plot design with three replications. The main plot treatments comprised of two mulberry cropping systems *viz.,* pure crop of mulberry (M_1) and intercropping with green gram (M_2). The sub plot treatments imposed were S_1 (100 per cent recommended dose of fertilizer (RDF) at 300 : 120 : 120 kg/ha/year), S_2 (Soil application of azospirillum at 20 kg/ha/year in two equal splits with only 50% N fertilizer), S_3 (Soil application of phosphobacteria at 10 kg/ha/year in two equal splits with 50% P fertilizer), S_4 (Soil application of Azophos at 15 kg/ha/year in two equal splits with 50% N and P fertilizer each) and S_5 (absolute control - no inorganics and biofertilizers).

The split doses of biofertilizers were applied twice on 10^{th} and 20^{th} days after pruning. Soil initial and final status was analyzed for total nitrogen, phosphorus and potassium content along with soil organic carbon, pH and electrical conductivity. Observations on leaf yield were recorded. The net income and expenditure right from the start of the experiment for both seasons were pooled and economics were worked out.

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Results and Discussion

Effect on mulberry leaf yield

There was significant difference in leaf yield of mulberry due to green gram intercropping. The treatment M_2 (Mulberry intercropped with green gram) recorded higher leaf yield (4588 kg/ha and 8348 kg/ ha) on 30 and 60 DAP, respectively in the first season and (4750 kg/ha and 8464 kg/ha) on 30 and 60 DAP, respectively in the second season as compared to the pure crop of mulberry (M_1) (Table 1). The reason might be the inclusion of leguminous crop green gram which fixed atmospheric nitrogen and improved the availability of nutrients and also due to suppression of weed growth and better mulberry leaf production which was similar to the observations made by Shukla *et al.* (1989).

The treatment S_1 (100 % RDF) recorded higher leaf yield (4588 kg/ha and 8348 kg/ha) on 30 and 60 DAP respectively in the first season and 4750 kg/ha and 8464 kg/ha on 30 and 60 DAP respectively in the second season which was on par with the treatment S_4 (Azophos 15 kg/ha/year + 50% reduction 'N' and 'P' fertilizer). The lowest leaf yield was recorded by the treatment S_5 (Pure crop of mulberry with no inorganics and biofertilizers) which produced 1819 kg/ha and 5226 kg/ha on 30 and 60 DAP, respectively in the first season and it continued to be the least with a leaf yield of 2064 kg/ha and 5333 kg/ha on 30th and 60th DAP, respectively in the second season. The increase in the leaf yield might be due to production of taller plants with more number of shoots per plant, more leaves per branch and higher single leaf weight in the above said treatments. In addition, adequate availability of major nutrients through inorganic fertilizers and biofertilizers which helped in fixation of atmospheric nitrogen and by solubilizing phosphorous which are required in larger quantity and thus directly help the plants to register higher yield.

Table 1. Effect of inorganic fertilizers and biofertilizers on leaf yield of mulberry (kg/ha/harvest)

Treatment	Season I (2009-2010)		Season II (2010-2011)	
	30DAP	60DAP	30DAP	60DAP
M_1S_1	3820	7082	4289	7288
M_1S_2	1993	6470	2743	6858
M_1S_3	2097	6357	2633	6737
M_1S_4	2621	6886	3720	7036
M_1S_5	1819	5226	2064	5333
M_2S_1	4588	8348	4750	8464
M_2S_2	3127	7521	3848	8045
M_2S_3	2955	7510	3873	7997
M_2S_4	3470	7872	4291	8285
M_2S_5	1945	6017	2732	6299
Mean				
M1	2470	6405	3090	6757
M2	3217	7454	3899	7658
S1	4204	7716	4520	7877
S2	2560	6996	3296	7452
S3	2526	6934	3254	7368
S4	3046	7380	4006	7661
S5	1882	5622	2399	5817

	SEd	CD(0.05%)	SEd	CD(0.05%)	SEd	CD(0.05%)	SEd	CD(0.05%)
M	52	225	229	988	76	330	154	662
S	153	325	363	771	140	298	346	735
M at S	201	456	514	1314	193	476	465	1097
S at M	217	460	514	1090	198	421	490	1040

* DAP- Days after pruning

The interaction effect was significant with regard to mulberry leaf yield. The treatment M_2S_1 (Mulberry + green gram intercropping system with 100 % RDF) recorded higher leaf yield (4588 kg/ha and 8348 kg/ ha) on 30 and 60 DAP, respectively in the first season and it was 4750 kg/ha and 8464 kg/ha on 30 and 60 DAP, respectively in the second season. This was closely followed by M_2S_4 (Mulberry + green gram intercropping system with Azophos 15 kg/ha/year + 50% cut in 'N' and 'P' fertilizer). The treatment M_1S_5 (Pure crop of mulberry with no inorganic fertilizers and biofertilizers) recorded the lowest leaf yield of 1819 kg/ha and 5226 kg/ha and 2064 kg/ha and 5333 kg/ ha on 30 and 60 DAP in their respective seasons. Higher leaf yield of mulberry in intercropping system with 100 % RDF and Azophos application might be due to combined effect of green gram with inorganic and biofertilizers which resulted in more supply of major nutrients resulted in higher leaf yield. Similar observations were also reported by Ahmed (1986) and Kabir (1991), who opined that higher leaf yield of mulberry, is due to application of inorganic fertilizers which was superior to control plot where no inorganics were used. The further Balasubramanian et al. (1992) who reported higher leaf yield due to inoculation of azospirillum and phosphobacteria confirtilizersm the results of the present findings.

Effect on soil nutrient status

There was increase in the N content of the soil in Azophos (S_4) applied plots (287 kg/ha) which was followed by azospirillum (S_2) and phosphobacteria (S_3). The N content was decreased (243 kg/ha) in plots where no inorganic f and biofertilizers were applied (S_5). Similar trend was followed by P and K contents of the soil where both P and K increased in biofertilizers applied soil and the lowest was noticed in control. The organic carbon was not much affected by application of inorganics and biofertilizers. There was a marginal decrease in pH (0.79) and EC (0.36) in soils receiving azophos (S_4), where as the pH and EC was not much affected by other treatments (Table 2). The activity of microorganisms in the soil due to azophos application might have caused the increase in NPK content and also marginal decrease in pH and EC of the soil. Similar findings were also reported by Ram Rao *et al.* (2007).

Economics

The data on economics revealed that the cost of cultivation was higher in the treatments where 100 per cent recommended dose of inorganic fertilizers were used and was comparatively reduced when it was substituted with biofertilizers. The gross income was higher in treatment where 100 per cent inorganic fertilizers were used (S_1) through higher yield but the net returns and B: C ratio were lower as compared to biofertilizers applied treatments (Table 3).

Table 2. Effect of inorganic fertilizers and biofertilizers on soil nutrient status

Treatment	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	pH	EC (dsm /m)
M_1S_1	0.72	272	12.0	448	8.1	0.40
M_1S_2	0.73	278	12.5	451	8.0	0.39
M_1S_3	0.72	274	12.5	449	8.0	0.38
M_1S_4	0.73	281	12.5	452	8.0	0.38
M_1S_5	0.70	243	10.5	437	8.1	0.39
M_2S_1	0.73	275	12.5	451	8.1	0.39
M_2S_2	0.74	282	13.0	454	8.0	0.37
M_2S_3	0.73	279	13.0	453	8.0	0.37
M_2S_4	0.76	287	13.0	457	7.9	0.36
M_2S_5	0.71	252	11.0	439	8.1	0.39

* Data not analyzed statistically

The mulberry with green gram intercropping system (M_2) recorded higher gross returns (Rs.9, 200) with higher B: C ratio (2.07) as compared to pure crop of mulberry (M_1). The mulberry applied with 100 % RDF (S_1) had higher gross returns but comparatively lower B: C ratio (1.78) than biofertilizers. This was due to lower cost of cultivation, higher leaf yield and comparatively higher gross returns. The lowest gross returns and B: C ratio were registered in S_5 (absolute control) which was Rs. 5,280 and 1.21, respectively. The green gram intercropped plots had higher B: C ratio as compared to pure crop of mulberry. This might be due to higher leaf yield and higher gross income obtained due to additional income from green gram.

The results showed that biofertilizers, a cheaper supplement to the expensive chemical fertilizers can be used in mulberry cultivation to reduce the use of chemical fertilizers and thus saving 50 per cent cost of chemical fertilizers. Further, use of biofertilizers helps to improve the soil fertility may be condensed status and soil health. The application of azophos, which is a combination of both azospirillum and phosphobacteria proved beneficial not only in terms of economizing N and P fertilizers by 50 per cent but also improved the leaf yield, silkworm growth and soil health. Hence, combined application of Azophos @ 15 kg /ha/year with 50% recommended N and P fertilizers registered increased leaf productivity and profitability with improved soil nutrient status as compared to individual application of either inorganics or biofertilizers alone in irrigated mulberry based green gram intercropping system.

Table 3. Effect of inorganics and biofertilzers on economics

Treatment	Total cost of cultivation (Rs/ha)	Gross Return (Rs.)	Net Return (Rs.)	B:C ratio
M_1S_1	4355	7185	2830	1.65
M_1S_2	3786	6664	2877	1.76
M_1S_3	3874	6547	2673	1.69
M_1S_4	3722	6961	3238	1.87
M_1S_5	4363	5280	916	1.21
M_2S_1	5169	9200	4031	1.78
M_2S_2	4640	8677	4037	1.87
M_2S_3	4718	8681	3963	1.84
M_2S_4	4380	9067	4687	2.07
M_2S_5	5012	6666	1654	1.33

* Data not analyzed statistically. Rs. 1.50/kg of leaf

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