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Research Article

Effect of Organic vis-à-vis Conventional Cultivation Practices on Growth and Yield of Mulberry (*Morus alba* L.)

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Abstract

A comparative study was conducted between organic vis-à-vis conventional cultivation practices with respect to soil properties, growth and yield of mulberry and economic viability of both the systems. The experiment was laid down in a red sandy loam soil with two cultivation practices i.e. conventional and organic with six replications. Soil samples (0-0.15m depth) before initiation of the experiment and each year after harvesting of fifth crop were collected for analysis of physical, chemical and biological properties of soils. Mulberry growth and yield parameters were recorded for each crops and a total of fifteen crops were harvested over a period of three years. Results suggested that there was an improvement in soil physical, chemical and biological properties in organic cultivation practices compared to conventional one. The nutrient concentration (N, P, K, Fe, Mn, Cu and Zn) in mulberry leaf of organic practices was higher than conventional practice. The average mulberry leaf yield was higher in conventional practice (60.3 t/ha/year) than organic practice (59.5 t/ha/year) with an annual yield gap of ~1.0t/ha. Benefit-cost ratio of both the cultivation systems showed that organic cultivation practice (BC: 1:1.74) is more viable than conventional practice (BC: 1:1.57).

Keywords: Organic cultivation, conventional practice, mulberry, yield gap, economic viability

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Introduction

Mulberry (*Morus alba* L.), the sole food plant of silkworm (*Bombyx mori* L.) is a perennial crop cultivated in many parts of India. With the advent of new technologies and mulberry varieties having a higher yield potential, the development of the sericulture industry walked miles in the recent years. Since, the mulberry is grown for more than 15- 20 years in the same land, continuous production of mulberry for a long time results in gradual reduction of leaf yield and quality [1]. As mulberry grows profusely with higher biomass production removes huge quantities of nutrients from soils causing depletion of nutrients in soil. Therefore, for sustainable leaf production and restoration of soil health, application of balanced nutrients is a pre-requisite.

Mulberry can be grown in different types of soil and topography where most of the agricultural crops are found not suitable [2]. However, it has been well established that mulberry prefers to grow in slightly acidic to neutral sandy loam soils having high organic carbon content. In order to meet the crop demand, huge quantity of chemical fertilizers is applied for mulberry cultivation. Continuous application of chemical fertilizers and pesticides could result in depletion of organic matter, increase soil compaction and overall degradation of soil quality [3, 4] besides the residual effect of pesticides in leaf and silk fibres. Moreover, 50% of the area under mulberry cultivation is rainfed and as such the nutrient use efficiency of the applied fertilizers found to be low. Application of organic manures could improve the moisture retention capacity of soils and improve the water use efficiency and good crops can be harvested per drop of water. Thus, cultivation of mulberry by following organic cultivation practices could be one of the feasible options. Organic farming is considered to be an alternative agricultural practice to mitigate the adverse effects of various inorganic fertilizers to soil conditions. This alternative practice is expected to improve the sericulture industry and the production of quality of leaf of mulberry [5]. Although, organic farming is denigrated to be poor yielding, application of balanced nutrients through organic means of cultivation could increase the yield of mulberry. Apart from that, organic farming could have a positive influence on carbon sequestration potential of soils and improvement of physical, chemical and biological properties of soils and consequent increase in soil fertility and restoration of soil health [6]. Moreover, the generation of nearly 10-12MT of farm residues including silkworm litter, left over leaf during rearing etc. in sericulture industry shows the huge potential of converting these residues to compost and raising of mulberry organically.

Several technologies on mulberry cultivation and nutrient management were developed by Central Sericultural Research and Training Institute and its nested units and tested in field [7-11], but there was no comprehensive, low cost, eco-friendly and improved package of practices available in respect of purely organic farming approach. Therefore, we aimed to evaluate the performance of mulberry under organic cultivation practices and compare its potential in terms of yield, quality, restoration of soil health and economic viability with respect to conventional cultivation practices.

Materials and Methods

A study was conducted in a red sandy loam soil at Central Sericultural Research & Training Institute, Mysore during 2016-2018 to compare the performance of mulberry in terms of yield, quality, restoration of soil health and economic viability in conventional vis-a-vis organic cultivation practices. The experiment was laid down with two cultivation practices viz., conventional (application of 10 MT of FYM and Chemical fertilizers @140:56:40 NPK kg/acre/yr. and prevention of disease pest infestation by spraying chemicals such as Kavach, Indofil M-45, DDVP etc.) and organic [application of 10 MT of FYM and Seri compost/Vermi compost (8 MT) + Green manure (20 kg) + bio-fertilizers (Azotobacter-10 kg, PSB-2 kg) + Neem cake (400 kg) prevention of disease pest infestation by application of neem cake/nimahari, release of bio-control agents such as Trichogramma chilonis, Cryptolaemus montrouzieri, Scymnus coccivora etc.] each replicated six times.

Soil samples at 0-0.15m depth were collected before the initiation of the experiment. Core and moist soil samples were collected for analysis of bulk density and microbial population count viz., bacteria, fungi and actinomycetes respectively. Collected soil samples were dried and processed for analysis of different chemical properties. The pH of the soil was measured with glass electrode pH meter in soil: water: 1:2.5 [12], oxidizable organic carbon was estimated by acid digestion method [13] using potassium dichromate. Available phosphorus and potassium were analyzed following the standard procedure [12]. The available micronutrients viz., iron, manganese, copper and zinc were analysed by extracting the soils with 0.02M DTPA solution followed by measuring their respective concentration in Atomic Absorption Spectrophotometer. Microbial population was enumerated following standard protocols of serial dilution technique [14].

Data on growth, yield and quality parameters were recorded in conventional vis-à-vis organic cultivation practices for three consecutive years. Average plant height, longest shoot length, number leaves per shoot, leaf: shoot, leaf area, moisture content and moisture retention capacity of leaf were recorded after each crop harvest and annually five crops were harvested and total leaf yield was calculated by pooling leaf yield in each crop harvest. Leaf area (cm^2) was recorded with the help of leaf area meter.

Leaf moisture (%) was determined by the oven dry method using the following formula:

$$\text{Leaf Moisture\%} = \{(FW - DW)/ FW\} \times 100$$

Where FW= fresh weight (g) immediately after harvest, and DW is the oven dry weight

The leaf moisture retention capacity (MRC) was estimated using the formula:

$$\text{MRC (\%)} = \{(FW1 - DW)/(FW0 - DW)\} \times 100$$

Where FW0= fresh weight (g) immediately after harvest, FW1 (g) is the weight at a particular hour after harvest and DW is the oven dry weight.

Leaf was analysed for its nutrient content such as N, P, K, Fe, Mn, Cu and Zn. Leaf samples were digested in sulphuric acid at 400^0C in presence of digestion mixture ($CuSO_4$+K_2SO_4+Se powder) and cooled and then distilled with 40% NaOH to release ammonia. Ammonia thus liberated was absorbed in boric acid- mixed indicator reagent which was then titrated against a standard acid to estimate the total N. Leaf P, K, Fe, Mn, Cu and Zn were analysed by dry ashing of leaf samples in muffle furnace at 550^0C for 5hours followed by dilution with 6N HCl. The concentration of phosphorus was measured in spectrophotometer by by vanadomolybdophosphoric yellow colour method. Potassium and other micronutrients i.e Fe, Mn, Cu and Zn were measured in flame photometer and atomic absorption spectrophotometer.

Statistical analysis for each year and pooled three years data was done at 5% critical difference.

Results and Discussion

Effect of organic vis-à-vis conventional cultivation practices on changes in physical, chemical and biological properties of soil

Results depicted in the **Tables 1** and **2** showed that cultivation of mulberry with organic vis-à-vis conventional practices resulted in change in soil physical, chemical and biological properties over the years. The data showed that pH of the soil was slightly reduced by the organic cultivation practices as compared to conventional practices in all the three years, but the reduction in pH was not significant among the cultivation practices. The electrical conductivity of the soil under conventional cultivation practice was higher compared to organic cultivation practices. This could be because of the addition of soluble salts in the form of fertilizer [15]. Soil physical properties such as bulk density and water holding capacity were positively influenced by organic cultivation practices in all the three years of study. Bulk density of the soil was reduced by 2.0%, 5.0%, 3.0% and water holding capacity was increased by 0.05 %, 3.0%, 4.5 % during 2016, 2017, 2018 respectively as compared to conventional practices. Continuous organic manure addition over the years reduced the bulk density with consequent improvement in water holding capacity [16]. Soil organic carbon content was high in organic cultivation practices in all the three years as compared to conventional practices. The average of three year data revealed that organic carbon content increased by 24% over conventional practice. Availability of phosphorus, potassium, and micronutrients to plants were positively influenced by the organic cultivation practices. The average of three year data showed that the available P and available K increased by 2.0 % and 3.0 % respectively over conventional practices. The improvement in nutrient availability to mulberry in organic cultivation practices may be because of enhanced microbial activities, reduced losses of nutrients and improved soil properties.

Microbial population viz., fungi, bacteria and actinomycetes were enumerated in soils of organic vis-à-vis conventional cultivation practices; the former being registered a higher population of these microbes all the three years. During the first year there is no significant difference among the cultivation practices with respect to actinomycetes population whereas in 2017 and 2018 the population was significantly different from conventional cultivation practices. The microbial population in the organically managed soil ranged from 125-142 x 10^{-7} cfu for bacteria, 24-29 x 10^{-7} cfu for fungi and 105-108 x 10^{-7} cfu for actinomycetes. Combined use of different sources of organic manures with bio-fertilizers might have improved the microbial load of the soil. The microbial population viz., bacteria, fungi and actinomycetes conspicuously increased with application of different organic N sources than the conventional practices. This is in accordance with the findings of Ravanachandar and Lakshmanan [17].

Table 1 Effect of organic vis-à-vis conventional cultivation practices on changes in physical, chemical and biological properties of soil over the years

#	Treat.	pH	EC (dS m^{-1})	BD (Mg m^{-3})	WHC (%)	OC (%)	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	Av. Cu (μgg^{-1})	Av. Zn (μgg^{-1})	Av. Fe (μgg-^{1})	Av. Mn (μgg-^{1})
	Initial	**7.72**	**0.23**	**1.32**	**35.4**	**0.54**	**28.9**	**316.2**	**3.15**	**0.75**	**7.79**	**28.6**
First year	Organic	7.65	0.22	1.31	36.7	0.69	33.12	328.41	3.15	0.8	8.66	31.2
	Conventional	7.67	0.24	1.28	36.42	0.59	32.8	328.4	3.02	0.85	8.01	30.78
	CD@5%	0.07	0.02	0.01	0.40	0.58	2.7	20.40	0.19	0.09	0.02	0.25
Second year	Organic	7.63	0.2	1.26	38.0	0.76	34.2	346.6	3.25	0.95	11.07	37.6
	Conventional	7.66	0.35	1.33	36.8	0.61	33.7	334.1	3.22	0.82	8.94	31.4
	CD@5%	0.71	0.031	0.11	2.79	0.73	2.42	24.35	0.12	0.09	1.01	3.27
Third year	Organic	7.61	0.19	1.25	38.8	0.82	35.3	352.8	3.46	1.02	12.8	39.6
	Conventional	7.60	0.34	1.29	37.1	0.63	34.1	332.59	3.24	0.86	9.21	33.6
	CD@ 5%	0.74	0.015	0.13	2.84	0.07	2.57	12.40	0.24	0.10	1.28	2.74
Pool data	Organic	7.63	0.20	1.27	37.8	0.76	34.2	342.6	3.29	0.92	10.84	36.13
	Conventional	7.64	0.31	1.30	36.7	0.61	33.5	331.70	3.16	0.84	8.72	31.93
	CD@5%	0.56	0.031	0.12	2.78	0.04	1.42	13.26	0.12	0.031	1.05	3.54

Effect of organic vis-à-vis conventional cultivation practices on growth and yield of mulberry

The growth and yield attributing parameters of mulberry were influenced by organic vis-à-vis conventional cultivation practices (**Table 3**). In first year, the average plant height (cm), longest shoot length (cm), number of shoots/ plant, number of leaves/ shoot, leaf area (cm^2), leaf: shoot ratio, moisture content as well as moisture retention capacity of leaf were higher in conventional method of cultivation compared to organic practice. This subsequently contributed to the higher yield in conventional system. In second year, similar trend of improvement in conventional system compared to organic practice was recorded with exception to moisture content as well as moisture retention capacity of mulberry leaf. In third year of cultivation, higher yield was recorded in organic system compared to conventional although the difference was not significant. Data recorded over the years (average of three years) showed that plant height (cm), longest shoot length (cm), number of shoots/ plant, number of leaves/ shoot, leaf area (cm^2), leaf: shoot ratio were higher in conventional cultivation practices compared to organic system with a yield difference of ~1.0 t/ha/year.

Table 2 Effect of organic vis-à-vis conventional cultivation practices on changes in microbial population in soils over the years

#	Treat.	Fungi ($x10^{-6}$) CFU	Bacteria ($x 10^{-7}$) CFU	Actinomycetes ($x10^{-7}$) CFU
	Initial	**19**	**125**	**95**
First year	Organic	24	132	105
	Conventional	20	127	98
	CD@5%	2.12	4.16	NS
Second year	Organic	27	136	106
	Conventional	22	128	99
	CD@5%	2.54	7.45	6.87
Third year	Organic	29	142	108
	Conventional	24	134	104
	CD@5%	2.9	7.20	9.80
Pool data	Organic	26.67	136.67	106.33
	Conventional	22.00	129.67	100.33
	CD@5%	2.57	6.64	0.11

Table 3 Effect of organic vis-à-vis conventional cultivation practices on growth and yield of mulberry

#	Treat.	Plant height (cm	Longest shoot length(cm)	No. of shoots/ plant	No. of leaves/ shoot	Leaf area (cm2)	Leaf : shoot ratio	Moisture content (%)	Moisture retention capacity (%)	Leaf Yield (t ha^{-1} $year^{-1}$)
First year	Organic	165.5	163	7.3	27.6	163.17	1.23	71.9	71.5	58.2
	Conventional	175.2	178.2	7.43	32.6	173.50	1.45	72.45	72.20	58.9
	CD@5%	12.1	11.7	NS	3.15	13.25	0.13	NS	NS	NS
Second Year	Organic	167.2	172.5	7.6	28.3	164.07	1.45	73.3	73.4	58.7
	Conventional	170.1	171.6	8.2	28.8	166.0	1.4	70.3	70.1	60.9
	CD@5%	NS	17.2	NS	2.97	NS	NS	NS	NS	6.25
Third year	Organic	173.4	184.6	8.2	31.9	169.27	1.5	73.6	72.8	61.6
	Conventional	174.6	175.2	8.3	29.6	170.5	1.5	72.9	72.5	61.38
	CD@5%	12.4	13.52	NS	NS	11.05	NS	NS	NS	4.29
Pool data	Organic	168.7	173.4	7.70	29.2	165.53	1.39	72.93	72.57	59.50
	Conventional	173.3	175.0	7.98	30.3	170.00	1.45	71.88	71.60	60.38
	CD@5%	14.3	15.5	NS	4.03	14.26	0.12	NS	NS	3.13

Macro- (N, P & K) and micronutrients (Fe, Mn, Cu & Zn) contents in mulberry leaf were analyzed and the results showed a significant improvement in organic practices compared to conventional one (**Table 4**). There was 20%, 66% & 6% improvement in N, P & K content in leaf in organic practices as compared to conventional practices. This might be due to the slow availability of nutrients in organic cultivation practices that could reduce the loss and increase plant assimilation. The contents of micronutrients such as Fe, Cu, Zn and Mn in leaf were also improved by the organic cultivation practices. The improved availability of macro-and micronutrients in soils of organic cultivation practice might have improved their respective contents in mulberry leaf. Similar trend of results were reported in second year of cultivation.

The average of three year data showed that N, P & K content in leaf was significantly influenced by organic cultivation practices over conventional practices. There was 17%, 54% & 4% improvement in N, P & K content in leaf in organic cultivation practices as compared to conventional practices. The improvement might be due to continuous and slow availability of these nutrients which are mostly applied through different sources of organics. The contents of micronutrients such as Fe, Cu, Zn and Mn in leaf were also improved by the organic cultivation practices.

Table 4 Effect of organic vis-à-vis conventional cultivation practices on nutrient content of mulberry leaf

#	Treat.	N (%)	P (%)	K (%)	Fe (μgg^{-1})	Cu (μgg^{-1})	Zn (μgg^{-1})	Mn (μgg^{-1})
First year	Organic	3.66	0.15	1.78	208.92	13.7	30.8	53.0
	Conventional	3.03	0.09	1.67	181.25	13.4	29.4	42.7
	CD@5%	0.32	0.014	0.12	25.80	1.32	NS	5.21
Second year	Organic	3.68	0.17	1.82	212.6	13.9	32.6	54.0
	Conventional	3.14	0.1	1.75	196.4	13.5	30.1	43.8
	CD@5%	0.23	0.014	0.18	14.26	1.10	2.24	5.40
Third year	Organic	3.71	0.2	1.86	214.6	14.2	34.7	55.2
	Conventional	3.24	0.15	1.69	202.4	13.8	32.1	44.9
	CD@5%	0.31	0.01	0.17	12.46	1.10	2.47	5.81
Pool data	Organic	3.68	0.17	1.82	212.04	13.93	32.70	54.0
	Conventional	3.14	0.11	1.70	193.35	13.57	30.53	43.8
	CD@5%	0.26	0.014	0.15	16.20	1.35	2.17	5.40

Benefit- cost ratio

The Benefit–Cost ratio is the net profit ratio of any production system which is calculated by taking into consideration the gross expenditure incurred to the net return. In this study, the benefit cost ratio of conventional vis-à-vis organic production system was calculated. The result (**Table 5**) showed that the organic production system witnessed a higher cost benefit ratio (1:1.74) compared to conventional (1:1.57) despite of being high cost involved for producing mulberry leaf in organic practice. This could be because of high amount of return in the organic production system being more prices for mulberry leaf than the conventional system with an additional return of Rs. 55,980/ha/yr.

Table 5 Economics of mulberry leaf production in conventional vis-à-vis organic cultivation practices

#	Particulars	Cost	
		Conventional cultivation	**Organic cultivation**
1	Farm yard manure (25 MTha/yr)@Rs.800/MT	20000	20000
2	Vermi compost (20 MT/ha/yr) @ Rs./1050 MT	---	21000
3	Green manure seeds (30 kg/ ha/yr) @ Rs.60/ kg)	---	1800
4	Azotobacter-25 kg /ha/yr) @ Rs.125/ kg)	---	3125
5	PSB-5kg/ ha/yr) @ Rs.160/ kg)	---	800
6	Fertilizer cost @ (1418 kg ammonium sulphate; 875 kg single super phosphate and 233 kg murate of potash (ha^{-1}year^{-1})	12658	---
7	Neem cake (400 kg/ha/yr@ Rs.15/ kg)	---	6000
8	Manure application (20 mandays) @ Rs.220 manday	4400	4400
9	Sericompost/ vermi. application (15 mandays) @ Rs.220 manday	--	3300
10	fertilizer application (30 mandays) @ Rs.220 manday	6600	--
11	Irrigation water cost	5000	5000
12	Irrigation (65 mandays @Rs.220/manday)	14300	14300
13	Inter-cultivation 20 mandays and 2 pairs of bullock - 5 times per year @Rs 220/ manday and Rs.220/- per bullock pair.	5500	5500
14	Shoot harvest (350 mandays @Rs.220/ manday)	77000	77000
15	Pruning and dressing of plants (25 mandays @Rs.220/ manday)	5500	5500
16	Land revenue	250	250
17	Miscellaneous	2500	2500
18	Total leaf production cost	153708	170475
19	Total leaf production (kg)	60380	59500
20	Gross/ total returns @Rs.4 /kg for recom and Rs. 5 for organically produced mulberry leaf	241520	297500
21	Net return (Rs./ha)	87812	127025
22	Additional return (Rs.) over existing recommendation		55980
23	Cost Benefit ratio	1:1.57	1:1.74

Conclusion

A detailed comparison between organic and conventional cultivation practices with respect to soil physical, chemical and biological properties, growth and yield of mulberry and economics were ascertained and it was found that the soil properties improved with enhanced microbial activities and nutrient availability in organic cultivation practices compared to conventional one. The benefit-cost ratio also suggested that a higher return will be achieved in organic cultivation practices than conventional practices. Although, the average yield of mulberry was higher in conventional cultivation practices than organic with an annual yield gap of ~ 1.0 t/ha, the organic practice can be recommended to farmers considering its effect on restoration of soil health and economic viability.

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