Organic farming approach for sustainable quality leaf production in mulberry (*Morus alba* L.) var. S-1635 under irrigated condition

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ABSTRACT

A field experiment was conducted at Central Sericultural Research and Training Institute, Berhampore to develop a sustainable organic farming package in mulberry cultivation under irrigated condition. Analysis of 5 crops data revealed statistically significance of the on treatments. Maximum plant height, no. of branches/plant, leaf area, LAI and leaf yield were recorded in T_2 (Control i.e. traditional practice- 20mt FYM/ha/year + 336N:180P:112K kg/ha/year) followed by T_7 (15mt VC/ha/year + biofertilizers + 50% RDF and T_3 (30mtVC/ha/year). Highest leaf yield (6,601.92 kg/ha/crop) was recorded in T_2 followed by T_7 (5,911.38 kg/ha/crop) and T_3 (4,884.73 kg/ha/crop). Maximum leaf area was observed in T_2 (157.73 sq. cm) followed by T_7 (137.50 sq.cm). The highest LAI was found in T_2 (5.73) followed by T_7 (5.26). The maximum (79.48%) leaf moisture was observed in T_5 (25mt VC/ha/year + green manuring followed by T_2 (78.82%) and T_7 (78.21%). With regard to the leaf quality study, it was found that maximum in T_2 (25.44mg/g fw) followed by T3 (25.35mg/g fw) in respect of total soluble protein while, T_3 (37.42mg/g fw) followed by T_4 i.e. 30mtVC/ha/year +Vermi wash as foliar spray (34.60mg/g fw) recorded total soluble sugar compared to control (31.52mg/g fw). The trend of above 5 crops result revealed that though the leaf yield is found still higher in T_2, but it is apparent that there is an increasing trend in leaf yield and other important parameters in T_7 and T_3. It was also observed that there is a gradual improvement in leaf yield and the yield difference is reduced from 22.84% to 4.96% against control in T_7 where as the yield difference is reduced from 53.09% to 18.03% in T_3 against control.

***Key words*:** Biofertilizer, green manure, leaf quality, organic farming and vermicompost

Mulberry is the sole food of silkworm, *Bombyx mori* L., which is a perennial crop cultivated for more than 15- 20 years in the same land and it is a prime constituent for the sericulture industry. In this era, sericulture has occupied an important place for the development of socio-economic status of the rural people. Due to intensive cropping pattern with 5 times whole shoot leaf harvest per year, yielding about 90mt green biomass/ha/year under Gangetic alluvial soil conditions of West Bengal, about 500 kg N, 90kg P_2O_5 and 300kg K_2O/ha/year are depleted from soil day to day. The similar trend of depletion was also experienced by Kar *et al*. (1997) in S1 when the biomass yield was 54mt/ha/year and uptake was 224 kg N, 44kg P_2O_5 and 160kg K_2O/ha/year under 4 crops schedule. As the extent of replacement of inorganic sources of nutrition is little known so the approach of the organic farming will be towards the organic management along with the integrated use of curtailed quantities of inorganic sources suitable for the long term cultivation of newly released high yielding variety of mulberry. Therefore, the enormous need of quality leaf in turn to produce quality silk depends upon the good health of soil and availability of sufficient quality balanced nutrients using various organic resources like, green manure, vermicompost, biofertilizers and vermibed / vermiwash as biopesticides because of its some antibiotic property so as to overcome the nutrient depletion (Zambare *et al.*, 2008 and Subsashri, 2004). Of course, sericulture industry has a big scope to produce quality vermicompost in a mass scale with the use of huge quantity of organic refuges like, rearing and farm waste.

The awareness on the harmful effect of toxic chemicals and the need for an eco-friendly sericultural, industrial and agricultural management with natural resources have been deeply felt which can only provide a new shape of the life style of the human being. Experiencing the ill effects of various chemicals in soil, declining the organic matter in the soil and ecological, environmental and social hazards, a new thrust on organic farming has been developed which is expected to be substantially better and potential to improve the sericulture industry in the way of improvement in leaf, cocoon as well as silk production and quality.

Large number of technologies about the mulberry farming and nutrition management system particularly integrated nutrient management were developed by Central Sericultural Research and Training Institute and also by other different organizations (Setua *et al*. 2007; Sudhakar *et al*. 2000; Kasiviswanathan and Iyenger, 1995; Kasiviswanathan, and Krishnawami, 1979 and Ghosh *et al*., 1997), but there was no comprehensive, low cost, eco-friendly and improved package of practices

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available in respect of purely organic farming approach.

Hence, the study has been made with an approach to combine the possible components of organic resources of plant nutrition and to evaluate the efficacy and extent of fully or partially replacement of chemical fertilizers for the irrigated, Gangetic alluvial soil conditions of West Bengal.

MATERIALS AND METHODS

The experiment was undertaken at CSR&TI, Berhampore, west Bengal with the help of 6- month-old AMF-inoculated and non-inoculated (recommended nutrient management) S-1635 (triploid) mulberry saplings at 60 x 60cm spacing under irrigated and alluvial soil conditions. The mulberry plants of 1 year old were pruned 5 times in a year as per 5 crop schedule at 15cm height for 4 times and once at ground level. The recommended package of practices for irrigated area (Ullal and Narasimhanna ,1987) was followed. The experiment was laid out in completely randomized block design with 7 treatment combinations and 3 replications. The treatments were T_1: Absolute control (No input); T_2 (recommended nutrient management): Farmyard manure @ 20mt and N:P_2O_5:K_2O @ 336:180:112kg/ ha / yr; T_3: 30mt vermicompost (VC) / ha /year; T_4: 30mt VC / ha /year + Vermi wash; T_5: 25mt VC / ha /year + green manuring (GM) with *Crotalaria juncea*; T_6: 20mt VC / ha /year + GM + *Azotobacter chroococcum* (AZB) + Arbuscular mycorrhizal fungi (AMF); T_7(INM):15mt VC / ha / year + AZB + AMF +168 N + 90 P_2O_5 + 56K_2O kg / ha / year. Full doses of FYM,VC *Azotobacter chroococcum* @ 20kg/ha/yr, Arbuscular mycorrhizal fungi @ 80 kg/ha (once in 4 years) and *GM* @ 25kg seed/ha were applied in July.

The pH of the soil was determined by following the method of Black (1965). Available N (Subbiah and Asija 1956), P and K in soil (Jackson (1973) were analyzed. Leaf moisture was determined by oven drying method and leaf area was estimated by leaf area meter (LICOR, LI-3050 A/4, sl.no.TBA-1045 – 8703, Made in USA). Total soluble protein and total soluble sugar content in leaf were determined by following the methods of Lowry *et al*. (1951) and Morris (1948) respectively.

Data on different growth, yield and quality parameters were recorded after continuous application of input for 5 seasons. Analysis of variance was performed on 5 seasons (July, Sept., Nov., Feb. and April). Seasonal effect on growth, yield and quality parameters along with season x treatment interaction were studied and the overall mean of each of the 7 treatments, critical difference value (P= 0.05) and co-efficient of variation (CV%) were also calculated.

RESULTS AND DISCUSSION

The soil was initially slightly alkaline (pH 7.93), E.C. 0.15 dS/m, with an optimum level of moisture holding capacity (45.8%) and organic carbon content (0.78%). Initial available nitrogen was found medium (196kg/ha), available phosphate was also observed medium (39kg/ha) and available potash was recorded high (444kg/ha).

Analysis of variance on leaf area index during July, Sept. and Feb, leaf area during July and Feb, plant height and leaf-shoot (%) during Nov. crops was found statistically not significant on treatments, but rest of the parameters were found significant (Table 1-5).

However, analysis of variance on plant height, leaf area, leaf area index (LAI), leaf shoot % and leaf yield was found statistically significant on various treatment combinations as per pooled data analysis of 5 crop seasons. Season x treatment interaction was also found significant (Table 6).

Growth attributes

Plant height and leaf area in T2 during July, Sept., Nov. and April, leaf area index in T2 during July, Nov. and April and leaf-shoot (%) in T1 during Nov., Feb. and April crop seasons were found maximum (Table 1-5). The statistical analysis of five crops pooled data revealed that maximum leaf area was recorded in T2 (recommended nutrient management) followed by T7 and T5. Highest LAI was found in T2 followed by T7 and T4 (Table 6).

Leaf yield

Maximum leaf yield was found in T2 during July, Sept., Nov. and April crops, while it was registered highest in T7 during February crop followed by T7 in 4 seasons and T3 in 3 seasons (Table 1-5). Pooled data analysis of 5 crops revealed that among the 7 treatments, maximum leaf yield was recorded in T2 (recommended nutrient management) *i.e.* 20mt farmyard manure and N, P and K @ 336:180:112kg / ha / yr followed by T7(15mt VC / ha / year + AZB + AMF +168 N + 90 P_2O_5 + 56 K_2O kg / ha / year) and T3 (30mt vermicompost / ha /year). An increasing trend in leaf yield (except treatment T1) was also observed in various seasons on different treatment combinations (Table 6).

Leaf quality

In respect of leaf quality, leaf moisture (%), total soluble protein and total soluble sugar content in leaf were found statistically at par on treatments in all

the 5 seasons. Season x treatment interaction was also found statistically not significant. However, the maximum leaf moisture content was observed in T5 followed by T2 and T7; maximum soluble protein was found in T2 followed by T3 and T6 and total soluble sugar content in leaf was observed in T_1 followed by T_3 and T_4.

The trend of above 5 crops result revealed that though the leaf yield is found still higher in T_2, but it is apparent that there is an increasing trend in leaf yield and other important parameters found in integrated nutrient packages i.e. T_7 (50% reduction of N&P with the use of other organic resources) and T3 (package of purely organic resources i.e. VC only). It was also observed that there is a gradual improvement in leaf yield and the yield difference is reduced from 22.84% to 4.96% against control in integrated nutrient management package (T_7) where as the yield difference is reduced from 53.09% to 18.03% in T3 against control.

It is apparent from the study that by using a suitable combination of different sources of organic nutrients such as, enriched vermicompost, produced through rearing and farm waste within a short period, vermi wash, green manuring, two types of bio-fertilizers i.e. both isolated from farm soil, were found to be highly effective, potential and economic and thus improved morphological characters, leaf yield and quality attributes. Although the leaf yield was found to be higher in control where full dose of organic and chemical fertilizers were applied. But it is also interesting to note that vermicompost alone, by supplying all soluble nutrients slowly, is capable to produce slightly lower (25.58%) quantity of leaf than the recommended nutrient management package (T2).

. Besides, the comprehensive integrated nutrient management package consists of lower dose of vermicompost, two types of biofertilizers and reduced doses of chemical fertilizers contributed very meager differences (8.07%) in leaf yield against control. It is evident that the treatment comprising of various organic resources and 50% N, 20%P_2O_5 and 75%K_2O or vermicompost alone in full dose could not compete with full dose of FYM and N, P and K (control i.e. T2) in respect of better leaf yield, might be due to quick mobilization, availability of plenty readily soluble inorganic nutrients from full dose of chemical fertilizers within a shortest period to the plants.

NH_4 form of soil mineral N, available from biofertilizers and reduced doses of chemical fertilizers is oxidized to NO_3 under aerobic condition that accumulates in the soil and is utilized by the plants in the form of NO_3-N. However, the result indicated that the nutrient available through mobilization and absorption from said resources were insufficient in T3 and T7 and hence still it could not attend in full potential on the growth and leaf yield over control. However, the performances of quality parameters were comparable. But it is interesting to note that total soluble sugar content in leaf was higher in T3 and T7 over control.

The beneficial effect of organic resources resulted in slow improvement in growth attributes, leaf yield and quality due to proper decomposition , mineralization , solubilizing effects and availability of sufficient nutrients as observed in T7 and T3. This corroborates the findings of Das *et al.* (1990), Setua et al. (2007) and Sudhakar *et al*.(2000) in mulberry particularly in relation to the use of two types of bio-fertilizers, vermicompost and integrated nutrient management package, Ladha *et al.*(1996), Alainclement *et al.* (1998), Balasubramaniyan (2004), Khanda *et al.* (2005) and Chettri and Mondal (2005) in rice, Patidar and Mali (2001) in sorghum, Jat and Ahlawat (2004) in gram and fodder maize.

Thus, it is inferred from the above study of 5 crops that out of 7 treatments, though T2 (recommended nutrient management) was found to be the best till date, but T7 comprising of vermicompost, *Azotobacter chroococcum*, arbuscular mycorrhizal fungi, 50% recommended dose of each of N, P and K and T3 comprising of vermicompost alone at 60 x 60cm spacing with 15cm pruning height under irrigated condition were also found to be slowly but steadily promising towards similar leaf yield and quality with full dose of FYM and chemical fertilizers (recommended nutrient management).

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Table 1. Effect of different packages on growth attributes and leaf yield in July, crop

Treatment	Plant height (cm)	Leaf area (sq.cm.)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	138.44	165.13	4.24	64.34	4823.66
T2	178.66	178.61	5.89	60.13	7597.04
T3	149.94	162.91	4.90	62.81	6511.49
T4	154.66	170.64	5.57	67.39	5859.47
T5	173.61	160.49	4.75	63.26	6791.57
T6	155.28	164.67	4.23	61.78	5876.27
T7	159.16	175.27	5.88	65.34	6890.42
LSD (0.05)	**20.20**	**NS**	**NS**	**2.71**	**1333.90**
CV%	**7.16**	**10.95**	**16.76**	**2.40**	**11.83**

Table 2. Effect of different packages on growth attributes and leaf yield in September, crop

Treatment	Plant height (cm)	Leaf area (sq.cm.)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	108.50	146.75	5.69	60.29	5041.51
T2	161.00	225.40	6.96	49.91	9387.38
T3	121.77	176.83	7.00	58.94	7060.67
T4	128.00	190.52	7.85	57.00	6440.10
T5	121.99	203.98	7.31	58.61	6114.24
T6	112.61	184.30	6.25	62.05	5845.14
T7	134.61	172.37	6.85	55.96	7428.62
LSD (0.05)	**20.26**	**38.10**	**NS**	**6.35**	**1802.90**
CV%	**8.97**	**11.53**	**20.46**	**20.46**	**14.99**

Table 3. Effect of different packages on growth attributes and leaf yield in November, crop

Treatment	Plant height (cm)	Leaf area (sq.cm.)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	60.47	60.15	1.35	72.53	1702.47
T2	98.40	124.65	5.31	64.41	4768.75
T3	63.07	59.77	1.78	69.67	2237.01
T4	65.00	63.50	2.04	68.66	2077.74
T5	69.27	69.38	2.29	66.56	2379.79
T6	62.00	87.03	2.54	72.41	2077.75
T7	76.60	97.08	3.46	68.46	3679.53
LSD (0.05)	**NS**	**37.50**	**1.72**	**NS**	**1181.63**
CV%	**24.40**	**26.28**	**36.09**	**4.48**	**24.57**

Table 4. Effect of different packages on growth attributes and leaf yield in February, crop

Treatment	Plant height (cm)	Leaf area (sq.cm.)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	59.53	97.33	2.54	71.22	2154.63
T2	78.93	109.70	3.49	64.67	3289.61
T3	69.00	103.09	3.74	63.89	3145.91
T4	78.40	101.27	4.17	62.99	3128.88
T5	73.87	105.82	3.33	69.90	2720.66
T6	83.33	110.77	3.67	64.26	2848.80
T7	79.67	114.99	3.85	60.94	3787.90
LSD (0.05)	**11.59**	**NS**	**NS**	**5.21**	**502.39**
CV%	**8.72**	**8.85**	**16.88**	**4.48**	**9.38**

Table 5. Effect of different packages on growth attributes and leaf yield in April, crop

Treatment	Plant height (cm)	Leaf area (sq.cm.)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	56.53	74.92	2.24	67.19	3047.60
T2	125.27	150.27	6.99	52.67	7966.83
T3	83.93	119.59	5.36	61.03	5468.59
T4	84.00	118.14	5.23	60.37	5305.48
T5	83.33	112.87	5.08	64.12	4834.83
T6	75.40	102.38	4.61	64.12	4570.86
T7	110.2	127.79	6.26	55.08	7770.40
LSD (0.05)	**11.64**	**19.75**	**2.06**	**4.59**	**1125.66**
CV%	**7.40**	**8.64**	**22.76**	**4.25**	**11.37**

Table 6. Effect of different packages on growth attributes and leaf yield (average of 5 seasons)

Treatment	Plant height (cm)	Leaf area (sq.cm)	Leaf area index	Leaf- shoot (%)	Leaf yield (kg/ha/crop)
T1	84.69	108.86	3.22	55.93	3353.98
T2	128.45	157.73	5.73	48.63	6601.92
T3	97.54	124.44	4.56	52.75	4884.73
T4	102.01	128.81	4.97	52.74	4562.33
T5	104.41	130.51	4.55	53.74	4568.22
T6	97.72	129.83	4.26	54.10	4243.76
T7	112.05	137.50	5.26	50.96	5911.38
LSD (0.05)	**14.91**	**15.69**	**0.68**	**1.82**	**830.19**
CV%	**8.32**	**6.73**	**8.18**	**1.94**	**9.57**

Table 7. Effect of different package on leaf quality (average of 5 seasons)

Treatment	Leaf moisture (%)	Soluble protein (mg/gm fresh wt.)	Soluble sugar (mg/gm fresh wt.)
T1	76.92	20.26	37.87
T2	78.82	25.44	31.52
T3	77.94	25.35	37.42
T4	77.79	23.41	34.60
T5	79.48	23.48	32.81
T6	77.52	24.10	33.56
T7	78.21	23.80	33.79
LSD (0.05)	**NS**	**NS**	**NS**
CV%	**1.30**	**8.27**	**12.16**