Weed management through leguminous herbs for sustainable leaf production in mulberry (*Morus alba* L.) var. S-1 under irrigated condition

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ABSTRACT

A field experiment was conducted at Central Sericultural Research and Training Institute, Berhampore West Bengal during 2001-2003 to develop a sustainable weed management practice through the use of leguminous herbs in mulberry under irrigated, alluvial condition. Analysis of pooled data for 8 seasons revealed that 6 monocotyledonous weeds with dominant Poaceous plants recorded 86.9% population while 16 dicotyledonous weeds registered 13.1% population. The weed population was found more (64.4%) on 35 days after pruning (DAP) and less (35.6%) on 70 DAP. In fact, once or twice weeding per crop registered minimum weed population and dry weight of weed bio-mass, maximum plant height, number of branches per plant, optimum leaf yield and N, P and K uptake in leaves in mulberry but it was costly and economically not viable. Among the leguminous crops tested, minimum (28.83/sq.m) weed population was observed in the treatment with Vigna sinensis indicated 32.91% reduction in weed population over control (44.46/ sq. m). Dry weight of weed biomass was also found to be reduced by 38.8% in V. sinensis (15.68g/sq.m) over control (25.62/sq.m). Mulberry grown with V. sinensis, in rows, recorded maximum plant height (122.33cm), number of branches per plant, similar leaf area, marginally higher leaf yield (25401.04 kg/ha/year), similar leaf moisture, maximum N uptake (171.92 kg/ha/year), similar phosphorus uptake and maximum potassium uptake (111.28 kg/ha/year) in leaves compared to control (traditional practice). Besides, total soluble protein was significantly increased and total soluble sugar though marginally higher, was statistically at par with the control. In addition, growing of V. sinensis could save Rs. 1385/ha, resulting 41% reduction in the cost of digging-cum-weeding activity which generally practiced after application of chemical fertilizer. It also improved soil fertility through the incorporation of green biomass (32.5 mt/ha/year), providing an eco-friendly approach without affecting leaf yield and quality. Hence growing of V. sinensis in mulberry may be recommended to the farmers as a weed control measure under irrigated condition.

Keywords: Mulberry, quality, weed management and yield,

Weeds cause 33% crop loss per year which means a loss of Rs 1650 crores annually out of total loss of Rs. 5000 crores pests caused due to total. However, number of works were done on weed control measure in agricultural crops through the application of weedicides (chemical control) and least through biological control i.e. biotechnology, bioherbicides, mycoherbicides and integrated weed management (Mukhopadhyay 1972,1983,1991, Sharma *et al.*2000, Singh *et al.*2000, Billore *et al.*2001, Saha and Aktar, 2008). Das *et al.* (1971) and Sikdar *et al.* (1981) reported that crop-weed competition severely affected the growth and yield of mulberry, the food plant of silkworm (*Bombyx mori* L). Das and Prasad (1972) observed that Tafazine and Tafapon in combination were effective towards controlling the weeds as pre-emergence in mulberry garden. Spraying of 0.71% Glycel (Glyphosate 41% SL) after 4 days of pruning of mulberry and use of Diuron and Pendimethalin in nursery could control the weeds to some extent (Mishra *et al.* 1992, Chandrasekharan and Venkatkrishnan 1992, Muniyappa and Shivkumar 1993). Although herbicides are effective for controlling weeds in mulberry at the initial growth stage but it is not possible to spray at the peak period of growth i.e., at 30 days of growth of mulberry. Besides, it is costly, toxic to soil health and beneficial microbial fauna. Further, it is. not eco-friendly and causes residual toxicity to the silkworms. Therefore, the alternative of weed control measure was thought of because some of the *Poaceous* weeds are grown quickly in clay soil under high rainfall area. As it is deep-rooted and encircled the root zone of mulberry, cause severe problem in weeding. Moreover, manual weeding is costly. Scanty information is available for weed control measure through the help of leguminous plants. Isamyl *et al.* (1993) observed that some leguminous cover crop like *Calopogonium caeruleum* and *Mucuna cochinchinensis* had the maximum phytotoxic effect towards the growth of 2 weed species *Asystasia intrusa* and *Paspalum conjugatum.* Ismail and Math (1993) found that *Mikania micrantha* inhibited germination and growth of some weeds i.e. *Asystasia intrusa*, *Chrysopogon aciculatus* and Paspalum *conjugatum.* Gnanasambandhan *et al.* (2000) also reported that intercropping of rainfed cotton (*Gossypium hirsutum* L.) with soybean (*Glycine max* L. Merr.) and sesame (*Sesame indicum* L.) suppressed weed population by 39.6% and 28.4%

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respectively and soybean intercropping in cotton increased cotton equivalent yield. Kathiresan (2000) observed that intercropping with *Crotalaria juncea* in single row on the ridge, suppressed weed growth and registered 43.3% weed control efficiency. *In situ* incorporation of its biomass increased sugarcane yield significantly. Keeping in view the above idea, a study was undertaken to develop a sustainable weed management programme with the identification of a suitable leguminous plant and its cultivation for controlling the weed population effectively in mulberry coupled with soil enrichment under irrigated condition.

MATERIALS AND METHODS

The experiment was conducted at Central Sericultural Research and Training Institute, Berhampore, West Bengal under irrigated, alluvial soil conditions. Organic carbon, pH and moisture-holding capacity were estimated (Black 1965). Nutrient status of soil before and after experimentation and nitrogen, phosphorus and potassium uptake by leaves were determined by the method of Jackson (1973). The experimental soil was mild acidic (pH 6.6) with an optimum level of moisture holding capacity (41.8%) and medium level of organic carbon content (0.76%). Available Nitrogen (246kg/ha) and Phosphate (40.8 kg/ha) contents were medium while Potassium content was high (320 kg/ha). Leaf moisture was determined by oven drying method and leaf area was estimated by Portable area meter, LI-3000, LI-COR, USA. Total soluble protein in leaf was determined by Lowry *et al.* (1951) and total soluble sugar in leaf was estimated by the method of Morris (1948).

Seven years old “S1”mulberry variety at 60 cm x 60 cm spacing was used in the experiment. The experiment was initiated with a ground level pruning and was laid out in a randomized block design with 6 treatments having 4 replicates in each treatment combination. Recommended cultural practices for irrigated mulberry and application of similar dose of farmyard manure @20mt/ha/year (in 2 equal splits during April and November) at the time of soil preparation and N, P and K @ 336:180:112 kg/ha/year after 20 days of pruning were applied followed by light digging-cum-weeding and irrigation (Ullal and Narasimhanna 1987). Cowpea [*Vigna sinensis* (VS)] and rice bean [*Vigna umbellata* (VU)] @15 kg./ha each were used as fresh leguminous green manure, containing 0.71% N, 0.15% P and 0.58% K and also cover the soil surface, while *Mimosa invisa* var. *inermis* (MII) @10 kg./ha was used as a fresh leguminous cover crop, generally used for soil moisture conservation in tea garden. These leguminous herbs were sown within the mulberry in rows after soil preparation and therefore, no light digging-cum-weeding was done after application of fertilizer. However, the incorporation of biomass was done after harvesting the mulberry crop. Mulberry without leguminous herb and with light digging-cum-weeding after application of fertilizer was treated as the control (CL). In addition, once weeding (OW) per crop on 25 days after pruning (DAP) and twice weeding (TW) per crop on 25 DAP and 50 DAP were also considered as two different treatments.

Identification of weeds, weed population count at 35 DAP and 70 DAP, dry weight of weed bio-mass on 70 DAP were done. Data on growth characters, leaf yield, leaf area, leaf moisture, N, P and K uptake by leaves, chlorophyll a and b, carotene, total soluble protein and sugar content in mulberry leaves were obtained during 4 seasons, i.e. February, May, August and November. Economics was also calculated. Analysis of variance was done on the data of 2 consecutive years. The overall mean of each of the 6 treatments and critical difference value ($p=0.05$) were calculated.

After experimentation, available nitrogen content in soil was found to be higher in control (345.3 kg/ha) while it was 280 kg/ha in *V. sinensis*, 294 kg/ha in *V. umbellata* and 256.7 kg/ha in *M. invisa* var *inermis* after incorporation of green biomass. However, the treatment with once or twice weeding per crop recorded medium status of nitrogen (224-233.3 kg/ha). Phosphate status were found to be improved in twice weeding per crop while it was similar in case of once weeding per crop with control. With regard to leguminous crop treatments, phosphate content was found to be marginally reduced over the initial status due to its consumption during growth period. Status of available potassium remained high in all the treatments (264-276 kg/ha) and control (256.5 kg/ha) and maximum in twice weeding per crop (292.5 kg/ha). However, it was found to be lower than initial status of potassium.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among the treatments ($P< 0.05$) for weed population, dry weight of weed biomass, plant height of mulberry, number of branches per plant, leaf yield, total soluble protein and N,P and K uptake by leaves, while leaf area, leaf moisture, total chlorophyll, carotene and total soluble sugar content in leaves were at par. Season x treatment interaction was not found significant at 5% level of significance except weed population, dry weight of weed biomass, leaf yield, P uptake by leaves and total soluble sugar content in leaves.

Six monocotyledonous weeds and 16 dicotyledonous weeds were found during experimentation of which the Poaceous plants were the dominant irrespective of seasons (Table 1). The population of monocotyledonous weeds were found significantly higher (86.9%) than dicotyledonous weeds (13.1%) and the weed population was found to be more on 35 DAP (64.4%) compared to 70 DAP (35.6%). It was observed that population of weed on 70 DAP was reduced by 57.7% over the population on 35 DAP (Table 2). However, once or twice weeding per crop recorded significant reduction in weed populaton over control. Among the leguminous crops tested (Table 2), minimum weed population (29.83/ sq.m) was observed in *V. sinensis* indicating significant reduction in weed population by 32.91% over control (44.96/ sq.m). However, the weed population was found marginally higher in the treatment with *V. umbellata* and significantly more in *M. invisa* var. *inermis* over control because the soil surface was not fully covered by these plants.

Dry wt. of weed biomass was found statistically significant on treatments (Table 2). Minimum dry wt. of weed biomass was observed in twice weeding/crop followed by once weeding /crop. While among the leguminous crops tested, minimum dry wt. (15.68 g/sq.m) of weed biomass was observed in *V. sinensis* indicated 38.8% reduction over control (25.62 g/sq.m). However, in case of *V.umbellata* and *M. invisa* var. *inermis*, dry wt. of weed biomass was more than control. The weed population was reduced significantly in the mulberry field in presence of *V. sinensis* probably due to more shading effect of broad and thick leaf canopy and vigorous growth of cowpea var E-C-4216. In case of VU (var K-1), less shading effect due to slightly narrow and thin leaf canopy and in MII having bipinnately compound smaller size of leaf canopy could not cover the soil surface properly, resulted more weed population compared to VS.

The dry weight of weed biomass was also found minimum in VS due to weak, thin, feeble and immatured weeds grown and later dried due to shading effect. In case of VU, dry weight of weed biomass was almost similar with the control due to non-shading effect while it was more in MII due to slow growth, smaller leaf size and non-shading effect caused heavy infestation of weeds. Comparable reduction in the weed dry weight in mulberry-cowpea intercropping system indicated that cowpea was most compatible intercrop compared to VU and MII.

Plant height of mulberry was found to be statistically significant on treatments (Table 3). Significantly higher plant height was observed in once weeding/crop followed by twice weeding/crop. Among the treatments with leguminous herbs, *V. sinensis* recorded maximum plant height (122.33 cm), while *V. umbellata* registered though marginally higher plant height but it was significantly reduced in MII over control (120.85 cm).

Maximum number of branches per plant was observed in TW followed by OW. In case of leguminous herbs sown in mulberry, no. of branches per plant in VS and MII were found statistically similar with control while it was significantly reduced in VU (Table 3). Leaf area was found to be statistically at par with all the treatments and control (Table 3). However, the highest leaf area was observed in TW (70.26 sq. cm) followed by VU (69.37 sq. cm) over control (65.85 sq. cm).

The leaf yield was found to be statistically significant in respect of treatments and also in season x treatment interaction (Table 3). Highest leaf yield was recorded in the treatments with once weeding per crop followed by twice weeding per crop with a very marginal difference between the two. However, the treatment with *V. sinensis* registered higher leaf yield (25401.84 kg/ha/year) among the leguminous crops tested with a marginal increase over control (25052.12 kg/ha/year). Leaf yield was though reduced marginally in VU, but it was statistically at par and significantly reduced in MII.

Leaf moisture in different treatments was found to be statistically similar with a marginal variation in control and treatments (Table 4). Chlorophyll a and b content in leaves were found statistically at par. Total chlorophyll though found statistically not significant but maximum was recorded in once weeding per crop followed by the treatment with VS. However, it was found reduced in control (Table 4). There was no significant difference in carotene content in leaves both in the control and the treatments (Table 4). Total soluble protein content in leaves was found to be statistically significant and maximum was observed in the treatment with VS followed by VU and TW compared to control. However, treatments were not significant in season x treatment interaction (Table 4).Total soluble sugar content in leaves was found statistically at par though maximum was observed in the treatment with VS followed by the treatment with OW and least in the control. However, season x treatment interaction was found statistically significant (Table 4).

N, P and K uptake by leaves were found statistically significant among treatments. Except P, N and K were not found significant in season x treatment interaction (Table 4), Total nitrogen uptake by leaves was recorded maximum in TW (202.84

kg/ha/year) followed by OW (197.20 kg/ha/year). Among the treatment with leguminous herbs, maximum N uptake was observed in VS (171.92 kg/ha/year) over control (163.12 kg/ha/year), while VU and MII recorded lower N uptake by leaves.

With regard to phosphorus uptake, OW registered maximum (28.28 kg/ha/year) followed by TW (27.88 kg/ha/year), while VS registered almost similar phosphorus uptake (24.64 kg/ha/year) with control (24.72 kg/ha/year). However, MII though registered similar P uptake with control but it was significantly reduced in VU. Similarly, it was also observed that TW recorded higher K uptake (130.72 kg/ha/year) followed by OW (123.0 kg/ha/year). Among the leguminous herbs, VS registered maximum K uptake (111.28 kg/ha/year) followed by MII (102.76 kg/ha/year), which is almost similar with control (114.56 kg/ha/year). However, VU registered significantly lower K uptake by leaves.

Incorporation of biomass (32.5 mt/ha/year) of VS as fresh green manure enriched the overall soil nutrient status, reduced weed population and dry weight of weed biomass due to shading effect and resulted improvement in mulberry plant height, leaf yield, leaf area , total soluble protein & sugar and N uptake by leaves. Similar performance was also observed in VS with control in respect of number of branches/plant, leaf moisture, chlorophyll & carotene content in leaves and P & K uptake by leaves. But the incorporation of biomass of VU (19.5 mt/ha/year) and MII (6.15 mt/ha/year) could not improve the yield and quality of mulberry compared to control and the treatment with *V. sinensis* because of poor growth in all the seasons.

Though of course once or twice weeding per crop in additional showed least weed population, dry weight of weed biomass and improved plant growth, leaf yield and to some extent the quality because of extra weeding which did not allow to grow the weeds. But, it was too costly. Raising of leguminous green manure plant fixes nitrogen at a certain level (Allison, 1973; Subba Rao, 1982 and Mandal *et al*. 1992). Incorporation of biomass of green manure in soil improved physical condition of soil health, farm productivity, soil fertility, soil moisture conservation and thus ensures sustainability of production. As a result it increased the leaf yield in mulberry under rainfed condition (Das *et al*. 1990), grain yield of rice & wheat and banana yield (Halepyati and Sheelavantar 1990, Ladha *et al*. 1996 , Ray and Yadav, 1996, Mandal *et al*. 1999). Biomass incorporation in soil after 50 to 60 days could also reduce soil N loss, assimilates NO_3 and recycling into the legume green manure, conserves soil NO_3, fixes atmospheric N_2 and residue is used as N source in following crop particularly for dry season (Kulkarni and Pandey, 1988, Buresh *et al*. 1993, George *et al*. 1993 and Ladha *et al*. 1996).

This is in confirmation with the findings of Isamyl *et al*.(1993) & Ismail and Math (1993) with some weed species, Gnanasambandhan *et al*.(2000) with rainfed cotton and Kathiresan (2000) with sugarcane. In all the cases the weeds were effectively controlled along with the improvement in yield and quality of mulberry by the influence of leguminous green manure.

From the present study overall better performance was observed that though in the treatment with additional once or twice weeding per crop where minimum of Rs.3000/ha is to be involved, it was not economic. Therefore, economic gain on weed control by the use of *V. sinensis* (Cowpea), a promising one, was estimated (Table 5). The calculation revealed that the total expenditure of Rs.3360.00/ha was incurred for light digging-cum-weeding which is a general practice after fertilizer application in control, while sowing of *V. sinensis* and incorporation of biomass for controlling weed population along with soil enrichment without digging-cum-weeding activity involved Rs.1975.00/ha only, indicated a saving of Rs.1385 i.e. 41% reduction in expenditure for digging-cum-weeding activity without affecting leaf yield and quality.

It is thus inferred from the above study that *Vigna sinensis* (cowpea) was found to be promising towards weed control upto the level of 32.9% in existing garden of mulberry without affecting the yield and quality of leaf reducingand 41% expenditure towards the cost of digging- cum- weeding activity required after application of chemical fertilizer. Therefore, V*igna sinensis* (cowpea) may be recommended as a weed control measure in mulberry garden at farmer’s level instead of using herbicides or hand weeding alone.

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Table 1: Common weeds found in mulberry field during experimentation

Sl.No.	***Name***	***Family***
A. Monocotyledonous weeds:		
1.	*Carex sps.*	Cyperaceae
2.	*Commelina benghalensis*	Commelinaceae
3.	*Cynodon dactylon*	Poaceae (Gramineae)
4.	*Cyperus rotundus*	Cyperaceae
5.	*Eucaliopsis binata*	Poaceae(Gramineae)
6.	*Imperata cylindrica*	Poaceae (Gramineae)
B. Dicotyledonous weeds:		
1.	*Achyranthes aspera*	Amaranthaceae
2.	*Argemone maxicana*	Papaveraceae
3.	*Chenopodium album*	Chenopodiaceae
4.	*Croton sparsiflorus*	Euphorbiaceae
5.	*Eclipta alba*	Compositae
6.	*Euphorbia hirta/ prostrata*	Euphorbiaceae
7.	*Heliotropicum indicum*	Boraginaceae
8.	*Hydrocotyle asiatica*	Umbelliferae
9.	*Impomoea palmata*	Convolvulaceae.
10.	*Oxalis cerniculata/ indica*	Oxalidaceae
11.	*Parthenium hysterophorus*	Compositae
12.	*Polygonum barbatum*	Polygoneceae
13.	*Scropularia dulcis*	Scropulariaceae
14.	*Sida acuta/ cordifolia*	Malvaceae
15.	*Solanum niagrum*	Solanaceae
16.	*Tridax procumbens*	Compositae

Table 2: Effect of leguminous herbs on weed population and dry weight of weed biomass

(2 years pooled data)

Treatments	Weed population (nos. /m²)						Dry wt. of weed biomass at 70 DAP (g/m²)
	M		D		T		
	35 DAP	70 DAP	35 DAP	70 DAP	35 DAP	70 DAP	
T1	69.08	35.38	9.56	9.58	78.64	44.96	25.62
T2	51.83	23.32	6.69	6.51	58.52	29.83	15.68
T3	85.22	41.07	6.41	5.77	91.63	46.83	26.20
T4	110.62	60.59	9.04	6.06	119.66	66.65	49.76
T5	18.79	11.83	4.42	7.01	23.21	18.84	6.35
T6	12.09	4.23	4.38	4.14	16.46	8.38	1.72
LSD (P=0.05)	**6.02**		**1.75**		**6.17**		**7.38**
SEm(±)	**2.66**		**0.48**		**2.86**		**2.28**
S x T	**12.04**		**3.49**		**12.33**		**14.75**

M- Monocotyledons; **D-** Dicotyledons; **T-** Total

Table 3: Effect of leguminous herbs on growth attributes and leaf yield of mulberry

(2 years pooled data)

Treatment	Plant height (cm)	No. of Branches	Leaf Yield (kg/ ha/year)	Leaf area (sq.m)
T1	120.85	10.05	25052.12	65.85
T2	122.33	9.48	25401.84	67.60
T3	121.81	8.75	23266.84	69.37
T4	114.25	9.49	21411.20	64.61
T5	126.20	10.83	29700.72	68.89
T6	123.99	11.18	29340.32	70.26
LSD (P=0.05)	**4.16**	**0.74**	**2022.88**	**NS**
SEm (±)	**3.04**	**0.17**	**184.0**	**1.72**
S x T	**NS**	**NS**	**4045.72**	**NS**

Table 4: Effect of leguminous herbs on leaf quality of mulberry (2 years pooled data)

Treatment	Leaf moisture (%)	Chl.a (mg/g fw)	Chl.b (mg/ g fw)	Total Chl. (mg/g fw)	Carotene (mg/g fw)	Total sol. protein (mg/g fw)	Total sol. sugar (mg/g fw)	Nutrient uptake by leaves (kg/ha)		
								N	P	K
T1	79.73	0.967	0.302	1.268	0.035	24.34	34.62	163.12	24.72	114.56
T2	79.97	1.058	0.323	1.380	0.038	27.86	39.62	171.92	24.64	111.28
T3	79.84	1.000	0.315	1.312	0.038	27.60	38.20	151.64	21.76	98.16
T4	79.50	0.970	0.330	1.299	0.037	26.31	35.87	140.92	23.12	102.76
T5	79.95	0.990	0.325	1.419	0.039	26.82	39.30	197.20	28.28	123.0
T6	79.79	0.925	0.297	1.220	0.038	27.27	38.11	202.84	27.88	130.72
LSD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**2.31**	**NS**	**15.40**	**2.20**	**12.34**
SEm(±)	**0.12**	**0.03**	**0.01**	**0.04**	**0.001**	**0.65**	**0.99**	**1.26**	**0.19**	**1.02**
S x T	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**8.07**	**NS**	**4.40**	**NS**

Table 5: Economic gain on weed control measure by the use of leguminous herbs (*Vigna sinensis*) in mulberry

Treatment	Cost (Rs./ha)	Percent reduction in cost of light digging-cum-Weeding activity	Leaf yield (Kg /ha/yr)
T_1 (Control)	∗ Cost of light digging-cum-Weeding Rs.3,360=00	-	25,052=12
T_2 (*Vigna sinensis*)	∗∗ Cost of seed: Rs,375=00	41.0	25,401=84
	∗∗∗Cost of sowing, biomass cutting & incorporation: Rs.1,600=00		
	Total Rs.1,975=00		

* @ 75 mandays/ ha & Rs.40/- per manday; ∗∗ @ 25 Kg/ha seed rate and Rs.15/Kg., ∗∗∗ @ 40 mandays /ha & Rs.40/- per manday

- Other cost of mulberry cultivation remained same i.e. Rs.47,070=00/ha/yr both in T1 & T2 excluding light digging-cum-weeding cost.