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Evaluation of soil fertility and mulberry leaf quality on silkworm rearing and cocoon characteristics

Y.L. RAMACHANDRA[1]*, S. PADMALATHA RAI[2], H.V. SUDEEP[1], P.S. SUJAN GANAPATHY[1] **AND** N.B. KRISHNAMURTHY[3]

[1]Department of Biotechnology and Bioinformatics, School of Biological Sciences, Kuvempu University, Jnana Sahyadri, SHIMOGA (KARNATAKA) INDIA

[2]Department of Biotechnology, Manipal Life Science Center, Manipal University, MANIPAL (KARNATAKA) INDIA

[3]Department of Biotechnology, Shridevi Institute of Engineering and Technology, Sira Road, TUMKUR (KARNATAKA) INDIA

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Soil samples were collected from six different mulberry growing areas of Malnad region of Karnataka and analyzed for the soil fertility and leaf quality parameters. The influence of soil nutrient status on mulberry plant growth and leaf quality with regard to five varieties M_5, DD, S_{54}, S_{36} and V_1 and the overall impact on silkworm larval growth and cocoon characteristics were studied in detail. It was observed that the six sampling areas differed significantly in the parameters analyzed. Variety V_1 from Kadur region showed the best result among all the five varieties grown in six sampling areas.

Key words : Cocoon characteristics, Leaf quality, Mulberry growth, Larval growth, Soil nutrient status.

INTRODUCTION

The fertility of soil, in general, plays the key role in the development of any crop plant so also the mulberry plant. The growth and leaf nutrient status of mulberry plant varies in different geographic locations as the soil conditions change. Significance of chemical and biochemical constituents of mulberry leaf with respect to silkworm nutrition has been recognized by several researchers (Ito and Arai, 1963; Chaluvachari and Bongale, 1995). Quality and yield of mulberry leaf directly influences the silkworm larval growth and cocoon characteristics (Krishnaswami *et al.*, 1970; Das and Vijayaraghavan, 1990). However, information on the biochemical composition of mulberry leaf, its relation with soil fertility parameters and its relevance to the silkworm cocoon performance is extremely scanty. No study was undertaken so far in this regard as an integrated approach. Hence, the present study has been undertaken to evaluate the influence of soil fertility status of mulberry gardens of six different areas on the mulberry plant growth, quality of leaf and subsequent influence on the silkworm growth and cocoon characteristics.

MATERIALS AND METHODS

Six mulberry growing areas in Malnad regions of Karnataka namely Sringeri (SA-I), Shimoga (SA-II), Kadur (SA-III), Honnali (SA-IV), Chikmagalur (SA-V) and Bhadravathi (SA-VI) were selected for the present study.

The six sampling areas were evaluated for soil fertility, mulberry plant growth and leaf nutrient status with respect to five varieties (M_5, DD, S_{54}, S_{36} and V_1) and silkworm (*Bombyx mori* L.) larval growth and cocoon characteristics.

Soil sampling:

The soil samples were collected at a depth of 15-30cm. The samples were air dried, processed, passed through 2mm sieve and preserved for analysis.

Soil analysis:

Soil samples were analyzed for selected fertility parameters *viz.* pH, organic carbon (OC), electrical conductance (EC), total nitrogen (tN), available phosphorus (P), available potassium (K) and micronutrients (Zinc, Copper, Manganese, Iron and Boron) following standard methods of soil analysis (Perur *et al.*, 1973).

Evaluation of mulberry growth:

Growth and leaf yield data were collected from ten individual plants selected randomly among the six replicate plots after 60th day of pruning for the five varieties in

* Author for correspondence.

respect of the parameters such as height of the plant, number of shoots, number of leaves, weight of leaves per plant, fresh weight and dry weight of hundred leaves and the moisture percentage.

Percentage moisture content was recorded using the formula,

$$\% \text{ moisture} = \frac{\text{Fresh weight of leaves–Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100$$

Leaf sampling:
Mulberry leaves at peak growth period (around 60 days after pruning) were collected. The leaves thus collected from each variety were air dried, powdered and preserved for further analysis.

Leaf biochemical analysis:
Leaf samples were analyzed for total nitrogen content, total soluble protein (Lowry *et al.*, 1951), total soluble sugars (Dubios *et al*., 1956) and total chlorophyll (Arnon, 1949) using Systronics UV-Visible spectrophotometer. The leaf micronutrients *viz.* zinc (Zn), manganese (Mn) and iron content (Fe) were estimated following the DTPA (Diethylene triamine pentaacetic acid) solvent extraction method (Lindsay and Norvell, 1978).

Evaluation of silkworm growth:
Leaves of five mulberry varieties from respective plots were used for feeding the silkworms. These silkworms were evaluated for following parameters:-

Larval weight (g):
Ten mature larvae were selected randomly from each replicate plot to record the larval weight with the help of electronic balance.

Single cocoon weight (g):
After five days of mounting, ten cocoons were harvested, weighed and the mean cocoon weight was recorded.

Single shell weight (g):
Cocoons selected for single cocoon weight were cut open to remove the pupae and empty shells were weighed. Average weight was recorded.

Cocoon shell ratio (CSR):
CSR was recorded using the formula:-

$$\text{CSR \%} = \frac{\text{Mean weight of cocoon shell (g)}}{\text{Mean weight of whole cocoon (g)}} \times 100$$

Total filament length (m):
Ten cocoons from each replicate plot reeled separately and the length of filament was recorded with the help of an Aprovate fitted with an automatic filament length recorder.

Denier:
Denier was calculated using the formula,

$$D = \frac{W}{L} \times 9000$$

where, D = Denier
W = Weight of reeled silk in g.
L = Length of reeled silk in m.

RESULTS AND DISCUSSION

Soil fertility status of mulberry gardens:
The results of soil analysis of six sampling areas are presented (Table 1). The pH values obtained ranged from acidic to alkaline pH (6.27 to 7.66). Among all the sampling areas, SA-III *i.e.*, Kadur region recorded lowest pH (6.27). SA-III also showed lower values for available phosphorus and potassium. However, the available micronutrients (except Boron) were more which is supported by earlier work from Landon (1991) saying that the lower pH values are also known to increase the availability of micronutrients. SA-I, on the contrary recorded significantly higher value for pH (7.66) but the micronutrients such as Zinc, Copper, Manganese and Iron (0.78ppm, 1.06ppm, 28.05ppm and 8.6ppm, respectively) contents were significantly low. These observations suggest a negative correlation between pH and the micronutrient status of soil.

The total nitrogen content and organic carbon content varied from 845.54kg/acre to 915.30kg/acre and 0.46 to 1.20%, respectively. Both total nitrogen content and organic carbon content were significantly higher in SA-III compared to rest of the sampling areas. No other sampling areas showed significant variations with regard to soil fertility parameters.

Evaluation of mulberry growth:
The mulberry plant growth evaluation data are recorded, tabulated and presented (Table 2). All sampling areas showed significant values. SA-III, however, recorded consistently higher values for all the parameters. V_1 variety of SA-III recorded the moisture content of 77.41 which was higher than any other variety studied. Also, the rest of the parameters such as height of the plant, number of shoots and number of leaves and weight of

Table 1 : Soil nutrient status of mulberry growing (25 samples each) gardens Shimoga and Chikmagalur districts

Sr. No.	Parameters	Sampling areas					
		SA-I	SA-II	SA-III	SA-IV	SA-V	SA-VI
1.	pH	7.66	7.18	6.27	7.0	6.84	7.2
2.	EC (Ω^{-1})	0.36	0.35	0.33	0.35	0.34	0.35
3.	OC (%)	0.46	1.00	1.20	1.09	1.12	0.90
4.	ON (Kg/acre)	32.30	31.00	28.00	30.00	28.60	31.23
5.	tN (Kg/acre)	845.54	880.00	915.3	895.40	900.00	850.43
6.	ON:tN	1:26	1:28	1:33	1:30	1:31	1:27
7.	Avail P (Kg/acre)	19.15	22.00	28.40	24.17	28.10	19.30
8.	Potassium (Kg/acre)	80.30	90.60	105.00	92.80	100.50	82.50
9.	Zinc (ppm)	0.78	0.98	1.05	1.00	1.01	0.85
10.	Copper (ppm)	1.06	2.08	2.21	2.10	2.18	1.75
11.	Manganese (ppm)	28.05	30.56	35.20	33.66	34.58	30.06
12.	Iron (ppm)	8.60	9.14	9.65	9.30	9.37	8.90
13.	Boron (ppm)	0.73	0.45	0.28	0.47	0.39	0.67

Table 2 : Growth and yield of mulberry varieties

Parameters → / Varieties ↓	Sampling area ↓	Plant height (cm)	No. of shoots/ plant	No. of leaves/ shoot	Wt. of leaves/ plant (g)	Fresh Wt. of 100 leaves (g)	Dry Wt. of 100 leaves (g)	Leaf moisture (%)
M_5	SA I	96.01	11.60	16.16	418.19	200.40	59.60	70.25
	SA II	98.56	12.95	17.25	419.70	197.00	55.97	71.58
	SA III	99.40	14.00	19.50	426.18	210.07	51.00	75.71
	SA IV	99.00	13.00	18.00	420.00	199.00	56.18	71.76
	SA V	99.34	13.75	19.00	421.62	198.00	55.00	72.22
	SA VI	97.50	12.63	17.19	418.60	201.00	57.90	71.19
DD	SA I	91.86	12.60	16.50	567.00	199.17	57.00	71.38
	SA II	92.10	13.00	17.50	571.29	206.87	57.20	72.34
	SA III	93.16	14.50	18.20	590.30	212.00	52.00	75.47
	SA IV	92.80	13.05	17.55	573.17	200.70	53.22	73.48
	SA V	92.62	13.75	17.60	574.37	202.01	53.05	73.73
	SA VI	92.00	12.78	16.85	570.65	198.39	56.27	71.63
S_{54}	SA I	99.07	12.25	20.75	605.28	218.63	61.68	71.78
	SA II	101.75	12.93	21.56	622.22	225.89	59.11	73.83
	SA III	103.71	14.01	23.70	654.50	238.07	58.35	75.49
	SA IV	102.69	13.20	22.09	627.00	228.50	59.03	74.16
	SA V	103.01	13.69	23.00	630.02	231.66	58.15	74.89
	SA VI	100.82	12.52	20.98	615.00	221.70	59.68	73.08
S_{36}	SA I	101.20	12.05	20.58	737.76	236.01	63.11	73.25
	SA II	103.00	13.08	21.78	745.05	220.08	58.17	73.56
	SA III	107.27	14.70	22.95	782.00	240.27	58.39	75.69
	SA IV	103.78	13.96	21.83	748.01	238.99	62.50	73.84
	SA V	105.80	14.01	22.50	750.88	239.11	62.23	73.97
	SA VI	102.25	12.88	21.01	741.95	219.75	58.26	73.48
V_1	SA I	110.70	14.70	23.75	838.38	265.82	64.77	75.63
	SA II	112.09	15.00	24.00	845.02	264.59	64.23	75.72
	SA III	114.85	16.98	25.06	853.11	278.93	63.01	77.41
	SA IV	112.90	15.08	24.50	845.33	267.01	64.58	75.81
	SA V	113.01	15.87	24.77	848.13	270.19	65.28	75.83
	SA VI	110.93	14.89	23.88	839.45	267.56	65.11	75.66

leaves per plant were more.

Leaf biochemical analysis:

Data presented (Table 3 and 4) reveal that the leaf samples taken from all the six sampling areas varied significantly with respect to the parameters studied. Among all, SA-III and SA-I recorded highest and lowest values, respectively for all the parameters analyzed. Variety V_1 was superior to other four varieties. There was a positive correlation of leaf micronutrients with chlorophyll, protein and sugar contents.

Evaluation of silkworm growth:

The silkworm fed on leaves of five mulberry varieties from all the sampling areas under study were evaluated for larval growth and cocoon characteristics. Results obtained are present in Table 5. Silkworm larvae fed on the leaf of V_1 variety from SA-III attained early maturity (spinning) and higher larval weight (45.58g).

From the results obtained, it is clear that the growth of mulberry plant and the nutrient content of leaves were significantly influenced by available soil nutrients. Among the growth parameters, it was observed that the moisture content was high in SA-III and in particular the V_1 variety that possessed highest total nitrogen content in the soil. Earlier reports also suggest that the application of nitrogen and potassium increased the moisture content of leaves (Kasiviswanathan and Iyengar, 1966). They also reported that the effect of nutrients on the leaf yield of mulberry crop in general is influenced more by nitrogen than other nutrients. Nitrogen fertilization was found to enhance leaf and shoot yield of mulberry.

The correlation of soil nutrient status with leaf quality has been reflected in SA-III which recorded better values with respect to soil fertility parameters and also showed higher leaf quality than other sampling areas studied. Relation between the soil nutrient status and leaf composition was highly positive with regard to the total nitrogen content and micronutrients *viz.* zinc, manganese and iron contents. There was also a positive correlation of these parameters and also the organic carbon content of soil with the chlorophyll, protein and sugar contents of leaves. Five varieties from SA-III having higher values of total soluble sugars, total nitrogen and total chlorophyll are associated with significantly higher larval weight, single cocoon weight, single

Table 3: Leaf biochemical composition of selected mulberry varieties

Parameters → / Varieties ↓	Total N (%)						Zn (ppm)						Mn (ppm)						Fe (ppm)					
	SA I	SA II	SA III	SA IV	SA V	SA VI	SA I	SA II	SA III	SA IV	SA V	SA VI	SA I	SA II	SA III	SA IV	SA V	SA VI	SA I	SA II	SA III	SA IV	SA V	SA VI
M_5	3.90	4.18	4.83	4.30	4.72	4.10	40.00	41.30	43.00	42.00	42.50	41.00	30.00	31.00	36.00	32.00	35.45	31.00	217	230	241	232	240	218
DD	4.00	4.10	4.80	4.40	4.75	4.05	40.00	41.00	42.00	41.00	41.33	40.84	28.00	31.00	34.95	32.00	33.00	29.00	218	222	227	224	226	220
S_{54}	4.10	4.15	4.95	4.80	4.91	4.11	38.00	42.00	46.00	42.70	43.00	41.00	30.00	32.50	38.85	32.85	34.00	32.16	219	231	251	237	240	230
S_{36}	4.20	4.65	5.00	4.70	4.74	4.60	42.00	43.63	47.00	44.95	46.00	43.00	31.00	34.05	37.96	37.00	37.50	32.00	218	220	244	225	232	218
V_1	4.90	4.96	5.40	5.05	5.20	4.92	46.58	48.77	51.05	49.50	50.00	48.00	34.00	39.00	42.75	40.05	40.25	38.00	230	240	252	242	247	238

Table 4 : Leaf biochemical composition of selected mulberry varieties

Parameters → / Varieties ↓	Total chlorophyll (mg/g)						Total protein content (%)						Total sugar content (%)					
	SA I	SA II	SA III	SA IV	SA V	SA VI	SA I	SA II	SA III	SA IV	SA V	SA VI	SA I	SA II	SA III	SA IV	SA V	SA VI
M_5	3.00	3.14	3.60	3.20	3.40	3.10	21.00	23.00	25.20	23.20	24.00	22.60	9.00	9.70	10.19	9.80	10.00	9.20
DD	2.25	2.86	3.10	2.90	3.00	2.80	23.00	23.24	25.00	24.70	24.80	23.05	8.80	9.41	9.88	9.66	9.70	8.85
S_{54}	3.10	3.20	3.40	3.22	3.30	3.15	24.00	26.10	27.00	26.30	26.50	25.60	8.90	9.10	9.94	9.26	9.80	8.95
S_{36}	3.10	3.38	3.80	3.60	3.70	3.20	25.00	26.30	27.10	26.40	26.70	26.00	8.60	9.00	9.91	9.07	9.20	8.70
V_1	4.50	4.90	5.02	4.98	5.00	4.60	26.80	27.00	29.00	28.00	28.10	27.00	11.00	11.60	12.86	12.00	12.60	11.40

Table 5 : Evaluation of silkworm growth reared on different mulberry varieties

Parameters → / Varieties ↓	Sampling area ↓	Mean wt. of mature larvae (g)	Mean cocoon wt.(g)	Mean wt. of single shell (g)	CSR %	Mean filament length (m)	Denier
M_5	SA I	40.63	1.72	0.35	20.23	682.50	2.29
	SA II	40.96	1.75	0.37	21.14	685.14	2.32
	SA III	42.57	1.82	0.42	23.07	690.38	2.40
	SA IV	41.50	1.75	0.38	21.71	686.20	2.34
	SA V	42.09	1.77	0.39	22.03	686.90	2.37
	SA VI	40.88	1.73	0.35	20.34	683.29	2.30
DD	SA I	42.60	1.71	0.33	19.29	682.66	2.27
	SA II	43.00	1.76	0.35	19.88	685.33	2.31
	SA III	44.18	1.83	0.42	22.95	696.22	2.41
	SA IV	43.09	1.75	0.37	21.14	688.05	2.33
	SA V	43.32	1.78	0.38	21.34	690.17	2.39
	SA VI	42.93	1.72	0.34	19.76	683.10	2.28
S_{54}	SA I	41.80	1.74	0.36	20.68	683.47	2.28
	SA II	42.57	1.80	0.38	21.26	689.82	2.31
	SA III	44.27	1.90	0.44	23.15	700.01	2.41
	SA IV	42.92	1.82	0.39	21.27	692.50	2.34
	SA V	43.01	1.88	0.40	21.66	694.26	2.38
	SA VI	41.98	1.74	0.37	20.87	685.39	2.30
S_{36}	SA I	41.65	1.73	0.35	20.23	725.61	2.22
	SA II	42.91	1.85	0.40	20.83	728.52	2.29
	SA III	44.12	2.00	0.45	22.50	735.92	2.42
	SA IV	43.05	1.92	0.41	20.91	729.00	2.32
	SA V	43.27	1.96	0.41	22.16	731.09	2.37
	SA VI	41.88	1.79	0.37	20.67	725.88	2.25
V_1	SA I	43.21	1.75	0.40	22.47	733.44	2.39
	SA II	43.48	1.85	0.43	22.56	739.00	2.43
	SA III	45.58	2.12	0.50	23.58	744.07	2.51
	SA IV	44.51	2.00	0.44	23.24	739.11	2.44
	SA V	44.97	2.04	0.46	23.42	740.50	2.48
	SA VI	43.77	1.78	0.41	22.54	735.22	2.41

shell weight, and CSR percentage and filament length than those from other sampling areas. The data available in this regard is from the temperate countries which reveal that leaf protein content of 20-25% could help in optimum growth of silkworm larvae. In the present study, leaf protein value of 25-30% was recorded consistently in SA-III and hence the silkworm larval growth was also better. The positive correlation coefficients of the cocoon shell weight and cocoon yield with the protein content in mulberry leaves is reported by Sarker *et al.* (1997). It was found from the present results that the soluble protein, sugars and moisture contents are higher in top tender leaves and which might have contributed for increased larval weight in larvae fed on V_1 variety. M_5 variety showed significantly less larval weight when compared with the others. The leaf moisture content also has positive correlation with silkworm growth. The results showed that mulberry silkworm feeding with higher moisture content of leaves lead to more moisture build up in the body of silkworm and a higher productivity in sericulture. In the present study, the leaf nitrogen content also influenced the silkworm growth positively.

It could be concluded from that feeding of silkworm with leaves of mulberry grown under nitrogen fertilization significantly increased the weights of larvae, single cocoon and shell, filament length and Denier. Mulberry varieties

with higher content of nitrogen in leaf showed higher production efficiency of cocoon shell weight. Out of the six sampling areas *viz*. Sringeri, Shivamoga, Kadur, Honnali, Chikmagalur and Bhadravathi, differed significantly with respect to soil fertility, mulberry plant growth and leaf nutrient status, hence also the silkworm larval growth and cocoon characteristics. However, among the varieties grown in SA-III (Kadur) area, which possessed the best soil fertility characteristics in turn, directly influence the silkworm cocoon characteristics and are highly beneficial as well as useful for the silkworm growers of this region. V_1 variety has the better leaf quality and a greater acceptance by the mono phytophagous lepidopteron mulberry silkworm larvae.

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