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PHYSIO-BIOCHEMICAL EVALUATION OF SOME IMPROVED MULBERRY VARIETIES IN THE GANGETIC ALLUVIAL SOILS UNDER IRRIGATED CONDITIONS

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SUMMARY

Ten improved mulberry varieties, viz. V1, C1730, C2016, C2017, Anantha, RFS-175, Thallaghatapura, Vishala, S1 and S1635 were evaluated for physiological and biochemical parameters under irrigated conditions in the alluvial soils of Gangetic plains of West Bengal as per zonal schedule. Leaf area, leaf fresh weight, % moisture content and moisture retention capacity were found to vary significantly among the varieties tested. Moreover, net photosynthetic rate, transpiration rate, physiological water use efficiency, stomatal conductance and biochemical parameters, viz. total chlorophyll, total soluble sugar, nitrate reductase activity, total soluble protein and phenol content also showed significant variation among the tested varieties. Among the varieties S1635 was recorded to have higher leaf area (305.70 cm^2), leaf yield (0.520 kg/plant/crop), fresh leaf weight (4.92 g), net photosynthetic rate (14.66 µmol CO_2 m^{-2} s^{-1}), nitrate reductase activity (13.25 µmol NO_2^- h^{-1} g^{-1} fw.), chlorophyll content (2.13 mg g^{-1} fw.), total soluble sugar (48.44 mg g^{-1} fw.) and total soluble protein (39.63 mg g^{-1} fw.) were also higher in S1635 showing its superiority over other tested varieties. The studies suggested that S1635 can be commercially exploited for cultivation under irrigated conditions in the Gangetic alluvial soils of West Bengal.

Key words **: Leaf yield, mulberry, nitrate reductase activity, photosynthesis, protein.**

INTRODUCTION

Increasing production of raw silk to a greater extent depends on higher yields and quality of mulberry leaves. Leaf yield in mulberry is a polygenic character influenced by several quantitative characters (Vijayan *et al.* 1997) and is the cumulative consequence of various physiological and biochemical processes. Menon and Srivastava (1984) reported that the biomass production and leaf yield of different crops depend primarily on photosynthetic CO_2 assimilation. Silkworm nutrition depends on the quality and quantity of food. Protein is one of the important constituent of cell for maintaining the metabolic activities of silkworm body and for silk and egg production (Zuhua 1994). Nitrate reductase is a key enzyme in nitrogen metabolism and one of the most important regulatory enzymes that catalyzes the reduction of nitrate to nitrite (Beevers and Hageman 1969). The enzyme NR was studied extensively in different crop plants (Srivastava 1980, Reddy *et al*. 1985, Paliwal and Ilangovan 1990, Abrol *et al*. 1999) and its activity was positively correlated with economic yield in rice (Rao *et al*. 1990), jute (Singh *et al*. 1994) and in berseem (Amaresh and Roy 1995). Eilrich and Hageman (1973) examined the relationship of NR with grain N in wheat. Johnson *et al*. (1976) observed that NRA determines leaf biomass and yield. In recent years, NR activity has been increasingly used as an additional parameter for

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identifying high yielding genotypes in several crop plants (Rao *et al*. 1990, Singh *et al*. 1994, Amaresh and Roy 1995). In mulberry, very few reports are available on NR activity (Paliwal and Ilangovan 1990, Rao *et al*. 2000, Misra and Das 2002). The present investigation was undertaken to evaluate varieties for their physio-biochemical characters and some of the yield attributing parameters so as to identify the best one for commercial exploitation under irrigated conditions in the Gangetic alluvial soils of West Bengal and Eastern and North Eastern regions.

MATERIALS AND METHODS

Well-rooted saplings of ten improved mulberry varieties, viz. V1, C1730, C2016, C2017, Anantha, RFS-175, Thallaghatapura, Vishala, S1 and S1635 were planted under 90×90 cm spacing between plant to plant as well as row to row in Randomized Block Design (RBD) with 3 replications. The experiment was carried out at the Institute of CSR&TI, Berhampore (WB). The soil type was Gangetic alluvial with pH 6.9; EC 0.12 m mhos/cm, OC 0.56% and status of NPK in the soil @ 243:60:480 kg/ha. In each replication 15 plants were utilized for observations, surrounded by one line of border excluding intervarietal border. Recommended cultural practices for cultivation under irrigated condition were applied (Ray *et al.* 1973). Data on various parameters were recorded from the 60 days old plants after pruning. Leaf yield / plant was recorded 5 times per year (February, April, July, September and November) in accordance with the silkworm rearing schedules in West Bengal. Moisture retention capacity (MRC) of mulberry leaves was calculated as follows:

MRC = (wt. of leaves after 6.0 h – leaf dry wt.) / (leaf fresh wt – leaf dry wt) ×100.

Net photosynthetic rate (Pn) was measured from fifth expanding leaves using a portable photosynthetic system (LI-COR model 6200; Licor Instrument Inc, USA) between 11-12 h under natural conditions with ambient temperature range of 28-30°C and relative humidity of 70-80%. Total soluble protein was determined in fresh leaves as described by Lowry *et al.* (1951). The *in vivo* nitrate reductase activity (NR) was assayed as per Hagemen and Hucklesby (1971). Total soluble sugar, chlorophyll and phenol content were measured as per Morris (1948), Arnon (1949) and Bray and Thrope (1954) respectively. All the biochemical constituents were determined in triplicate and repeated twice in fresh leaves on 60th day after pruning. The data were analyzed statistically to estimate critical difference and the simple linear correlation coefficients between NR activity / Pn and different characters were computed (Gomez and Gomez 1983). Selection indexing was done out as per Smith (1936).

RESULTS AND DISCUSSION

Among the tested varieties S1635, Vishala and C1730 exhibited high NR activity and soluble protein content in leaves. NR activity was found maximum in S1635 (13.25 µmol NO^-_2 h^{-1} g^{-1} fr. wt.) and minimum in C2016 (7.85 µmol NO^-_2 h^{-1} g^{-1} fr. wt.). S1, C2017, V1, RFS -175, Thallaghatapura and Anantha showed moderate NR activity and protein content, low NR activity and low protein content were obtained in C2016, which clearly indicates that the level of NR activity is closely related with that of total protein content (Table 1). It was reported that any factor that affects the leaf NR activity will directly affect its protein content (Ghosh *et al*. 1994) as this enzyme is believed to be rate limiting in overall assimilation of nitrate (Beevers and Hageman 1969). The varieties having more NR activity will be having more in-built nitrogen utilization efficiency (Amaresh and Roy 1995), which may probably enhance the protein content (Paliwal and Ilangovan 1990). In the present study a significant positive correlation (r = 0.90) was observed between NR activity and protein content (Fig. 1).

The phenol content was also significantly varied among the varieties evaluated in this study. Chattopadhyay (1989) has reported enhanced fungal disease tolerance in plants having higher phenol content in leaves. The varieties, viz. C1730, C2017 have showed higher phenol content in leaves whereas a moderate level of phenol was observed in V1, Vishala and S1635 (Table 1).

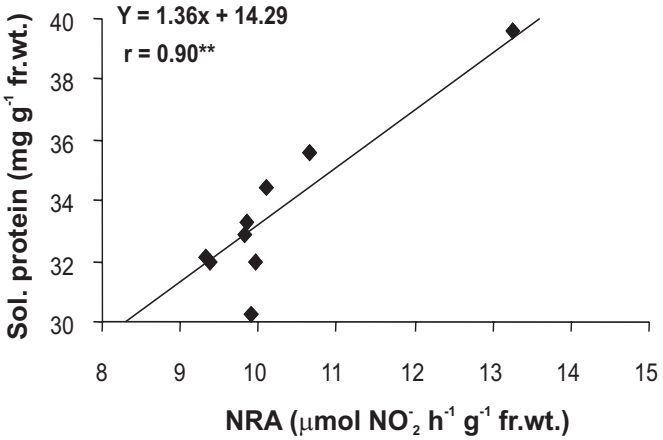
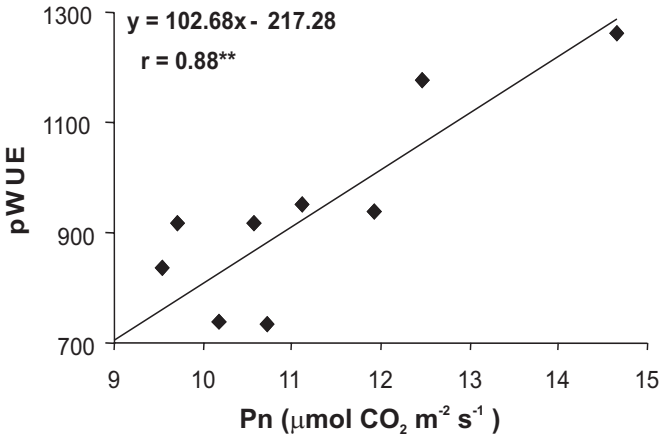


Fig. 1. Regression and correlation coefficients between nitrate reductase activity (NRA) and soluble protein, analyzed from all the data



Fig, 3. Regression and correlation coefficients between net photosynthetic rate (Pn) and physiological water use efficiency (pWUE), analyzed from all the data

In situ gas exchange parameters differed significantly among the tested varieties (Table 2). Varieties S1635 and Vishala were found to have higher net photosynthetic rates, stomatal conductance and pWUE. These results find support from work of Chattopadhyay *et al*. (1996) where they found a significant positive correlation between net photosynthetic rate and stomatal conductance. Irigoyen *et al*. (1992) opined that low stomatal conductance reduce the photosynthetic rate by restricting the availability of CO_2 for its fixation. In the current study a significant positive correlation was observed between Pn and stomatal conductance (Fig. 2) and between NPR and pWUE (Fig. 3).

Total chlorophyll, total soluble sugar, protein, phenol, moisture content and its retention capacity have shown distinct variation among the varieties (Table 1 & 2). RFS-175 had the lowest chlorophyll content while S1635 got the highest. Those varieties having higher chlorophyll content were found photosynthetically more efficient. This finding is in complete agreement with that of Chattopadhyay *et al*. (1996) and Das *et al*. (1997). Zelitch (1982) reported a close relationship among chlorophyll content, photosynthesis and crop yield. In present study a significant positive correlation was observed between Pn and chlorophyll content (Fig. 4) and between NPR and leaf yield (Fig. 5).

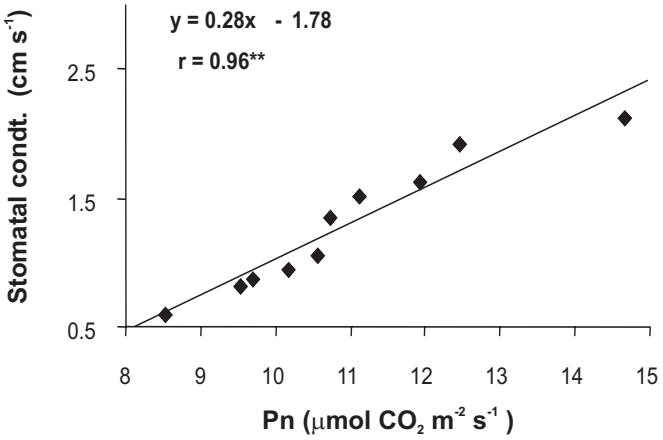


Fig. 2. Regression and correlation coefficients between net photosynthetic rate (Pn) and stomatal conductance, analyzed from all the data

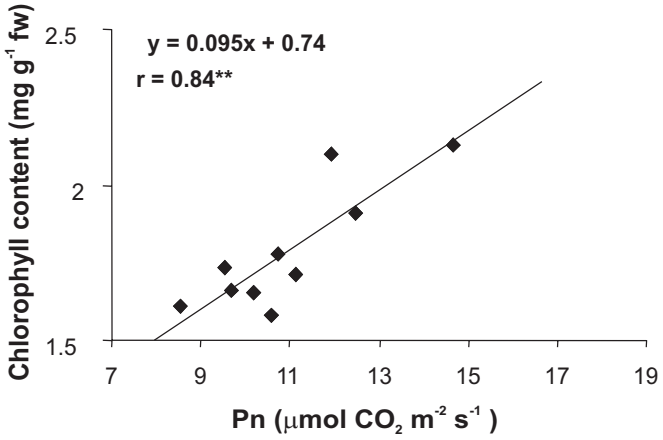


Fig. 4. Regression and correlation coefficients between net photosynthetic rate (Pn) and chlorophyll content, analyzed from all the data

Table 1. Nitrate Reductase Activity (NRA), total soluble protein, total soluble sugar, total chlorophyll content and phenol content in ten improved mulberry varieties.

Variety	NRA (µmol NO_2^- $h^{-1}g^{-1}$ fw)	Total soluble protein (mg g^{-1} fw)	Total soluble sugar (mg g^{-1} fw)	Total chlorophyll (mg g^{-1} fw)	Phenol (mg g^{-1} fw)
V1	9.84	33.31	44.09	1.78	0.24
C1730	10.09	34.40	45.62	1.71	0.38
C2016	7.85	30.04	40.00	1.73	0.19
C2017	9.92	30.25	41.03	2.10	0.34
Anantha	9.38	32.00	42.16	1.66	0.22
RFS 175	9.82	32.90	44.51	1.58	0.19
Thallaghatapura	9.34	32.15	43.29	1.61	0.22
Vishala	10.66	35.58	46.76	1.91	0.24
S1	9.97	32.00	44.27	1.65	0.19
S1635	13.25	39.63	48.44	2.13	0.23
CD at 5%	0.214	0.121	0.982	0.21	0.032

Table 2. Net photosynthetic rate (Pn), transpiration rate, physiological water use efficiency (pWUE), stomatal conductance, leaf moisture content and moisture retention capacity (MRC) in ten improved mulberry varieties.

Variety	Pn (µmol CO_2 $m^{-2}s^{-1}$)	Transpiration (mol m^{-2} s^{-1})	pWUE	Stomatal conductance (cm s^{-1})	Moisture content %	MRC upto 6 h (%)
V1	10.72	0.0146	734.24	1.34	78.42	80.73
C1730	11.12	0.0117	950.42	1.52	80.97	82.16
C2016	9.53	0.0114	835.96	0.82	77.46	79.79
C2017	11.92	0.0127	938.58	1.63	79.33	81.35
Anantha	9.71	0.0106	916.03	0.87	78.19	81.24
RFS 175	10.57	0.0115	919.13	1.06	73.77	80.56
Thallaghatapura	8.53	0.0145	588.27	0.59	79.75	79.21
Vishala	12.46	0.0106	1175.47	1.92	81.27	85.11
S1	10.17	0.0138	736.95	0.95	82.75	83.69
S1635	14.66	0.0116	1263.79	2.12	80.62	83.05
CD at 5%	1.05	0.005	130.12	0.30	1.35	1.48

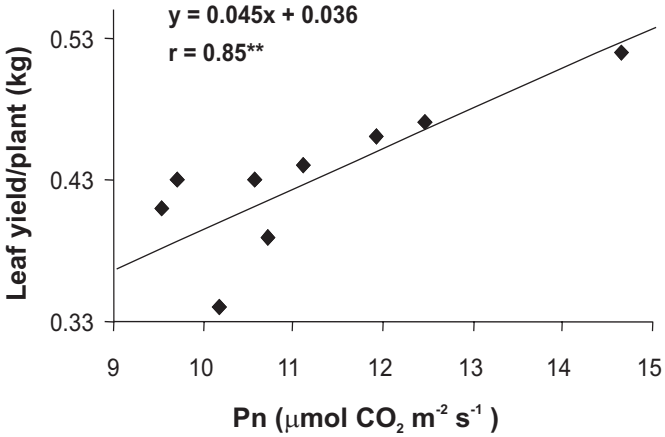


Fig. 5. Regression and correlation coefficients between net photosynthetic rate (Pn) and leaf yield / plant, analyzed from all the data.

All the varieties have shown leaf moisture content above 70% and moisture retention capacity above 79 % after 6 hours of storage. High leaf moisture content and its retention capacity are the important parameters considered by Chaluvachari & Bongale (1995) for getting better growth and development in silkworm.

Data on different morphological characters revealed that S1635 showed higher leaf yield compared to other varieties which may be mainly due to their increased leaf fresh weight, leaf area and specific leaf weight (Table 3). The leaf weight might have been influenced by some other parameters like stem weight, leaf number / plant, leaf size (Bari *et al*. 1989) and some physiological parameters like Pn, pWUE, higher stomatal conductance, low transpiration rate etc. (Chattopadhyay *et al*. 1996). In the present study, the varieties with higher NR activity showed high leaf protein content and leaf yield, which may be due to their greater ability of nutrient uptake and more in-built nitrogen utilization efficiency. This is in confirmation with the view of Johnson *et al*. (1976) that NRA is such a parameter which ultimately determines future of the actively growing plant particularly in terms of yield or leaf biomass.

Perusal of Table 4 revealed that based on selection indexing 10 improved varieties used in present study can be arranged in chronological orders of S1635 > Vishala > C1730 > C2017 > S1 > V1 > RFS-175 > Anantha > C2016 > Thallaghatapura. Thus, from the overall physio-

Table 3. Leaf fresh weight, leaf dry weight, leaf area, specific leaf weight, leaf yield/plant and shoot yield/plant in ten improved mulberry varieties.

Variety	Leaf fresh weight (g)	Leaf dry weight (g)	Leaf area (cm^2)	Specific leaf weight (g m^{-2})	Leaf yield / plant (kg)	Shoot yield/ plant (kg)
V1	3.43	0.70	223.09	31	0.390	0.640
C1730	3.89	0.80	239.23	33	0.440	0.760
C2016	2.84	0.64	215.15	30	0.410	0.720
C2017	3.00	0.62	202.66	31	0.460	0.760
Anantha	2.75	0.79	270.67	29	0.430	0.690
RFS 175	3.66	0.86	275.53	31	0.430	0.670
Thallaghatapura	2.47	0.50	164.52	30	0.330	0.620
Vishala	3.99	1.02	297.69	34	0.470	0.810
S1	2.90	0.50	163.43	31	0.340	0.620
S1635	4.92	1.15	305.70	38	0.520	0.900
CD at 5%	0.553	0.091	30.07	1.258	0.107	0.191

Table 4. Selection indexing scoring values in ten improved mulberry varieties.

Index	Variety	Rank
539.24	S 1635	1
554.56	Vishala	2
972.57	C 1730	3
1245.85	C 2017	4
1265.96	S 1	5
1303.59	V 1	6
1467.98	RFS-175	7
1559.30	Anantha	8
1835.40	C 2016	9
2025.55	Thallaghatapura	10

biochemical and leaf yield performance it could be concluded that the variety S1635 is superior to all other varieties in the Gangetic alluvial soils under irrigated conditions.

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