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Mulberry genotypes suitable for northern West Bengal

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ABSTRACT

Soil acidity is one of the major problems in the sericulture which limits mulberry growth, leaf productivity and quality in many parts of the hills and foothills. More lands are becoming unproductive every year due to accumulation of acidic salts in the regions where the silkworm rearing is an age-old practice. The strategy for maintaining the sericulture production at the optimum level in the areas affected by soil acidity could be the use of mulberry genotypes with comparatively higher soil acidity tolerance. Hot spot evaluation of nine improved mulberry genotypes viz., Tr-4, Tr-8, Tr-10, Tr-12, Tr-20, Tr-23, C-1735, C-2028, S-146 along with BC_259 as ruling check was done in foot hills at Matigara sericulture complex, Siliguri (pH 5.2) and in hills at RSRS, Kalimpong (pH 4.6). The experiment was laid out in RBD with three replications and data were recorded for three years on the following characters viz. leaf yield, physiological parameters like net photosynthetic rate (NPR), transpiration rate, physiological water use efficiency (pWUE), stomatal conductance and biochemical parameters like total chlorophyll, soluble sugar, nitrate reductase activity (NRA) and soluble protein. The variances were highly significant against all the characters. Genotype Tr-23 showed superiority over the rest of genotypes for NPR (13.25 μmol m^{-2} s^{-1}), NRA (12.59 μmol NO_2^- h^{-1} g^{-1} fruit wt.), total chlorophyll content (1.82 mg g^{-1} fr. wt.), soluble sugar (31.50 mg g^{-1} fr. wt.) and soluble protein content (25.44 mg g^{-1} fruit wt.) It also has recorded higher leaf yield at both the locations, i.e. 24,558 and 14,429 kg/ha/year at Matigara and Kalimpong, respectively as compared to ruling variety, BC_259 (15,738 kg $ha^{-1}year^{-1}$at Matigara and 8,130 kg $ha^{-1}year^{-1}$at Kalimpong). The genotype, Tr-23, is included in All India Co-ordinated Experimental Trials for Mulberry (AICEM)- Phase-III to ascertain its suitability over wider area.

Key words: Acidic soil tolerant mulberry, NPR, NRA, soluble protein

The soils of West Bengal have been grouped into seven classes *viz.*, Brown forest, Teesta and Tarai alluvium, Gangetic alluvial, Vindhyan alluvial, coastal alluvial, Red and laterite and Gravelly. The soils in hilly regions of north come under the group brown forest soil and mostly are sandy loam in texture. However, sandy clay loam soils are also found in some areas. These are porous, shallow in depth with poor water holding capacity and strong to moderately acidic in reaction (pH 4.2–5.8).

Soil acidity is one of the major problems in the sericulture that hampers the normal growth and development of mulberry plant and ultimately quantity and quality of the leaf produced is deteriorated. More lands are becoming progressively unproductive due to accumulation of acidic salts in the regions where the silkworm rearing is an age-old practice. As the soil acidity in this region is a natural phenomenon, so amelioration of soil through application of dolomite / lime is a recurring expenditure for the poor farmers. The long term and cost effective strategy for maintaining the sericulture production at the optimum level in such areas could be the use of mulberry genotypes with comparatively high soil acidity tolerance.

With this objective a project was undertaken from 2004-08 to identify acidity tolerant superior mulberry genotype with better leaf productivity and quality over the ruling check, BC_259. Initially, in the laboratory at the institute, screening of 22 improved mulberry genotypes was conducted in the acidic environment in the sand cultures with nutrient medium (Knop's solution) at pH levels ranging from 2.0 to 7.0 to short list promising mulberry genotypes for further evaluation in acidic soils in the hot spot. Of these, some genotypes showed tolerance up to pH 4.0 without showing deterioration in the shoot length, leaf area, root volume and fresh and dry weight of root, shoot and leaf. On the basis of selection indexing, nine promising acidic medium tolerant mulberry genotypes were identified, *viz.*, Tr-4, Tr-8, Tr-10, Tr-12, Tr-20, Tr-23, C-1735, C-2028, S-146 which were evaluated along with BC_259 as ruling check at two hot spot locations: Matigara Sericulture Complex, Siliguri, Govt. of West Bengal (pH 5.2) and Regional Sericultural Research Station, Central Silk Board, Kalimpong, West Bengal (pH 4.6).

MATERIALS AND METHODS

Well-rooted 6-month old saplings of nine improved mulberry genotypes developed at CSR&TI, Berhampore (WB) *viz.*, Tr-4, Tr-8, Tr-10, Tr-12, Tr-20, Tr-23, C-1735, C-2028, S-146 along with BC_259 as ruling check were transplanted during July, 2004 at both the locations in RBD with three replications at the spacing of 60 × 60 cm with a net plot size of 180 m^2 at Matigara and at 90 × 90 cm at Kalimpong with net plot size of 162 m^2 surrounded by a common border. Recommended cultural package of practices for cultivation under irrigated condition were applied in foot hill at Matigara sericulture complex and that for rain fed condition at RSRS, Kalimpong (Ray, 1973). After one year of establishment, data on plant growth (days to sprout after pruning, number of shoots / plant, longest shoot length, internodal distance, total shoot length and leaf fall %) and leaf yield were recorded for consecutive three years from 2005 to 2007 during April, July and September

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matching with the three silkworm rearing crop seasons per year as per zonal silkworm rearing schedule. Five plants were used for recording of morphological data whereas all the plants were considered for recording leaf yield. Prior to leaf harvest, data on physiological and leaf quality parameters were also recorded. Physiological parameters [Net photosynthetic rate (NPR), transpiration rate and physiological water use efficiency (pWUE)] of the test genotypes were recorded with the help of portable photosynthetic system (LI-COR model 6200; Licor Instrument Inc, USA). Biochemical parameters *viz.*, soluble protein (Lowry *et al.*, 1951), soluble sugar (Morris, 1948) and chlorophyll (Arnon, 1949) content were determined as per standard procedures. To assess the over all leaf quality, bioassay experiment (wt. of 10 mature larvae, ERR of 10,000 larvae by number and weight., single cocoon weight, single shell weight and shell %) was conducted during April, 2007 crop season by using NB18×P5 at RSRS, Kalimpong and N×M12W at DOS, Matigara Farm. The pooled data were analyzed statistically to estimate critical difference and CV% (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Study of growth and yield

All the genotypes sprouted within fortnight at Matigara and within 15 days at Kalimpong. The shortest sprouting duration was recorded in Tr-10 (11.78 days). Number of shoots plant^{-1}, total shoot length and annual leaf yield was recorded significantly higher in Tr-23 as compared to check variety BC_259 at both the locations (Table 1).

Physiological study

At Matigara the pooled data analysis revealed significantly higher value with respect to NPR (13.90 μ mol m^{-2} s^{-1}), stomatal conductance (5.68 cm s^{-1}) and water use efficiency (1.41) in Tr-23 as compared to the check variety. The rate of transpiration (12.94 mol m^{-2} s^{-1}) was maximum in C-1735, which was at par with BC_259 (Table 3).

At Kalimpong NPR (13.25 μ mol m^{-2} s^{-1}) and stomatal conductance (5.47 cm s^{-1}) was also significantly higher in Tr-23 than the check variety and other test genotypes. The rate of transpiration was maximum in S-146 (9.28 mol m^{-2} s^{-1}) which was at par with Tr-23 and C-1735. Water use efficiency was found higher in Tr-10 (1.71) and it was at par with Tr-12, Tr-8 and Tr-23 (Table 3).

Table 1: Leaf yield performance of different mulberry genotypes at Matigara sericulture complex and RSRS, Kalimpong

Mulberry genotype	Matigara sericulture complex				RSRS, Kalimpong			
	Shoot plant^{-1}	Shoot length (cm)	Leaf yield (kg ha^{-1}year^{-1})	Leaf yield gain (%)	Shoot plant^{-1}	Shoot length (cm)	Leaf yield (kg ha^{-1} year^{-1})	Leaf yield gain (%)
Tr-4	5.72	732.16	19580.07	24.41	6.05	516.64	6291.63	-22.61
Tr-8	5.50	684.23	17685.17	12.37	6.12	571.69	7953.64	-2.17
Tr-10	6.01	742.09	16850.91	7.07	6.72	575.47	5835.29	-28.23
Tr-12	5.72	642.89	13987.49	-11.13	6.26	576.72	6098.61	-24.99
Tr-20	6.38	698.79	18318.96	16.40	6.57	601.35	7501.46	-7.73
Tr-23	8.22	943.79	24558.77	56.04	9.38	897.75	14429.48	77.48
C-1735	5.33	606.48	16953.69	7.72	6.32	527.63	6113.55	-24.80
C-2028	5.76	637.15	13303.23	-15.47	7.07	522.47	7578.38	-7.28
S-146	5.58	575.36	16377.30	4.06	6.46	594.57	8620.90	5.69
BC_259	5.34	512.57	15738.41	-	5.86	538.73	8130.01	-
LSD (0.05)	**0.32**	**16.69**	**798.24**	**-**	**0.47**	**23.43**	**1082.46**	**-**
CV%	**8.11**	**3.73**	**6.98**	**-**	**10.72**	**5.99**	**20.88**	**-**

Biochemical study

The genotypic variation in chlorophyll content, soluble sugar, soluble protein and nitrate reductase activity were found to be significant. The pooled data analysis revealed that the genotype Tr-23 was superior in respect of all the above parameters in both the locations as compared to the check variety (Table 4).

Bioassay study

Bioassay results revealed that cocoon yield per 10,000 larvae, single cocoon weight, single shell weight and shell % were highest in Tr-23 in both the locations (Table 4). Results on different morphological characters of ten improved mulberry genotypes revealed that at Matigara number of shoots plant^{-1}, total shoot length and annual leaf yield were significantly higher in Tr-23 as compared to check variety BC_259 with the leaf yield gain of 56% (Table 1). The same genotype maintained its superiority at Kalimpong also in respect of above parameters where the leaf yield gain was 77 % (Table 1). The highest leaf yield in the genotype Tr-23 at both the locations may be mainly due to their increased unit leaf fresh weight, number of shoots per plant and total shoot length. The leaf weight might have been influenced by some other parameters like stem weight, leaf number plant^{-1}, leaf size (Bari *et al.*, 1989) and some physiological parameters like NPR, pWUE, higher stomatal conductance, etc. (Chattopadayay *et al.*, 1996).

Table 2: Net photosynthetic rate (NPRμ mol $m^{-2}s^{-1}$), transpiration rate (mol m^{-2} s^{-1}), physiological water use efficiency (pWUE) and stomatal conductance (cm s^{-1}) in ten mulberry genotypes at two locations

Mulberry genotype	NPR		Transpiration		pWUE		Stomatal Conductance	
	K	M	K	M	K	M	K	M
Tr-4	7.95	9.28	6.33	10.31	0.85	0.97	2.15	2.59
Tr-8	9.22	10.90	6.43	11.04	1.01	1.34	2.54	3.87
Tr-10	9.48	8.12	5.82	9.76	1.05	0.82	2.78	2.35
Tr-12	7.88	9.56	5.37	11.52	0.80	1.09	2.04	2.75
Tr-20	9.69	9.50	7.85	11.59	1.14	1.10	2.89	2.64
Tr-23	13.25	13.90	9.18	10.11	1.53	1.56	5.47	5.68
C-1735	9.08	10.49	9.05	12.94	0.98	1.40	2.24	3.51
C-2028	10.02	10.77	8.55	11.37	1.35	1.43	3.17	3.68
S-146	9.98	10.68	9.28	11.77	0.89	1.45	2.28	3.66
BC259	8.26	10.79	8.41	12.87	1.27	1.39	3.04	3.57
LSD (0.05)	**0.83**	**0.97**	**0.87**	**1.07**	**0.15**	**0.11**	**0.67**	**0.72**
CV%	**9.27**	**9.84**	**12.12**	**10.03**	**11.59**	**12.20**	**5.45**	**6.34**

K=RSRS, Kalimpong; M=Matigara sericulture complex

In situ gas exchange parameters differed significantly among the test genotypes (Table 2). Genotypes Tr-23, C-2028, C-1735, S-146 and BC_259 were found to have higher net photosynthetic rate. Stomatal conductance was also found higher in these genotypes. This observation is in accordance with Chattopadhyay *et al.* (1996) where they found a significant positive correlation between these two parameters and attributed to the higher availability of CO_2 for its fixation during photosynthesis. Irigoyen *et al.* (1992) opined that low stomatal conductance reduces the photosynthetic rate by restricting the availability of CO_2 for its fixation. Physiological water use efficiency also varied significantly among the genotypes and the variation was associated with the variations in photosynthetic capacity as well as stomatal conductance, which was in accordance with the results of Condon *et al.* (1990) in wheat. In the present study a significant positive correlation ($r = 0.98$) was found between NPR and stomatal conductance (Fig. 1) and NPR and pWUE ($r = 0.91$) (Fig. 2).

Table 3: Nitrate reductase activity (NRA μmol NO_2^- $h^{-1}g^{-1}$ fresh weight), soluble protein (mg g^{-1} fr. wt.), soluble sugar (mg g^{-1} fr. wt.), total chlorophyll content (mg g^{-1} fr. wt.), and leaf moisture (%) in ten mulberry genotypes at two test locations

Mulberry genotype	NRA		Soluble protein		Soluble sugar		Total chlorophyll		Leaf moisture (%)	
	K	M	K	M	K	M	K	M	K	M
Tr-4	10.25	9.62	22.36	21.88	25.14	26.12	1.17	1.26	79.34	78.74
Tr-8	9.78	9.88	21.65	21.95	26.91	27.41	1.20	1.49	77.95	80.13
Tr-10	11.32	10.84	23.46	22.94	25.30	25.12	1.12	1.36	79.94	79.38
Tr-12	9.81	8.47	21.84	20.56	29.37	28.48	1.29	1.22	78.41	78.88
Tr-20	9.15	9.08	21.34	21.11	27.69	26.20	1.01	1.39	79.42	79.00
Tr-23	13.57	12.59	25.44	24.80	31.50	31.42	1.55	1.82	79.50	79.87
C-1735	10.22	9.70	22.27	21.86	27.39	26.16	1.14	1.31	79.87	78.52
C-2028	11.76	10.14	23.58	22.25	26.35	24.83	1.04	1.42	78.14	77.23
S-146	9.27	8.79	23.03	22.35	28.99	24.95	0.87	1.01	77.64	77.41
BC259	11.13	10.10	21.29	20.86	28.16	25.49	1.10	1.36	78.14	77.65
LSD (0.05)	**0.28**	**0.34**	**0.92**	**0.97**	**1.55**	**1.14**	**0.10**	**0.11**	**1.48**	**1.56**
CV%	**2.78**	**2.85**	**4.30**	**4.67**	**5.92**	**4.55**	**9.45**	**8.30**	**1.99**	**2.10**

K=RSRS, Kalimpong; M=Matigara Sericulture Complex

Among the genotypes tested, Tr-23, Tr-10, Tr-4, C-1735, S-146 and C-2028 exhibited high NR activity and soluble protein content in leaves. NR activity was found maximum in Tr-23 and minimum in Tr-20 whereas Tr-8, Tr-12 and BC_259 showed moderate NR activity and protein content. Low NR activity and low protein content were observed in Tr-20, which clearly indicates that the level of NR activity is closely associated with that of total protein content (Table 3). It was reported that any factor (nutrient uptake) that affects the leaf NR activity will directly affect its protein content (Ghosh *et al.*, 1994). As the enzyme (NR) 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, 1955), 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. 4).

Table 4: Bioassay studies during April, 2007 crop season by using NB18×P5 at RSRS, Kalimpong and N×M12W at DOS, Matigara Farm

Mulberry Genotype	Wt. of 10 mature larvae		Yield / 10000 larvae (No.)		Yield / 10000 larvae (wt.)		Single cocoon wt. (g)		Single Shell wt. (g)		Shell %	
	K	M	K	M	K	M	K	M	K	M	K	M
Tr-4	41.49	28.95	8267	8300	14.80	9.17	1.85	1.29	0.35	0.17	18.95	13.47
Tr-8	41.24	30.14	8000	8200	15.07	9.50	1.96	1.29	0.37	0.17	18.99	13.44
Tr-10	47.11	27.93	7867	7500	14.80	9.47	1.98	1.29	0.37	0.18	18.75	13.70
Tr-12	45.32	30.65	7467	7700	13.87	9.37	1.96	1.27	0.36	0.15	18.58	12.07
Tr-20	42.79	29.84	8133	7500	13.20	9.30	1.99	1.28	0.38	0.17	18.95	13.06
Tr-23	49.48	30.94	8800	8100	16.53	9.93	2.00	1.30	0.39	0.19	19.62	14.58
C-1735	41.43	28.73	7733	7900	14.00	9.07	1.97	1.28	0.36	0.16	18.21	12.27
C-2028	37.13	30.26	8267	7800	13.60	9.37	1.99	1.27	0.38	0.16	18.99	12.59
S-146	41.19	26.41	7600	8000	13.20	9.20	1.92	1.25	0.35	0.15	18.09	12.00
BC_259	43.08	27.76	8000	8100	15.20	9.50	1.99	1.28	0.38	0.17	18.90	13.31
LSD (0.05)	**3.64**	**0.18**	**612.3**	**405.13**	**0.78**	**0.32**	**0.07**	**0.01**	**0.01**	**0.01**	**0.72**	**1.06**
CV%	**4.93**	**0.37**	**4.45**	**2.99**	**3.17**	**1.98**	**1.98**	**0.60**	**0.80**	**4.64**	**2.25**	**4.72**

K=Kalimpong, M=Matigara

Total chlorophyll, soluble sugar, soluble protein and moisture content have shown distinct variation among the genotypes (Table 3). S-146 had the lowest chlorophyll content while Tr-23 got the highest. Those varieties having higher chlorophyll content were found photosynthetically more efficient. A significant positive correlation (r = 0.58) was observed between NPR and chlorophyll content (Fig. 4) and between NPR and leaf yield plant^{-1} (r = 0.59) (Fig. 5). This finding is corroborated with that of Chattopadhyay *et al.* (1996) where it was found that the chlorophyll content and photosynthetic rate were significantly correlated in five Chinese mulberry varieties grown under tropical conditions. Similarly, Das *et al.* (1997) found higher CO_2 fixation in mulberry genotypes having higher chlorophyll content. Zelitch (1982) reported a close relationship among chlorophyll content, photosynthesis and crop yield. All the genotypes have shown leaf moisture content above 77%. According to Satyanarayana *et al.* (1990) and Chaluvachari and Bongale (1995) leaf moisture content is an important parameter for getting better growth and development in silkworms. On the basis of above results it can be concluded that morphometric parameters were maximum in Tr-23 at both the locations. The annual leaf yield of Tr-23 was 24.5 mt and 14.4 mt at Matigara and Kalimpong which out yielded the check variety, BC_259 by a margin of 56% and 77% at respective locations. In respect of bio-chemical constituents also Tr-23 was found superior. The bioassay performance for economic characters like single cocoon weight, single shell weight and shell% was superior in Tr-23 over the check variety BC_259. Thus, from the overall investigation the mulberry genotype, Tr-23 has been identified as significantly superior with respect to growth, yield, leaf quality and bioassay parameters at both the locations over the existing recommended variety BC_259. Hence, the genotype Tr-23, needs to be further evaluated under multilocational trial / All India Co-ordinated Experimental Trials for Mulberry (AICEM) followed by popularization/exploitation in the problematic acidic soils in hills and foot hills of West Bengal and other similar environments.

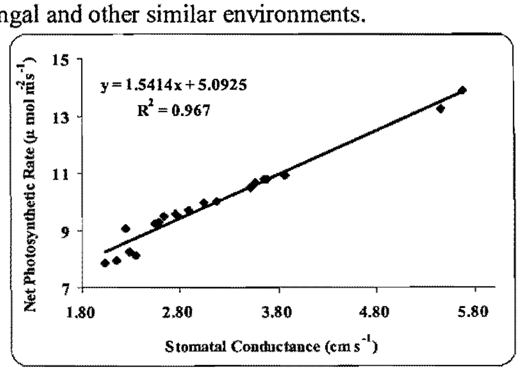

Fig.1. Regression and correlation coefficients between stomatal conductance and net photosynthetic rate

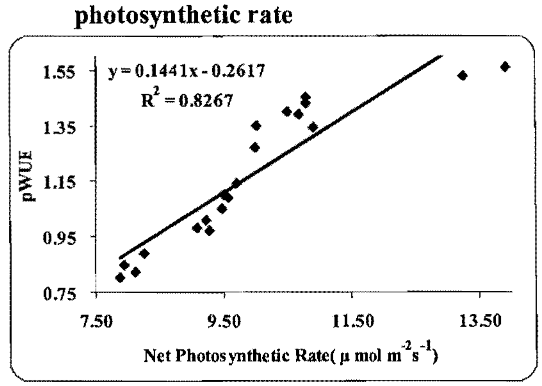

Fig.2. Regression and correlation coefficients between net photosynthetic rate and pWUE

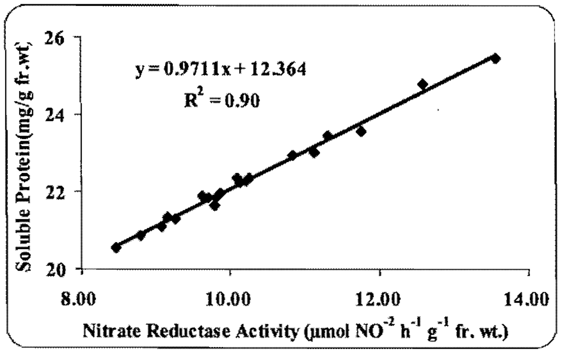

Fig.3. Regression and correlation coefficients between nitrate reductase activity and soluble protein

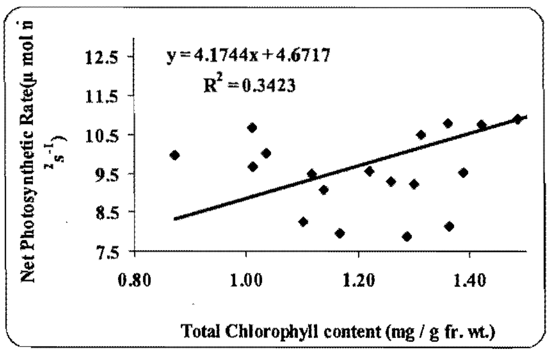

Fig.4. Regression and correlation coefficients between net photosynthetic rate and chlorophyll content

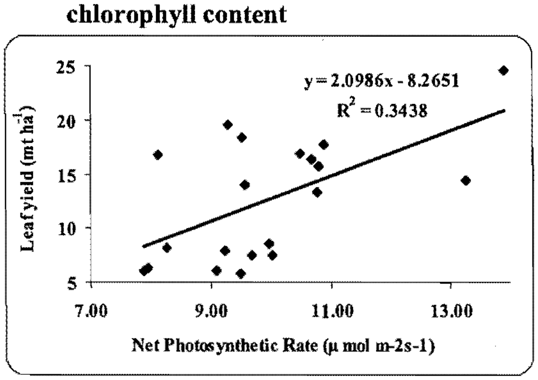

Fig.5. Regression and correlation coefficients between net photosynthetic rate and leaf yield plant $^{-1}$

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