Evaluation of Mulberry Germplasm (*Morus* spp.) for Leaf Yield and Quality through Bioassay

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Twenty - four elite mulberry germplasm each of indigenous and exotics were studied for their leaf yield and compared with commercial check (V_1 and Kosen). Accession MI-0416 and ME-0169 out yielded the check accession in leaf yield /plant. The other few mulberry germplasm were also performed at par with the checks. For quality test and bioassay were conducted with the leaves of selected mulberry germplasm. Among the selected twelve mulberry accessions used for bioassay, MI-0376 and ME-033 performed better than check (V_1, Kosen). Other mulberry accessions i.e., MI-0310 and MI-0437 are on par with the check as far as the bioassay is concerned. MI- 0376 and ME-0033 out yielded in rearing parameters and qualified for 11 and 10 rearing and related traits. Other mulberry accessions i.e., MI-0310 and MI-0437 were also qualified for eight rearing traits along with check (V_1). The mulberry accessions tested after selection from the preliminary characterization seems to be better and equally good in rearing and leaf yield compared to check (V_1, Kosen), which provides scope for selection and further evaluation. The selected mulberry accession may be included in crop improvement programme.

Key words: Mulberry accessions, *Morus* spp. elite, quality, and bioassay

Introduction

Mulberry silkworm (*Bombyx mori* L) responds to nutri-

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tional parameters depending on the environmental effect the physiology and the quality feeds provided through mulberry varieties. The nutritional requirement and food consumption has direct effect on larval weight, cocoon weight, amount of silk production and reproductive traits. The different commercial and reproductive characters ensure the crop stability and harvest of good cocoons and fetch higher values for the produce. The mulberry varieties, which are grown in different environmental condition, respond on different factors and the seasonal variation is obvious. Under such condition the suitable mulberry variety is to be tested against the silkworm rearing for its quality and subsequent recommendation for commercial utilization for the silk industry. Central Sericultural Germplasm Resources Centre (CSGRC), Hosur is situated in dry tropical belt of India having Latitude 12°45", Longitude77°51"E, altitude 942 m above mean sea level is a premier Centre which is maintaining 1100 mulberry germplasm resources (Indigenous - 836, Exotic - 264). The mulberry accessions collected from different sources and maintained in the field gene bank of CSGRC, Hosur. Initially the studied mulberry accessions were short listed based on their performance particularly yield and yield traits and subjected to test in different multilocational trial to find out their suitability in different conditions. After getting the performance again the mulberry accessions were subjected to bioassay in order to test their suitability for silkworm rearing for quality aspects. In sericulture practice more than 60 percent of the cost of cocoon production is towards raising mulberry crop (Rangaswami *et al.*, 1976). The huge mulberry germplasm maintained at CSGRC, Hosur requires evaluation based on leaf yield, leaf quality and silkworm rearing results. Sengupta *et al.*, 1973, reported the effect of mulberry variety on silkworm rearing. A number of workers failed to recognize significant differences in survival and cocoon characters using leaves of different mulberry cultivars in feeding experiments (Lombardi, 1960; Das and Sikdar,

1970; Das and Prasad, 1974). But on the other hand a number of workers such as Abdullaev (1961), Narayanan *et al.*, (1966) and Krishnaswami *et al.*, (1971) recorded some distinct varietal superiorities with regard to larval growth, success of cocoon crop and cocoon characters. Thus, the present study aims to evaluate and select elite mulberry varieties for leaf yield and quality assessment through bivoltine commercial hybrid silkworm (CSR2 × CSR4).

Materials and Methods

The mulberry germplasm evaluated after preliminary characterization in the field gene bank. The selected accessions were subjected to multi-locational yield trial in different agro-climatic condition. The selected 24 mulberry accessions along with check were planted at CSGRC, Hosur. The experiment was set up in Partial lattice design with three replications, 9 plants/replication with 90 × 90 cm spacing. Recommended cultural practices were followed to maintain the experimental plantation. The plants were pruned after one year of establishment and data recorded after 75 - 90 days of pruning. The leaf yield and growth traits were recorded namely, number of branch, length of the longest shoot (cm), total shoot length (cm), internodal distance (cm), leaf moisture content (%), leaf moisture retention capacity (%), leaf yield/plant (g) and single leaf weight (g). The data were processed and

analyzed in partial lattice design statistical package. The selected mulberry accessions were subjected to bioassay for quality test. The silkworm is the ultimate consumer for selecting or accepting the mulberry leaf. The silkworm rearing experiments were conducted during two season (February-March 2006 and May, 2006) under completely randomized block design with two replication of 300 larvae each after third moult of CSR2 × CSR4 hybrids by providing mulberry leaves from 12 elite varieties including 2 check. The standard rearing techniques recommended were followed (Krishnaswamy, 1978). The observations were recorded on 8 quantitative traits having commercial value viz., weight of 10 matured larvae (g), (LWT), fifth age larval duration (hrs) (VLD), pupation rate (%) (PR), cocoon yield by number/10,000 larvae (CYN), cocoon yield by weight (kg) (YWT)/10,000 larvae, single cocoon weight (g) (CWT), single shell weight (g) (SWT) and shell ratio (%) (SR). For reeling study standard silk reeling technology package was followed. The post cocoon quantitative parameters like average filament length (m) (FL), non-breakable filament length (m) (NBFL) and denier (DEN) etc. were recorded after harvesting of cocoons based on single cocoon evaluation. The data were subjected to analysis of variance (ANOVA) using the computer packages developed by Indostat Service Pvt. Ltd. Hyderabad, India. The best mulberry varieties for desired rearing parameters and its response to silkworm hybrid was evaluated through Evaluation index (E.I.) method (Mano *et al.*, 1993), which was arrived by

Table 1. Performance of selected indigenous mulberry germplasm (Mean of 13 crops) (CIMMYT index)

Acc.	Index	No. of branch	Length of the longest shoot (cm)	Total shoot length (cm)	Inter-nodal ditance (cm)	Leaf moisture content (%)	Leaf moisture retention capacity (%)	Leaf yield/ plant (g)	Single leaf weight (g)
MI-0416	16	11.66	174.19	1553.13	4.98	73.34	70.68	1070.77	5.14
MI-0308 (Check)	18	11.18	165.55	1418.43	5.20	74.99	72.42	905.56	4.42
MI-0376	18	13.08	176.12	1715.00	6.02	75.17	70.80	902.75	4.13
MI-0437	19	10.77	146.04	1247.39	5.04	75.87	72.74	950.68	5.58
MI-0310	19	11.22	149.77	1336.41	5.56	74.74	72.33	993.10	5.45
MI-0369	21	12.24	141.83	1358.56	5.15	74.11	69.91	862.34	3.81
MI-0029	21	14.28	155.62	1715.92	5.03	73.49	62.52	818.30	2.27
MI-0431	21	10.77	146.89	1263.16	5.11	74.06	69.69	858.91	4.54
MI-0154	22	11.96	166.47	1523.12	4.43	71.34	65.82	866.57	2.34
MI-0290	22	12.63	172.43	1611.19	5.36	73.85	63.10	797.19	2.62
Mean		11.52	151.94	1352.32	5.16	73.27	67.63	778.42	3.82
Minimum		9.30	123.43	897.66	4.20	70.03	60.69	495.79	1.75
Maximum		14.38	176.45	1715.92	6.93	75.87	72.74	1070.77	6.84
SD		1.38	14.53	223.37	0.59	1.53	3.81	138.77	1.39
CV%		12.01	9.56	16.52	11.50	2.09	5.63	17.83	36.30

Table 2. Performance of selected exotic mulberry germplasm (Mean of 13 crops) (CIMMYT index)

Acc.	Index	No.of branch	Length of the longest shoot length (cm)	Total shoot length (cm)	Inter-nodal ditance (cm)	Leaf moisture content (%)	Leaf moisture retention capacity (%)	Leaf yield/ plant (g)	Single leaf weight (g)
ME-0169	18	11.79	161.49	1488.71	5.98	73.64	72.47	1254.44	7.21
ME-0058	18	13.11	174.66	1794.27	5.03	74.27	64.54	938.52	3.43
ME-0129	19	12.17	156.64	1486.50	5.66	74.45	68.75	878.29	4.78
ME-0052	19	10.06	169.39	1295.53	5.11	73.46	70.35	870.01	5.36
ME-0143	19	9.51	176.93	1255.43	5.22	73.38	71.39	888.39	5.74
ME-0033	19	13.08	152.54	1541.69	5.46	74.82	67.07	890.60	3.68
ME-0168	20	9.93	161.32	1263.18	5.63	73.97	70.25	883.82	6.46
ME-0170	21	9.62	156.57	1187.86	5.52	73.60	72.79	829.70	6.07
ME-0130	21	10.64	162.48	1324.18	6.03	73.91	74.32	796.95	5.35
ME-0007	21	12.18	149.33	1426.24	5.22	72.76	67.89	880.24	4.33
ME-0066 (Check)	23	7.67	136.00	792.43	4.78	74.77	69.96	572.01	5.43
Mean		10.38	164.89	1324.15	5.46	73.62	69.22	781.88	4.80
Minimum		5.71	123.80	555.92	4.58	70.54	62.36	426.31	3.00
Maximum		13.11	206.19	1828.55	6.59	75.22	74.54	1254.44	7.21
SD		1.78	21.53	325.96	0.50	1.06	3.70	158.01	27.65
CV%		17.13	13.06	24.62	9.09	1.44	5.34	20.21	1.32

the following formula:

Evaluation index $(E.I.) = A - B/C \times 10 + 50$

Where, A = Mean of the particular trait for a hybrid, B = Overall mean of the particular trait (the experimental mean), C = Standard deviation, 10 = Standard and 50 = Constant. The mulberry accessions responded by silkworm and the score value of particular traits above 50 are considered to have greater economic value.

Results and Discussion

At CSGRC, Hosur both indigenous and exotic mulberry accessions were tested. Altogether 13 crops data recorded in 3 years and processed for statistical analysis. The mean performance of selected entries of indigenous accessions presented in Table 1. The mulberry accessions were ranked as per selection index based on CIMMYT package. MI-0416 performed better than check (V$_1$) and some other mulberry accessions (MI-0437, 0310, 0369) also performed better or on par with check (V$_1$). Maximum leaf yield recorded in MI-0416 (1070.77 g/plant) followed by MI-0437 (950.68 g) and MI-0310 (993.10 g). Single leaf weight was higher in MI-0416, 0437, 0310, 0431 than the check. MI-0437 showed high leaf moisture content

and leaf moisture retention capacity (75.87; 72.74%). The leaf yield data of exotic accessions were recorded for 13 crops. The data were compiled and ranked the accession following CIMMYT analysis. Among the 24 mulberry accessions, 10 selected entries are presented in Table 2. ME-0169 showed better performance than other entries. All the 10 selected entries showed better performance

Table 3. Selected mulberry accessions used for silkworm rearing

Mulberry accessions	Accession name	Collected from	Status of accession	Ploidy status
ME-0033	Thailand male	Thailand	Exotic	Diploid
ME-0058	Thaibeelad	Thailand	Exotic	Diploid
ME-0143	SRDC-1	----	Exotic	Diploid
ME-0168	M.multicaulis	Indonesia	Exotic	Diploid
ME-0169	Georgia	----	Exotic	Diploid
ME-0066 (Check)	Kosen	Japan	Exotic	Diploid
MI-0310	Chak Majra	India	Indigenous	Diploid
MI-0369	Resham Majri-6	India	Indigenous	Diploid
MI-0376	Kunjagao-2	India	Indigenous	Diploid
MI-0416	Keeraithodu	India	Indigenous	Diploid
MI-0437	Baragarh-2	India	Indigenous	Diploid
MI-0308 (Check)	V$_1$	India	Indigenous	Diploid

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Table 4. Rearing performance of selected mulberry acc. with silkworm race (CSR2 × CSR4)

Mulberry accession	Weight of 10 mature larvae (g)	Fifth age larval duration (h)	Pupat-ion rate (%)	Cocoon yield/ 10,000 larvae	Cocoon yield weight (kg)/ 10,000 larvae	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)	Non-broken filament length (m)	Denier
ME-0033	43.83	173.00	97.75	9650.00	20.27	1.94	0.477	24.58	1239.39	1032.66	2.972
ME-0058	40.14	182.50	96.75	9675.00	18.25	1.71	0.440	25.85	1223.44	1019.53	2.920
ME-0066 Check	41.71	182.50	96.60	9550.00	18.41	1.71	0.415	24.02	1172.02	856.41	2.915
ME-0143	39.35	182.50	96.00	9500.00	17.50	1.82	0.455	24.98	1075.78	897.47	2.907
ME-0168	36.87	182.50	97.00	9600.00	16.27	1.78	0.447	25.15	1166.22	1020.19	2.900
ME-0169	40.40	173.00	93.50	9300.00	16.93	1.82	0.455	24.91	1155.53	1012.63	3.018
MI-0308 Check	46.71	173.00	97.25	9575.00	19.93	1.99	0.500	25.16	1016.44	757.42	3.525
MI-0310	43.17	173.00	98.00	9750.00	19.86	1.89	0.471	24.94	1138.50	887.20	3.110
MI-0369	42.99	182.50	95.75	9475.00	18.36	1.65	0.403	24.39	1157.69	928.82	3.118
MI-0376	46.31	173.00	97.00	9700.00	20.04	1.98	0.495	25.10	1218.75	1015.50	3.035
MI-0416	40.90	182.50	97.00	9700.00	15.28	1.84	0.440	23.90	1006.41	829.51	2.910
MI-0437	44.02	173.00	90.25	9000.00	22.01	2.14	0.540	25.23	1303.85	1086.57	3.265
Mean	46.20	177.75	90.25	9539.58	18.59	1.86	0.46	24.58	1156.17	945.32	3.05
Minimum	36.87	173.00	95.98	9000.00	16.27	1.65	0.41	23.90	1006.41	757.42	2.90
Maximum	46.71	182.50	90.25	9750.00	22.01	2.14	0.54	25.85	1303.86	1086.57	3.53
S.E.	2.03	2.74	98.00	141.84	0.53	0.06	0.01	0.39	27.62	58.11	0.09
CV%	11.05	3.95	1.32	3.47	11.52	9.37	10.12	3.59	8.79	15.37	8.15
F-test Mulberry	**	**	*	**	**	**	**	**	**	**	**
Season	**	**	**	**	**	**	**	NS	NS	**	**
Mulberry × Season	**	**	**	**	**	**	**	**	NS	**	NS

than check (Kosen). The leaf yield was observed 1254.44 g/plant/harvest which is better than indigenous accession. The coefficient of variation observed maximum in total shoot length (24.12%) followed by leaf yield/plant (20.21 %) and least in single leaf weight (1.32%). A total of selected 12 mulberry accessions (including check) were subjected to bioassay. The details of the selected mulberry accessions are presented in Table 3. The mean rearing performance with different mulberry accessions are presented in Table 4. The general statistics i.e. mean, minimum, maximum values indicate a wide range of variation among the accessions (Table 4). The pooled ANOVA for two rearing crops revealed that all mulberry accessions showed significant variation for all rearing traits except silk ratio %. The trait average filament length showed no variation for two rearing season. The interaction between silkworm race and mulberry accessions were highly sig-

nificant in all the pre-cocoon and post cocoon traits except average filament length and denier. The maximum CV% was observed in non-broken filament length and minimum in cocoon yield/10,000 larvae. Larval weight showed coefficient of variation upto 11.05%. The same silkworm race reacts with different mulberry accessions and varied in larval growth and weight (Sikdar, 1993). Like wise the Vth stage larval duration varies with different mulberry accessions. The quantum of mulberry leaves consumed and converted into end product depends on the quality of the mulberry leaves (Sarkar, 1993). Thus the duration decreases or increases based on the quality mulberry leaves. Rearing performances showed a clear picture between the ability of larvae to digest and assimilate the mulberry leaves resulting quality cocoons. The pupation rate is the grainage parameter, which signifies the quality seed production for next generation. The high

Table 5. Ranking of mulberry accessions based on silkworm rearing performance (Mano Index)

Mulberry accession	Weight of 10 matured larvae (g)	Fifth age larval duration (h)	Pupation rate (%)	Cocoon yield/ 10,000 larvae	Cocoon yield weight (kg)/ 10,000 larvae	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Fila-ment length (m)	Non-broken fila-ment length (m)	Denier	Cum_ Index	Traits qualified
MI-0376	64.31	40.43	54.70	57.64	57.53	58.55	58.81	54.50	57.07	57.00	49.22	55.43	11
ME-0033	55.66	40.43	58.16	55.26	58.73	55.91	54.08	4.99	59.40	58.71	45.85	53.38	10
MI-0308 Check	65.71	40.43	55.86	51.69	56.99	59.69	60.13	55.58	34.22	31.27	75.41	53.36	8
MI-0310	53.39	40.43	59.31	60.01	56.59	52.49	52.50	51.60	48.01	44.21	53.23	51.98	8
MI-0437	56.33	40.43	23.60	24.32	67.82	70.38	70.65	56.99	66.68	64.08	61.51	54.80	8
ME-0058	42.83	59.57	53.55	56.45	48.19	39.38	44.35	68.27	57.60	57.40	43.07	51.88	6
ME-0168	31.44	59.57	54.70	52.88	37.90	44.51	46.19	55.51	51.14	57.46	42.01	48.48	6
ME-0169	43.74	40.43	38.58	38.60	41.35	47.51	48.29	51.07	49.93	56.71	48.31	45.86	4
ME-0066 Check	48.31	59.57	47.79	50.50	49.06	39.53	37.77	34.76	51.79	41.14	42.81	45.73	3
ME-0143	40.06	59.57	50.10	48.12	44.30	47.65	48.29	52.38	40.92	45.23	42.38	47.18	3
MI-0416	45.47	59.57	54.70	57.64	32.74	48.93	44.35	32.70	33.09	38.45	42.54	44.56	3
MI-0369	52.74	59.57	48.94	46.93	48.80	35.47	34.61	41.66	50.17	48.35	53.66	47.36	2

pupation rate ensures the quality seed with required number of laying. The pupation rate achieved by different mulberry accessions varies from 90.00 - 98.00 percentages and the coefficient of variation is 1.32%. This indicates that all mulberry accessions tested are equally good for pupation rate. The cocoon yield in number and weight is the more beneficial aspects for producers. The total number of cocoons harvested were calculated based on 10,000 larvae brushed and weight was taken based on the actual and converted to number of larvae brushed (10,000). The cocoon number varied from 9000 - 9750 and yields 16.27 - 22.01 kg. The yield in number and weight was significantly varied among the mulberry accessions. Maximum cocoon yield observed in MI-0437 whereas maximum cocoon number in MI-0310. The single cocoon weight was maximum in MI-0416 followed by MI-0308, MI-0376 and minimum in MI-0369. The single shell weight was maximum in MI-0437 followed by MI-0308 and least in ME-0066. The shell ratio ranges from 23.90 - 25.85. The coefficient of variation is 3.59.

The post cocoon traits were tried based on single cocoon assessment to know the performance of different mulberry accessions on silkworm rearing and subsequent performance in average filament length and denier (size) of the silk. The average filament length ranges from 1006.41 - 1303.86 m and non-broken filament length (757.42 - 1086.57 m). The denier (size) of the silk ranges from 2.90 to 3.53. The performance of the rearing traits confirmed by the result of post cocoon traits i.e., cocoon yield, single

cocoon weight and silk ratio is the indicator of long filament length in this study which corroborates with the findings of Kumaresan *et al.*, 2003 and Sikdar, 1993.

The mean rearing data of two crops were analysed to score the index value based on Mano's evaluation index (EI) method and assigned overall rank based on cumulative superiority of the traits (Table 5). The highest EI values obtained for first six-mulberry accessions viz., MI-0376, ME-0033, MI-0308, MI-0310, MI-0437 and ME-0058 are promising for selection on quality aspects. MI-0376 mulberry accession qualified for 11 rearing traits followed by ME-0033 (10), MI-0308 (8), MI-0310 (8), and MI-0437 (8). Other accessions qualified for 6 traits (ME-0058, ME-0168), 4 traits (ME-0169) 3 traits (ME-0066, ME-0143, MI-0416) and MI-0369 for 2 traits. Among the qualified mulberry accession MI-0308 (V₁) and ME-0066 (Kosen) are the popular commercial varieties used as check. From the rearing result it is observed that some new accessions (MI-0376, ME-0033, MI-0310, MI-0437) are performing better to provide scope of selection. Such reports are available with silkworm races where one or two mulberry varieties are used for feeding (Kumaresan *et al.*, 2003).

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