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Studies on heterosis and yield stability in improved mulberry hybrids under irrigated gangetic alluvial soils of West Bengal

M. K. GHOSH, N. K. DAS, SHIV NATH, P. K. GHOSH, A. GHOSH AND A. K. BAJPAI

Central Sericultural Research and Training Institute, Berhampore – 742 101, West Bengal

ABSTRACT

Eight newly developed mulberry (Morus sp.) hybrids viz., C-2036, S-1908, C-2037, C-2038, C-2039, C-2040, C-2041 and C-2042 were evaluated against S-1635 as check variety for growth, yield, physio-biochemical and bioassay parameters under irrigated conditions and zonal schedule of package of practices for cultivation in the alluvial soils of Gangetic plains of West Bengal. Among the test hybrids, C-2038 was recorded to have higher number of shoots per plant (10.93), total shoot length (1059.95 cm), unit leaf area (284.06 cm^2), unit leaf weight (4.87 g), net photosynthetic rate (13.53 µ mol m^2 s^{-1}), physiological water use efficiency (1.028), carboxylation efficiency (0.0442), chlorophyll content (2.53 mg g^{-1} fr wt), total soluble protein (31.44 mg g^{-1} fr wt), total soluble sugar (37.41 mg g^{-1} fr wt) and leaf yield (55.23 mt/ha/year) and better economic parameters of cocoon showing its superiority over check and other test hybrids. Heterosis was studied for leaf yield and its attributing characters in 8 hybrids developed. Significant positive heterosis ranging from 5.95 to 159.31% over better parent, 13.92 to 159.31% over mid parent and 1.50 to 27.79% over standard variety (S-1635) was observed among the crosses for leaf yield. The leaf yield performance of eight hybrids and one check was tested for 3 years through stability analysis for 5 crop seasons per year. Significant genotype × environment (G × E) interaction was observed. Variance for deviation from regression (S_{di}^2) of hybrids S-1908 and C-2039 did not differ significantly from zero. The b_i value of these two hybrids is also not significantly different from unity hence these may be considered to be stable ones. The hybrid C-2038 having b_i not significantly different from unity (1.023) and moderate but significant S_{di}^2 (0.35) emerged as a high yielder with high heterotic value for leaf yield. This hybrid has been recommended for national trial before field level exploitation and S-1908 and C-2039 may be considered as stable parents in future breeding programmes

Keywords: Biochemical, heterosis, leaf yield, mulberry, physiological and stability.

In Eastern India, the local mulberry was cultivated till 1960 with a very poor leaf yield of around 8-10 mt per hectare per year depending on the availability of irrigation / good rain (Sarkar and Ghosh, 2005). In the process of development of new mulberry varieties specific to agro-climatic zones of Eastern India, a number of varieties have been evolved and recommended for commercial use. S-1635 developed for irrigated condition has leaf yield potential of 43.6 mt/ha/year which is more than 52% of the previously best recommended variety S-1 (Sarkar and Ghosh, 2005).Heterosis in mulberry has been studied for leaf yield and its component characters by several workers. Vijayan *et al.* (1998) reported that heterosis breeding in mulberry is quite possible, though the plant is known to be highly heterozygous. It has further been observed that a hybrid Berhampore-1× Kajli is highly promising for future utilization. Sahu *et al.* (1995) and Bari *et al.* (1989) found negative heterosis for internodal distance which is desirable as this would enhance the number of leaves per unit length of the stem, thereby increasing the leaf yield per unit area.The productivity of a genotype is the function of its adaptability to a particular environment. Stability of a genotype depends on the ability to retain certain morphological and physiological characters along with its production efficiency over variable environments (Freeman and Perkins, 1971). Chakraborti *et al*. (2004) reported that a mulberry genotype C-1999 performed better in high yielding environments but its performance fell down in stress environments compared to its genetic potentiality. Deka and Talukdar (1997) also observed similar findings while working out stability of soybean (*Glycine max*) genotypes. Chakraborti *et al*. (2004) also reported that none of the genotypes could be identified as stable for leaf yield in strict consideration with respect to mean performance, linear response (regression) and magnitude of deviation from regression. The present investigation was undertaken to evaluate eight newly developed improved mulberry hybrids *viz.* C-2036, S-1908, C-2037, C-2038, C-2039, C-2040, C-2041 and C-2042 against S-1635 as recommended check variety (Anon. 2007) for their growth, yield, physio-biochemical and bioassay parameters so as to identify the best one for commercial exploitation under irrigated conditions in the Gangetic alluvial soils of West Bengal. It was also attempted to investigate the level of heterosis for leaf yield and its attributing characters. Moreover, their stability analysis was done on the basis of their growth and yield performance for 3 years covering 5 crop seasons per year to select a stable one for diverse environments.

MATERIALS AND METHODS

Four month-old saplings of 8 mulberry hybrids *viz.*, C-2036, S-1908, C-2037, C-2038, C-2039, C-2040, C-2041 and C-2042 along with S-1635 as check variety were transplanted under 60×60 cm spacing between plant to plant as well as row to row in randomized block design (RBD) with 3

E mail: drmrinalghosh@gmail.com

replications. Some of these hybrids are having same parents (Table 6), yet they were considered for this study as they showed considerable variability owing to heterozygous and heterogeneous nature of mulberry. The experiment was carried out at the Institute of CSR&TI, Berhampore, West Bengal during the year 2003-07. The soil type is Gangetic alluvial with pH 6.9; EC 0.12m mhos/cm, OC 0.56% and NPK level of 243:60:480 kg/ha. Recommended (Anon. 2007) cultural practices for cultivation under irrigated condition were followed. Data on various parameters were recorded from 60 day-old plants after pruning. Growth parameters, leaf yield, physiological and biochemical parameters were recorded 5 times per year (February, April, July, September and November) in accordance with the silkworm rearing schedule in West Bengal. Bioassay experiment was also conducted as per the standard procedure suggested by Das *et. al.* (1998).

Net photosynthetic rate (NPR) was measured from fifth expanding leaves on 60^{th} day after pruning 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 28-30ºC and relative humidity of 70-80%.m All the biochemical constituents/ parameters *viz.*, total soluble protein (Lowry *et al.*, 1951), total soluble sugar (Morris, 1948) and chlorophyll content (Arnon, 1949) were determined in triplicate and repeated twice in fresh leaves on 60^{th} day after pruning. Three years' pooled data were analyzed statistically to estimate critical difference and CV%. Simple linear correlation coefficients of chlorophyll content, NPR, stomatal conductance, carboxylation efficiency and pWUE with leaf yield were also computed (Gomez and Gomez, 1983). Selection indexing was done as per Smith (1936).

Heterosis value of each hybrid was worked out for number of tillers sprouted from the stump after pruning, height of the longest tiller on 70^{th} day of pruning, total shoot length, internodal distance, fresh weight of 100 leaves, leaf twig ratio, survival % of cuttings and leaf yield / plant / crop for three years by utilizing its mean and that of each parent in all three replications. Relative heterosis was calculated as the per cent deviation of the F_1 hybrids from its mid parental value. Heterobeltiosis in each hybrid combination was expressed for each character as per cent increase or decrease of F_1 value over corresponding better parent value and the standard heterosis was calculated over the standard check variety to show the superiority of hybrid over the recommended variety (S-1635). Three types of heterosis were estimated using the following formulae (Chaudhury, 1996).

Relative Heterosis = di = $(F_1 / MP - 1) \times 100$

Heterobeltiosis = dii = $(F_1 / BP - 1) \times 100$

Standard Heterosis = diii = $(F_1 / SC - 1) \times 100$

Where,
F_1 = Mean of hybrid
MP = Mean of two parents involved in the hybrid combination
BP = Mean of better parent of the hybrid combination
SC = Mean of standard check

Significance for heterosis was tested by using LSD value at 1 and 5 per cent levels of significance for relative heterosis, heterobeltiosis and standard heterosis tested by the following formulae

i.) 't' for relative Heterosis = $(F_1 – MP) / \sqrt{(3e/2r)}$

ii) 't' for heterobeltiosis = $(F_1 – BP) / \sqrt{(2e/r)}$.

iii) 't' for Standard Heterosis = $(F_1 – SC) / \sqrt{(2e/r)}$

Where,

e = Error variance, r = number of replications.

The stability analysis was done by using the Eberhart and Russel (1966) model.

RESULTS AND DISCUSSION

Evaluation

Data on different growth and yield characters revealed that C-2038 had higher leaf yield (55.23 mt/ha/year) compared to other test hybrids which could mainly be attributed to its increased number of shoots per plant (10.93), total shoot length (1059.95 cm), unit leaf fresh weight (4.87g) and single leaf area (284.06 cm^2) (Table 1). 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 NPR, pWUE, higher stomatal conductance, etc. (Chattopadhyay *et al*., 1996).

In situ gas exchange parameters varied significantly among the tested hybrids (Table 2). Hybrids C-2038, S-1908, C-2037, C-2039 and C-2041 were found to have higher net photosynthetic rate, stomatal conductance, pWUE and carboxylation efficiency. The results corroborate with the work of Chattopadhyay *et al*. (1996) who observed a significant positive correlation between net photosynthetic rate and stomatal conductance. Irigoyen *et al*. (1992) opined that low stomatal conductance reduces the photosynthetic rate by restricting the availability of CO_2 for its fixation. In the current study a significant positive correlation was observed between NPR and stomatal conductance and between NPR and pWUE (Table 4).

Total chlorophyll, total soluble sugar, total soluble protein, moisture content and its retention capacity showed distinct variation among the hybrids (Table 3). C-2037 had the lowest chlorophyll content while C-2038 had the highest. These hybrids having higher chlorophyll content were found photosynthetically more efficient. This finding is in complete agreement with those of Chattopadhyay *et al*. (1996) and Das *et al*. (1997). Zelitch (1982) reported a close relationship among chlorophyll content, photosynthesis and crop yield. In the present study a significant positive correlation was observed between NPR and chlorophyll content and between NPR and leaf yield (Table 4).

All the hybrids showed leaf moisture content and moisture retention capacity after 6 hours of storage above 76 and 85%, respectively. High leaf moisture content and its retention capacity are considered as the important leaf quality parameters for better growth and development of silkworms (Chaluvachari and Bongale, 1995). Perusal of table 5 revealed that based on selection indexing 8 newly developed improved mulberry hybrids along with ruling variety S-1635 used in present study can be arranged in ascending order of their performance as C-2038 > C-2039> S-1908 > C-2036 > C-2041 > S-1635 > C-2042 > C-2037 > C-2040. Thus, from the overall physio-biochemical and leaf yield evaluation it could be concluded that the hybrid C-2038 under irrigated Gangetic alluvial soils is superior to all other hybrids and the check varietiy.

Heterosis study

Analysis of variance (Table 6) revealed significant differences among the parents and crosses for all the characters. Higher values of mean sum of squares for all the entries including parents indicate greater variability among them, which opens up possibility of getting more heterosis. Hybrids were found to be highly significant for all the characters studied, suggesting that these traits are under the control of additive genes. The significant difference noticed for leaf yield and its attributing characters between means of parents as a group and those of hybrids suggests that heterosis resulted from dominant genes and its interactions or from complementary gene interactions, as reported in rice (Gravois and Mc New, 1993).

Only one hybrid, C-2038, cross of CF_1-10 and C-763, showed significant positive heterosis of 37.12% over mid parent, 28.52% over better parent and 24.52% over standard check for number of tillers (Table 7). Except C-2038 and C-2036, none of the hybrids exhibited significant positive heterosis for leaf yield over the standard check (Table-9), it rather significantly decreased in C-2037 and C-2040. Similar trend was observed for plant height and total shoot length (Table 7). Negative heterosis for internodal distance (Table 8) has usually been considered desirable as this would enhance the number of leaves per unit length of the stem thereby increasing the leaf yield per unit area (Bari *et al.*, 1989; Sahu *et al.*, 1995). For survival percentage, positive heterosis was observed in C-2038 (18.89 & 16.85%), C-2041 (7.09 & 5.25%), C-2039 (18.91 & 12.43%) and C-2040 (32.24 & 26.41%) over mid parent and better parent, respectively (Table 8).

From this investigation it can be concluded that heterosis breeding in mulberry is quite possible, though mulberry is known to be a highly heterozygous and heterogeneous plant. It has further been observed that the hybrid, C-2038, is highly promising for future utilization.

Stability study

Pooled analysis of variance for stability study (Table 10) showed highly significant differences among test hybrids for leaf yield over 5 different seasons, indicating that the hybrids/genetic diversity and seasons greatly influence the leaf yield.

Linear component of Genotype × Environment interaction was also significant for leaf yield (Table 10). Partitioning of mean squares due to genotype × environment interaction into linear and residual components revealed that major portion of interaction was due to linear component. These two indicate that the hybrids not only exhibited difference in their overall yield performance and high response to different seasons but a good prediction can also be made for performance across the seasons.

Eberhart and Russel (1966) have emphasized two parameters of stability i.e., linear regression and deviation from such regression. While, linear regression reflects the response of a particular genotype to environmental variation, deviation from regression measures its stability. Accordingly, for a stable genotype, linear regression could be around unity and deviation from regression should not be significantly different from zero.

The estimates of the above mentioned two parameters of stability i.e., regression coefficient (b_i) and deviation from regression (S_{di}^2) and mean performance in leaf yield (x) are presented in table 11. The range of average leaf yield in 9 mulberry hybrids was observed to be between 7.0 and 11.0 mt./ha/crop. The linear regression of two hybrids *viz.*, C-2036 and C-2040 were found to deviate significantly from unity. The variety with high mean performance, regression coefficient approaching unity and low deviation from regression are considered to be an average stable variety, which could be expected to perform uniformly well over variable environments.

Seasonal and annual leaf yield of the hybrids are presented in Table 12. It is found that highest leaf yield occurred in July followed by April, September, November and February, which is supported by the respective environmental index values (Table 13). The maximum average stability for leaf yield was exhibited by S-1908 followed by C-2039 (Table 11 and 12). Both the hybrids have b_i closer to unity (1.094 and 1.078, respectively) and low S_{di}^2 (0.08 and 0.10, respectively) and may be considered to be stable hybrids with moderate leaf yield. These two hybrids are recommended for utilization in future breeding programmes. On the other hand, the hybrid C-2038 is a high yielder with high heterotic value having b_i not significantly different from unity (1.023) and moderate but significant S_{di}^2 (0.35). This hybrid has been recommended for national trial before field level exploitation.

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Table 1: Growth and yield parameters mulberry hybrids

Genotypes	Number of shoots / plant	Total shoot length (cm)	Unit leaf area (cm^2)	Unit leaf weight (g)	Leaf yield (mt/ha/ year)	Gain % in leaf yield over check
C-2036	9.01	964.95	247.95	4.52	50.27	14.36
S-1908	8.51	873.98	234.25	4.22	44.04	2.33
C-2037	8.14	776.72	188.01	3.77	35.90	-
C-2038	10.93	1059.95	284.06	4.87	55.23	26.14
C-2039	9.67	915.70	252.44	4.46	47.21	8.81
C-2040	7.84	701.35	188.74	3.29	35.11	-
C-2041	8.53	912.92	229.86	4.23	44.56	2.27
C-2042	8.18	788.58	220.27	4.17	42.66	-
S-1635 (Check)	8.80	890.22	244.73	4.32	43.09	-
LSD (p=0.05)	**0.17**	**12.10**	**3.00**	**0.04**	**0.43**	
CV%	**3.83**	**2.75**	**2.53**	**1.87**	**9.57**	

Table 2: Physiological parameters of mulberry hybrids

Genotypes	NPR (μ mol $m^{-2}s^{-1}$)	Stomatal Conductance (cm s^{-1})	pWUE	Carboxylation efficiency
C-2036	11.84	4.084	0.696	0.0237
S-1908	11.07	3.253	1.019	0.0379
C-2037	8.04	3.947	0.827	0.0361
C-2038	13.53	4.901	1.028	0.0442
C-2039	11.52	3.734	0.757	0.0412
C-2040	7.85	2.422	0.769	0.0241
C-2041	9.50	2.991	0.667	0.0310
C-2042	6.77	2.559	0.556	0.0223
S-1635 (Check)	8.09	1.752	0.673	0.0230
LSD(P=0.05)	**1.02**	**0.45**	**0.13**	**0.003**
CV%	**6.04**	**8.03**	**9.64**	**5.93**

Table 3: Biochemical, leaf moisture and moisture retention capacity of mulberry hybrids

Genotypes	Total chlorophyll (mg g^{-1} fr wt)	Total soluble protein (mg g^{-1} fr wt)	Total soluble sugar (mg g^{-1} fr wt)	Leaf moisture content (%)	Moisture retention capacity (%)
C-2036	2.21	25.10	32.65	77.53	89.45
S-1908	2.17	22.16	34.50	76.97	86.20
C-2037	1.92	23.51	32.79	77.85	85.34
C-2038	2.53	31.44	37.41	78.57	87.39
C-2039	2.25	25.28	31.28	77.77	89.00
C-2040	2.06	29.15	31.70	78.84	89.41
C-2041	2.17	27.09	31.47	77.85	88.72
C-2042	2.17	24.19	33.75	78.21	92.69
S-1635 (Check)	2.34	31.28	33.76	79.29	86.87
LSD(P=0.05)	**0.07**	**1.35**	**1.33**	**0.74**	**2.69**
CV%	**2.49**	**4.06**	**3.19**	**0.75**	**2.42**

Table 4. Correlation of NPR, stomatal conductance, pWUE, leaf yield and carboxylation efficiency with component characters

	NPR	Stomatal conductance	pWUE	Leaf yield	Caboxylation efficiency
Chlorophyll	0.63*	0.24 NS	0.26 NS	0.86**	0.28 NS
NPR	-	0.78**	0.63*	0.84**	0.67*
Stom. Conduct	-	-	0.56*	0.55*	0.71*
pWUE	-	-	-	0.27 NS	0.77**

* Significant at 5% level of significance, **significant at 1% level of significance

Table 5: Ranking of eight hybrids of mulberry along with check variety S1635

Index	Genotypes	Rank
224.99	C-2038	1
837.41	C-2039	2
1048.09	S-1908	3
1051.81	C-2036	4
1086.38	C-2041	5
1119.13	S-1635(Check)	6
1412.23	C-2042	7
1688.14	C-2037	8
1845.80	C-2040	9

Table 6. Mean performance and ANOVA of dioecious parents, standard check and their hybrids for leaf yield and its attributing characters

Parent	No. of tiller	Plant height (cm)	Total shoot length (cm)	Internodal distance (cm)	Fresh wt. of 100 leaf (g)	Leaf twig ratio	Survival % of cuttings	Leaf yield / plant / crop (g)
M. indica HP	7.32	95.33	585.53	3.82	208.58	0.48	73.33	273.13
$CF_1$23	8.06	112.33	685.63	5.20	296.34	0.50	77.33	253.11
M. rotundiloba	5.00	89.00	398.25	4.23	151.23	0.47	69.67	121.26
C-530	5.70	92.33	422.85	4.47	166.15	0.51	73.00	146.45
S-1	7.00	107.33	653.52	4.10	156.60	0.52	75.33	202.39
$CF_1$10	8.61	115.67	723.11	5.25	376.07	0.51	68.00	250.49
C-763	7.53	107.33	617.03	4.15	222.22	0.52	65.67	291.19
$CF_1$1	7.20	107.83	558.50	4.86	205.70	0.50	65.33	228.59
Assambola	6.28	97.33	488.72	4.32	209.33	0.48	68.00	178.39
Almora local	6.30	102.18	614.55	4.27	279.08	0.47	62.00	127.92
Standard check	8.89	123.85	901.37	4.78	433.15	0.53	79.65	309.78
Mean	**6.41**	**104.59**	**604.46**	**4.49**	**245.85**	**0.49**	**70.66**	**216.60**
Hybrids								
C-2036 [1 × 2]	9.02	138.26	948.97	4.86	447.82	0.56	69.22	354.34
C-2042 [1 × 2]	8.29	113.63	798.51	4.46	416.22	0.56	65.51	304.30
S-1908 [OPH of 3]	8.65	124.35	877.56	4.46	417.42	0.54	55.42	314.43
C-2037 [4 × 5]	8.20	111.32	790.66	4.25	379.49	0.54	62.43	251.98
C-2038 [6 × 7]	11.07	140.66	1070.15	4.89	493.27	0.58	79.46	395.86
C-2041 [6 ×7]	8.64	113.37	811.70	4.40	422.84	0.57	71.57	308.53
C-2039 [1 × 8]	8.71	125.42	909.61	4.66	444.64	0.57	82.45	334.83
C-2040 [9 × 10]	8.01	105.78	720.21	4.24	361.09	0.54	85.96	258.27
Mean	**8.82**	**121.59**	**865.92**	**4.52**	**422.84**	**0.55**	**71.50**	**315.31**
SEm (±)	**0.28**	**2.66**	**27.18**	**0.08**	**7.92**	**0.01**	**1.60**	**8.45**
MSS	**5.57**	**609.86**	**97946**	**0.49**	**39890**	**0.00**	**171.41**	**16542**
F value**	**72.75**	**85.92**	**132.61**	**80.73**	**636.52**	**59.51**	**67.12**	**231.69**
LSD(P=0.05)	**0.46**	**4.40**	**44.92**	**0.13**	**13.09**	**0.01**	**2.64**	**13.97**

Table 7. Heterosis for number of tillers, plant height and total shoot length in mulberry hybrids

Hybrid	No. of Tillers			Plant height (cm)			Total shoot length (cm)		
	di	dii	diii	di	dii	diii	di	dii	diii
C-2036	17.28**	11.87**	1.42	33.16**	23.08**	11.63**	49.31**	38.41**	5.28*
C-2042	7.78**	2.81	-6.79*	9.43**	1.15	-8.25**	25.64**	16.46**	-11.41**
S-1908	72.93**	72.93**	-2.74	39.72**	39.72**	0.40	120.35**	120.35**	-2.64
C-2037	29.08**	17.10**	-7.80**	11.50**	3.71	-10.12**	46.91**	20.98**	-12.28**
C-2038	37.12**	28.52**	24.52**	26.15**	21.61**	13.57**	59.71**	47.99**	18.72**
C-2041	7.02**	0.31	-2.81	1.68	-1.98	-8.46**	21.14**	12.25**	-9.95**
C-2039	20.00**	19.04**	-2.02	23.46**	16.31**	1.26	59.02**	55.35**	0.91
C-2040	27.77**	27.09**	-9.94**	6.04*	3.52	-14.59**	30.56**	17.19**	-20.10**

* Significant at p = 0.05 and ** significant at p = 0.01

Table 8. Heterosis for internodal distance, leaf fresh wt. and leaf twig ratio in mulberry hybrids

Hybrid	Internodal distance (cm)			100 No. Fresh Leaf wt. (g)			Leaf Twig Ratio		
	di	dii	diii	di	dii	diii	di	dii	diii
C-2036	7.87**	-6.47**	1.81	77.38**	51.12**	3.39*	13.51**	11.26**	5.00**
C-2042	-1.07*	-14.23**	-6.63**	64.87**	40.45**	-3.91*	13.51**	11.26**	5.00**
S-1908	5.43**	5.43**	-6.56**	176.02**	176.02**	-3.63*	14.79**	14.79**	1.88
C-2037	-0.70*	-4.78**	-10.96**	135.16**	128.40**	-12.39**	6.19**	5.16**	1.88
C-2038	4.11**	-6.79**	2.44	64.89**	31.16**	13.88**	13.27**	12.90**	9.38**
C-2041	-6.45**	-16.25**	-7.96**	41.35**	12.44**	-2.38	10.03**	9.68**	6.25**
C-2039	7.53**	-3.98**	-2.37	114.66**	113.17**	2.65	14.86**	12.58**	6.25**
C-2040	-1.20	-1.78	-11.24**	47.86**	29.38**	-16.64**	12.59**	11.03**	0.63

Table 9. Heterosis for survival % and leaf yield / plant / crop in mulberry hybrids

Hybrid	Survival % of cuttings			Leaf yield / plant / crop (g)		
	di	dii	diii	di	dii	diii
C-2036	-8.12**	-10.49**	-13.10**	34.67**	29.73**	14.38**
C-2042	-13.04**	-15.29**	-17.76**	15.65**	11.41**	-1.77
S-1908	-20.44**	-20.44**	-30.42**	159.31**	159.31**	1.50
C-2037	-15.82**	-17.12**	-21.62**	44.47**	24.50**	-18.66**
C-2038	18.89**	16.85**	-0.25	46.16**	35.95**	27.79**
C-2041	7.09**	5.25**	-10.14**	13.92**	5.95*	-0.40
C-2039	18.91**	12.43**	3.51*	33.47**	22.59**	8.09
C-2040	32.24**	26.41**	7.91**	68.63**	44.77**	-16.63**

Table 10. Analysis of variance for leaf yield

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares
Total	44	132.9	-
Variety	8	36.7	4.58**
S+(V×S)	36	96.2	
Season (Linear)	1	16.26	
V× S (Linear)	8	136.9	17.11**
Pooled Deviation	27	7.23	0.27
C-2036	3	2.78	
S-1908	3	0.33	
C-2037	3	1.84	
C-2038	3	0.59	
C-2039	3	0.14	
C-2040	3	0.46	
C-2041	3	1.18	
C-2042	3	0.40	
S-1635	3	0.02	
Pooled Error	90	6.50	0.07

Table 11: Mean leaf Yield and Stability value

Genotype	Mean Yield (mt / ha / crop)	Regression coefficient (b_i)	Variance for deviation from regression (S_{di}^2)
C-2036	9.84 (2)	0.505**	2.04**
S-1908	8.73 (4)	1.094	0.08
C-2037	7.00 (9)	0.791	1.60**
C-2038	11.00 (1)	1.023	0.35**
C-2039	9.30 (3)	1.078	0.10
C-2040	7.17 (8)	1.276*	0.22**
C-2041	8.57 (6)	1.196	0.94**
C-2042	8.45 (7)	1.053	0.16*
S-1635	8.60 (5)	0.983	0.22**
Mean	**8.74**	**1.000**	**0.63**
SE	**0.26**	**0.128**	**0.07**

Figures in parentheses indicate the rank. For b_i, higher the ranks, closer to unity.
** Significant at 1% level, *Significant at 5% level.

Table 12: Seasonal and total leaf yield of mulberry hybrids

Genotypes	Leaf yield (mt / ha/ year)					
	April	**July**	**Sept.**	**Nov**	**Feb**	**Total**
C-2036	10.21	11.43	10.34	8.11	9.13	49.21
S-1908	9.87	10.65	10.20	7.59	5.36	43.67
C-2037	8.28	8.13	7.50	7.07	4.02	35.00
C-2038	12.94	12.65	11.78	9.49	8.38	55.23
C-2039	10.83	11.10	10.43	8.14	6.01	46.50
C-2040	8.83	10.00	7.99	5.38	3.67	35.87
C-2041	9.58	10.72	10.16	7.79	4.61	42.85
C-2042	9.80	10.55	9.59	6.62	5.71	42.26
S-1635	9.94	10.42	9.61	7.27	5.80	43.02
Mean	**10.03**	**10.63**	**9.73**	**7.50**	**5.85**	**43.73**
LSD(P=0.05)						**1.58**
CV%						**8.74**

Table 13: Seasonal index

April	July	September	November	February
1.29	1.89	0.99	-1.25	-2.92