The Bioscan 9(4): 1399-1404, 2014
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EVALUATION OF MULBERRY GERMPLASM BASED ON LEAF AND YIELD PARAMETERS

SHABIR A. WANI[1], G. N. MALIK[1], M. R. MIR[1], G. PARVEEZ[1], NAINA MAJID[1] AND M. ASHRAF BHAT[2]
[1]Temperate Sericulture Research Institute (TSRI), Mirgund, SKUAST- Kashmir,
Shalimar-190 025, Jammu and Kashmir, INDIA
[2]Molecular Biology Laboratory, Centre for Plant Biotechnology, SKUAST-Kashmir,
Shalimar -190 025, Jammu and Kashmir, INDIA
e-mail: shabirwani67@gmail.con

KEYWORDS
Genetic variability
Correlation
Cluster analysis
Mulberry germplasm

Received on :
18.12.2013

Accepted on :
05.10.2014

***Corresponding author**

ABSTRACT
The nature and magnitude of genetic variability and their interrelationship were studied for leaf and yield traits in 17 genotypes of mulberry (*Morus spp*).Analysis of variance of Lamina length, Lamina width, Lamina weight, Petiole weight and Leaf petiole ratio by weight, Petiole length, Leaf petiole ratio by length and leaf yield per plant showed significant variation. Leaf yield was recorded highest (4.751 kg/plant) in Goshoerami followed by SKM-33 (4.100 kg/plant) during spring season while as it was recorded (4.863 kg/plant) in Goshoerami and (4.450 kg/plant) in SKM-33 during autumn season. The correlation coefficient showed significant association of leaf yield with lamina weight (0.72**); lamina length (0.37**) and petiole weight (0.60**). Divergence analysis grouped the genotypes into 3 clusters, cluster I contained 15 genotypes, cluster II and Cluster III contained 1 genotype each on pooled over spring. The genotypes were grouped in to 2 clusters, cluster I contained 16 genotypes and cluster II contained 1 genotype on pooled over autumn. The variability among the genotypes measured by inter-cluster distance showed variation, which can be utilised for mulberry crop improvement. Goshoerami and SKM-33 exhibit highest leaf yield which can utilized in future breeding programmes.

INTRODUCTION

Mulberry (*Morus spp.*) the chief source of food for the silkworm (*Bombyx mori L.*) which grows in diverse climatic conditions and an economically very important. Mulberry (*Morus*) the only food plant of *Bombyx mori* L. Unlike other agricultural crops, leaf is the economic product in mulberry cultivation. Mulberry leaf contributes 38.2% towards the production of a successful cocoon crop (Boraiah 1986).Therefore, improvement of mulberry leaves in quality and quantity through breeding has a great bearing on the silk industry as a whole. Moreover, genetic diversity within and among the population is the backbone of conservation of plant genetic resources for both present and future use (Quedraogo, 2001). Mulberry breeders will require as much genetic diversity as possible from which to select and recombine favorable traits through cross breeding (Tikader and Dandin, 2007a; Tikader and Dandin, 2008, 2008a) to develop varieties that are adopted to different environment. Improvement through breeding or clonal selection depends on the extent of magnitude of diversity between the accessions. The process requires grouping the accessions into different clusters and select for utilization. Different authors highlighted grouping and selection of accessions from different clusters for crop improvement many authors indicated different growth characters of mulberry related with yield and suggested to include feasible combination of characters during selection (Bari *et al.*, 1989; Das and Krishnaswami, 1969; Sarkar *et al.*, 1987; Tikader, 1997). Characterization based on qualitative traits is useful in establishing the taxonomical identity. Phenotypic characterization is the first step in the description and classification of the germplasm (Smith and Smith, 1989).Moreover, estimates of genetic variables and relationship between germplasm collections are very useful and facilitate efficient utilization and management of germplasm (Rabbani *et al.*, 1998). Due to wide behavioral variation in mulberry there are many practical difficulties in the selection procedure. Improvement of a crop depends on the variation existing in genetic stock. The processes of selection indicated the association of parameters for better growth and yield performance among the germplasm accessions. Evaluation of any crop is a continuous process to evolve new varieties suitable for specific zones for commercial utilization. The present scenario of sericulture industry demands new varieties suitable for various agro- climatic conditions. Identification of suitable parents from large number of germplasm accessions is a prerequisite for the purpose.Hence the present study was undertaken to characterize the 17 mulberry genotypes and assess the genetic variability for growth and yield traits during 2009-2010.

MATERIALS AND METHODS

The present investigation was carried out at Temperate Sericulture Research Institute, SKUAST-Kashmir, Mirgund. The plant material for the study comprised seventeen mulberry genotypes (Table I) maintained in the Germplasm Bank of the Temperate Sericulture Research Institute, SKUAST-Kashmir,

Table 1: List of the mulberry (*Morus* spp.) genotypes used in the estimation of genetic diversity

S.No.	Genotype	Country of origin	S. No.	Genotype	Country of origin
1.	Goshoerami	Japan	11.	Brentul	Kashmir (India)
2.	Ichinose	Japan	12.	Botetul	Kashmir (India)
3.	Kokuso-20	Japan	13.	Chatatul Mirgund	Kashmir (India)
4.	Kokuso-21	Japan	14.	Local Mulberry	Kashmir (India)
5.	Kokuso-27	Japan	15.	SKM-27	TSRI (Mirgund, Kashmir, India)
6.	KNG	Japan	16.	SKM- 33	TSRI (Mirgund, Kashmir, India)
7.	Kanva-2	Karnataka (India)	17.	SKM- 48	TSRI(Mirgund, Kashmir,, India)
8.	Kasuga	Japan			
9.	Lemoncina	Italy			
10.	Chinese white	China			

Table 2: Performance of 17 mulberry genotypes (pooled over spring)

Genotypes	Lamina length (cm)	Lamina width (cm)	Lamina wt. (g)	Petiole wt. (g)	Leaf petiole ratio by wt.	Petiole length(cm)	Leaf petiole ratio by length	Leaf yield plant^{1} (kg)
Goshoerami	19.75	12.75	3.11	0.36	8.35	3.10	6.33	4.751
Ichinose	11.46	8.10	2.11	0.18	11.35	2.15	5.30	3.233
Kokuso-20	17.11	11.58	1.95	0.17	11.40	2.01	8.53	3.575
Kokuso-21	14.68	10.36	2.93	0.21	13.75	2.78	4.88	3.530
Kokuso-27	14.21	8.58	1.70	0.18	9.20	2.80	4.68	3.058
KNG	10.01	6.68	1.70	0.17	9.70	2.01	6.28	3.728
Kanva-2	16.00	11.40	1.26	0.16	7.80	2.20	6.96	1.443
Kasuga	14.06	8.58	1.83	0.17	10.50	2.00	5.73	3.255
Lemoncina	9.73	6.93	1.31	0.14	9.00	2.08	5.50	2.528
Chinese white	12.05	6.08	1.16	0.18	6.90	1.85	6.81	2.051
Brentul	14.68	10.56	1.80	0.18	9.70	2.03	6.35	3.301
Botatul	10.58	7.10	1.21	0.15	8.00	1.96	5.90	3.593
Chatatul Mirgund	14.08	8.78	1.68	0.19	10.25	2.15	6.00	3.351
Local-mulberry	11.60	9.50	1.20	0.14	8.48	2.03	6.76	2.076
SKM-27	15.28	14.13	1.75	0.20	8.50	1.95	6.90	2.435
SKM-33	17.88	13.35	3.06	0.36	8.18	3.06	6.06	4.100
SKM-48	12.26	12.10	2.11	0.20	10.26	2.05	5.36	2.820
Mean	13.85	9.80	1.37	0.20	9.49	2.25	6.14	3.10
CD at 5%	0.190	0.139	0.097	0.029	0.612	0.072	0.920	0.133

Mirgund. The plantations were maintained as dwarf spacing 6' x 6' with recommended cultural practices. The plants were pruned once in a year. Foliar characters were recorded after 90 days of pruning.

The study was under taken in both spring and autumn season to characterize the mulberry genotypes based on following phenotypic characters by following the standard descriptor (Thangavelu *et al.,* 1997). The yield attributed traits was measured and weight. Correlation coefficients were computed according to the method suggested by Singh and Chaudhary (1985). The genetic divergence was estimated by Mahalanobis (1936) D^2 statistics and the grouping of the genotypes into clusters were done using Tochers method (Rao,1952).

RESULTS AND DISCUSSION

Growth and yield attributing traits

The seasons selected for evaluation (spring and autumn) had significant effect on the expression of all the traits (Table 2 and 3). Analysis of variance exhibit significant variation. In spring lamina length was maximum in Goshoerami (19.75 cm) and minimum in Lemoncina (9.73 cm). Lamina width was recorded highest in SKM-27 (14.13 cm) and lowest in Chinese white (6.08 cm). Lamina weight was observed highest in Goshoerami (3.11 g) followed by SKM-33 (3.06 g) and average Lamina weight was recorded 1.37 g. Petiole weight was found highest in Goshoerami (0.36 g) and lowest in local mulberry (0.14 g). Leaf petiole ratio by weight was maximum (13.75) in Kokuso-21 and minimum (6.90) in Chinese white. Petiole length was found highest in Goshoerami (3.10 cm) followed by SKM-33 (3.06 cm) and average petiole length was 2.23 cm. Leaf petiole ratio by length was recorded highest in Kokuso-20 (8.53) and lowest in Kokuso-27 (4.68). Leaf yield plant^{-1} was recorded highest in Goshoerami (4.751 kg) followed by SKM-33 (4.100 kg) and average yield was 3.10 kg.

During autumn (Table 3) lamina length was maximum (22.25 cm) in Goshoerami and minimum (9.61 cm) in Lemoncina. Lamina width was highest (18.10 cm) in SKM-33 and lowest (8.46 cm) in Botatul. Lamina weight was observed highest (5.03 g) in Goshoerami followed by SKM-33 (4.43 g) and average being 2.53 g. Petiole weight was found highest (10.53 g) in Goshoerami and lowest (0.16 g) in Chinese white. Leaf petiole ratio by weight was maximum (11.45) in Kokuso-20 and minimum (9.39) in Kanva-2. Petiole length was found highest (4.63 cm) in Goshoerami followed by SKM-33 (4.46 cm) and average petiole length was 3.12 cm. Leaf petiole ratio by length was highest (6.41) in Kokuso-20 and lowest (3.33) in Lemoncina. Leaf yield plant^{-1} was recorded highest (4.863

Table 3: Performance of 17 mulberry genotypes (pooled over autumn)

Genotypes	Lamina length (cm)	Lamina width (cm)	Lamina wt. (g)	Petiole wt. (g)	Leaf petiole ratio by wt.	Petiole length(cm)	Leaf petiole ratio by length	Leaf yield Plant^{-1} (kg)
Goshoerami	22.25	15.83	5.03	0.53	9.52	4.63	4.75	4.863
Ichinose	13.60	10.16	2.65	0.25	10.41	3.11	4.33	3.580
Kokuso-20	18.51	12.36	2.73	0.24	11.45	2.83	6.41	4.075
Kokuso-21	15.68	11.66	3.18	0.27	11.09	3.50	4.51	3.970
Kokuso-27	15.56	10.95	2.45	0.22	11.12	3.18	5.00	3.970
KNG	11.65	8.93	2.16	0.20	10.51	2.96	3.86	4.618
Kanva-2	17.15	11.00	1.75	0.18	9.39	2.78	6.13	1.685
Kasuga	14.26	10.65	2.10	0.20	10.25	2.80	5.08	3.560
Lemoncina	9.61	8.98	1.78	0.18	9.91	2.83	3.33	2.776
Chinese white	13.00	8.85	1.55	0.16	9.39	2.68	4.73	2.525
Brentul	15.48	11.58	2.51	0.22	11.11	3.18	4.88	4.348
Botatul	13.85	8.46	1.73	0.18	9.45	2.71	4.93	4.378
Chatatul Mirgund	15.46	10.40	2.16	0.19	10.74	2.90	5.30	4.080
Local-mulberry	13.38	10.20	1.63	0.17	9.62	2.80	4.71	2.735
SKM-27	14.20	12.55	2.51	0.23	10.65	2.78	5.06	3.821
SKM-33	19.23	18.10	4.43	0.40	10.98	4.46	4.26	4.450
SKM-48	13.00	11.91	2.68	0.25	10.60	2.95	4.28	3.893
Mean	15.05	11.25	2.53	0.24	10.36	3.12	4.80	3.72
CD at 5%	0.282	0.286	0.148	0.008	0.682	0.107	0.164	0.060

Table 4: Genotypic and phenotypic correlation coefficients for growth and yield attributing traits of 17 mulberry genotypes (pooled over spring)

S. No.	Traits	Lamina length	Lamina width	Lamina wt.	Petiole wt.	Leaf pet. ratio by wt.	Petiole length	Leaf pet. ratio by length	Leaf yield plant^{-1}
1.	Lamina length (cm)	-	0.78**	0.64**	0.72**	0.07	0.63**	0.34*	0.38**
2.	Lamina width (cm)	0.77**	-	0.57**	0.58**	0.04	0.41**	0.29*	0.16*
3.	Lamina wt. (g)	0.64**	0.57**	-	0.85**	0.41**	0.79**	-0.23	0.73**
4.	Petiole wt. (g)	0.67**	0.54**	0.77**	-	-0.11	0.81**	-0.07	0.65**
5.	Leaf petiole ratio by wt.	0.06	0.03	0.41**	-0.13	-	0.09	-0.28*	0.31**
6.	Petiole length (cm)	0.62**	0.41**	0.78**	0.74**	0.10	-	-0.37**	0.56**
7.	Leaf petiole ratio by length	0.24*	0.20*	-0.19	-0.02	-0.27*	-0.28	-	-0.16
8.	Leaf yield plant^{-1} (kg)	0.37**	0.16	0.72**	0.60**	0.29**	0.55	-0.13	-

*, ** Significant at 5 % and 1 % level respectively

Table 5: Genotypic and phenotypic correlation coefficients for growth and yield attributing traits of 17 mulberry genotypes (pooled over autumn)

S. No.	Traits	Lamina length	Lamina width	Lamina wt.	Petiole wt.	Leaf pet. ratio by wt.	Petiole length	Leaf pet. ratio by length	Leaf yield plant-1
1.	Lamina length (cm)	-	0.82**	0.76**	0.76**	0.16	0.72**	0.52**	0.35**
2.	Lamina width (cm)	0.81**	-	0.88**	0.84**	0.34**	0.83**	0.15	0.42**
3.	Lamina wt. (g)	0.75**	0.87**	-	0.98**	0.29**	0.95**	-0.09	0.61**
4.	Petiole wt. (g)	0.76**	0.83**	0.96**	-	0.10	0.94**	-0.10	0.55**
5.	Leaf petiole ratio by wt.	0.11	0.24**	0.28**	0.05	-	0.16	0.09	0.54**
6.	Petiole length (cm)	0.71**	0.81**	0.93**	0.93**	0.07	-	-0.20	0.52**
7.	Leaf petiole ratio by length	0.51**	0.14	-0.08	-0.10	0.11	-0.22	-	-0.16
8.	Leaf yield plant^{-1} (kg)	0.35**	0.42**	0.60**	0.55**	0.38**	0.51**	-0.16	-

*, ** Significant at 5 % and 1 % level respectively

kg) in Goshoerami followed by SKM-33 (4.450) and mean was 3.72 kg. All the genotypes indicated significant variation at 5% level. As the data were recorded in two different seasons, the seasonal variation was found significant in all the traits among the genotypes at 5 % and1% CD level, respectively.

Correlation among different parameters

Associations of traits were estimated at both the phenotypic and genotypic levels. Genotypic correlation coefficients were, by and large, higher in magnitude, though similar in direction, than their corresponding correlation coefficients at the phenotypic level. Character association at genotypic and phenotypic level studied in pooled over spring (Table 4) revealed that lamina length had positive and significant correlation with lamina width (0.78**), lamina weight (0.64**), petiole weight (0.72**), petiole length (0.63**), leaf petiole ratio by length (0.34*) and leaf yield plant^{-1} (0.38**) at both levels. Lamina width showed positive and significant correlation with lamina length (0.77**), lamina weight (0.57**), petiole weight(0.58**), petiole length (0.41**), leaf petiole ratio by length (0.29*) and leaf yield plant^{-1} (0.16*)at both levels. Lamina weight exhibited positive and significant

Table 6: Classification of 17 mulberry genotypes into different clusters on the basis of divergence

S.No.	Clusters	No. of Genotypes	Germplasm name
1	I	15	Kasuga, Chatatul Mirgund, Local Mulberry, Lemoncina, Botatul, Chinese white, KNG, SKM-48, Kokuso-20, SKM-27, Brentul, SKM-33, Kokuso-21, Goshoerami, Kokuso-27
2	II	1	Ichinose
3	III	1	Kanva-2

Table 7: Classification of 17 mulberry genotypes into different clusters on the basis of divergence

S.No.	Clusters	No. of Genotypes	Germplasm name
1	I	15	Kasuga, Chatatul Mirgund, Local Mulberry, Lemoncina, Botatul, Chinese white, KNG, SKM-48, Kokuso-20, SKM-27, Brentul, SKM-33, Kokuso-21, Goshoerami, Kokuso-27,Ichinose
2	II	1	Kanva-2

Table 8: Mean intra and inter-cluster distance (D^2) among 17 mulberry genotypes (pooled over spring)

Cluster No.	Cluster-I	Cluster-II	Cluster-III
Cluster-I	8901.66	27975.07	92687.51
Cluster-II		0.0	24684.18
Cluster-III			0.0

Table 9: Mean intra and inter-cluster distance (D^2) among 17 mulberry genotypes (pooled over autumn)

Cluster No.	Cluster –I	Cluster-II
Cluster –I	5022.43	28404.90
Cluster –II		0.0

correlation with lamina length (0.64**), lamina width (0.57**), petiole weight (0.85**), leaf petiole ratio by weight (0.41**), petiole length (0.79**) and leaf yield plant^{-1} (0.73**). Petiole weight revealed significant and positive correlation with lamina length (0.67**), lamina width (0.54**), lamina weight (0.77**), petiole length (0.81**) and leaf yield plant^{-1} (0.65**) at both the levels. Leaf petiole ratio by weight displayed significant and negative correlation with leaf petiole ratio by length but showed positive and significant correlation with lamina weight (0.41**) and leaf yield plant^{-1} (0.31**) at both the levels. Petiole length exhibited positive and significant correlation with lamina length (0.62**), lamina width (0.41**), lamina weight (0.78**), petiole weight (0.74**) and leaf yield plant^{-1} (0.56**) but showed negative and significant correlation with leaf petiole ratio by length at both genotypic and phenotypic levels. Leaf petiole ratio by length revealed significant and positive correlation with lamina length (0.24*) and lamina width (0.20*) but had negative and significant correlation with leaf petiole ratio by weight at both the levels. Leaf yield plant^{-1} showed positive and significant correlation with lamina length (0.37**), lamina weight (0.72**), petiole weight (0.60**) and leaf petiole ratio by weight (0.29**).

Character association at genotypic and phenotypic level studied in pooled over autumn (Table 5), lamina length had significant and positive correlation with lamina width (0.82**), lamina weight (0.76**), petiole weight (0.76**), petiole length (0.72**), leaf petiole ratio by length (0.52**) and leaf yield plant^{-1} (0.35**)at both the levels. Lamina width exhibited positive and significant correlation with lamina length (0.81**), lamina weight (0.88**), petiole weight (0.84**), leaf petiole ratio by weight (0.34**), petiole length (0.83**), leaf yield plant^{-1} (0.42**). Lamina weight revealed significant and positive correlation with lamina length (0.75**), lamina width(0.87**), petiole weight (0.98**), leaf petiole ratio by weight (0.29**), petiole length (0.95**) and leaf yield plant^{-1} (0.61**)at both the levels. Petiole weight had positive and significant correlation with lamina length (0.76**), lamina width (0.83**), lamina weight (0.96**), petiole length (0.94**), leaf yield plant^{-1} (0.55**) at both genotypic and phenotypic levels. Leaf petiole ratio by weight exhibited positive and significant correlation with lamina width (0.24**), lamina weight (0.28**) and leaf yield plant^{-1} (0.54**) at both genotypic and phenotypic levels. Petiole length revealed positive and significant correlation with lamina length (0.71**), lamina width (0.81**), lamina weight (0.93**), petiole weigh (0.93**), leaf yield plant^{-1}(0.52**).Leaf petiole ratio by length displayed positive and significant correlation with lamina length (0.51**) but negative correlation with lamina weight, petiole weight, petiole length and leaf yield plant^{-1}.Leaf yield plant^{-1} showed positive and significant correlation with lamina length (0.35**), lamina width (0.42**), lamina weight (0.60**), petiole weight (0.55**), leaf petiole ratio by weight (0.38**), petiole length (0.51**), at both the levels. Similar observations on mulberry leaf yield and correlation with shoot number, total shoot length, lamina weight, lamina length and petiole weight was reported by various authors (Tikader and Roy, 2001; Vijayan *et al.,* 1997).

Estimation of genetic divergence

Genetic divergence using Mahalanobis D^2 statistics was estimated in 17 mulberry genotypes from the data pooled over spring and autumn. Analysis of variance for dispersion revealed that the genotypes tested, expressed significant variability for the various growth and yield traits in the pooled analysis over the seasons.

Based on the performance of the genotypes, the 17 genotypes got grouped into into three clusters(Table 6) as per the Mahalanobis D^2 analysis employing Tocher's method (Rao, 1952) cluster-I contained (15) genotypes, cluster-II comprised only one genotype and cluster-III also contained only one genotype. While as, pooled over autumn (Table 7), genotypes got clustered into 2 clusters cluster-I comprised maximum genotypes (16) while as only one genotype Kanva-2 was found

Table 10: Cluster means for different traits in 17 mulberry genotypes (pooled over spring)

Cluster No.	No.of genotype in clusterin cluster	Lamina Length	Lamina width	Lamina wt.	Petiole wt.	Leaf petiole ratio by wt.	Petiole length	Leaf Petiole ratio by length	Leaf Yield per Plant[1]
I	15	13.87	11.81	2.90	0.20	11.48	2.26	6.97	3.21
II	1	11.47	8.10	1.12	0.18	9.35	2.15	5.30	3.01
III	1	12.00	9.40	1.27	0.16	7.80	2.20	6.14	1.44

Table 11: Cluster means for different traits in 17 mulberry genotypes (pooled over autumn)

Cluster No.	No. of genotypes in cluster	Lamina Length	Lamina width	Lamina weight	Petiole weight.	Leaf petiole ratio by wt.	Petiole length	Leaf Petiole ratio by length	Leaf yield plant[1]
I	16	17.92	11.27	2.58	0.25	10.43	3.15	6.72	3.85
II	1	14.15	11.00	1.75	0.19	9.39	2.78	4.13	1.69

in cluster-II. The cluster-I had genotypes which were characterized by maximum lamina length, lamina width, lamina weight, petiole weight, petiole length and leaf yield. The cluster-II had genotype with lowest leaf yield. As the indigenous and exotic genotypes were clustered together, the grouping pattern did not show any relationship between genetic divergence and geographic diversity. Similar observations were reported earlier (Rajan *et al.*, 1997, Tikader and Roy, 2002).

Estimation of mean intra and inter- cluster distances among the genotypes, grouped on the basis of pooled performance spring (Table 8) revealed that cluster-I had an intra cluster (D^2) distance of 8901.66. The maximum inter-cluster distance (D^2) value of (92687.51) was observed between cluster-I and cluster-III followed by the value of (27975.07) between cluster-I and cluster-II, the genotypes grouped in this cluster had maximum diversity. The minimum inter- cluster distance was observed between cluster-II and cluster-III (24684.18) revealing close relationship among the genotypes grouped in the clusters. On the basis of pooled performance of autumn (Table 9) revealed that the cluster-I had intra-cluster (D^2) value of (5022.43). The inter-cluster distance (D^2) was 28404.90 between cluster-1 and cluster- II.

Cluster means for different traits in pooled over spring (Table 10) revealed that the range of variation in cluster means for lamina length ranged from 11.47 (cluster-II) to 12.00 (cluster-III). The lowest lamina width was expressed by cluster-II (8.10cm) and highest by cluster-I (11.81). The lamina weight was highest in cluster-I (2.90) and lowest for cluster-II (1.12). Maximum petiole weight was recorded in cluster-I (0.20) and minimum in cluster-III (0.16). Mean leaf petiole ratio by weight ranged from (7.80) cluster-III to (11.48) cluster-I. The lowest mean of petiole length were exhibited by cluster-II (2.15cm) and highest by cluster-I (2.26cm). The mean value of leaf petiole ratio by length was highest for cluster-I (6.97) and lowest for cluster-II (5.30). Maximum mean leaf yield plant^{-1} were recorded in cluster-I(3.21kg) and minimum in cluster-III (1.44kg).

Cluster means for different traits in pooled over autumn (Table 11) revealed that the cluster mean for lamina length ranged from 14.15 (cluster-II) to 17.92 (cluster-I). The lowest mean of lamina width were expressed by cluster-II (11.00cm) and highest by cluster-I (11.27cm). The mean value of lamina weight was highest for cluster-I (2.58) and lowest for cluster-II (1.75). Maximum mean petiole weight was recorded in cluster-I (0.25) and minimum in cluster-II (0.19). Mean leaf petiole ratio by weight ranged from (9.39) cluster-II to (10. 43) cluster-I. The lowest mean of petiole length were exhibited by cluster-II (2.78cm) and highest by cluster-I (3.15 cm). The mean value of leaf petiole ratio by length was highest for cluster-I (6.72) and lowest for cluster-II (4.13). Maximum mean leaf yield plant^{-1} were recorded in cluster-I (3.85kg) and minimum in cluster-II (1.69 kg).

Keeping in view the genetic distance and association between characters, potential parents may be selected to combine different traits through hybridization. Thus, the observation clearly indicates that lamina length, lamina width, lamina weight, petiole weight were the important traits to improve the leaf yield. Thus it could be concluded that cluster mean for these traits was found highest in cluster 1 and genotypes of this cluster can be utilized for future breeding programme.

REFERENCES

Bari, M. A., Qaiyyum, M. A. and Ahmad, S. U. 1989. Correlation studies in mulberry (*Morus alba*). *Indian J. Sericulture* **28**: 11-16.

Boraiah, G. 1986. Mulberry cultivation. *In Lectures on Sericulture*. pp. 16-18

Das, B. C. and Krishnaswami, S. 1969. Estimates of components of variation of leaf yield and its related traits in mulberry. *J. Sericulture*, Japan **38(3):** 242-248.

Mahalanobis, P. C. 1936. On the genetical distance in statistics. *Proc. Nat. Inst. Sci. India*. **2:** 265-275.

Quedraogo, A. S. 2001. Conservation,management and use of forest genetic resources. Recent Research and development in Forest genetic Resources. Proceedings of the training workshop on the conservation and sustainable use of forest genetic resources in Eastern and Southern Africa.6-11 dec.1999,Nairobia, Kenya. pp. 1-14

Rabbani, M. A., Suzuki, T. and Takayanagi, K. 1998. Phenotypic variation and the relationships among mustard (*Brassica juncea* L.) germplasm from Pakistan. *Euphytica*. **101(3):** 357-366.

Rajan, M. V., Chaturvedi, H. K. and Sarkar, A. 1997. Multivariate analysis as an acid to genotypic selection for breeding in mulberry. *Indian J. Sericulture*. **36(2):** 111-114.

Rao, C. R. 1952. Advanced Statistical Methods in Biometric Research. J. Wiley Sons, New York, 390

Singh, R. K. and Chaudhary, B. D.1985. Biometric methods in quantative genetic analysis, Kalyani Publ., New Delhi.

Sarkar, A., Roy, B. N., Gupta, K. K. and Das, B. C. 1987. Character association in mulberry under close planting. *Indian J. Sericulture*. **26**: 76-78.

Smith, J. C. S. and Smith, O. S. 1989. The description and assessement of distance between inbred lines of maize : the utility of morphological, biochemical and genetic descriptors and a scheme for the testing of distinctiveness between inbred lines. *Maydica*. **34:** 151-161.

Thangavelu, K., Mukkerjee, P., Tikader, A., Ravindran, S., Goel, A. K., Rao, A. A., Naik, G. V. and Sekar, S. 1997. Catalogue on mulberry (*Morus* spp.) germplasm. Hosur, Tamil Nadu, India. **1:** 20-22.

Tikadar, A. 1997. Studies on heritabilities, genetic parameters and response to selection in mulberry germplasm accessions. *Bulletin of Sericulture Research*. **8**: 19-22.

Tikadar, A. and Rao, A. A. 2002. Intra- and inter-specific hybridization studies in mulberry. *Bulletin of Indian Academy of Sericulture*. **6**: 17-22.

Tikadar, A. and Roy, B. N. 2001. Multivariate analysis in some mulberry germplasm (*Morus* spp.) germplasm accessions. *Indian J. Sericulture*. **40(2):** 71-74.

Tikader, A. and Dandin, S. B. 2007. Pre-breeding efforts to utilize two wild *(Morus spp)*. *Current Sci*. **92:** 1729-1733.

Tikader, A. and Dandin, S. B. 2008a. Genetic enhancement through introgression of wild gene in cultivated (*Morus spp). Green Farming*. **1:** 11-15

Tikader, A. and Dandin, S. B. 2008. Foliar morphology and venation pattern in different mulberry (*Morus* spp.). *Indian J. Forestry*. **31(1):** 77-84.

Vijayan, K., Tikader, A., Das, K. K., Chakraborty, S. P. and Roy, B. N. 1997. Correlation studies in mulberry (*Morus* spp.). *Indian J. Genetics and Plant Breeding*. **57(4):** 455-460.