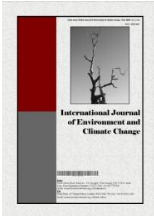

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Genetic variation for Vegetative and Reproductive Traits in Mulberry (*Morus spp*) Accessions

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Authors' contributions

This work was carried out in collaboration among all authors. Authors CS and Chikkalingaiah designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BNA managed the analyses of the study. Author SM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To assess genetic variability for vegetative and reproductive traits in different seasons.
Study Design: Field experimental design was used.
Place and Duration of Study: The experiment was conducted in different seasons during 2019-20 at Department of Sericulture, University of Agricultural Sciences, GKVK, Bangalore.
Methodology: The present study comprised of Seventy one mulberry accessions.
Results: The mean performance of leaf moisture content (64.41 & 55.42%) and leaf yield (1268.71 & 872.21g) in rainy and winter season, respectively. There are large differences were observed between the minimum and maximum range leaf moisture content was varied from 45.16 to 78.51 per cent and leaf yield was varied from 235.90 to 29008.89 during rainy season. In winter season the range of leaf moisture content was varied from 15.28 to 72.35 per cent and leaf yield was varied from 94.43 to 2975.00 g. Phenotypic coefficient of variation (PCV %) was found to be higher than the respective genotypic coefficient of variation (GCV %) for all the characters denoting variability among genotypes in both the seasons. Estimates of phenotypic and genotypic coefficient of variations were high for leaf yield per plant (98.63, 98.49%) and (89.69, 89.62%) in rainy and winter season, respectively. Maximum heritability was observed for leaf yield per plant (99.71 %), (99.85 %) in rainy and winter season, respectively. High heritability coupled with high genetic

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advance as percent of mean in respect of number of days for first flower initiation, plant height and single leaf area at 45th, 60th, and 75th DAP, number of branches, leaf moisture content and leaf yield per plant was observed in rainy and winter seasons.

Keywords: Mulberry; genetic variability; phenotypic coefficient of variation; genotypic coefficient of variation.

1. INTRODUCTION

Mulberry is the host plant of silkworm (*Bombyx mori* L.) and it is utilized on a large scale for silk production. It is a perennial plant belongs to the genus *Morus,* family Moraceae*,* division Magnoliophyta, class Magnoliopsida and comes under the order Urticales. The genesis of mulberry is Indochina and distributed in the lower slopes of Himalayan belt of Indochina. Genus *Morus* has 68 recognized species available in different parts of the world, of which 35 species are found in Asia and 14 in continental America. Mulberry is a perennial, fast-growing, deciduous, woody and dioecious plant. It has a deep root system. The leaves are simple, alternate, stipulate, petiolate, entire or lobed. Plants are generally dioecious. Inflorescence is catkin with pendent or drooping peduncle bearing unisexual flowers. Male catkins longer than female catkins. The ovary is one celled and stigma is bifid. Information on the reproductive behaviour and floral biology forms the pre-requisites for breeding programme of sexually reproducing crops. Though the mulberry is vegetative propagated, studies on floral biology in general and pollen fertility, viability and germination still play a vital role in conventional breeding methods like open pollinated hybrid selection, controlled hybridization and polyclonal nursery. Mulberry is highly heterogeneous and heterozygous plant easily adapted to different agro ecological conditions and hybridised both naturally and artificially which creating the wide series of variability in the existing gene pool. Characterization and evaluation of diverse genotypes are important for long-term improvement in yield, quality and resistance to diseases [1]. Genetic variability is the prerequisite for initiation of crop improvement programme including mulberry and selection acts upon the variability which is present in the genotypes. The precise information on nature and degree of genetic diversity aids the plant breeder to choose the diverse parents for hybridization programme. Genetic variation is also fundamental for species conservation to meet present and future requirement. The extent of measure of genetic variability in mulberry germplasm helps the crop improvement through conventional breeding method. For making effective selection based on the metric traits estimation of genetic variability parameters *viz*., heritability and genetic advance provides the extent of traits transmissibility from generation to generation.

2. MATERIALS AND METHODS

The experimental material for the present study comprised of seventy- one mulberry accessions which comprises of indigenous, exotic and local species were used for to study vegetative and reproductive traits. These mulberry accessions maintained at department of Sericulture, UAS, GKVK, Bangalore. Each mulberry accession was planted in one row with four plants with spacing of 2.4 x 2.5 m. The experiment was conducted in two seasons *viz.,* rainy and winter seasons of 2019 to 2020. These genotypes are being maintained with all the recommended practices like weeding, fertilizer application is followed as per the package of practices for rain fed mulberry [2]. Pruning was done at five feet height from the ground level and thereafter all the vegetative and reproductive traits were recorded from four plants in each accession. The accessions were evaluated on 45th, 60th and 75th day after pruning for different vegetative and reproductive parameters during rainy and winter seasons. The analysis of variance for vegetative and reproductive characters was carried out using mean data to assess the genetic variability among different accessions as given by [3]. The level of significance was tested at 5% and at 1% using F-test. The phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) was estimated as suggested by [4]. Heritability and genetic gain were calculated by following Lush *et al*., (1945) [5] and Johnson *et al*., (1955) [6] procedure respectively.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance and Genetic Variability Parameters for Vegetative and Reproductive Traits during Rainy Season

The analysis of variance among the Seventy-one (71) mulberry accessions indicated, highly significant differences for vegetative and reproductive traits during rainy season indicating presence of sufficient amount of genetic variability in respect of all the traits studied (Table 1). The estimates of genetic parameter for different traits revealed that the range in mean values does not reflect the total variance in the traits studied amongst all the genotypes. There are large differences were observed between the minimum and maximum range. Hence, actual variance has to be estimated for the characters to know the extent of existing variability. The genotypic variance measures the magnitude of genetic variability present in the crop and phenotypic variance indicates the amount of variation which is due to the phenotypic values (Table2).

Phenotypic variations were high as compared to genotypic variation for all traits studied. Genotypic variance was maximum in leaf yield per plant (1564603.00) followed by single leaf area at 75th DAP (3022.55), single leaf area at 60th DAP (2913.87), single leaf area at 45th DAP (2689.87), plant height at 75th DAP (854.63) and plant height at 60th DAP (814.43), while inflorescence breadth (0.05) showed least genotypic variance. Phenotypic variance was maximum in leaf yield per plant (1566137.82) followed by single leaf area at 75th DAP (3176.14), single leaf area at 60th DAP (3119.13), single leaf area at 45th DAP (2866.30), plant height at 75th DAP (1186.26) and plant height at 60^{h} DAP (1134.40), while least phenotypic variance was recorded in inflorescence breadth (0.07). Genetic analysis of genotypes suggested greater phenotypic and genotypic variability among the accessions and sensitiveness of the attributes for making future improvement through selection. PCV was higher than the respective GCV for all the characters denoting environmental factors influencing their expression to some degree or other. Estimates of phenotypic and genotypic coefficient of variation were high for leaf yield per plant (98.49, 98.63), number of branches per plant (57.06, 54.33%), leaf area at 45th (55.65, 53.91%), 60th (52.42, 50.67%),75th (46.89, 45.74%) DAP, leaf yield per plant (98.63, 98.48%) and inflorescence length (42.03, 41.00%). The present results are agreement with the earlier findings Bari *et al*. (1988) [7], Bhat, G.G, (1989) [8], Patil *et al*. (1999) [9], Ram Rao *et al*. (2006) [10] and Vijayashekar, (2009) [11] who reported sufficient genetic variation for different traits in mulberry accessions. Maximum heritability percentage was observed for leaf yield per plant (99.71 %) due to major role of genetic constitution in the expression of the character. Whereas least heritability percentage was recorded for plant height at 45th DAP (56.02 %) distance indicating their reliability for effective selection for high leaf parameters. High genetic advance was recorded in leaf yield per plant (1567.97) followed by single leaf area at 75th DAP (696.57), single leaf area at 60th DAP (690.29), single leaf area at 45th DAP (661.72), plant height at 75th DAP (425.70), plant height at 60th DAP (416.29), plant height at 45th DAP (294.22), number of branches (239.31), leaf moisture content (99.02) and days for first flower initiation (20.22), inflorescence length (13.14) and inflorescence breadth (3.27) were observed. The present results are agreement with the earlier findings (Tikader *et al*., 2008 [12]; Biradar *et al*., 2015 [13] and Suresh *et al*., 2017[14]). High heritability coupled with high genetic advance as percent of mean in respect of plant height at 45th, 60th and 75th DAP, number of branches, single leaf area at 45th, 60th, 75th DAP, leaf moisture content and leaf yield per plant and number of days for first flower initiation was observed this is may be due to additive gene action.

3.2 Analysis of Variance and Genetic Variability Parameters for Vegetative and Reproductive Traits During Winter Season

The analysis of variance among Seventy-one (71) accessions of mulberry indicated highly significant differences among vegetative and reproductive traits during winter season indicating presence of sufficient amount of variability in respect of all the traits studied (Table 3). The present results are agreement with the earlier findings of Sarkar *et al*., (1987) [15], Tikader and Roy (2001) [16], Tikader *et al*., (2004) [17], Doss *et al*., (2006)[18], Mallikarjunappa *et al*., (2008)[19]. During winter season there are large differences observed between the minimum and maximum range. Hence, actual variance has to be estimated for the characters to know the extent of existing variability. The genotypic variance measures the magnitude of genetic variability present in the crop and phenotypic variance indicates the amount of variation which is due to the phenotypic values presented in (Table 4). Phenotypic variations were high as compared to genotypic variation for all traits under study. Genotypic variance was maximum in leaf yield per plant (61122.4) followed by single leaf area at 75th DAP (2787.21), single leaf area at 60th DAP (2632.21), single leaf area at 45th DAP (2286.56), plant height at 75th DAP (1114.48) and plant height at 60h DAP (1008.31), while inflorescence breadth (0.03) showed least genotypic variance and phenotypic variations was maximum in leaf yield per plant (612000.68) followed by single leaf area at 75th DAP (2930.04), single leaf area at 60th DAP (2757.81), single leaf area at 45th DAP (2470.51), plant height at 75th DAP (1349.70), and plant height at 60th DAP (1156.39), while least phenotypic variance was recorded in inflorescence breadth (0.04). Genetic analysis of genotypes suggested greater phenotypic and genotypic variability among the accessions and sensitiveness of the attributes for making future improvement through selection. PCV was higher than the respective GCV for all the characters denoting environmental factors influencing their expression to some degree or other. Estimates of phenotypic and genotypic coefficient of variation were high for leaf yield per plant (89.62, 89.69), number of branches per plant (61.32, 60.71), leaf area at 45th (61.32, 58.99), 60th (58.36, 57.01),75th (54.65, 53.30) DAP, leaf yield per plant (89.69, 89.62) and inflorescence length (47.77, 46.67). Maximum heritability percentage was observed for leaf yield per plant (99.85 %) due to major role of genetic constitution in the expression of the character. Whereas least heritability percentage was recorded for days to first flower initiation (64.05 %) distance indicating their reliability for effecting selection for high leaf parameters. High genetic advance was recorded in leaf yield per plant (9669.28) followed by single leaf area at 75th DAP (669.04), single leaf area at 60th DAP (649.08), single leaf area at 45th DAP (614.34), plant height at 75th DAP (454.08), plant height at 60th DAP (420.31), plant height at 45th DAP (241.78), number of branches (149.70), leaf moisture content (134.36) and days for first flower initiation (17.22), inflorescence length (13.58) and inflorescence breadth (2.62) was observed. The present results are agreement with the earlier findings Patil *et al*. (1999)[9], Ram Rao *et al*. (2006)[10] and Vijayashekar, (2009) [12]who reported sufficient genetic variation for different traits in mulberry accessions. High heritability coupled with high genetic advance as percent of mean in respect of plant height at 45th, 60th and 75th DAP, number of branches, single leaf area at 45th, 60th and 75th DAP, leaf moisture content and leaf yield per plant and number of days for first flower initiation was observed this is may be due to additive gene action. The present results are agreement with the earlier findings (Tikader *et al*., 2008a [20]; Biradar *et al*., 2015 [13] and Suresh *et al*., 2017) [14].

Table 1. Analysis of variance for vegetative and reproductive traits during rainy season

Source of variation	d.f	Plant height(cm) 45th DAP	Plant height(cm) 60th DAP	Plant height(cm) 75th DAP	NOB	Single leaf area(cm^2) 45th DAP	Single leaf area(cm^2) 60th DAP	Single leaf area(cm^2) 75th DAP	Leaf moisture content (%)
Replication	2	879.25	810.87	394.17	194.61	140.88	33.34	53.26	11.18
Accessions	70	1836.54**	1948.85**	2040.89**	714.81**	5556.18**	6033**	6198.7**	122.57**
Error	140	249.212	319.97	331.63	34.94	176.43	205.26	153.59	5.81

Table 1. Continued...

Source of Variation	d. f	Leaf yield / plant	No. of days required for first flower initiation	Inflorescence length(cm)	Inflorescence breadth(cm)
Replication	2	20523.8	4.34272	0.11933	0.15808
Accessions	70	3127741**	4.1214**	2.21125**	01217**
Error	140	4534.42	0.81415	0.05596	0.02074

DAP- days after pruning, NOB-number of branches, Significant at P= 0.05%

Table 2. Mean and genetic variability parameters for vegetative and reproductive traits of mulberry accessions during rainy season

Characters	Mean	Range		GV	PV	EV	GCV (%)	PCV (%)	Broad sense Heritability (%)	Genetic advance	GA as % mean
		Min	Max								
Vegetative traits											
Plant height at 45th DAP (cm)	181.10	115.20	239.80	317.46	566.67	249.21	9.83	13.14	56.02	294.22	162.46
Plant height at 60th DAP (cm)	219.43	132.53	273.70	814.43	1134.40	319.97	13.00	15.34	71.79	416.29	189.71
Plant height at 75th DAP (cm)	253.35	164.50	312.06	854.63	1186.26	331.63	11.53	13.59	72.04	425.70	168.03
Number of branches/plants	33.93	8.66	79.66	339.93	374.87	34.94	54.33	57.06	90.67	239.31	705.30
Leaf area at 45th DAP (cm^2)	96.19	28.73	215.26	2689.87	2866.30	176.43	53.91	55.65	93.84	661.72	687.93
Leaf area at 60th DAP (cm^2)	106.53	38.30	222.26	2913.87	3119.13	205.26	50.67	52.42	93.14	690.29	647.98
Leaf area at 75th DAP (cm^2)	120.17	50.36	2317.23	3022.55	3176.14	153.59	45.74	46.89	95.16	696.57	579.65
Leaf moisture content (%)	64.41	45.16	78.51	58.38	64.19	5.81	11.86	12.43	90.94	99.02	153.74
Leaf yield/plant (g)	1268.71	235.90	29008.89	1564603	1566137.82	4534.42	98.49	98.63	99.71	1567.97	1219.18
Reproductive traits											
Days to first flower initiation	10.36	1.20	2.46	1.65	2.46	0.81	12.41	15.16	67.01	20.22	187.38
Inflorescence length (cm)	2.53	1.46	5.50	1.07	1.13	0.05	41.00	42.03	95.13	13.14	519.55
Inflorescence breadth (cm)	1.73	1.20	2.46	0.05	0.07	0.02	12.92	15.29	71.42	3.27	189.02

GV- Cenotypic Variance, PV-Phenotypic Variance, EV: Environmental Variance, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, GA: Genetic Advance

Table 3. Analysis of variance for vegetative and reproductive traits during winter season

Sources of variation	d. f	Plant height (cm)			NOB	Single leaf area (cm^2)			Leaf moisture Content (%)
		45th DAP	60th DAP	75th DAP		45th DAP	60th DAP	75th DAP	
Replication	2	8.69761	356.39	336.91	70.624	133.20	64.338	61.421	3.964915
Accessions	70	1581.67**	2164.70**	2464.18**	290.48**	4757.0**	5390.03**	5717.27**	231.1125**
Error	140	82.90	148.0863	235.2241	2.943461	183.9575	125.60	142.831	5.240556

Table 3. Continued…

		Mean sum of squares			
Source of variation	d.f	Leaf yield/ Plant(g)	No. of days required for first flower initiation	Inflorescence length(cm)	Inflorescence breadth(cm)
Replication	2	34.0205	4.01271	0.09526	0.01259
Accessions	70	1223123**	3.01384**	2.36767**	0.08981**
Error	140	878.274	0.61851	0.05573	0.01053

Table 4. Mean and genetic variability parameters for vegetative and reproductive traits for mulberry accessions during winter season

Characters	Mean	Range		GV	PV	EV	GCV (%)	PCV (%)	Broad sense Heritability (%)	Genetic advance	GA as % mean
		Min	Max								
Vegetative traits											
Plant height at 45th DAP (cm)	145.7	96.30	193.30	299.75	382.65	82.90	11.88	13.42	78.33	241.78	165.94
Plant height at 60th DAP (cm)	169.52	118.83	236.21	1008.31	1156.39	148.08	18.73	20.06	87.19	420.31	247.94
Plant height at 75th DAP (cm)	191.23	139.46	263.60	1114.48	1349.70	235.22	17.45	19.21	82.57	454.08	237.45
Number of branches per plant	19.75	5.66	47.33	143.77	146.71	2.94	60.71	61.32	97.99	149.70	758.02
Leaf area at 45th DAP (cm)	81.05	26.65	215.26	2286.56	2470.51	183.95	58.99	61.32	92.55	614.34	757.98
Leaf area at 60th DAP (cm)	89.98	28.73	231.61	2632.21	2757.81	125.60	57.01	58.36	95.44	649.08	721.36
Leaf area at 75th DAP (cm)	99.04	34.71	246.23	2787.21	2930.04	142.83	53.30	54.65	95.12	669.04	675.53
Leaf moisture content (%)	55.42	15.28	72.35	112.93	118.17	5.24	19.17	19.61	95.56	134.36	242.44
Leaf yield/plant (g)	872.21	94.43	2975.00	611122.4	612000.68	878.27	89.62	89.69	99.85	9669.28	1108.59
Reproductive traits											
Days to first flower initiation	10.14	1.20	2.46	1.15	1.22	0.75	11.19	14.11	64.05	17.22	172.11
Inflorescence length(cm)	2.3	1.15	5.36	1.15	1.20	0.05	46.67	47.77	95.44	13.58	590.51
Inflorescence breadth(cm)	1.51	1.20	2.23	0.03	0.04	0.01	12.38	14.04	77.77	2.62	173.63

GV: Genotypic Variance, PV: Phenotypic Variance, EV: Environmental Variance, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, GA: Genetic advance

4. CONCLUSION

The present study indicated that there is adequate genetic variability present in the accessions studied. Based on the studies on genetic variability parameters (broad sense heritability and genetic advance) it is concluded that plant height, number of branches, single leaf area, leaf moisture content were the most important yield attributing components. A wide spectrum of genetic variability among the accessions indicated the possibilities of improvement in leaf yield through successful breeding programmes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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