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Variability in Specific Leaf Weight in Mulberry Germplasm and Its Inheritance Pattern

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Specific leaf weight (SLW), defined as the mass of tissue per unit leaf area has been found to be an important physiological parameter as it indicates the relative thickness of leaves. Greater SLW provides more photosynthetic potential per unit area of leaf and hence it is frequently been considered as correlated with photosynthesis in several plant species. Collections of 165 mulberry (*Morus* sp.) germplasm accessions, both Indian and exotic in origin were evaluated for their variability with respect to SLW. The mean specific leaf weight ranged from 35.3 to 72.3 g/m^{-2}. The distribution of SLW was found to be normal. High heritability (97.08%) and a small difference between genotypic and phenotypic variance demonstrates the genetic control over SLW. Significant heterotic effect with respect to SLW was observed in crosses when parents with high and low SLW were chosen.

Key words: Mulberry, Specific leaf weight, Variability, Distribution, Inheritance pattern

Introduction

Specific leaf weight (SLW) is considered as one of the important physiological parameters under growth analysis (Causton and Venus, 1981). It is defined as the mass of tissue per unit area of leaf. In mathematical term, SLW is the ratio of foliage dry weight to respective foliage leaf area and it indicates very broadly, what kind of leaf structure is made from the available dry material. SLW has frequently been correlated with net photosynthesis in alfalfa (Delaney and Dobrenz, 1974) and soybean (Hesketh *et al.*, 1981; Wiebold *et al.*, 1981) and so on. Genotypic differences in SLW have been found in alfalfa (Pearce *et al.*, 1969), soybean (Bhatia *et al.*, 1996; Lugg and Sinclair, 1979; Nelson and Schweitzer, 1988), birdsfoot trefoil, orchard grass (Carlson *et al.*, 1970), perennial rye grass (Wilson and Cooper, 1969), mungbeen (Islam *et al.*, 1994) and mulberry (Rahman *et al.*, 1995). Specific leaf weight was considered as a potential criterion for evaluating the germplasm of soybean (Nelson and Schweitzer, 1988). Wells *et al.* (1986a, b) indicated that the differences in canopy apparent photosynthesis (CAP) in soybean were associated with differences in specific leaf weight and that greater SLW provided more photosynthetic potential per unit area. Though a clear-cut relationship with SLW and photosynthesis in mulberry has not been established fully, high SLW in conjunction with superior growth parameters is expected to increase the yield of leaves. The use of single, specific and quantifiable physiological trait like SLW in selection is a modest and practical first step in applying physiology to breeding (Wallace *et al.*, 1972; Wilson, 1981). Recently, while assessing quality of different mulberry genotypes, Rahman *et al.* (2002) conducted a feeding trial with silkworm larvae and observed a strong positive correlation of SLW with moulting percentage (moulting test), the percentage of larvae coming out of the first moult. Moulting test is considered as a parameter for assessing mulberry leaf quality. Hence, the study has been undertaken to elucidate the genetic variability for specific leaf weight that exists in mulberry germplasm collections at this institute and the possibility of exploiting the same for future breeding programme.

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Material and Methods

One hundred and sixty five accessions of mulberry, maintained in the germplasm bank of Central Sericultural Research and Training Institute, Mysore were used in this study. These 165 accessions consisted of 66 exotic collections from Japan, China, France, USSR, Bangladesh, Burma, Italy, Paraguay, Indonesia, Australia, Pakistan and 99 indigenous (Indian) collections from temperate, tropical and semi-arid zones. All accessions were maintained under 150×150 cm spacing with a fertilizer dosage of N : P : K at 300 : 120 : 120 kg/ha/year and irrigation once a week during non-rainy seasons.

Samples were collected after 60 days of pruning of plants. Samples were collected on a fully sunny day between 11.00 and 13.00 hrs to reduce the possibility of diurnal changes in specific leaf weight. Specific leaf weight was determined from circular punches (1 cm^2) with the use of a cork borer on the 5/6th leaf from the tip of the branch, which was in full sunlight. Ten circular punches were taken from each of the 3 replicates in case of all 165 genotypes. Care was taken to avoid major veins and edges. All samples were oven dried at 65°C for 48 hrs and weights were recorded. The specific leaf weight was then calculated as SLW = LW/LA, where, SLW = Specific leaf weight in g/m^{-2}, LW = Leaf oven dry weight in g, and LA = Leaf area in m^2.

For comparison of accessions, analysis of variance was computed. The range of variability of SLW was classified into five categories using mean ($\overline{X}$) and standard deviation (SD). Prior to such categorization, normality of the distribution was tested. Basing on the specific leaf weight, the accessions were categorized into i) Very low (below $\overline{X}$ - 2SD), ii) Low ($\overline{X}$ - 2 SD to $\overline{X}$ - SD), iii) Medium ($\overline{X}$ - SD to $\overline{X}$), iv) High ($\overline{X}$ to $\overline{X}$ + SD) and v) Very high (above $\overline{X}$ + SD). To establish the practical utility of the study, crosses were made involving representatives of different categories of SLW like, medium × low, high × low, along with low × low, medium × medium and high × high SLW grades. After the establishment of different progenies in the field evaluated for SLW by adopting the same procedure mentioned above.

Results and Discussion

The mean specific leaf weight values for different accessions ranged from 35.3 to 72. 3 g/m^{-2} with mean, 51.7 g/m^{-2} and standard deviation of 6.50. The distribution pattern of specific leaf weight is presented in Table 1. The distribution of SLW values followed normal distribution as indicated by non-significant Chi-square value (X^2 = 7.534 at 4 d. f.) at 5% level of significance. Both coefficient of skewness (0.109) and coefficient of kurtosis (2.933) were also found non-significant, which also supported the normality of the distribution (Table 2). A perusal of Table 1 indicated that higher percentage of genotypes (56.1%) fall in the category of high and very high SLW in exotic accessions, whereas in case of indigenous accessions higher percentage was found in medium category (47.5%).

The analysis of variance for SLW among 165 accessions indicated highly significant variation among the lines tested (Table 3). Due to absence of a definite block effect, the residual includes the variation associated with experimental error. The difference between genotypic variance (41.370) and phenotypic variance (42.615) was very small which indicated high heritability (97.08%) in broad sense. This clearly demonstrates genetic control over SLW.

Table 2. Test of normality of the distribution for specific leaf weight of germplasm accessions

Chi-square test (Goodness of fit)	= 7.534	Not significant
Co-efficient of skewness	= 0.109	Not significant
Co-efficient of kurtosis	= 1.754	Not significant

Table 3. Analysis of variance for specific leaf weight of 165 mulberry genotypes

Source	D. F.	Mean square	Expected mean square
Genotypes	164	125.355**	$\sigma^2 e + 3\sigma^2 g$
Residual	330	1.244	$\sigma^2 e$

Where, $\sigma^2 e$ = Environmental variance, and $\sigma^2 g$ = Genotypic variance. **Significant at 1% level.

Table 1. Distribution pattern of specific leaf weight (SLW g/m^{-2}) in germplasm collections of mulberry

SLW category	Class interval	Frequency		Total frequency	Expected frequency
		Exotic	Indigenous		
Very low	Below 38.7 – 45.2	0	1	1	3.76
Low	45.2 – 51.7	6	18	24	22.42
Medium	51.7 – 58.2	23	47	70	56.31
High	Above 58.2	26	20	46	56.31
Very high		11	13	24	26.18
Total		66	99	165	165

It has been indicated that high SLW would be the desired characteristic but the inheritance pattern of SLW may provide a useful tool for future genetic and physiological improvements to produce high heterotic effect after hybridization. Mulberry is a highly heterozygous crop and cross pollinated, and hence the crossings between two parents, which are already heterozygous, would lead to segregation. The distribution of progeny in respect of SLW is presented in Table 4 and in Fig. 1. It is clear from the Table 4 that improvement in SLW is not possible with crossing of like types. Cross combination between the parents with low and high SLW gave rise to a sizable portion of seedlings falling under very high SLW category, thus indicating that both extremes of SLW may

Table 4. Progeny distribution pattern for specific leaf weight in crosses of mulberry germplasm accessions

Sl. no.	Cross combinations	Nature[b] of cross	SLW of parents (g/m^{-2})	Progeny with range of variations in SLW (g/m^{-2})[a]					Total number of plants	Overall mean
				Very low <38.7	Low 38.7–45.2	Medium 45.2–51.7	High 51.7–58.2	Very high >58.2		
1	Acc.118×Acc.144	L×L	42.2×43.3	50 (76.9)	13 (20.0)	2 (3.1)	0 (0.0)	0 (0.0)	65	35.78
2	Acc.122×Acc.141	M×M	48.5×45.8	3 (6.9)	12 (27.9)	22 (51.2)	6 (13.9)	0 (0.0)	43	47.15
3	Acc.176×Acc.209	H×H	56.4×54.2	2 (2.0)	16 (15.7)	46 (45.1)	36 (35.3)	2 (2.0)	102	49.05
4	Acc.122×Acc.144	M×L	48.5×43.4	0 (0.0)	3 (4.0)	40 (54.1)	28 (37.8)	3 (4.0)	74	51.13
5	Acc.130×Acc.129	L×H	45.0×55.7	1 (0.7)	2 (1.5)	44 (32.4)	62 (45.6)	27 (19.8)	136	53.91
6	Acc.197×Acc.101	L×H	39.1×53.6	0 (0.0)	10 (16.7)	22 (36.7)	19 (31.7)	9 (15.0)	60	50.71
7	Acc.130×Acc.101	L×H	45.0×53.6	0 (0.0)	6 (18.8)	12 (37.5)	11(34.4)	3 (9.4)	32	50.33
8	Acc.197×Acc.190	L×H	39.1×55.1	0 (0.0)	1 (4.3)	7 (30.4)	12 (52.2)	3 (13.0)	23	53.32

[a]Figures in parenthesis indicates percent of plants in the progeny.
[b]Grades of SLW : L = Low, M = Medium and H = High.

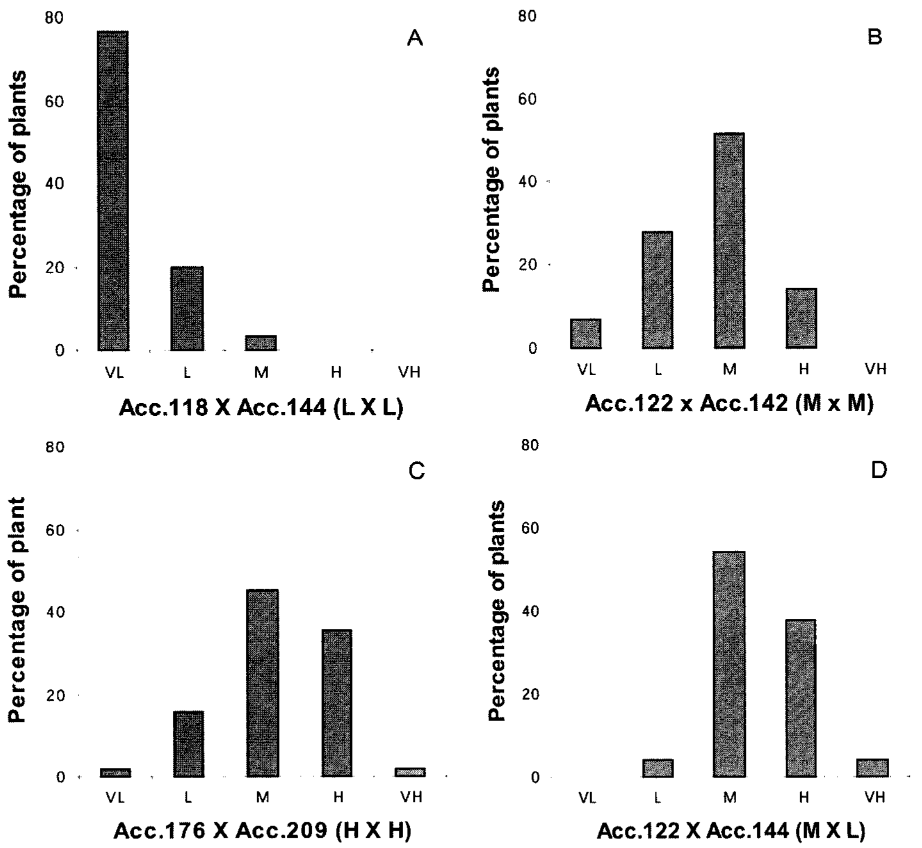

Fig. 1. Distribution pattern of progeny among crosses between parents with varying SLW g/m^{-2}. Abbreviations: VL = Very low (<38.7), L = Low (38.7–45.2), M = Medium (45.2–51.7), H = High (51.7–58.2), VH = Very high (>58.2).

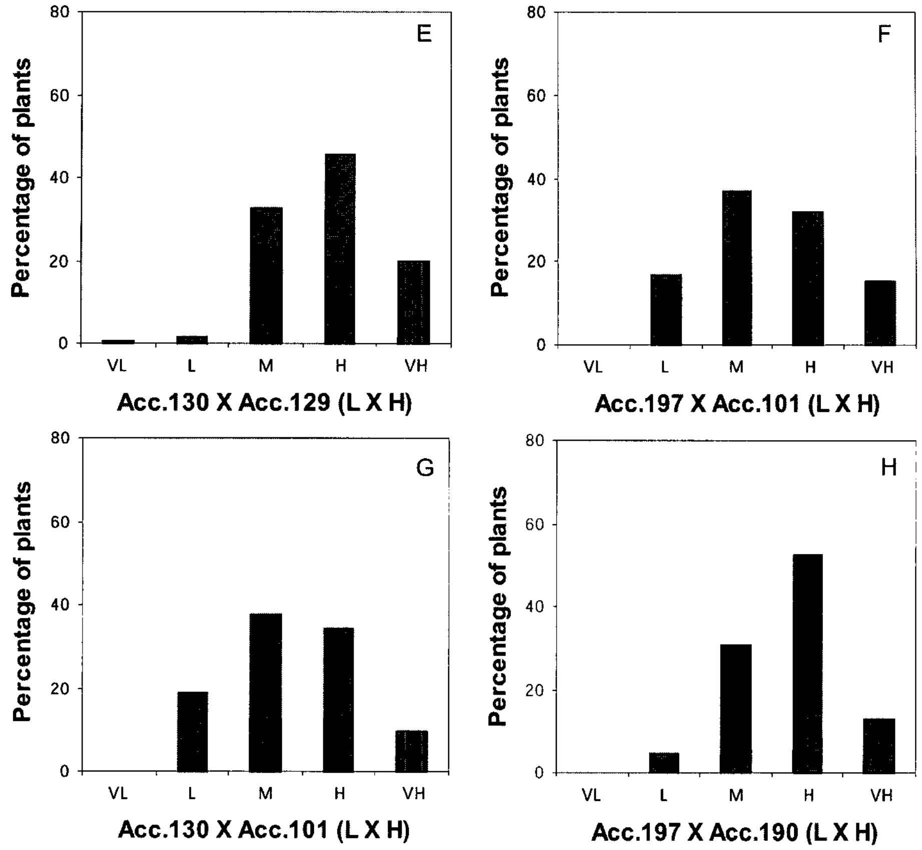

Fig. 1. Continued.

be exploited for the future breeding programme. This provides ample opportunity to select desirable genotypes with high SLW.

The selection of a specific physiological trait like SLW, which affects photosynthesis, may be used in conjunction with the yield for more accurate identification of superior genotypes in mulberry. Combined selection of yield with SLW is expected to be effective as the specific leaf weight showed a high heritability. The study of SLW appears to be more meaningful in mulberry as leaf being the sole assimilatory organ and constitutes the only food for silkworm, *Bombyx mori* L. The increased mass of tissue per unit area of leaf is expected to improve the yield and quality.

Genetic variability hence observed for SLW may offer a good scope to the plant breeder for further improving the promising genotypes and also to isolate physiologically efficient and superior plant types of breeder's choice.

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