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APPLICATION OF SOME PARAMETRIC METHODS IN IDENTIFICATION OF STABLE MULBERRY GENOTYPES AND STUDY OF CHARACTER ASSOCIATION AND PATH COEFFICIENT ANALYSIS OF PHENOTYPIC CHARACTERS IN MULBERRY GENOTYPES

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ABSTRACT

The material for this study was collected from the experiment conducted under the Department of Sericulture, UAS, GKVK, Bangalore. The experimental set up included 16 genotypes of Mulberry under six seasons. The parameters computed were single leaf area, 100 fresh leaf weight, moisture content and moisture retention capacity at 6 and 12 hours. Three different parametric stabilit models ie., Eberhart and Russell model, Perkins and Jinks model and Freeman and Perkins model are used to study the stability of yield and yield attributing characters of mulberry. Over the seasons for leaf Yield, the genotype Karanahalli was well adapted to all environments and also specially adapted to unfavorable environment. The genotype C-763 was poorly adapted to all environments. The genotypes ME-18 and MR-2 were specially adapted to favorable environment. Leaf yield was positive associated with single leaf area, 100 fresh leaf weight, moisture content and moisture retention capacity at 6 and 12 hours whereas, it had negative and low significant association with moisture retention capacity at 24 hours. Path coefficient analysis revealed that hundred fresh leaf weight had the highest positive direct effect on leaf yield. Moisture content and moisture retention capacity at 12 hours had the next highest direct effect.

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INTRODUCTION

Sericulture is one of the important agro-based industry on which millions of farming families are dependent on this industry for their livelihood across the world, including India. Success of sericulture enterprise depends on successful rearing of silkworms. Among the different types of silk production practices in India, Mulberry silk is the most important which is contributing to the tune of 90 percent of the total production in India.

India is the second largest producer of mulberry raw silk in the world and Karnataka is the pioneering state contributing about 45% of Indian silk production. It is one of the income generating and employment oriented industry. For the economic growth of the state/ country, it is essential to give much emphasis to produce superior quality raw silk in order to compete in the international market. To achieve his goal in identifying a stable and good quality mulberry genotype is the need of the hour.

Mulberry varieties show wide fluctuation in their yielding ability when grown over varied agro-climatic conditions. There is persistent demand for identifying suitable genotypes which can withstand environmental variations and ensure reasonably good yields. Testing breeding lines or advanced generation progenies under different conditions forms an integral part of breeding programme aimed at identifying stable genotypes which can perform well under different growing situations. Identifying a phenotypically stable variety is particularly important from the point of view of increasing Mulberry production. It is observed that the relative performance of genotype to give the same response in different environments is a definite indication of genotype-environment GxE interaction. These differential responses of genotypes in different environments are termed as GxE-interaction. The occurrence of GxE interaction has been a major challenge for plant breeders. Kadhem, *et al.* (2010), Hossein *et al*. (2011), Hasan Kilic (2012), Nagaraja *et al*. (2012) also studied different parametric stability models.

Mulberry leaf yield is a complex character jointly contributed by a good number of component characters and is highly influenced by environment and genotypes. A clear picture of contribution of each component in final expression of a complex character would emerge through the study of path concept which reveals different ways in which component attribute influence the complex trait. Adesoji. A.G *et al.,* (2015), Solomon Fantaw *et al*. (2014), Desawi Hdru Teklu *et al*. (2014), Rajanna. B *et al*. (2014) and Kamleshwar Kumar *et al*. (2013) also studied correlation and path coefficient analysis for phenotypic characters in different crop genotypes. In the present study, an attempt has been made to find out the parametric models for stability of mulberry genotypes across seasons and also to find out the correlation and path coefficient analysis of phenotypic characters in mulberry genotypes.

MATERIALS AND METHODS

The study was undertaken with an objective of analyzing stable genotype (s) in Mulberry across the seasons over years. The experimental material for the present study was taken from an evaluated data of 16 Mulberry accessions maintained at

Department of Sericulture, UAS, GKVK, Bangalore during the summer, rainy and winter seasons for 2 years.

The original experimental set up included 16 genotypes of Mulberry established in 3 blocks. The experimental design employed was a simple randomized complete block design (RCBD) with three replications in each season. Genotypes considered in the present investigation for leaf yield per plant (g) were ME-18, ME-52, Surat Local, C-776, Karanahalli. MI-79, MI-0142, C-763, *Morus indica*, C-20, China White, MR-2, MI-139, MI-524, MI-506 and $V_{(I)}$

The characters considered in the present investigation are, Single leaf area (SLA) (cm^2), 100 fresh leaf weight (100 FLW) (g), Leaf moisture content (MC) (%), Leaf moisture retention capacity (MRC) (%) at 6, 12, and 24 hours and Leaf yield per plant (g).

Stability models are used to find stable genotypes in the present investigation are Eberhart and Russell Model (1966), Perkins and Jinks Model (1968), Freeman and Perkins Model(1971)

Eberhart and Russell Model

$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$

Where, Y_{ij}: Mean of the i^{th} genotype at the j^{th} environment (i = 1....10, j = 1... 9), μ_i: The mean of i^{th} genotype over all the environments, β_i : The regression coefficient that measures the response of i^{th} genotype to varying environment, δ_i : The deviation from regression of the i^{th} genotype of j^{th} environment and I_j: j^{th} environmental index obtained by subtracting the regression of the i^{th} genotype grand mean from the mean of all genotype at j^{th} environment.

Perkins and Jinks model

$$Y_{ij} = m + d_i + e_j(1+\beta_i) + \delta_{ij} + e_{ij}$$

Where,

Y_{ij} is the yield of i^{th} variety in j^{th} environment, m is the general mean, d_i is the additive genetic effect, e_j is the additive environmental effect, e_{ij} is the error associated with each observation, δ_{ij} is the variance of i^{th} variety due to deviation from regression in j^{th} environment $\hat{a}_i$ is the regression coefficient of the i^{th} variety.

Freeman and Perkins Model

$$Y_{ijk} = m + d_i + e_j + g_{ij} + e_{ijk}$$

Where,

Y_{ijk} is performance in k^{th} replicate of i^{th} genotype in j^{th} environment, m is general mean, d_i is additive genetic effect of i^{th} genotype, e_j is additive environmental effect, g_{ij} is genotype-environment interaction effect, e_{ijk} is error associated with k^{th} observation in j^{th} environment for i^{th} genotype.

Stability parameters

The mean (m_i), the regression coefficient (b_i) and mean square deviation from linear regression line (S^2d_i) are the three stability parameters proposed by Eberhart and Russell (1966) in their stability model. These parameters were computed by using the following formula:

$$\mu_i \text{ (mean)} = \frac{\sum_j Y_{ij}}{n}$$

$$b_i \text{ (regression coefficient)} = \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}$$

$$S^2di \text{ (deviation from the regression coefficient)} = \frac{\delta_e^2}{r} - \frac{\sum_j \delta_{ij}^2}{n-2}$$

Where,

$\frac{\delta_e^2}{r}$: Mean square for (estimate of) pooled error

n : Number of environments

Y_{ij} : Performance of i^{th} genotype in j^{th} environment

$S_j\delta^2_{ij}$: Sum of squares of deviations from the regression line

I_j : Environmental index (i.e., environmental mean- grand mean)

$$I_j = \frac{\sum_j Y_{ij}}{v} - \frac{\sum_i Y_{ij}}{nv}$$

Where,

n : Number of environments

v : Number of genotypes with $S_j I_j = 0$

The total variation is partitioned into genotypes, environment, environment (linear), genotype ´ environment (linear), pooled deviation and pooled error.

Path coefficient analysis

Path coefficient is a standardized partial regression coefficient and as such it is a measure of direct and indirect effect of a set of variables (component characters) as a dependent variable such as leaf yield. Direct and indirect effect of component characters on leaf yield were computed using appropriate correlation coefficient of different component characters as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Thus, the correlation coefficient of any character with leaf yield was split into the direct and indirect effects adopting the standard formula.

$r_{iy} = r_{i1}P_1 + r_{i2}P_2 + r_{i3}P_3 + \ldots\ldots\ldots\ldots + r_{in}P_n + \ldots\ldots\ldots r_{ii}P_i$

Where,

r_{iy} = Correlation of i^{th} character on leaf yield

r_{1i} = Indirect effect of i^{th} character on grain yield through first character

$r_{in}P_n$ = Correlation between nth character and i^{th} character

n = Number of independent variables

P_i = Direct effect of i^{th} character on leaf yield

Direct effects of component character on leaf yield were obtained by solving the following equations.

r_{iy} = $(P_{iy})(r_{ij})$

Where,

(P_i) = Matrix of direct effects

(r_{iy}) = Matrix of correlation coefficients among all the n component characters

(r_{i1}) = Matrix of correlation of all component characters with grain yield

r_{i1} = Indirect effect of 1 character grain yield through first character

The residual effect was obtained by the following formula.

Residual effect =

Where, P_{ij} and r_{iy} are as given above.

RESULTS AND DISCUSSION

The performances of genotypes in different seasons for leaf yield are presented in the Table 1. It was observed that the genotype MI-524 performed uniformly well over all the seasons (Mean = 1176.43, C.V = 13.84%), whereas Surat local showed greater variation in leaf yield over all seasons (Mean = 1821.91, C.V = 87.73%). Among the seasons it was observed that kharif 2nd year showed uniform moisture content over all the genotype (Mean = 1886.21, C.V = 39.11%) whereas rabi 2nd year showed greater variability with respect to genotype (Mean = 1499.92, C.V = 50.99%).

Over the seasons, all the sixteen genotypes were highly significant with respect to regression coefficient according to all the three parametric stability models i.e., Eberhart and Russell model, Perkins and Jinks model and Freeman and Perkins model for leaf yield (Table 2).

Association among different characters.

Yield is the results of combined effect of several characters and environment. Understanding of the interaction of characters among themselves and with the environment will be of great use for plant breeders. Correlation studies provide information on the nature and extent of association between any two pairs of metric characters. From this, it would be possible to bring about genetic upgradation in one character by selection of the other of a pair. Grafius (1959) opined that there may not be any gene for yield as such, but operates only through its components. Obviously, knowledge about character association will surely help to identify the character to make selections for higher leaf yield. With a view to determine the extent and nature of relationship prevailing among yield contributing characters, an attempt was made to study the character association in sixteen genotypes over six seasons of two years at phenotypic level.

Single leaf area showed significant positive correlation with leaf yield at phenotypic level. A highly significant and positive correlation at phenotypic level was found between this trait and 100 fresh leaf weight and moisture content. Its relationship with moisture retention capacity at 24 hours was significant and positive at phenotypic level, and its relationship with moisture retention capacity at 6 hours and 12 hours was positive at phenotypic level (Table 4).

Hundred fresh leaf weight expressed positive correlation with leaf yield at phenotypic level. This result confirmed the findings of Susheelamma *et al.*(1988), Masilamani and Kamble (1998) and Ram Rao *et al.* (2006). A highly significant and positive correlation at phenotypic level was found with single leaf area, moisture content and moisture retention capacity at 12 hours. Its relationship with moisture retention capacity at 6 and 24 hours was positive at phenotypic level (Table 4).

Moisture content at phenotypic level expressed positive correlation with leaf yield. This result confirmed the findings of Susheelamma *et al.*(1988). A highly significant and positive correlation at phenotypic level was found with single leaf area, 100 fresh leaf weight, moisture retention capacity at 6, 12 and 24 hours (Table 4).

At phenotypic level moisture retention capacity at 6 hours gave positive correlation with leaf yield. A highly significant and positive correlation at phenotypic level was found with moisture content, moisture retention capacity at 12 and 24 hours. It had positive association with single leaf area and 100 fresh leaf weight (Table 4).

Table 1: Performance of Genotypes in different seasons for leaf yield for 2 years

Treatments	1st year Kharif	Rabi	Summer	2nd Year Kharif	Rabi	Summer	2 YearsPooled mean	CV (%)
ME-18	1323.33	1261.67	1704.65	2820.86	3212.31	3737.30	2343.35	44.94
ME-52	1441.21	1344.33	2030.80	2471.47	1865.74	2241.29	1899.14	23.32
Surat Local	3213.06	3072.00	3537.05	423.57	295.12	390.69	1821.91	87.73
C-776	3121.00	2852.33	980.83	3066.56	2350.36	2728.80	2516.65	31.85
Karanahalli	2413.47	2266.67	2880.10	2343.95	1766.33	2133.84	2300.76	15.85
MI-79	1566.67	1439.33	2103.53	1635.92	1218.80	1304.96	1544.87	20.38
MI-0142	1698.33	1642.33	1346.56	1589.15	1125.57	1323.90	1454.32	15.37
C-763	1354.00	1255.00	1410.80	1281.72	936.66	1088.92	1221.18	14.50
Morus indica	3064.00	2855.67	3686.90	1244.76	2368.87	2498.54	2619.79	31.29
C-20	1243.00	1132.33	788.44	2891.63	559.67	760.06	1229.18	69.37
China White	1163.67	1044.33	1760.45	1925.01	2009.41	1715.68	1603.09	25.13
MR-2	1660.00	1558.67	1970.34	2546.40	1963.87	2233.19	1988.74	18.33
MI-139	1182.33	1085.67	1682.03	1244.76	901.10	981.82	1179.62	23.44
MI-524	1363.30	1272.00	1090.44	1300.91	932.12	1099.83	1176.43	13.84
MI-506	1275.00	1154.00	1120.50	1744.17	1257.41	1584.94	1356.00	18.53
$V_{(I)}$	1857.37	1767.33	3750.48	1648.62	1235.30	1450.99	1951.68	46.59
Mean	1808.73	1687.73	1990.24	1886.21	1499.92	1704.67		
CV (%)	40.1741	40.73	48.86	39.11	50.99	49.85		

Table 2: Estimation of Stability parameters for Leaf yield using three different parametric stability models

Treatments	Eberhart And Russells			Perkins And Jinks			Freeman And Perkins		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
ME-18	2343.35	-2.46	1,63,775.47**	2064.56	-3.46	1,63,775.47**	2344.77	-2.34	1,68,807.00**
ME-52	1899.14	0.75	2,24,074.17**	1830.71	-0.25	2,24,074.17**	1900.13	0.75	2,18,003.30**
Surat Local	1821.91	4.57	4,25,859.92**	2108.16	3.57	4,25,859.92**	1821.85	4.35	4,58,876.00**
C-776	2516.65	-1.68	6,98,399.44**	2474.22	-2.68	6,98,399.44**	2517.72	-1.60	7,02,722.60**
Karanahalli	2300.73	2.00*	17,883.74**	2334.10	1.00*	17,883.74**	2300.01	1.95	16,914.13**
MI-79	1544.87	1.68	19,953.49**	1592.85	0.68	19,953.49**	1544.87	1.62	20,044.98**
MI-0142	1454.32	0.57	50,181.74**	1480.39	-0.43	50,181.74**	1448.93	0.58	56,254.63**
C-763	1221.18	0.93	7,008.58**	1247.64	-0.07	7,008.58**	1222.13	0.89	5566.42
M. indica	2619.79	1.01	8,01,961.85**	2644.04	0.01	8,01,961.85**	2611.46	0.74	8,09,109.30**
C-20	1229.19	2.15	7,38,766.97**	1323.01	1.15	7,38,766.97**	1229.94	2.14	7,24,546.90**
China White	1603.09	-0.11	2,01,937.51**	1580.57	-1.11	2,01,937.51**	1604.73	-0.11	1,98,271.20**
MR-2	1988.74	0.50	1,56,344.07**	1939.85	-0.50	1,56,344.07**	1989.14	0.52	1,54,282.20**
MI-139	1179.62	1.46	17,128.08**	1219.18	0.46	17,128.08**	1180.08	1.41	16,902.87**
MI-524	1176.43	0.45	25,259.34**	1191.75	-0.55	25,259.34**	1176.38	0.44	23,173.50**
MI-506	1356.01	0.13	77,842.68**	1310.22	-0.88	77,842.68**	1356.51	0.14	75,517.86**
$V_{(I)}$	1951.68	4.07	4,24,376.47**	2051.82	3.08	4,24,376.47**	1952.17	3.91	4,39,943.90**
Mean	1762.92		2,53,172.10	1774.57		2,53,172.10	1762.55		

* Significant at 5%, ** Significant at 1%.

Table 3: Stable genotypes over years for leaf yield according to different models

Remarks	ER	PJ	FP
Well adapted to all environment	-	Karanahalli	-
Poorly adapted to all environments	C-763	C-20	C-763
Specially adapted to favorable environment	ME-18, MR-2	ME-18, MR-2	ME-18, MR-2
Specially adapted to unfavorable environment	Karanahalli, MI-79	-	Surat local, Karanahalli

Table 4: Correlation Matrix to study association between growth parameters and yield.

	SLA	100FLW	Mc	MRC at 6hrs	MRC at 12hrs	MRC at 24hrs
SLA	1.0000					
100FLW	0.7384 **	1.0000				
Mc	0.1875 **	0.2255 **	1.0000			
MRC at 6hrs	0.0725	0.0948	0.8065 **	1.0000		
MRC at 12hrs	0.1008	0.1617 **	0.7158 **	0.7929 **	1.0000	
MRC at 24hrs	0.1201 *	0.0590	0.6121 **	0.7372 **	0.9195 **	1.0000
Leaf yield/plant	0.5050	0.8138	0.2839	0.1036	0.1322	-0.0091

At phenotypic level moisture retention capacity at 12 hours recorded positive association with leaf yield. A highly significant and positive correlation at phenotypic level was found with 100 fresh leaf weight, moisture content and moisture retention capacity at 6 and 24 hours. It had positive association with single leaf area (Table 4).

Moisture retention capacity at 24 hours recorded negative phenotypic correlation with leaf yield. A highly significant and positive correlation at phenotypic level was found with moisture content, moisture retention capacity at 6 and 12 hours. It exhibited positive and significant association with single leaf area. The association with 100 fresh leaf weight was positive (Table 4).

The correlation coefficient measures the relationship existing between pair of characters. A dependent character is an interaction product of many mutually associated component characters and change in any one component will disturb whole network of cause and effect system. The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect relation between the variables is unique in partitioning the association into direct and indirect effect through other independent variables. The path coefficient analysis also measures the relative importance of causal factors involved. This is simply a standardized partial regression analysis, wherein total correlation value is subdivided into causal scheme. Li (1956) emphasized the importance of path diagram which facilitates the understanding of the nature of cause and effect system. In the present study, the path coefficient analysis was done at phenotypic level and the results are discussed below.

In the present study single leaf area had significant correlation with leaf yield, in addition to this, it had negative direct effect on leaf yield at phenotypic level. However, its indirect effect viz. 100 fresh leaf weight, moisture content and moisture retention capacity are positive and are having highly significant correlation. Hence, single leaf area may not be useful as a criterion in the selection for increased leaf yield (Table 5).

Through path coefficient analysis it is evident that positive correlation of hundred fresh leaf weight with leaf yield, was

Table 5: Path analysis to study direct and indirect effects on grain yield at phenotypic level in Mulberry Treatments

	SLA	100 FLW	MC	MRC at 6Hrs	MRC at 12Hrs	MRC at 24Hrs
SLA	-0.180	-0.130	-0.03	-0.01	-0.01	-0.02
100 FLW	0.660	0.890	0.20	0.08	0.14	0.05
MC	0.050	0.056	0.25	0.20	0.18	0.15
MRC at 6Hrs	-0.005	-0.008	-0.06	-0.08	-0.06	-0.06
MRC at 12Hrs	0.008	0.014	0.06	0.06	0.08	0.08
MRC at 24Hrs	-0.020	-0.001	-0.13	-0.15	-0.19	-0.21
Leaf Yield/plant	0.510	0.810	0.28	0.1	0.13	-0.1

reflected by its high direct positive effect at phenotypic level. However, its indirect effect viz. moisture content and moisture retention capacity at 12 hours are positive and are having highly significant correlation and it had negative indirect effect with single leaf area, moisture retention capacity at 6 and 24 hours. Hence, it suggests a considerable contribution of 100 fresh leaf weight for improvement of leaf yield (Table 5).

Through path coefficient analysis it is evident that positive correlation of moisture content with leaf yield, was reflected by its high direct positive effect at phenotypic level. However, its indirect effect viz. hundred fresh leaf weight and moisture retention capacity at 12 hours are positive and are having highly significant correlation and it had negative indirect effect with single leaf area, moisture retention capacity at 6 and 24 hours. Hence, it suggests a considerable contribution of moisture content for improvement of leaf yield (Table 5).

In the present study moisture retention capacity had significant positive correlation with leaf yield and this was not reflected by its direct effect which was negative at phenotypic level. Through path coefficient analysis it is evident that positive correlation of moisture content with leaf yield, was reflected by its high direct positive effect at phenotypic level. However, its indirect effect viz. hundred fresh leaf weight and moisture retention capacity at 12 hours were positive and are having highly significant correlation and it had negative indirect effect with single leaf area, moisture retention capacity at 12 and 24 hours. Hence, it suggests a considerable contribution of moisture content for improvement of leaf yield (Table 5).

Direct contribution of moisture retention capacity at 12 hours was positive and low at phenotypic level and it had positive association with leaf. However, its indirect effect viz. hundred fresh leaf weight, moisture content were positive and are having highly significant correlation and it had negative indirect effect with single leaf area, moisture retention capacity at 6 and 24 hours. Hence, it suggests a considerable contribution of moisture retention capacity at 12 hours for improvement of leaf yield (Table 5).

Direct contribution of moisture retention capacity at 24 hours was negative at phenotypic level and it had negative association with leaf yield. However, its indirect effect viz. hundred fresh leaf weight, moisture content and moisture retention capacity at 12 hours were positive and hence were having highly significant correlation and it had negative indirect effect with single leaf area, moisture retention capacity at 6 hours. The results suggested that due to its negative direct effect and negative association with leaf yield this trait may not be useful as a criterion of selection for increased leaf yields (Table 5).

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