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Genetic variability, correlation path analysis for cured leaf yield and its components in Bidi Tobacco (*Nicotiana tabacum* L.)

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Abstract
The present investigation was carried out with fifteen genotypes of bidi tobacco in randomized complete block design with three replications. The analysis of variance revealed significant differences among genotypes for all the characters, indicating the presence of great deal of variability for different traits. The genetic variance contributed major proportion of total variance for all the characters under study suggesting that these characters were largely under genetic control. The moderate values of genotypic and phenotypic coefficient of variation and high genetic advance coupled with high heritability were observed for cured leaf yield, plant height, leaf width, leaf thickness, spangle score, nicotine content, chloride content and reducing sugar content indicating the presence of sufficient variability and predominance of additive gene action in the inheritance of these traits. Days to flowering and leaf length showed significant and positive association with cured leaf yield, at both genotypic and phenotypic level indicating mutual association of these traits. Further, path coefficient analysis revealed that days to flowering (1.038**), leaf length (1.370**), leaf width (0.761**) and leaf thickness (0.796**) in that order, were major characters having positive direct effects and significant association with cured leaf yield, indicating scope for considering these characters in selection programme for bringing out an improvement in tobacco yield.

Keywords: Correlation, genetic variability, path analysis, Bidi tobacco

Introduction

Tobacco (*Nicotiana tabacum* L.) belongs to the family Solanaceae with chromosome number 2n=2x=48. It is one of the most important industrial crops grown in subtropical and temperate regions of the world. Out of 66 species of *Nicotiana*, only two species *viz.*, *N. tabacum* L. and *N. rustica* L. are under cultivation. *Nicotiana rustica is* amphidiploid arise n by hybridization of wild progenitor *N. undulata* and *N. peniculata*. The *Nicotiana rustica* varieties in India are popularly known as Vilayati or Calcutti tobacco, which are characterized by short plant stature with puckered leaf and yellow flowers. Tobacco plays significant role in national economy in India as it directly or indirectly supports 36 million people in rural and urban areas, who are engaged in its production, processing, marketing and export (Anonymous, 2012b) [3]. Further, India occupies second place in tobacco production (0.875 million tonnes) in world after China (3.20 million tonnes). In India, total area under tobacco cultivation is 0.495 million hectares, which accounts only 0.27% of net cultivated area in the country with a production of 0.875 million tonnes and productivity of 1768 kg/ha (Anonymous, 2012a) [2].

In any crop improvement programme, the knowledge of existing genetic variability and estimation of heritability for economic yield and its components is of great significance in determining the influence of environment for the expression of the characters and the extent to which improvement would be possible after selection. Moreover, the study of correlation of characters will help in simultaneous selection for more than one character. Furthermore, the yield is dependent on many component characters and the total correlation is insufficient to explain the true association among the characters. Therefore, path coefficient analysis helps for sorting out the total correlation into direct and indirect effects and useful in selecting high yielding accessions.

Hence, keeping all these facts in mind, the present investigation was undertaken using 15 genotypes of bidi tobacco with the following objectives:

1. To ascertain the extent of variability present among the genotypes with respect to cured

leaf yield, its components and quality traits.
2. To study the extent of phenotypic and genotypic correlations between yield and yield attributes including quality characters.
3. To study path coefficient for assessing the relative contribution of each of yield components towards yield, through their direct and indirect effects.

Materials and Methods

The experiment was carried out with 15 diverse genotypes of bidi tobacco (*Nicotiana tabacum* L.) at Regional Agricultural Research Station, Nandyal. It was conducted in Randomized Block Design (RBD) with three replications. Each plot consisted of a two rows of 10 plants with inter and intra row spacing of 75 cm and 75 cm, respectively. The guard rows were provided on all sides of each block. All the agronomic package of practices were adopted to grow a healthy crop in each replication. The observations on cured leaf yield and its components were recorded from five randomly selected tagged plants for each genotype and the average value per plant was computed. Observations were recorded in 10 characters *viz,* days to flowering, plant height (cm), leaf length (cm), leaf width (cm), leaf thickness (mg/cm2), spangle score, nicotine content (%), reducing sugar content (%), chloride content (%) and cured leaf yield (kg/ha). The recorded data were analyzed as suggested by Snedecor and Cochran (1937) [12] for analysis of variance. The formula suggested by Burton (1952) [4] was employed to calculate genotypic and phenotypic coefficients of variation. The heritability and expected genetic advance (GA) was calculated for each character by adopting the procedure suggested by Allard (1960) [1]. The correlation was estimated as suggested by Hazel *et al*. (1943) [7] and path coefficient analysis was carried out according to the method suggested by Dewey and Lu (1959) [6].

Results and Discussion

The mean sum of squares revealed highly significant differences among genotypes for all the characters, which indicated the presence of considerable variability among the genotypes for various characters.

The estimates of genotypic and phenotypic variance revealed that in all the characters genotypic variance contributed larger in phenotypic variance, which indicated less influence of environmental factors on the expression of the characters studied (Table 1).

The estimates of GCV were moderate for cured leaf yield (9.20), plant height (8.08), leaf width (12.22), leaf thickness (8.02), spangle score (14.90), nicotine content (17.63), chloride content (13.63) and reducing sugar content (22.32); while for days to flowering (5.97) and leaf length (6.47) GCV estimates were found to be low. The narrow differences between GCV and PCV estimates of respective character indicated that environmental factors had insubstantial role for the expression of the characters studied. Similar results reported by Patel (1997) [11] and Datta (2002) [5].

The estimates of heritability were high for all the characters studied. High heritability coupled with high genetic advance as per cent of mean were observed for cured leaf yield (10.66%), days to flowering (8.68%), plant height (9.72%), leaf length (7.58%), leaf width(18.46%), leaf thickness (7.56%), spangle score (18.09%), nicotine content (27.16%) and reducing sugar content(34.54%) which indicated better scope of their improvement through selection, as these characters were predominantly governed by additive genetic variance. While chloride content (13.84%) showed high heritability coupled with low genetic advance (0.17), which indicated that it was largely governed by non additive gene action, and hence would not be improved by simple selection. The present findings are similar with to the results reported by Dobhal (1987), Smalcej and Vasilij (1984), Datta (2002) [5] and Patel and Kinganokar (2005) [8].

The results of correlation studies (Table 2) revealed that cured leaf yield showed positive and significant association with days to flowering (1.038**,0.377*) and leaf length (1.370**,0.370*) at both genotypic and phenotypic levels, which indicated that selection for late maturing genotypes would likely to increase cured leaf yield. Other characters showed positive and significant associations with cured leaf yield were plant height (0.117*), leaf width (0.761**) and leaf thickness (0.796**). Hence, these characters should be given due account while selecting for increasing cured leaf yield. On the other hand, spangle score (-0.337*), nicotine content (-0.445**), reducing sugar content (-0.950**) and chloride content (-0.672**) were negatively and significantly correlated with cured leaf yield. The estimated value of genotypic and phenotypic correlations revealed comparatively higher degree of genotypic correlation coefficient than their phenotypic counterpart for most of the characters, which indicated strong and inherent association between two characters. Similar results were reported by Patel and Makawana (2002) [9] and Patel and Kinganokar (2005) [8].

The overall path coefficient analysis (Table 3) based on genotypic correlations revealed those days to flowering (1.038**), leaf length (1.370**), leaf width (0.761**) and leaf thickness (0.796**) were major characters having positive direct effects and significant association with cured leaf yield.

Table 1: Estimates of genetic variability and heritability parameters for different characters in bidi tobacco

S. No.	Characters	Genetic parameters						
		Genotypic variance	**Genotypic coefficient of variation (GCV %)**	**Phenotypic variance**	**Phenotypic coefficient of variation (PCV %)**	**Heritability (H^2) %**	**Genetic advance at 5%**	**GA (% of mean)**
1	Days to flowering	241.73	5.97	254.81	8.46	49.81	11.29	8.68
2	Plant height(cm)	223.5	8.08	230.6	13.83	34.12	8.10	9.72
3	Leaf length(cm)	38.0	6.47	40.0	11.39	32.28	3.19	7.58
4	Leaf width(cm)	16.03	12.22	18.03	16.67	53.75	3.07	18.46
5	Leaf thickness (mg/cm^2)	5.64	8.02	7.54	17.54	20.92	0.86	7.56
6	Spangle score	2.18	14.90	3.20	25.29	34.72	0.81	18.09
7	Nicotine %	2.05	17.63	3.22	23.56	55.96	1.136	27.16
8	Reducing sugars %	0.35	22.32	0.39	29.72	56.41	0.47	34.54
9	Chlorides %	0.17	13.63	0.19	27.65	24.30	0.17	13.84
10	Cured leaf yield (kg/ha)	322606.8	9.20	322905.5	16.36	31.64	289.72	10.66

Table 2: Genotypic and phenotypic correlations between characters in bidi tobacco

Characters	Days to flowering	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mg/cm^2)	Spangle score	Nicotine %	Reducing sugars %	Chlorides %	Cured leaf yield (kg/ha)
Days to flowering r_g	1.000	-0.472**	0.490**	0.505**	-0.021	-0.639**	-0.416**	-0.541**	0.083	1.038**
Days to flowering r_p	1.000	-0.159	0.238	0.225	0.059	-0.340*	-0.250	-0.304*	-0.099	0.377*
Plant height (cm) r_g		1.000	0.828**	0.613**	0.204	0.580**	0.078	-0.329*	-1.367**	0.117
Plant height(cm) r_p		1.000	0.225	0.331*	0.028	0.345*	-0.061	-0.052	-0.324*	0.163
Leaf length(cm) r_g			1.000	1.095**	1.072**	-0.035	-0.393**	-0.483**	-1.079**	1.370**
Leaf length(cm) r_p			1.000	0.533**	0.283	-0.032	-0.051	-0.228	-0.213	0.370*
Leaf width(cm) r_g				1.000	0.539**	-0.275	-0.532**	-0.059	-1.105**	0.761**
Leaf width(cm) r_p				1.000	0.087	-0.137	-0.306*	-0.077	-0.321*	0.234
Leaf thickness (mg/cm^2) r_g					1.000	0.897**	0.335*	0.268	0.428**	0.796**
Leaf thickness (mg/cm^2) r_p					1.000	0.262	0.237	0.093	-0.158	0.155
Spangle score r_g						1.000	0.912**	0.263	-0.082	-0.337*
Spangle score r_p						1.000	0.412**	0.201	-0.077	0.008
Nicotine % r_g							1.000	0.301*	0.532**	-0.445**
Nicotine % r_p							1.000	0.229	0.120	-0.140
Reducing sugars % r_g								1.000	0.286	-0.950**
Reducing sugars % r_p								1.000	0.369*	-0.209
Chlorides % r_g									1.000	-0.672**
Chlorides % r_p									1.000	-0.154
Cured leaf yield (kg/ha) r_g										1.000
Cured leaf yield (kg/ha) r_p										1.000

Note:*, ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 3: Path coefficient analysis showing direct and indirect effects of different characters on cured leaf yield in bidi tobacco

Characters	Days to flowering	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mg/cm^2)	Spangle score	Nicotine %	Reducing sugars %	Chlorides %	Genotypic correlation with cured leaf yield (kg/ha)
Days to flowering	0.675	-0.111	-0.035	0.212	-0.006	-0.358	0.258	0.369	0.034	1.038**
Plant height(cm)	-0.318	0.235	-0.059	0.257	0.066	0.324	-0.048	0.224	-0.564	0.117
Leaf length(cm)	0.330	0.194	0.072	0.460	0.347	-0.019	0.244	0.329	-0.445	1.370**
Leaf width(cm)	0.340	0.144	-0.079	0.420	0.174	-0.153	0.330	0.040	-0.456	0.761**
Leaf thickness (mg/cm^2)	-0.014	0.048	-0.077	0.226	0.324	0.502	-0.207	-0.182	0.176	0.796**
Spangle score	-0.431	0.136	0.002	-0.115	0.291	0.560	-0.566	-0.179	-0.033	-0.337*
Nicotine %	-0.281	0.018	0.028	-0.223	0.108	0.510	-0.621	-0.205	0.219	-0.445**
Reducing sugars %	-0.365	-0.077	0.034	-0.024	0.086	0.147	-0.186	-0.683	0.118	-0.950**
Chlorides %	0.056	-0.321	0.078	-0.464	0.138	-0.046	-0.330	-0.195	0.412	-0.672**

Note:*, ** significant at 0.05 and 0.01 levels of probability, respectively.
Residual effect = -0.6673

Therefore, selection pressure imposed on these characters would bring improvement in cured leaf yield of bidi tobacco. It was noticed that leaf thickness showed positive significant correlation with cured leaf yield due to high positive indirect effects through spangle score, nicotine content and chloride content. The direct effect of spangle score, nicotine content, reducing sugar content and chloride content were negative significant association, which contributed negative genotypic correlation of these characters with cured leaf yield. Hence, selection based on days to flowering, leaf length and leaf width with high positive direct effects and leaf thickness with moderate to high indirect effects would be useful for improving the cured leaf yield. Similar results were also reported by Patel *et al*. (1981) [10] and Datta (2002) [5].

The findings of present investigation lead to the conclusion that isolation of genotypes with higher cured leaf yield along with good quality attributes is possible amongst the genotypes studied. The characters *viz.,* cured leaf yield, days to flowering, plant height, leaf length, leaf width, leaf thickness, spangle score, nicotine content, chloride content and reducing sugar content displayed sufficient variability, high heritability and high genetic advance. Hence, these characters could be improved by selection. The character days to maturity showed low variability and low magnitude of genetic advance for the improvement of this character through selection. The correlation study revealed that selection based on the characters *viz.,* days to flowering, plant height, leaf length, leaf width and leaf thickness would ultimately improve the cured leaf yield. Four component characters *viz.,* days to flowering, leaf length, leaf width and leaf thickness showed highly significant and positive correlation with each other and also with cured leaf yield, which indicated that these characters should be given due consideration for increasing cured leaf yield. Further, path coefficient analysis revealed that days to flowering, leaf length, leaf width and leaf thickness in that order, were major characters having positive direct effects and significant positive association with cured leaf yield and also leaf thickness with moderate to high positive indirect effects indicating due weightage need to be given to these characters in selection Programme for bringing out an improvement in cured leaf yield of bidi tobacco.

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