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National Academy of Agricultural Science (NAAS) Rating : 3.03

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

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Abstract: *The present investigation was carried out with fourty genotypes of rustica 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, days to flowering, number of leaves per plant, plant height, leaf width, 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, number of leaves per plant, plant height, leaf length, leaf width and days to maturity 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 leaf length (0.451), plant height (0.229) and days to flowering (0.178) 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, Rustica 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 arisen 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). 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).

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.

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Hence, keeping all these facts in mind, the present investigation was undertaken using 40 genotypes of rustica tobacco with the following objectives: **A)** To ascertain the extent of variability present among the genotypes with respect to cured leaf yield, its components and quality traits. **B)** To study the extent of phenotypic and genotypic correlations between yield and yield attributes including quality characters. **C)** 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 experimental material for present investigation comprised of 40 diverse genotypes of rustica tobacco (*Nicotiana rustica* L.) obtained from the Bidi Tobacco Research Station, Anand Agricultural University, Anand. The experiment 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 60 cm and 60 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 11 characters *viz,* Cured leaf yield (g/plant), days to flowering, number of leaves per plant, leaf length (cm), leaf width (cm), plant height (cm), leaf thickness (mg/cm^2), days to maturity, nicotine content (%), chloride content(%) and reducing sugar content (%). The recorded data were analysed as suggested by Snedecor and Cochran (1937) for analysis of variance. The formula suggested by Burton (1952) 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). The correlation was estimated as suggested by Hazel *et al*. (1943) and path coefficient analysis was carried out according to the method suggested by Dewey and Lu (1959).

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.Cured leaf yield showed wide range of variability (83.10 to 175.00 g/plant). The genotype Sk-241 recorded significantly highest cured leaf yield (175.00 g), while the lowest cured leaf yield (83.10 g) was recorded by the genotype S-7. Days to flowering ranged from 27.30 to 55.70 days. The genotype Peshawar Snuff (27.30) flowered the earliest, while the genotype HAR-1(55.70) was late flowering with the mean value of 42.69 days. Number of leaves per plant ranged from 9.30 to 17.00. Genotype HAR-1 had the maximum number of leaves per plant (17.00), while genotype S-7 had the minimum number of leaves per plant (9.30) with mean value of 12.39. Nicotine content ranged from 2.20 to 4.60 per cent. The genotype Snuff-7 recorded the highest nicotine content (4.60%), while the genotype GC-1 had the lowest nicotine content (2.20%). The average nicotine content was 3.30 per cent. 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 2).

The estimates of GCV were moderate for cured leaf yield, days to flowering, number of leaves per plant, plant height, leaf width, leaf thickness, nicotine content, chloride content and reducing sugar content; while for leaf length and days to maturity GCV estimates were found to be low. The narrow differences between GCV and PCV estimates of respective character indicated that environmental factors had meagre role for the expression of the characters studied. Similar results reported by Patel (1997) and Datta (2002).

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, days to flowering, number of leaves per plant, plant height, leaf width, leaf thickness, nicotine content, chloride content and reducing sugar content, which indicated better scope of their improvement through selection, as these characters were predominantly governed by additive genetic variance. While, days to maturity showed high heritability coupled with low genetic advance, 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 akin with to the results reported by Dobhal (1987), Smalcej and Vasilij (1984), Datta (2002) and Patel and Kinganokar (2005).

The results of correlation studies (Table 3) revealed that cured leaf yield showed positive and significant association with days to flowering and

days to maturity 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 number of leaves per plant, plant height, leaf length and leaf width. Hence, these characters should be given due weightage while selecting for increasing cured leaf yield. On the other hand, leaf thickness and reducing sugar content 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

Table 1
The estimates of range, general mean, standard error of mean, C.D. and C.V value for different characters in rustica tobacco

Sr. No.	*Characters*	*Range*		*Means*	*Standard Error of mean*	*C.D. (P= 0.05)*	*C.V.%*
		Max.	*Min*				
1	Cured leaf yield (g/plant)	175.00 (Sk-241)	83.10 (S-7)	120.32	3.98	11.20	5.73
2	Days to flowering	55.70 (HAR-1)	27.30 (Peshawar Snuff)	42.69	1.24	3.49	5.04
3	No. of leaves/plant	17.00 (HAR-1)	9.30 (S-7)	12.39	0.53	1.51	7.52
4	Plant height (cm)	90.20 (Sk-241)	36.30 (GCT-2)	55.43	2.51	7.07	7.85
5	Leaf length (cm)	46.30 (AR-42)	32.70 (S-7)	39.92	0.65	1.82	2.81
6	Leaf width (cm)	43.50 (Sk-88)	27.60 (S-7)	33.85	0.60	1.68	3.06
7	Leaf thickness (mg/cm^2)	14.10 (Sk-407)	6.60 (Sk-241)	10.22	0.45	1.29	7.84
8	Days to maturity	123.30 (Mothihari)	101.30 (C-10)	114.31	0.71	2.23	1.20
9	Nicotine content (%)	4.60 (Snuff-7)	2.20 (GC-1)	3.30	0.07	0.19	3.69
10	Chloride content (%)	3.30 (Sk-193-2 and GCT-3)	2.00 (C-10)	2.82	0.04	0.11	2.38
11	Reducing sugarcontent (%)	4.00 (S-7)	2.00 (Sk-241 and Snuff-7)	2.89	0.03	0.08	1.80

Table 2
The estimates of genotypic variance (σ^2_g) phenotypic variance (σ^2_p) and other variability parameters for different characters in rustica tobacco

Sr. No.	*Characters*	σ^2_g	σ^2_p	*GCV %*	*PCV %*	H^2_b *%*	*GA (% of mean)*
1	Cured leaf yield	407.21	454.73	16.77	17.72	89.50	32.68
2	Days to flowering	55.51	60.14	17.45	18.17	92.30	34.55
3	No. of leaves/plant	2.89	3.76	13.72	15.64	76.90	24.77
4	Plant height	119.72	131.49	18.64	20.23	84.90	35.37
5	Leaf length	11.98	13.24	8.67	9.12	90.50	17.00
6	Leaf width	12.92	14.00	10.62	11.05	92.30	21.00
7	Leaf thickness	2.88	3.52	16.63	18.39	81.80	31.01
8	Days to maturity	28.19	30.07	4.65	4.80	93.70	9.26
9	Nicotine content	0.397	0.411	19.46	19.81	96.50	39.39
10	Chloride content	0.102	0.106	11.35	11.60	95.80	23.04
11	Reducing sugarcontent	0.249	0.252	17.28	17.37	98.90	35.29

Table 3
Genotypic and phenotypic correlations between different characters in rustica tobacco

character		*Cured leaf yield*	*Days to flowering*	*No of leaves/plant*	*Plant height*	*Leaf length*	*Leaf width*	*Leaf thickness*	*Days to maturity*	*Nicotine content*	*Chloride content*	*Reducing sugar content*
Cured leaf yield	r_g	1.000	0.675**	0.607**	0.399*	0.710**	0.503**	-0.539**	0.641**	-0.251	0.161	-0.659**
	r_p	1.000	0.622**	0.497**	0.396**	0.658**	0.468**	-0.473**	0.595**	-0.218	0.157	-0.621**
Days to flowering	r_g		1.000	0.793**	0.252	0.658**	0.531**	-0.436**	0.625**	-0.168	0.191	-0.586**
	r_p		1.000	0.684**	0.228*	0.614**	0.505**	-0.374**	0.566**	-0.151	0.175	-0.565**
No of leaves/plant	r_g			1.000	0.292	0.573**	0.509**	-0.523**	0.691**	-0.263	0.415**	-0.693**
	r_p			1.000	0.259*	0.456**	0.442**	-0.405**	0.569**	-0.220*	0.354**	-0.606**
Plant height	r_g				1.000	0.105	-0.084	-0.221	0.432**	-0.271	-0.084	-0.304
	r_p				1.000	0.100	-0.076	-0.160	0.405**	-0.243*	-0.074	-0.274*
Leaf length	r_g					1.000	0.697**	-0.380*	0.620**	-0.054	0.350*	-0.676**
	r_p					1.000	0.651**	-0.339**	0.584**	-0.048	0.332**	-0.639**
Leaf width	r_g						1.000	-0.454**	0.620**	-0.217	0.508**	-0.493**
	r_p						1.000	-0.399**	0.579**	-0.202	0.473**	-0.471**
Leaf thickness	r_g							1.000	-0.525**	0.329*	-0.425**	0.492**
	r_p							1.000	-0.455**	0.282*	-0.384**	0.453**
Days to maturity	r_g								1.000	-0.446**	0.277	-0.707**
	r_p								1.000	-0.430**	0.269*	-0.677**
Nicotine content	r_g									1.000	0.042	0.168
	r_p									1.000	0.045	0.167
Chloride content	r_g										1.000	-0.294
	r_p										1.000	-0.286**
Reducing sugar content (%)	r_g											1.000
	r_p											1.000

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

Table 4
Path coefficient analysis showing direct and indirect effects of different characters on cured leaf yield in rustica tobacco

Character	*Days to flowering*	*No. of leaves/plant*	*Plant height (cm)*	*Leaf length (cm)*	*Leaf width (cm)*	*Leaf thickness (mg/cm²)*	*Days to maturity*	*Nicotine content (%)*	*Chloride content (%)*	*Reducing sugar content (%)*	*Genotypic correlation with cured leaf yield*
Days to flowering	**0.178**	0.006	0.058	0.297	0.033	0.106	-0.054	0.009	-0.031	0.074	0.675**
No of leaves/plant	0.141	**0.008**	0.067	0.258	0.032	0.127	-0.060	0.013	-0.067	0.087	0.607**
Plant height (cm)	0.045	0.002	**0.229**	0.048	-0.005	0.054	-0.038	0.014	0.013	0.038	0.399*
Leaf length (cm)	0.117	0.005	0.024	**0.451**	0.043	0.092	-0.054	0.003	-0.056	0.085	0.710**
Leaf width (cm)	0.094	0.004	-0.019	0.314	**0.062**	0.110	-0.054	0.011	-0.081	0.062	0.503**
Leaf thickness (mg/cm²)	-0.078	-0.004	-0.050	-0.171	-0.028	**-0.243**	0.046	-0.017	0.068	-0.062	-0.539**
Days to maturity	0.111	0.006	0.099	0.279	0.039	0.127	**-0.087**	0.023	-0.044	0.089	0.641**
Nicotine content (%)	-0.030	-0.002	-0.062	-0.024	-0.013	-0.080	0.039	**-0.051**	-0.007	-0.021	-0.251
Chloride content (%)	0.034	0.003	-0.019	0.157	0.032	0.103	-0.024	-0.002	**-0.160**	0.037	0.161
Reducing sugar content (%)	-0.104	-0.006	-0.069	-0.304	-0.031	-0.119	0.061	-0.009	0.047	**-0.126**	-0.659**

Note: *, ** significant at **0.05** and **0.01** levels of probability, respectively.
Residual effect = 0.2879

of the characters, which indicated strong and inherent association between two characters.Similar results were reported by Patel and Makawana (2002) and Patel and Kinganokar (2005).

The overall path coefficient analysis based on genotypic correlations revealed that leaf length, plant height, days to flowering, leaf width and numbers of leaves per plant were major characters having positive direct effects and significant association with cured leaf yield. Therefore, selection pressure imposed on these characters would bring improvement in cured leaf yield of rustica tobacco. It was noticed that days to maturity showed positive significant correlation with cured leaf yield due to high positive indirect effects through days to flowering, leaf length and leaf thickness. The direct effect of leaf thickness and reducing sugar content were negative and high, which contributed negative genotypic correlation of these characters with cured leaf yield. Hence, selection based on leaf length, plant height and days to flowering 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) and Datta (2002).

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, number of leaves per plant, plant height, leaf width, leaf thickness, 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, number of leaves per plant, plant height, leaf length, leaf width and days to maturity would ultimately improve the cured leaf yield. Three component characters *viz*., number of leaves per plant, leaf length and leaf width 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 leaf length, plant height and days to flowering 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 effectsindicating due weightage need to be given to these characters in selection programme for bringing out an improvement in cured leaf yield of rustica tobacco.

ACKNOWLEDGEMENT

Authors are highly thankful to Dr. J. S. Patel (Professor and Head) and Dr. D. J. Parmar (Associate Professor) Department of Agricultural Statistics, B. A. College of Agriculture, Anand Agricultural University, Anand for providing facilities for statistical analysis and also to the Bidi Tobacco Research Station, Anand Agricultural University, Anand for providing laboratory facilities for the nicotine, chloride and reducing sugar content analysis of the experimental material.

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