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Phenotypic and genotypic correlation for leaf and quality characters in flue cured virginia tobacco

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Abstract

To study phenotypic and genotypic correlation among different yield and quality traits, an experiment comprising four tobacco parental cultivars and their 12 F_2 populations was conducted in a randomized complete block (RCB) design with three replications. The characters studied include days to flowering, plant height, leaf area, number of leaves plant^{-1}, weight of green leaves m^{-2}, number of green leaves kg^{-1}, number of cured leaves kg^{-1}, grade index, yield ha^{-1}, nicotine content and reducing sugar. Analysis of variance showed highly significant differences among all the genotypes for all the characters. Leaf yield showed significantly positive phenotypic and genotypic correlations with leaf area, number of leaves plant^{-1}, weight of green leaves m^{-2} and grade index. The above given F_2 populations have positive significant correlation for various yield and quality traits which could be used for further assessment in tobacco breeding programs.

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Introduction

Tobacco (*Nicotiana tabaccum* L.) is an industrial plant and polyploid in nature. Numerous types of tobacco are defined to a large extent by region of production, intended use in manufacturing (e.g., cigar filler and cigar wrapper), method of curing (dark air-cured and fire-cured) as well as their morphological and biochemical characteristics (Ren and Timko, 2001). The most important aim of tobacco breeding programs is improving dry leaf yield of the plant which is a complex trait associated with many interrelated components. Dry leaf yield in tobacco is a quantitative trait largely influenced by the environment and hence has a low heritability (Xiao *et al*., 2007). Therefore, the response to direct selection for dry leaf yield may be unpredictable unless there is good control of environmental variation (Sabaghnia *et al.,* 2010). Commonly, plant breeders prefer to select for yield related traits that indirectly increase yield. According to the literature, indirect selection by yield related traits such as plant height, leaf area index, number of leaves, leaf length and flowering date can increase tobacco dry leaf yield (Legg and Collins, 1975). White *et al*. (1979) used simple correlation analysis based on agronomic, physical and chemical characteristics to show the interrelationships among flue-cured tobacco genotypes and indicated that all agronomic traits present positive correlations with dry leaf yield. Honarnejad and Shoai-Deylami (2004) found high significant correlations between dry leaf yield and agronomic traits except for plant height and leaf number in a F2 population of tobacco. Wenping *et al.* (2009) reported that the most strongly correlated traits with dry leaf yield are leaf number and leaf length. Since increasing numbers of independent variables can compound apparent interdependence, therefore, correlations may be insufficient to explain the associations in a way to enable breeders to decide on a direct or indirect selection strategy.

The correlation represents a relationship between various plant traits and provides the basics to evolve new plant types with desirable plant traits. Correlation analysis provides information on associated response of plant characters and therefore, leads to a directional model for yield prediction (Rehman and Qureshi, 1997). The objectives of this research were to study the mean performance of 16 tobacco genotypes (four parental cultivars and 12 F_2 populations) for yield and quality characteristics and to estimate phenotypic and genotypic correlations among various traits of 16 tobacco genotypes.

Materials and methods

To determine the phenotypic and genotypic correlation among different traits of flue cured virginia tobacco (FCV) (*Nicotiana tabacum L.*) research was conducted at Tobacco Research Station, Khan Gari, Mardan.

Plant material

Plant material was comprised of four parental cultivars and their 12 F_2 populations (Table 1). Nursery of all genotypes was raised on 16 December 2010. Seedlings were transplanted on 21 March 2011. In this experiment, randomized complete block (RCB) design was used with three replications by maintaining row to row distance of 90 cm while plant to plant distance was kept 60 cm.

Plot designing

Each plot was consisted of three rows. Number of plants per row was ten. Seedlings of same size (5-8 inches) height and (8-10 mm) thickness were transplanted to the field. Diseased and weak seedlings were discarded at the time of transplantation. All recommended cultural practices and inputs were applied to all the entries from transplantation till harvesting. Picking and curing was done in four steps.

Plant Parameters

Data was recorded on days to flowering, plant height, leaf area, number of leaves plant^{-1} and weight of green leaves m^{-2}, number of green leaves kg^{-1}, number of cured leaves kg^{-1}, grade index, yield ha^{-1}, nicotine content and reducing sugar.

Statistical analysis

The data recorded on each parameter was subjected to analysis of variance (ANOVA) techniques appropriate for an RCB for different quantitative and qualitative traits Gomez and Gomez (1984). Phenotypic (r_P) and genotypic (r_G) associations amid various traits were worked out using the procedure of Kwon and Torrie (1964) as per following formulae:

$$Phenotypic\ correlation(r_P) = \frac{COV_{P(x_1x_2)}}{\sqrt{V_{P(x_1)}.V_{P(x_2)}}}$$

$$Genetic\ correlation(r_G) = \frac{COV_{G(x_1x_2)}}{\sqrt{V_{G(x_1)}.V_{G(x_2)}}}$$

Where,

$COV_{P(x1x2)}$ = Phenotypic covariance amid traits x_1 and x_2

$V_{P\ (x1)}$ = Phenotypic variance of trait x_1

$V_{P\ (x2)}$ = Phenotypic variance of trait x_2

$COV_{G(x1x2)}$ = Genetic covariance amid traits x_1 and x_2

$V_{G\ (x1)}$ = Genotypic variance of trait x_1

$V_{G\ (x2)}$ = Genotypic variance of trait x_2

The significance of phenotypic and genotypic correlation coefficients was tested as per the correlation table of Fisher and Yates (1963).

Results and discussion

Results of analysis of variance revealed that the mean genotypic differences for most of the traits were highly significant ($P \leq 0.01$) as shown in table 2. Phenotypic and genotypic correlation coefficients for days to flowering were significantly positive with the leaf area, while with the rest of the traits it was non-significant.

Table 1. Genotypes and their F_2 population studied during the project.

Parental genotypes	F_2 populations		
KHG-21	KHG-21 × KHG-22	KHG-22 × KHG-21	KHG-24 × KHG-21
KHG-22	Spt-G-28 × KHG-21	KHG-21 × KHG-24	KHG-22 × KHG-24
KHG-24	KHG-24 × KHG-22	Spt-G-28 × KHG-22	KHG-21 × Spt-G-28
Spt-G-28	KHG-22 × Spt-G-28	KHG-24 × Spt-G-28	Spt-G-28 × KHG-24

Thus, delayed flowering, with its positive associations with leaf area had no influence on the yield and other traits. White *et al. (1979)* reported that among several tobacco cultivars days to flowering significantly positive associated with leaf area and non significant with the other traits. Plant height showed significantly positive phenotypic correlation with number of green leaves kg^{-1} and number of cured leaves kg^{-1}, but non-significant with remaining traits. Hence, plant height has positive influence on the number of green leaves kg^{-1} and number of cured leaves kg^{-1} (Table 3). These results confirm the findings of Rehman and Qureshi (1997) who studied phenotypic correlation for yield and yield components in eight tobacco genotypes. Genotypically plant height was highly significant and positively associated with number of green leaves kg^{-1} and number of cured leaves kg^{-1}, whereas non-significant with other traits (Table 4). Hassan (1994) also obtained similar results, indicated strong genotypic correlations of plant height with number of green and cured leaves kg^{-1} among 10 hookah tobacco cultivars.

Table 2. Mean square values for all traits.

Parameters	Replication (df= 2)	Genotypes (df= 15)	Error (df= 30)
Days to flowering	5.396	11.061*	5.240
Plant height	47.478	110.336**	33.320
Leaf area	1420.641	14025.303**	2354.869
Number of leaves $plant^{-1}$	0.396	15.156*	7.618
Weight of green leaves m^{-2}	0.239	0.211**	0.081
Number of green leaves kg^{-1}	0.563	31.276**	4.651
Number of cured leaves kg^{-1}	2.771	1224.467**	53.571
Grade index	26.271	140.128**	51.715
Yield ha^{-1}	2986.521	225869.443**	5699.076
Nicotine content	0.028	0.125**	0.014
Reducing sugar	0.051	17.806**	0.101

*, ** = significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

Phenotypic correlation coefficient of leaf area was significantly positive with weight of green leaves m^{-2} and nicotine content whereas, highly significant negative with number of green leaves kg^{-1} and number of cured leaves kg^{-1}. Phenotypically leaf area was highly significant and positive associated with yield ha^{-1} (Table 3).

Table 3. Phenotypic correlation coefficients (r) for different yield and quality characters in FCV tobacco.

	Days to flowering	Plant height (cm)	Leaf area (cm^2)	No. of leaves $plant^{-1}$	weight of green leaves m^{-2} (kg)	No. of green leaves kg^{-1}	No. of cured leaves kg^{-1}	Grade index (%)	Yield ha^{-1} (kg)	Nicotine content (%)	Reducing sugar (%)
Days to flowering	1.00	0.05^{ns}	0.30*	0.13^{ns}	0.16^{ns}	-0.22^{ns}	-0.17^{ns}	0.13^{ns}	0.05^{ns}	-0.13^{ns}	-0.08^{ns}
Plant height (cm)		1.00	0.14^{ns}	-0.26^{ns}	-0.26^{ns}	0.28*	0.36*	-0.08^{ns}	-0.07^{ns}	0.25^{ns}	-0.02^{ns}
Leaf area (cm^2)			1.00	-0.19^{ns}	0.30*	-0.53**	-0.54**	-0.09^{ns}	0.65**	0.31*	-0.25^{ns}
No. of leaves $plant^{-1}$				1.00	0.82**	-0.29 *	-0.30*	0.39**	0.46**	0.35*	0.05^{ns}
Green wt leaves m^{-2} (kg)					1.00	-0.29 *	-0.28*	0.38**	0.41**	0.05^{ns}	0.01^{ns}
No. of green leaves kg^{-1}						1.00	0.79**	-0.20^{ns}	-0.45**	-0.07^{ns}	-0.23^{ns}
No. of cured leaves kg^{-1}							1.00	-0.10^{ns}	-0.55**	-0.04^{ns}	-0.28*
Grade index (%)								1.00	0.49**	-0.07^{ns}	0.14^{ns}
Yield ha^{-1} (kg)									1.00	0.22^{ns}	0.18^{ns}
Nicotine content (%)										1.00	-0.01^{ns}
Reducing sugar (%)											1.00

*, ** = significant at 5% and 1% level of probability respectively

ns = non-significant.

Janardhan and Nataraju (1990) also observed correlation, derived from data on 5 yield components in 10 flue-cured Virginia cultivars. Genotypic correlation coefficient of leaf area was highly significant positive with weight of green leaves m^{-2} and yield ha^{-1}, whereas highly significant but negatively correlated with number of green leaves kg^{-1} and number of cured vergina leaves kg^{-1}. Genotypically leaf area was significantly positive correlated with grade index. Hence, leaf area has greater influence on yield and quality traits (Table 4). Hassan *et al.* (1997) also found similar results for genotypic correlation of leaf area with yield and yield related traits in 10 promising tobacco cultivars. Number of leaves $plant^{-1}$ revealed highly significant positive correlations (phenotypic and genotypic) with weight of green leaves m^{-2}, grade index and yield ha^{-1}, whereas significantly negative with number of green leaves kg^{-1} and number of cured leaves kg^{-1}. Phenotypic and genotypic correlation coefficients of number of leaves $plant^{-1}$ were significantly positive with nicotine content (Table 3 and 4). Hence, number of leaves $plant^{-1}$ had greater influence on yield and quality parameters. Legg and Collins (1975) reported significant associations of leaves $plant^{-1}$ with yield and quality characters in tobacco genotypes. Phenotypic correlation coefficient of weight of green leaves m^{-2} was highly significant and positive with grade index and yield, while significantly negative with the number of green leaves kg^{-1} and number of cured leaves kg^{-1} (Table 3). Dobhal and Rao (1988) found that green leaf weight is positive correlated with yield and quality characters in hookah chewing tobacco genotypes. Genotypic correlation coefficient of green leaves weight m^{-2} was highly significant and positive with yield, whereas significantly negative with number of green leaves kg^{-1} and number of cured leaves kg^{-1} (Table 4). Green leaf weight had significantly positive correlation with yield in 20 hookah tobacco (*Nicotina tabacum* L.) varieties Hassan and Aamer (1994). Number of green leaves kg^{-1} have highly significant and positive correlations (phenotypic and genotypic) with number of cured leaves kg^{-1}, while highly significant but negative with yield ha^{-1}. Its mean number of green leaves kg^{-1} has negative effect on the final yield. Paul *et al.* (1970) observed negative correlation for number of green leaves kg^{-1} with yield and yield related components in F_2 generation of a cross between two burley varieties of tobacco (*Nicotiana tabacum* L). Phenotypic correlation coefficient of number of cured leaves kg^{-1} was highly significant and negative with yield while significantly negative with the reducing sugar (Table 3). Paul *et al.* (1970) also reported negative correlation for number of leaves kg^{-1} with yield and alkaloid contents among in F_2 generation of a cross derived from two burley varieties of tobacco (*Nicotiana tabacum* L). Genotypic association of number of cured leaves kg^{-1} was highly significant and negative with the yield (Table 4).

Table 4. Genotypic correlation coefficients (r) for different yield and quality characters in FCV tobacco.

	Days to flowering	Plant height (cm)	Leaf area (cm^2)	No. of leaves plant^{-1}	weight of green leaves m^{-2} (kg)	No. of green leaves kg^{-1}	No. of cured leaves kg^{-1}	Grade index (%)	Yield ha^{-1} (kg)	Nicotine content (%)	Reducing sugar (%)
Days to flowering	1.00	0.24^{ns}	0.56^{*}	0.34^{ns}	0.42^{ns}	-0.48^{ns}	-0.37^{ns}	0.26^{ns}	0.25^{ns}	-0.29^{ns}	-0.19^{ns}
Plant height (cm)		1.00	0.40^{ns}	-0.34	-0.38^{ns}	0.65^{**}	0.78^{**}	-0.31^{ns}	-0.16^{ns}	0.38^{ns}	-0.05^{ns}
Leaf area (cm^2)			1.00	-0.39^{ns}	0.99^{**}	-0.72^{**}	-0.70^{**}	0.59^{*}	0.84^{**}	0.43^{ns}	-0.36^{ns}
No. of leaves plant^{-1}				1.00	0.84^{**}	-0.59^{*}	-0.54^{*}	0.55^{*}	0.88^{**}	0.57^{*}	0.31^{ns}
Green weight leaves m^{-2} (kg)					1.00	-0.55^{*}	-0.52^{*}	0.43^{ns}	0.65^{**}	0.35^{ns}	0.28^{ns}
No. of green leaves kg^{-1}						1.00	0.98^{**}	-0.35^{ns}	-0.64^{**}	-0.26^{ns}	-0.35^{ns}
No. of cured leaves kg^{-1}							1.00	-0.36^{ns}	-0.69^{**}	-0.32^{ns}	-0.46^{ns}
Grade index (%)								1.00	0.91^{**}	-0.45^{ns}	0.35^{ns}
Yield ha^{-1} (kg)									1.00	0.41^{ns}	0.26^{ns}
Nicotine content (%)										1.00	-0.42^{ns}
Reducing sugar (%)											1.00

*, ** = significant at 5% and 1% level of probability respectively

ns = non-significant.

While, number of cured leaves kg^{-1} has negative effect on the final yield. Matzinger (1968) observed negative genotypic correlation for number of leaves kg^{-1} with yield and quality characters among full-sib and self progenies obtained from parental plants in the F_2 generation of a cross of two varieties of *Nicotiana tabacum* L.

Grade index revealed highly significant and positive correlations (phenotypic and genotypic) with yield. Thus, this quality parameter has good influence on yield. White and Matzinger (1960) studied strong positive correlations of grade index percentage with yield and its components among eight tobacco varieties and their all possible F_1 crosses. For yield, correlation coefficients (phenotypic and genotypic) were highly significant and positive with number of leaves plant^{-1}, weight of green leaves m^{-2} and leaf area, while highly significant and negative with number of leaves kg^{-1}. This result revealed that yield is more affected by the mentioned traits. Janardhan and Nataraju (1990) and Chaubey *et al.* (1990) also reported similar correlations of yield with leaf area, number of leaves and leaf weight among different tobacco genotypes.

Nicotine content showed significant phenotypic and genotypic correlations with number of leaves plant^{-1} while non-significant with the rest of traits. However, nicotine has no effect on yield but having influence on quality of tobacco. These results are concurrent with the findings of Liang *et al.* (2007) who observed significant positive associations of chemical components with number of leaves in K-326 tobacco variety.

Correlation coefficients (phenotypic and genotypic) of reducing sugar were non significant with almost all the traits (Table 3 and 4). Hence, there is no effect of reducing sugars on yield and its related traits but effect the taste quality of tobacco leaves. Gopalakrishna and Rao (1980) also reported no associations of alkaloid contents with yield and its components among Natu tobacco cultivars.

Conclusions

Phenotypic and genotypic correlations association could be used to identify important traits causing variation in tobacco genotypes. Days to 50% flowering, green weight of leaves m^{-2}, nicotine content, grade index and number of leaves per plant made significant contributions to leaf yield of flue cured virginia tobacco.

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