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Combining Ability Analysis for Cured Leaf Yield and its Component Traits in FCV (Flue-Cured Virginia) Tobacco (*Nicotiana tabacum* L.)

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ABSTRACT

Keywords

Combining ability, FCV (Flue-Cured Virginia) tobacco, GCA (General combining ability) and SCA (Specific combining ability)

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The research was conducted to assess the combining ability in respect to leaf yield and its component characters through 6 x 6 diallel mating design involving thirty hybrids and six parents in FCV tobacco during *kharif* 2016 at ZAHRS (Zonal Agricultural and Horticultural Research Station), College of Agriculture Shivamogga. Combining ability analysis was carried out for leaf yield and its components in FCV tobacco. Both General combining ability (GCA) and Specific combining ability (SCA) variances were highly significant for almost all the characters. Parents and F_1 hybrids differ significantly for GCA and SCA effects for all the characters respectively. Study on the combining ability revealed that the parents Kanchan, FCH-222 and Tobios-6 were found to be best general combiners for cured leaf yield than others. The highest significant positive SCA effects was observed in the cross 2 x 4 followed by 1 x 3, 6 x 1, 1 x 4 and 1 x 5 for cured leaf yield. These hybrids were found to be suitable for obtaining higher cured leaf yield in FCV tobacco.

Introduction

Tobacco (*Nicotiana tabacum* L.) is one of the most important non-edible commercial crop in India. In the development of national economy it has been playing a prominent role. Tobacco is called as 'The Golden leaf'. It is one of the members of Solanaceae family and belongs to genus *Nicotiana.* It is self-pollinated allopolyploid species. It is an amphidiploids (2n=48) of *Nicotiana sylvestris* (2n=24) and *Nicotiana tomentosa* (2n=24), the wild progenitor species (Gerstel, 1960 and Gerstel, 1963) and are believed to be originated in tropical America (Akehurst, 1981). The quality of tobacco produced in Karnataka light soils (KLS) is on par with the best in the world and is in great demand for export purpose but in Karnataka yield levels of FCV tobacco are lower than the national average. Due to several fold increase in the cost of inputs and labour wages, farmers are not able to realize higher profit. The genetic potential of the present cultivated varieties has stagnated at 2000 kg/ha. Hence, it is desirable to enhance the genetic yield potential of the varieties up to 3000 kg/ha through genetic improvement of the crop. Medicinally tobacco is used as a sedative, diuretic, expectorant, discutient and internally only as an emetic, when all other emetics fail. Externally nicotine is used as an antiseptic. Tobacco produces nicotine sulphate which is used as an insecticide. Tobacco is claimed to be miracle crop because of its nature and properties, which is used for range of purpose right from pesticides, narcotics, stimulants and medicinal uses (Narasimha Rao and Krishnamurthy, 2007).

To enhance the present yield levels, it is essential a systemic varietal improvement through hybridization and exploitation of generated variability through recombination breeding. To achieve this, the role of combining ability is important in choosing suitable parents to nick well in the expression of heterosis. Thus the evaluation of genotypes for their nicking ability is a pre-requisite for the final selection of parents in hybridization programme. This is because the *per se* performance of a parent is not always a true indicator of its potential in hybrid combination. Combining ability gives addition information on nature of gene action which will be helpful to develop efficient crop improvement programme. It is necessary to have detailed information about the desirable parental combination in any breeding programme that can involve a high degree of heterotic response. Top-cross, poly-cross and diallel crossing methods are used for the assessment of variability, combining ability and heterosis. The objectives of this study were to use diallel mating design to determine the general and specific combining abilities for cured leaf yield and its component traits.

Materials and Methods

During *kharif* season 2016, investigation was carried out on analysis of combining ability in FCV tobacco (*Nicotiana tabacum* L.). The experiment on combining ability was conducted in the experimental plot, College of Agriculture, ZAHRS (Zonal Agricultural and Horticultural Research Station), University of Agricultural and Horticultural Sciences, Shivamogga, Karanataka. Shivamogga comes under Southern transition agro climatic zone of Karnataka, (Zone number-7). Geographically, Shivamogga is situated between 130 27' to 140 39' latitude and 740 37' E longitude with an altitude of 650 m above the MSL. A total rainfall of 1232.8 mm was received during the year of investigation.

The experimental material for study comprised of thirty F_1 populations and their six parents (Bhavya, FCV- Special, Sahyadri, Kanchan, Tobios-6 and FCH-222), where Kanchan is used as a Standard check. These materials were used for genetic analysis of leaf yield and its component traits in FCV tobacco. On the raised seed beds seedlings were grown in the nursery. Length of rows of is 6m with spacing of 90 x 60 cm and planted in a Simple Lattice Design (SLD) with three replications, during *kharif* 2016. Crop was raised as per the recommended package of practices. Leaves were harvested by priming method as and when they assume yellowish green colours. The pre and post harvest observations were recorded *viz.*, Days to 50 per cent flowering, Days to maturity, Plant height (cm), Chlorophyll content, Stem girth (mm), Internodal distance (cm), Number of leaves per plant, Specific leaf weight (mg/cm^2), Leaf length (cm), Leaf width (cm), Leaf area per plant (dm^2), Green leaf yield (q/ha), Cured leaf yield (q/ha), Top grade equivalent (q/ha), Reducing sugar (%) and Nicotine content (%).

The mean data collected for each character on individual plant basis for five observational plants was statistically analyzed to work out combining ability for yield and its components. Combining ability analysis was carried out following Model I, Method 1 described by Griffing (1956). Analysis was done using WINDOW stat 9.2 software. Variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of crosses or hybrids were worked out on the procedure developed by Kempthorne (1957).

Results and Discussion

The knowledge of combining ability provides a useful clue for selection of desirable parents for development of superior hybrids. The ultimate choice of parents to be used in a breeding programme is determined by *per se* performance and their behaviour in hybrid combination. Some idea on the usefulness of the parents may be obtained from their individual performance, particularly in respect of yield components. It is therefore, necessary to assess genetic potentialities of the parents in hybrid combination through systematic studies in relation to general and specific combining abilities. The combining ability concept was proposed by Sprague and Tatum (1942) in corn, according to them, the general combining ability (GCA) is the comparative ability of the line to combine with other lines. It is deviation of the mean performance of all the crosses involving a parent from overall mean. Specific combining ability (SCA) was defined as the deviation in the performance of specific cross from the performance expected on the basis of general combining ability effects of parents involved in the crosses. A positive general combining ability (GCA) indicates a parent that produces above average progeny, whereas parent with negative GCA produces progeny that performs below average of the population. Specific combining ability (SCA) can be either negative or positive and sca always refers to a specific cross.

From the Table 1 it is evident that variances due to general combining ability (GCA) were significant for the characters days to maturity, plant height, chlorophyll content, specific leaf weight, stem girth, internodal distance, leaf length, leaf breadth and nicotine content. The SCA variance was found significant for the characters days to 50 per cent flowering, days to maturity, plant height, chlorophyll content, stem girth, internodal distance, leaf length, leaf breadth, leaf area, green leaf yield, cured leaf yield and top grade equivalent (TGE). Whereas the reciprocal variance was significant for all the characters except for the internodal distance, number of leaves per plant, reducing sugar and nicotine content.

Number of leaves per plant is one of the important yield contributing traits in FCV tobacco. The GCA effects of the Parent-1 *i.e*. Bhavya, Parent-6 *i.e*. FCH-222 and Parent-2 *i*.e. FCV-Special were found to be significantly positive in favorable direction, whereas Parent-5 *i.e.* Tobios-6 was highly significant in the un-favorable direction followed by Parent-3 *i.e.* Sahyadri and Parent-4 *i.e*. Kanchan (Table 2). Among the thirty hybrids nine of the hybrids exhibited significant positive SCA effects. Two crosses exhibited significant negative SCA effect (Table 3). Similar observations for gca and sca effects were recorded Bronius (1970), Dubey (1976), Patel *et al.*, (2005), Aleksoska and Aleksoski (2012), Ramachandra *et al.*, (2015) and Katba *et al.*, (2017).

Leaf area is one of the important yield contributing traits in FCV tobacco. The GCA effects of the Parent-3 *i.e*. Sahyadri and Parent-6 *i.e.* FCH-222 were found to be significantly positive in favorable direction.

Table.1 Analysis of variance for Combining ability in FCV tobacco

Source	GCA	SCA	Reciprocal	Error	GCA variance	SCA variance	Reciprocal variance	GCA variance / SCA variance
Days to 50 per cent flowering	21.618	66.978**	1009.703**	13.554	0.672	53.424	26.880	0.013
Days to maturity	115.263**	63.768**	287.097**	5.27086	9.166	58.498	140.913	0.157
Plant height (cm)	171.2981**	251.669**	250.863**	2.64888	14.054	249.021	124.107	0.056
Chlorophyll Content	4.51875**	2.67043**	1.46859*	0.67480	0.320	1.996	0.397	0.161
Specific leaf weight (mg/cm^2)	0.47077**	0.21876	0.55233**	0.13970	0.028	0.079	0.206	0.349
Stem girth (mm)	0.71504*	2.10840**	1.81746**	0.26067	0.038	1.848	0.778	0.020
Internodal distance (cm)	0.88409**	0.74271**	0.09431	0.12295	0.0634	0.6197	-0.0143	0.1023
Number of leaves/plant	0.32440	0.31885	0.75630	0.44419	-0.010	-0.125	0.156	0.080
Leaf length (cm)	10.36416**	6.68076**	10.55274**	2.53148	0.653	4.419	4.011	0.157
Leaf breadth (cm)	2.23274*	2.31264**	4.61659**	0.71178	0.127	1.601	1.952	0.079
Leaf area (dm^2)	7172.152	12236.773**	10757.776*	5280.141	157.667	6956.632	2738.817	0.023
Green leaf yield (q/ha)	13623.267*	35952.59**	16917.005**	7164.086	538.265	12001.245	4876.400	0.045
Cured leaf yield (q/ha)	297.04*	526.87**	333.64**	102.34	7.7510	172.818	70.221	0.045
Top grade equivalent (q/ha)	106.93	189.67**	120.11**	36.84	2.790	62.214	25.279	0.045
Reducing Sugar (%)	0.84722	1.18009	0.46357	0.71248	0.011	0.468	-0.124	0.024
Nicotine Content (%)	0.00888*	0.00219	0.00270	0.00321	0.00047	-0.001	0.00025	-0.465

Where GCA – General combining ability, SCA – Specific combining ability.
* - Significant at 5 per cent probability, ** - Significant at 1 per cent probability.

Table.2 General combining effects for six parents in FCV tobacco

Parents	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Chlorophyll Content	Specific leaf weight (mg/cm^2)	Stem girth (mm)	Internodal distance (cm)	Number of leaves per plant	Leaf length (cm)	Leaf breadth (cm)	Leaf area (dm^2)	Green leaf yield (q/ha)	Cured leaf yield (q/ha)	Top grade equivalent (q/ha)	Reducing Sugar (%)	Nicotine Content (%)
Bhavya	-2.279**	-2.465**	-1.533	0.3369*	-0.310**	-0.105	-0.1125	0.269**	-0.850*	-0.722**	-3.0373**	-1.9585	-0.2927	-0.1756	0.053	-0.028**
FCV-Special	1.513**	0.919*	-1.972*	-0.079	0.145*	-0.015	-2.119**	0.024*	0.100	0.106	1.1187	-5.1048*	-0.7657*	-0.4594*	-0.104*	-0.029**
Sahyadri	1.174*	-0.087	-2.617**	-1.002**	-0.108	-0.060	0.4807*	-0.098*	1.100**	0.333**	2.7620**	-1.3463	-0.1804	-0.1082	0.191*	0.012*
Kanchan	0.088	-4.081**	-3.356**	0.791**	-0.201*	-0.184	0.0007	-0.220**	-1.239**	0.378**	-3.052**	3.5523**	0.5028**	0.3017**	-0.404**	0.005
Tobios-6	-0.156	4.871**	3.711**	0.193*	-0.162	-0.122	-0.124*	-0.031*	-0.028	0.217	1.0048	1.8633*	0.3002*	0.1801*	0.361**	-0.003
FCH-222	-0.340	0.844*	5.767**	-0.273	0.017	0.484**	-0.121*	0.057*	0.917*	-0.311	1.2041*	2.9941*	0.4358*	0.2615*	-0.098	0.043**
(gi) SEm±	0.9702	0.6051	0.4288	0.2164	0.0985	0.1345	0.0924	0.1756	0.4192	0.2223	1.9148	2.2304	0.2676	0.1605	0.2224	0.0149
CD at 5 %	3.864	2.409	1.708	0.862	0.392	0.536	0.368	0.699	1.670	0.885	7.6257	8.8825	1.0659	0.6395	0.886	0.059
CD at 1%	6.060	3.779	2.679	1.352	0.615	0.840	0.578	1.097	2.619	1.389	11.9615	13.9330	1.6719	1.0031	1.389	0.093

*- Significant at 5 per cent probability, ** - Significant at 1 per cent probability

Table.3 Number of parents and crosses showing significant GCA and SCA effects to the positive and negative directions and ranges

Sl No.	Characters	No. of parents with GCA effects				No. of hybrids with SCA effects			
		Positive	Negative	Total	Range	Positive	Negative	Total	Range
1	Days to 50 per cent flowering	2	1	3	-2.279 to 1.513	8	8	16	-40.007 to 11.829
2	Days to maturity	3	2	5	-4.081 to 4.871	8	14	22	-20.73 to 9.7
3	Plant height (cm)	2	4	6	-3.356 to 5.767	12	14	26	-27.233 to 19
4	Chlorophyll Content	3	1	4	-1.002 to 0.791	7	5	12	-1.5933 to 2.26
5	Specific leaf weight (mg/cm^2)	1	2	3	-0.31 to 0.145	11	5	16	-0.9 to 0.6866
6	Stem girth (mm)	1	0	1	-0.184 to 0.484	11	10	21	-1.914 to 1.671
7	Internodal distance (cm)	1	3	4	-2.119 to 0.4807	6	6	12	-0.9046 to 0.51
8	Number of leaves/plant	2	4	6	-0.22 to 0.269	9	2	11	-0.7 to 1.4
9	Leaf length (cm)	2	2	4	-1.239 to 1.1	5	9	14	-5.833 to 1.95
10	Leaf breadth (cm)	2	1	3	-0.722 to 0.378	8	11	19	-3.2 to 2.133
11	Leaf area (dm^2)	2	2	4	-3.0525 to 2.7620	7	9	16	-13.84 to 11.194
12	Green leaf yield (q/ha)	3	1	4	-5.1048 to 3.5523	7	7	14	-28.454 to 8.1662
13	Cured leaf yield (q/ha)	3	1	4	-0.7657 to 0.5028	12	7	19	-4.2201 to 1.445
14	Top grade equivalent (q/ha)	3	1	4	-0.4594 to 0.3017	8	10	18	-2.5321 to 0.8187
15	Reducing Sugar (%)	2	2	4	-0.404 to 0.361	11	7	18	-1.232 to 0.954
16	Nicotine Content (%)	2	2	4	-0.029 to 0.043	5	5	10	-0.08 to 0.072

Table.4 Performance of top ten superior experimental hybrids over check with respect to per se value of sixteen characters in FCV tobacco

Experimental Hybrids	DFF	DM	PH	CC	SLW	SG	ID	NLP	LL	LB	LA	GLY	CLY	TGE	RS	NIC
6 x 1	129.53	189.06	189.93	15.01**	4.98	23.89	4.20**	12.26	47.86	25.46	94.366	141.7093	17.0051	10.2030	12.6	1.00
3 x 1	119.00**	162.06**	163.33	15.22**	5.99	24.20	4.03**	13.26**	49.13	27.26**	112.486**	139.7407	16.7688	10.0613	11.2	1.07
2 x 1	108.06**	170.26	147.66	14.51	6.01	24.70	4.03**	13.33**	39.46	25.93	88.376	137.4793	16.4975	9.8985	11.6	1.01
4 x 1	124.36	158.40**	161.73	14.63**	5.08	24.01	4.04**	11.80	49.53	27.20**	100.389	136.9820	16.4378	9.8627	12.6	0.98
6 x 2	133.66	183.80	185.86	13.30	5.52	25.87	4.09**	12.53**	48.26	24.33	93.517	134.3467	16.1216	9.6729	11.8	1.10
2 x 4	114.76*	148.80**	170.53	16.20**	5.55	23.92	4.04**	12.53**	45.73	27.33**	98.941	133.8807	16.0656	9.6394	12.6	1.04
5 x 1	124.60	170.73	173.33	15.30**	5.23	25.60	3.86**	11.73	49.60	27.13**	100.338	133.0213	15.9625	9.5775	13.7	0.95
5 x 3	124.86	185.66	166.86	12.98	4.54	23.31	3.96**	12.66**	47.66	26.53**	101.142	130.3627	15.6435	9.3861	12.1	0.94
1 x 4	127.5	157.63**	170.46	17.01**	5.80	25.44	4.16**	14.60**	37.86	22.06	76.335	129.1413	15.4969	9.2981	12.4	1.03
1 x 5	118.63**	148.33**	174.40	16.08**	6.14	22.17	3.99**	13.26**	43.13	23.66	86.380	128.378	15.4053	9.2432	12.6	1.04
Mean	**122.496**	**167.473**	**170.409**	**15.024**	**5.484**	**24.311**	**4.04**	**12.796**	**45.822**	**25.686**	**95.227**	**134.5042**	**16.1405**	**9.6843**	**12.32**	**1.013**
Check (Kanchan)	**123.333**	**172.467**	**150.40**	**16.80**	**5.68**	**25.41**	**4.54**	**11.80**	**44.20**	**26.13**	**56.043**	**122.397**	**14.688**	**8.813**	**10.5**	**1.02**

* - Significant at 5 per cent level, ** - Significant at 1 per cent level

Where,

DFF - Days to 50 per cent flowering
DM - Days to maturity
PH - Plant height (cm)
CC - Chlorophyll Content
SLW - Specific leaf weight (mg/cm^2)
SG - Stem girth (mm)

ID - Internodal distance (cm)
NLP - Number of leaves plant
LL - Leaf length (cm)
LB - Leaf breadth (cm)
LA - Leaf area (dm^2)
GLY - Green leaf yield (q/ha)

CLY - Cured leaf yield (q/ha)
TGE - Top grade equivalent (q/ha)
RS - Reducing Sugar (%)
NIC - Nicotine Content (%)

The Parent-1 *i.e.* Bhavya and Parent-4 *i.e.* Kanchan were highly significant in the un-favorable direction (Table 2). Nine crosses exhibited significant negative sca effect (Table 3). Similar results of GCA and SCA effects by Dubey (1976), Patel *et al.,* (2005) and Gopal *et al.,* (2016).

Total Cured leaf yield is one of the important yield contributing traits in FCV tobacco. Out of six parents, Parent-4 *i.e.* Kanchan, Parent-6 *i.e.* FCH-222 and Parent-5 *i.e.* Tobios-6 exhibited significant positive GCA effects. Whereas Parent-2 *i.e*. FCV-Special exhibited significant negative effect (Table 2). The significant SCA effects were observed for nineteen hybrids among the thirty crosses, of which twelve hybrids exhibited positive and the remaining seven hybrids exhibited negative effects for cured leaf yield. Similar reports made by Dubey (1976), Jadeja *et al.,* (1984), Patel *et al.,* (2005), Lohitha *et al.,* (2010), Aleksoska and Aleksoski (2012), Ramachandra *et al.,* (2015), Gopal *et al.,* (2016) and Katba *et al.,* (2017).

The combining ability studies indicated high proportions of SCA variances than GCA variances. Study on combining ability variance revealed that non-additive gene action was predominant for all the traits studied and these traits can be improved for combining ability through recurrent selection schemes or heterosis breeding. These hybrids would be advantageous for production and quality improvement.

The crosses 6 x 1, 3 x 1, 2 x 1, 4 x 1, 6 x 2, 2 x 4, 5 x 1, 5 x 3, 1 x 4 and 1 x 5 were the superior hybrids selected for total cured leaf yield since these crosses exhibited significant gca and sca effects for total cured leaf yield (Table 4). Ten promising single cross hybrids identified for leaf yield (cured leaf yield) need to be tested in multi-locations trials for their stability across locations/seasons on large scale basis before their commercial utilization. Promising single crosses having good general combining parents can be used for further improvement of parents in later generations. Selected parents with desirable *per se* and combining ability effect can be used in multiple crossing schemes to recombine different productivity components.

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