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STUDIES ON COMBINING ABILITY AND HETEROSIS FOR YIELD AND ITS COMPONENT TRAITS IN FLUE CURED VIRGINIA (FCV) TOBACCO (*NICOTIANA TABACCUM* L.)

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Flue Cured Virginia tobacco (FCV) is an export oriented important commercial crop grown in India. In Karnataka, due to unexpected climate changes and ever increasing cost of cultivation, there is constant reduction in the profitability of tobacco cultivation. Estimating combining ability and heterosis of the parental lines is very important in the development of cultivars with high yield with desirable qualities. Seven advanced breeding lines/ varieties were used to synthesize twenty one half diallel crosses, which were evaluated in a replicated trial for two seasons *(kharif* of 2016 and 2017). The diallel analysis of variance of two seasons revealed significance of both gca and sca for plant height, green leaf yield and cured leaf yield indicating preponderance of both additive and non additive gene actions. Variety, FCH 222 recorded highest positive gca effect for plant height, cured leaf and bright leaf yield. With respect to specific combining ability (sca), very few cross combinations recorded significant positive sca effect for yield and yield related characters. Only two crosses, JL-32#2 × FCH 249 and Kanchan × JL-32#2 recorded positive sca values for cured leaf yield. Mid parent heterosis was not significant in desirable direction for plant height, number of leaves, bright leaf yield and TGE, however, the cross, JL 53#2 × FCH 249 recorded significant positive mid parent heterosis for green leaf yield and cured leaf yield. The better general and specific combiners identified in the study can be utilised in the future breeding programs.

INTRODUCTION

FCV tobacco (*Nicotiana tobaccum* L) is an export oriented important commercial crop grown in India. It is predominately cultivated in the states of Karnataka and Andhra Pradesh. In Karnataka it is cultivated in the southern transitional zones during *Kharif* season under rain fed conditions. It occupies around 85,000-90,000 ha with production ranging from 90-100 m kg. FCV tobacco in KLS is valued for its potential to generate farm income to many small and marginal farmers and employment to farm labourers. However, due to unexpected climate changes, ever increasing cost of cultivation including labour shortage, there is constant reduction in the profitability of tobacco. Apart from these, regulation on area under tobacco owing to Framework Convention on Tobacco Control (FCTC) and also in view of continued negative perception, enhancing productivity through development of high yielding varieties/hybrids with desirable qualities is the only logical option to sustain tobacco growers and to meet export demand. Earlier, development of hybrids in FCV tobacco suffered set back compared to other non FCV tobacco owing to low level heterosis and exacting quality restrictions by trade. Prasannasimharao *et al.*, 1993 reported higher and significant gca for FCV tobacco yield and major yield components. However, with the development of high yielding varieties, advanced breeding lines and cytoplasmic male sterile lines, small but significant heterosis was observed in FCV tobacco (Ramana rao *et al.*, 1993; Megha Ganachari *et al.*, 2018) which can be exploited to develop hybrids. Estimating the combining abilities and heterosis for yield in the breeding materials is essential in tobacco improvement programme. In order to estimate combining abilities and heterosis seven advanced breeding lines/varieties were used to synthesize twenty one half diallel crosses. The resulting twenty one crosses and seven parents were evaluated in a replicated trial for two seasons *(kharif* of 2016 and 2017) at ICAR-Central Tobacco Research Institute, Research Station, Hunsur, Karnataka.

MATERIALS AND METHODS

Seven advanced breeding lines/varieties *viz.*, FCH 222, Kanchan, NLST 3, FCH 201, JL 53#12, FCH 239 and FCH 249 (Table 1) were crossed in a half diallele mating design to produce twenty-one crosses during 2015 *kharif* season. These 21

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crosses were evaluated along with parents in a randomised bock design for two seasons (2016-17 &2017-18) with three replications with spacing of 100 × 55 cm and 24 plants per plot at ICAR-CTRI research Station, Hunsur. Data was recorded on plant height, number of leaves, green leaf yield, cured leaf yield and bright leaf yield and was subjected to the statistical analysis. Combining ability analysis was done according to Method 2 and model 1 by Griffing (1956) in INDOSTAT and mid parent (MP) heterosis was estimated as MP = $(F_1\text{-MP})/\text{MP}\times100$.

Table 1: Description of varieties/lines used in crossing program

Sl No.	Variety/line	Salient features
1	FCH 222	A wilt resistant medium cast high yielding variety with higher bright grade yield
2	Kanchan	A high yielding dark cast popular variety
3	NLST 3	A medium to dark cast advanced breeding lines with high yield
4	FCH 201	A light to medium cast high yielding line with higher bright grade yield
5	JL 53#12	A dark cast line with short internodes and thick and puckered leaves
6	FCH 239	A medium cast high yielding line
7	FCH 249	A medium cast high yielding line

RESULTS AND DISCUSSION

The performance of parents and their crosses for yield and yield attributing characters are presented in Table 2 revealed that the plant height ranged from 88.67cm (JL 53#2) to 100.61cm (FCH22) among the parents and among crosses it ranged from 93.39cm (FCH222 × NLST3) to 101.68 (Kanchan × FCH239). Number of leaves per plant were in the range of 22 (FCH 249) to 23 (FCH 222) in parents and 22 (NLST3 × JL53#2) to 24 (Kanchan × FCH 239) in crosses. The green leaf yield varied from 735gm (FCH249) to 922 gm (NLST3) among parents and in crosses it varied from 857gm (Kanchan ×FCH249) to 999 gm (FCH22 × Kanchan and FCH 222× FCH 239). The highest mean value of cured leaf was 127gm (FCH 222 and FCH 239) and lowest was 121 gm (FCH249) among the parents. Among crosses, cured leaf yield ranged from 115 gm (Kanchan × FCH249) and 135 gm (FCH 222 × FCH 239). Among parents bright leaf yield and TGE was lowest in FCH 249 (71gm & 77) and highest bright leaf was recorded in Kanchan (88gm) while, highest TGE in NLST3 (92). Among crosses bright leaf yield ranged from 80gm (FCH 201× FCH249) to 90gm in (FCH222 × FCH239). The TGE among the crosses varied from 84 (FCH201 × Kanchan) to 97 (FCH 222 × FCH239).

The diallel analysis of variance of two seasons (Table 3) revealed significance of both gca and sca for characters like plant height, green leaf yield, cured leaf yield. However, for number of leaves only sca values were significant and for bright leaf yield and TGE only gca values were significant. Significance of both gca and sca values indicate preponderance of both additive and non additive gene action while significance of gca indicate preponderance of additive gene action and significance of sca indicate preponderance of non-additive gene action. Similar reports on significance of both gca and sca effects for yield and its attributing characters were reported by Aleksoka and Aleksoski (2012); Gopal *et.al.*, (2016) and Megha Ganachari *et.al.*, (2019).

Variety FCH 222 recorded highest positive gca effect for plant height, cured leaf and bright leaf yield (Table 4) and thus can be used as a good general combiner in improving these traits. While line, JL53#2 exhibited significant negative gca effects for plant height and can be used as parent to develop plants with short internodes which is a desirable trait. Line FCH 239 also exhibited significant positive gca effects for cured leaf yield. Similar high and positive gca values of variety FCH 222 for characters plant height and green leaf yield was reported by Megha Ganachari *et al.*, (2019) but the results of high gca values for bright leaf yield and non significant sca values for TGE is contrary to the results of Megha Ganachari *et al.*, (2019).

Out of the 21 crosses studied, very few cross combinations recorded significant positive sca effect for yield and yield related characters (Table 5). Only one cross combination FCH 201× FCH

Table 2: Mean performance of parents and their crosses for yield and yield attributing traits

Traits	Plant Height (cm)	No. of leaves	Green Leaf Yield (g/plant)	Cured Leaf Yield (g/plant)	Bright Leaf Yield (g/plant)	TGE
Parents						
FCH 222	100.61	23.11	940	127	87	91
NLST 3	90.67	22.22	922	125	87	92
FCH 201	91.96	22.06	882	125	84	91
Kanchan	95.38	21.66	893	123	88	91
JL 53#2	88.67	22.28	878	121	82	88
FCH 249	91.51	22.05	735	101	71	77
FCH 239	93.44	22.22	956	127	82	88
Mean	93.18	22.23	886.57	121.27	83.00	88.27
SE±	1.47	0.17	23.92	3.01	1.91	1.71
Range	88.67-100.61	22-24	735-956	101-127	71-88	77-92
Crosses						
FCH 222 × NLST-3	93.39	22.77	959	129	87	93
FCH 222 × FCH 201	98.17	22.33	901	125	85	91
FCH 222 × Kanchan	100.17	23.28	999	132	86	94
FCH 222 × JL 35#2	102.17	22.18	956	128	81	88
FCH 222 × FCH 249	102.89	23.45	911	126	81	89
FCH 222 × FCH 239	104.28	23.01	999	135	90	97
NLST-3 × FCH 201	100.27	23.38	963	132	83	92
NLST-3 × Kanchan	101.28	23.27	949	130	88	94
NLST-3 × JL 35#2	92.22	21.78	963	122	81	87
NLST-3 × FCH 249	95.67	22.06	899	120	79	86
NLST-3 × FCH 239	100.72	23.61	903	125	87	90
FCH 201 × Kanchan	97.43	22.39	868	118	78	84
FCH 201 × JL 35#2	100.38	23.49	911	121	79	86
FCH 201 × FCH 249	108.67	23.01	935	125	80	89
FCH 201 × FCH 239	95.99	20.56	942	131	87	94
Kanchan × JL 35#2	93.72	21.83	971	133	86	94
Kanchan × FCH 249	93.82	22.56	857	115	76	82
Kanchan × FCH 239	101.68	23.77	950	127	84	91
JL 35#2 × FCH 249	94.72	22.23	917	127	83	88
JL 35#2 × FCH 239	96.62	22.4	920	124	83	90
FCH 249 × FCH 239	96.66	22.34	911	128	87	93
Mean	98.62	22.65	932.57	126.33	83.38	90.10
SE±	0.91	0.17	8.27	1.12	0.82	0.83
Range	92.22-108.67	22-24	857-999	115-135	76-90	82-97

Table 3: ANOVA for combining ability for yield and yield components

	DF	Plant Height	No. of leaves	Green Leaf Yield	Cured Leaf Yield	Bright Leaf Yield	TGE
GCA	6	47.485*	0.599	0.012**	0.001**	0.001**	0.001**
SCA	21	42.742*	1.261*	0.003*	0.001*	0.0001	0 .0001
Environments	1	6958.771**	5.762**	0.255**	0.007**	0.002**	0.004**
GCA(Environments)	6	33.801	1.214	0.01**	0.001**	0.001*	0 .0001
SCA(Environments)	21	31.118	1.055	0.002	0 .0001	0 .0001	0 .0001
Error	108	21.295	0.719	0.002	0 .0001	0 .0001	0 .0001

Note:* Significant at p=0.05 ** Significant at p=0.01

Table 4: General combining ability (gca) effects for yield and yield components

Parents	Plant Height	No. of leaves	Green Leaf Yield	Cured Leaf Yield	Bright Leaf Yield	TGE
FCH 222	2.705**	0.356	-0.059	0.026**	0.003**	0.002
NLST 3	-1.445	0.056	0.667	0.012	0.001	0.001
FCH 201	0.802	-0.133	0.65	-0.009	0	-0.001
Kanchan	0.057	0.036	-0.448	0.001	0	0.001
JL 53#2	-2.334*	-0.212	-0.557	0.003	-0.001	-0.001
FCH 249	-0.285	-0.064	-0.535	-0.052**	-0.006**	-0.004**
FCH 239	0.5	-0.04	0.019	0.003*	0.002	0.002

Note:* Significant at p=0.05 ** Significant at p=0.01

Table 5: Specific combining ability (sca) effects for yield and yield components

Crosses	Plant Height	No. of leaves	Green Leaf Yield	Cured Leaf Yield	Bright Leaf Yield	TGE
FCH 222 × NLST-3	-5.067	3.494*	-0.002	0.0001	0.0001	0.0001
FCH 222 × FCH 201	-2.48	-2.506	-0.035	-0.004	0.001	-0.001
FCH 222 × Kanchan	0.148	1.043	0.049	0.003	0.0001	0.002
FCH 222 × JL 35#2	4.372	-1.281	0.006	0.0001	-0.003	-0.003
FCH 222 × FCH 249	3.157	4.296**	0.018	0.004	0.0001	0.001
FCH 222 × FCH 239	3.872	-3.02*	0.033	0.005	0.003	0.004
NLST-3 × FCH 201	3.653	2.552	0.039	0.006	-0.001	0.002
NLST-3 × Kanchan	5.464	-2.683	0.015	0.004	0.003	0.003
NLST-3 × JL 35#2	-1.145	0.159	0.025	-0.003	-0.002	-0.003
NLST-3 × FCH 249	0.14	-0.363	0.015	0.001	-0.001	-0.001
NLST-3 × FCH 239	4.355	1.87	-0.049	-0.004	0.001	-0.002
FCH 201 × Kanchan	-0.682	-0.05	-0.047	-0.007	-0.005	-0.006*
FCH 201 × JL 35#2	4.709	1.943	-0.005	-0.004	-0.002	-0.002
FCH 201 × FCH 249	10.894**	-0.013	0.077**	0.006	0.001	0.004
FCH 201 × FCH 239	-2.508	-0.063	0.011	0.003	0.003	0.003
Kanchan × JL 35#2	-1.263	1.041	0.046	0.008*	0.002	0.005
Kanchan × FCH 249	-3.212	1.919	-0.012	-0.004	-0.004	-0.004
Kanchan × FCH 239	3.753	-1.798	0.008	-0.001	-0.002	-0.001
JL 35#2 × FCH 249	0.079	0.244	0.046	0.009*	0.005	0.004
JL 35#2 × FCH 239	1.194	-0.972	-0.021	-0.003	-0.001	0
FCH 249 × FCH 239	-0.921	-0.094	0.024	0.007	0.006*	0.005

Note:* Significant at p=0.05 ** Significant at p=0.01

249 recorded significant positive sca values for plant height and green leaf yield. Two crosses FCH-222 × NLST-3 and FCH 222 × FCH 249 recorded positive sca values for number of leaves. Similarly crosses JL-32#2 × FCH 249 and Kanchan × JL-32#2 recorded positive sca values for cured leaf yield. Only one cross FCH 249 × FCH 239 exhibited positive sca values for bright leaf yield indicating that these cross combinations are governed by non additive gene effects and can be utilised for developing hybrids for specific characters. No single cross exhibited significant positive sca effects for

Table 6: Mid parent heterosis for yield and yield components

Crosses	Plant Height	No. of leaves	Green Leaf Yield	Cured Leaf Yield	Bright Leaf Yield	TGE
FCH 222 × NLST-3	-2.32	0.96	2.86	2.11	-0.1	1.46
FCH 222 × FCH 201	1.99	-1.36	-0.91	-1.19	-0.39	-0.09
FCH 222 × Kanchan	2.25	3.97	8.81	4.91	-1.9	3.39
FCH 222 × JL 35#2	7.77	-2.27	5.22	3.16	-3.65	-1.58
FCH 222 × FCH 249	6.96	4.46	9.16	9.99	2.21	5.86
FCH 222 × FCH 239	7.53	1.14	5.45	6.61	5.7	7.91
NLST-3 × FCH 201	9.74	4.86	6.64	5.06	-2.83	1.37
NLST-3 × Kanchan	9	5.81	4.49	4.7	0.86	3.01
NLST-3 × JL 35#2	3	-2.62	6.75	-0.75	-3.56	-2.7
NLST-3 × FCH 249	4.96	-0.49	8.25	6.57	0	2.08
NLST-3 × FCH 239	9.39	6.65	-3.9	-1.26	3.05	0.84
FCH 201 × Kanchan	4.02	2.66	-2.53	-4.95	-8.9	-7.34
FCH 201 × JL 35#2	11.17	6.19	3.31	-2.1	-4.32	-2.99
FCH 201 × FCH 249	18.32**	3.92	15.88*	10.38*	2.9	6.77
FCH 201 × FCH 239	3.59	-7.74*	2.36	3.76	4.6	5.41
Kanchan × JL 35#2	1.93	-0.64	9.59	8.81	0.69	5.22
Kanchan × FCH 249	0.4	3.58	5.42	2.6	-4.91	-1.59
Kanchan × FCH 239	7.68	8.19	2.61	1.13	-1.75	1.68
JL 35#2 × FCH 249	5.1	-0.34	13.96*	14.44*	8.93	7.51
JL 35#2 × FCH 239	6.17	0.56	0.45	0.4	0.51	2.28
FCH 249 × FCH 239	4.38	1.43	7.89	12.13*	13.33	12.35

Note:* Significant at p=0.05 ** Significant at p=0.01

plant height, number of leaves and yield indicating distribution of yield related alleles among different parents. Similar results were reported by Megha Ganachari *et al.*, (2019), Patel *et al.*, (2005), Aleksoska and Aleksoski (2012) *etc.*,

Mid parent heterosis was not significant in desirable direction for plant height, number of leaves, bright leaf yield and TGE (Table 6). However, two crosses *viz.*, FCH 201 × FCH 249 and JL 53#2 × FCH 249 recorded significant positive mid parent heterosis for green leaf yield (15.08 & 10.38) and cured leaf yield (13.96 & 14.44) respectively. Cross FCH 249 × FCH 239 (12.13) also registered significant positive mid parent heterosis for cured leaf yield.

Marginal mid-parent heterosis could be attributed to the lack of distinct and distant genetic relationship between the lines used in the crosses. The scope for use of distinct and distant lines in tobacco is limited by the strict imposition of leaf quality by trade. Similar results were reported by Gopinath *et al.*, 1966 and 1967.

From the present study, FCH 222 was identified as better general combiner for yield and can be used in multiple crossing program to develop high yielding varieties. Cross combinations like FCH-222 × NLST-3 and FCH 222 × FCH 249 were better specific combiners for number of leaves and crosses JL-32#2 × FCH 249 and Kanchan × JL-32#2 were better specific combiners for cured leaf yield.

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