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Studies on general combining ability, specific combining ability, heterosis and their relationship in FCV tobacco (*Nicotiana tabacum* L.)

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Abstract: *An investigation was carried out to evaluate seven lines and four testers to asses combining ability using Line × Tester mating design. The 28 hybrids along with 11 parents were grown in a randomized block design with three replications at Zonal Agricultural Research Station, Navile, Shimoga, during Kharif 2007. Overall status of a parent or cross with respect to gca and sca/heterosis respectively was determined following a method suggested by Arunachalam and Bandopadyaya (1979) and modified by Mohan Rao et al. (2004). Combining ability analysis and the heterosis, mid parent heterosis and standard heterosis (taking Kanchan as standard parent) an attempt was made to deduce a systematic relationship if any between gca, sca and heterosis. It was interesting to note that, given a cross with high overall sca status, the probability of it to be a H × L and H × H combination was higher than the probability of finding it to be a L × L. Similarly for heterosis, given a cross with high overall heterotic status, the probability of it to be an H × L and H × H combination was higher than the probability of finding it to be an L × L. Thus the present study clearly established the superiority of H × L and H × H category of crosses. Whenever a female parent with high gca status was involved, it produced crosses with high overall sca/heterotic status over a number of characters. This suggested the ability of these female parents in transmitting additive alleles with increasing effects to their progeny, again suggesting the emphasis to be laid on the gca effects for the selection of parents for hybridization. It is worthwhile to start with H × L and H × H for realizing hybrids with high heterosis and sca effects.*

Key words: General combining ability, specific combining ability, tobacco, *Nicotiana tabaccum*

INTRODUCTION

Tobacco is one among the commercial crops of national importance after sugar cane and cotton. It has been playing a prominent role in the development of nation's economy. More than 98% of the area under FCV tobacco is in Andhra Pradesh and Karnataka. 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. Even though FCV tobacco is growing in Karnataka yield levels are lower than the national average. To achieve this, heterosis breeding is one of the tools which can be effectively used to improve yield. In this context, it is worth mentioning the role of combining ability concept, which reiterates the importance of choosing suitable parents to nick well in the expression of heterosis. Thus the evaluation of genotypes for their nicking ability is a prerequisite 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. Further, predicting the magnitude and frequency of heterotic hybrids assumes greater importance. Under these premise the present investigation was undertaken.

MATERIAL AND METHOD

The experimental material consisted of seven females and four males crossed in Line × Tester design to generate 28 hybrids. The experiment was laid out in a Randomized Block Design with three replications at the Zonal Agricultural Research Station, Navile, Shimoga, during *kharif* 2007. The observations were recorded on sixteen morphometric traits in five plants selected randomly for each genotype and the average value was computed. Heterosis, mid parent heterosis and standard heterosis (taking Kanchan as standard parent) were estimated as per standard formulae in vogue and the mid parent heterosis values were used to calculate the overall status of a parent or cross with respect to gca and sca/heterosis. Combining ability analysis was done according to Kempthrone (1957).

Overall gca status of parents, sca and heterotic status of crosses

Since yield and its component characters are correlated either positively or negatively, it is usual to find, for particular parent and cross gca and sca/heterosis, respectively in the desirable direction for some character and undesirable direction for the others. The problem of ascertaining the status of a parent with respect to gca and sca/heterosis for crosses over a number of characters assumes importance under present context. Therefore, overall status of a parent or cross with respect to gca and sca/heterosis respectively was determined following a method suggested by Arunachalam and Bandopadyaya (1979) and modified by Mohan Rao *et al*. (2004).

General combining ability effects of parents, specific combining ability effects and estimates of mid parent heterosis (MPH) of crosses were ranked by giving highest rank for the parent or a cross which manifested highest gca effects and sca effects or heterosis, respectively. The lowest rank was given for parents or the cross with lowest gca effects and sca effects or heterosis for a character, respectively. This was repeated for all characters except for days to 50 percent, midrib to lamina ratio and nicotine per cent, ranking was given in a reverse order because parents or hybrids which are low value for these characters were required. The ranks obtained by parents/ crosses were summed up across all characters to arrive at total score for each of the parent or a cross. Further, the mean of the total scores thus obtained was used as the final norm to ascertain the status of a parent or a cross for their gca and sca/heterosis. The parents and crosses whose total rank exceeded the final norm were given as high (H) overall gca and sca/heterotic status, respectively. On the other hand, the parents or crosses which secured a total rank less than the final norm were given as low (L) overall gca and sca/heterotic status, respectively.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) revealed that mean squares due to parents, crosses and parents vs crosses (modified line × tester) were significant indicating the presence of substantial variation among the parents and also among hybrids thereby justifying that appropriate material has been involved in the research. Four out of seven lines viz,. KST-27, LV-2, KST-29 and SBS-1 and two of testers FCH-197 and KANCHAN had high (H) overall general combining ability status (Table 2), while the remaining parents had low (L) overall general combining ability status implying that 50 percent of the lines and testers were high over all general combiners suggesting their ability to transmit additive genes in desirable direction for the traits under study. The overall sca status of each hybrid was determined. From the results (Table 3), it is evident that 13 out of 28 hybrids had high (H) overall sca and the remaining had low (L) overall sca status across the traits. It was found that 50 percent, *i.e*., 14 out of 28 crosses (Table 4) were high (H) overall heterotic and the remaining had low (L) overall heterotic status across the traits. Based on overall gca effects, the crosses were classified into HH (both the parents in a cross with high overall gca status), HL (one parent with high and the other parent with low overall gca status) and LL (both the parents in a cross with low overall gca status).

Relationship between overall gca, sca and heterosis

Encouraged by a definite relationship between gca effects of parents with sca and heterosis of their crosses, an attempt was made to deduce systematic relationship if any between gca, sca and heterosis. The method suggested by Arunachalam and Bandopadyaya (1979) and modified by Mohan Rao *et al*. (2004) was used in the present investigation and employed to arrive at such a relationship.

A perusal of Table 5 indicated that the number of hybrids with high (H) overall specific combining ability status were more in H × H and H × L (both 5) than L × L (3) category of crosses. Conditional probability that a cross with high overall sca status is found in HH, HL or LL category was worked out. From the results, it was interesting to note that, given a cross with high overall sca status, the probability of it to be a H × L (0.38) and H × H (0.38) combination was higher than the probability of finding it to be a L × L (0.23). Similarly for heterosis, given a cross with high overall heterotic status, the probability of it to be a H × L (0.47) and H × H (0.47) combination was higher than the probability of finding it to be a L × L (0.07). Thus the present study clearly established the superiority of H × L and H × H category of crosses. This type of observation was also brought out by the studies of similar nature in *Brassica campestris* (Bandyopadhyay and Arunachalam, 1980), sesame (Ramesh *et. al.,* 2000) and in sunflower (Mohan Rao *et. al.,* 2004). It is worth mentioning here that, whenever a female parent with high gca status was involved, it produced crosses with high overall heterotic status over a number of characters. This suggested the ability of these female parents in transmitting additive alleles with increasing effects to their progeny, again suggesting the emphasis to be laid on the gca effects for the selection of parents for hybridization. Thus, the established superiority of H × L and H × H crosses, in the present study in producing crosses with high sca and heterotic status is of practical utility to a breeder, when he has to attempt successful hybridization economically in terms of time, cost and the number of crosses. It is worthwhile to start with H × L and H × H for realizing hybrids with high heterosis and sca effects.

Table 1: Analysis of variance for yield, quality and other quantitative traits in FCV tobacco

Source of variance	df	Plant height (cm)	Leaves per plant	Inter nodal length (cm)	Leaf Length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Days to 50% flowering	Green leaf yield ($t\ ha^{-1}$)
Replications	2	26	7.14	0.03	99.07	11.72	28192	24.0	5.34
Genotypes	38	1591**	27.16**	1.64**	99.79**	10.07**	48130**	314.7**	12.21**
Parents	10	1945**	26.75**	1.09**	133.1**	9.06**	55580**	237.5**	8.63**
Crosses	27	1500**	28.29**	1.87**	83.54**	10.21**	43155**	339.8**	13.19**
Parents vs. Crosses	1	511**	0.91	0.73**	206.2**	16.24*	107946**	412.2**	21.42**
Lines	6	2764*	38.70	2.02	59.48**	17.95**	48408	619.6**	21.91
Testers	3	1658**	45.64	3.68	176.6**	9.09*	77820**	219.8**	14.22
Line × Testers	18	1052**	21.93**	1.52**	76.05**	7.82**	35627**	266.5**	10.11**
Error	76	19	0.89	0.02	2.41	2.69	3125	2.7	0.02

Source of variance	df	Cured leaf yield ($t\ ha^{-1}$)	Top grade equivalent ($t\ ha^{-1}$)	Midrib to lamina Ratio		Nicotine (%)		Reducing sugar (%)	
				X leaves	L leaves	X leaves	L leaves	X leaves	L leaves
Replications	2	0.01	3417	0.006	0.009	0.64	0.01	8.60	7.38
Genotypes	38	0.23**	34579**	0.031**	0.034**	1.36**	0.39**	8.74**	10.39**
Parents	10	0.17	30382**	0.037**	0.014**	0.03	0.07	9.19	6.36**
crosses	27	0.24*	34529**	0.030**	0.042**	1.35**	0.45**	8.87**	11.61**
Parents vs. Crosses	1	0.42**	77885**	0.011*	0.012*	14.89**	1.80**	0.59	17.85**
Lines	6	0.40	54598	0.029**	0.043**	1.50**	0.44**	10.94**	22.96*
Testers	3	0.26	31409	0.023**	0.023**	1.74**	0.69**	6.69**	3.14
Line × Testers	18	0.18**	28360**	0.031**	0.045**	1.24**	0.42**	8.54**	9.23**
Error	76	0.01	16	0.002	0.003	0.02	0.04	0.33	1.02

*significant at P= 0.05 level **significant at P= 0.01 level

Table 2: Overall general combining ability status of parents in FCV tobacco

Lines	Total rank	Overall GCA status
KST-29	77	H
SBS-1	69	H
SMG-02-4-9	55	L
SMG-02-1-6	27	L
SMG-02-1-3	49	L
LV-2	78	H
KST-27	93	H

Final norm: 64

Testers	Total rank	Overall GCA status
FCH-197	58	H
A-1	29	L
A-3	33	L
KANCHAN	40	H

Final norm: 40

Table 3: Overall specific combining ability status of hybrids in FCV tobacco

Testers Lines	FCH-197 (H)	A-1 (L)	A-3 (L)	KANCHAN (H)
KST-29 (H)	H (340)	L (194)	L (125)	H (256)
SBS-1 (H)	L (213)	L (219)	H (255)	H (256)
SMG-02-4-9 (L)	H (334)	L (160)	L (186)	L (224)
SMG-02-1-6 (L)	L (147)	H (343)	H (276)	L (159)
SMG-02-1-3 (L)	L (132)	H (309)	L (169)	L (197)
LV-2 (H)	L (173)	L (167)	H (354)	H (234)
KST-27 (H)	H (367)	L (126)	H (292)	H (287)

Values in the parenthesis indicate total score secured by the crosses across 16 traits

Final norm: 231.93

H: Overall high combiner L: Overall low combiner

(H): overall high general combiner (L): overall low general combiner

Table 4: Overall heterotic status of hybrids in FCV tobacco

Values in the parenthesis indicate total score secured by the crosses across 16 traits

Testers Lines	FCH-197 (H)	A-1 (L)	A-3 (L)	KANCHAN (H)
KST-29 (H)	H (336)	L (225)	L (159)	H (243)
SBS-1 (H)	H (270)	H 269	H 306	H 269
SMG-02-4-9 (L)	H (254)	L (122)	L (157)	L (135)
SMG-02-1-6 (L)	L (132)	L (207)	L (189)	L (104)
SMG-02-1-3 (L)	L (164)	H (309)	L (140)	L (150)
LV-2 (H)	H (276)	L (225)	H (364)	H (267)
KST-27 (H)	H (324)	H (232)	H (343)	H (320)

Final norm: 231.82

(H): overall high general combine (L): overall low general combiner

H: overall high specific combiner L: overall low specific combiner

Table 5: Distribution of heterotic crosses in relation to overall gca of parents and sca of crosses in FCV tobacco

Parental GCA	Number of crosses under the category	Number of crosses with high overall sca status	Number of crosses with high overall heterotic status	Conditional probability of given cross belonging to high sca status	Conditional probability of given cross belonging to high heterotic status
H × H	8	5	7	0.38	0.47
H × L or L× H	14	5	7	0.38	0.47
L × L	6	3	1	0.23	0.07

H × H: Both the parents are high in their overall general combining ability
H × L: one parent is high and the other low in their overall general combining ability
L × L: Both the parents are low in their overall general combining ability

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