Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(1): 399-404
Received: 20-11-2016
Accepted: 21-12-2016

PJ Katba
Department of Genetics and Plant Breeding, B. A. College of Agriculture Anand Agricultural University, Anand, Gujarat, India.

RG Hadiya
Department of Genetics and Plant Breeding, B. A. College of Agriculture Anand Agricultural University, Anand, Gujarat, India.

VN Kapadia
Department of Genetics and Plant Breeding, B. A. College of Agriculture Anand Agricultural University, Anand, Gujarat, India.

DC Patel
Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat, India.

AD Patel
Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat, India.

Correspondence
PJ Katba
Department of Genetics and Plant Breeding, B. A. College of Agriculture Anand Agricultural University, Anand, Gujarat, India.

Genetics studies on yield and pharmaceutical quality parameters in tobacco (*Nicotiana rustica* L.)

PJ Katba, RG Hadiya, VN Kapadia, DC Patel and AD Patel

Abstract
Tobacco is one of the world's creditable crops. This relevant study significant and desirable determine of variability due variance of specific combining ability (sca) suspend significantly for all the traits under study indicating the importance of non-additive gene action for the inheritance of these characters. As variance due to both GCA and SCA were found significant for most of the character appeared to be under the influence of both additive and non-additive gene actions. The estimates of gca effects suggested those parents, GC 1, AR 72, Motihari Hemti and Sel.15-16 were good general combiners for cured leaf yield and its related attributes. The estimates of sca effects indicated that the cross GC 1, AR 72, Motihari Hemti and Sel.15-16 were the most promising for cured leaf yield and some of its related traits. The success of any breeding programme largely depends on choice of parents and breeding procedure adopted. Persistent efforts are being made to improve yield and yield contributing characters in tobacco through hybridization.

Keywords: Tobacco, combining ability, gca & sca, *Nicotiana* spp.

1. Introduction

Tobacco is one of the industrial important crops in the world. It has varies from uses of quality *e. g.*, flue cured virginia, hookah, cigar, lanka and bidi *etc*. Bidi tobacco is more grown in Asian countries like India and Pakistan. The quality and prices of bidi tobacco is assessed based on the spangle score, nicotine content, chloride content reducing sugars and the ratios between reducing sugar to nicotine. The genetic enhancement work done very limited scale on the bidi tobacco. The experiment work conducted in Bidi Tobacco Research Station, Anand. Tobacco is also important cash crops status which it attained in India since 1930. The tobacco has more than 68 species of *Nicotiana spp.* available in the world from only two species are cultivable *viz*., *N. tabacum* L. and *N. rustica* L. Among them *N. tabacum* is practiced throughout the world, but that of *N. rustica* is restricted to India, Russia and other Asian countries. Different grades will be made in the market based on quality especially on the spangles score which gives sort of puckering and in turn also on appearance of golden colour which depends on content of nicotine and chloride.

2. Materials and Methods

The present investigation entitled combining ability analysis in tobacco (*N. rustica* L.) was undertaken at Bidi Tobacco Research Station, Anand Agricultural University, Anand during 2010-11. A line x tester analysis of 25 hybrids developed by crossing 5 lines with 5 testers lines along with parents [Table 1] was carried out for yield and its components. The variation existing in the hybrids was partitioned into portion attributed to lines, testers, lines x testers and error sources and one check AR 85 were grown in a randomized block design with three replications and observations were recorded for cured leaf yield per plant, days to flowering, number of leaves per plant, plant height, leaf length, leaf width, days to maturity, nicotine content and total reducing sugar content to get an estimate of performance of the material in middle Gujarat condition. The objectives of present investigations were to study gene action and combining ability effects. A line x tester analysis has been popular mating system to assess the combining ability of parents and crosses. From the various genetic designs, l x t mating design is also very useful for evaluation of crosses and parents for study of combining ability and effects and gene action. The l x t analysis has a distinct advantage for studying quantitative traits in segregating generations and it also requires relatively fewer individuals for an efficient estimation. The variation among hybrids was attributed to general combining ability (gca) and specific combining ability (sca) components [6]. Selection of appropriate parents is very crucial in any planned hybridization programme. Eventually, the lines, which produce good progenies on crossing, are of immense value for the plant breeder. In crop improvement programme, much of the success depends upon isolation of valuable gene combinations as determined in the form of lines with high combining ability. Similarly, the nature of gene action has a bearing on the development of efficient breeding procedures. The concept of general and specific combining ability as a measure of gene action [20]. The combining ability is an average performance of a line in hybrid combinations and can be recognized as a measure of additive gene action and specific combining ability is the deviation from expectation on the basis of average performance of lines involved and can be regarded as measure of non-additive gene action.

3. Result

3.1 Analysis of Variance for Combining Ability

Analysis of variance for combining ability revealed that the variance due to hybrids showed significant differences for all the characters except days to maturity [Table 2]. The mean squares due to females and mean squares due to males were generally highly significant for all the characters except days to maturity. The mean squares due to female x male interaction were observed to differ significantly for all the characters under study. A perusal of the estimates of component due to various sources revealed that variances due to females (σ^2_f) were highly significant for cured leaf yield per plant, days to flowering, number of leaves per plant, leaf width, Nicotine content and total reducing sugar content. Estimates of variance component due to males (σ^2_m) were found to be highly significant for all the traits except days to maturity. A comparison of the variance components due to lines and testers indicated that females exhibited higher magnitude of variability for number of leaves per plant, days to maturity, Nicotine content and total reducing sugar content. Variance estimates due to general combining ability (gca) were observed to be highly significant for most of the traits which revealed that these characters are governed by additive gene action. The estimates of variances due to specific combining ability (sca) differed significantly for all the characters indicating the importance of non-additive gene action for the inheritance of these traits. The ratio ($\sigma^2_{sca}/\sigma^2_{gca}$) below unity indicated that gca variance component was observed to be higher than respective sca variance component indicating the predominant role of additive gene action for the inheritance of these traits. The ratio ($\sigma^2_{sca}/\sigma^2_{gca}$) was found above the unity for all the characters, these indicating the predominant role of non-additive gene action for the inheritance of all these traits.

3.2 Gene action and combining ability effects

The character wise estimates of general combining ability effects for each parent and specific combining ability effects of hybrids. The salient features of general combining ability effects and specific combining ability effects of different characters are given below.

3.3 Cured leaf yield: The estimates of gca effects for cured leaf yield [Table 4] revealed that among females Motihari Hemti followed by AR 72 appeared as good general combiners as they depicted significant positive gca effects. Among testers Sel.15-16 exhibited highly significant positive gca effect indicating its superiority as a good general combiner for cured leaf yield. Among hybrids, 3 revealed highly significant and positive sca effects [Table 5] were GCT 4 X SK 49 followed by GCT 4 X Black Queen and GC 1 X Sel.15-16. An examination of magnitude of gca and sca variance [Table 3] for cured leaf yield indicated that both σ^2 gca and σ^2sca was highly significant revealing that this character is governed by both additive and non-additive gene action. However, the σ^2sca/ σ^2gca ratio revealed that there was preponderance of additive and non-additive gene action in the expression of this trait [1, 2, 9, 16-19].

3.4 Days to flowering: The estimate of gca effects for days to flower [Table 4] revealed that among females Motihari Hemti appeared as good general combiners as they displayed significant negative gca effect. Among male parents SK 49 followed by HDM 4 exhibited highly significant negative gca effect indicating their superiority as good combiner for early flowering. Among hybrids, estimates of sca effect for days to flower revealed that Motihari Hemti X SK 49, GC 1 X HDM 4 and GCT 2 X Sel.15-16 revealed significant and negative sca effect [Table 5]. The variance due to gca and sca were found significant [Table 3]. This indicated that the character is governed by both additive and non-additive gene action. The sca variances was higher in magnitude than gca variance indicating that this character is governed by non-additive gene effect suggesting involvement of non-additive gene action for the expression of days to flowering [5, 7].

3.5 Number of leaves per plant: The estimates of gca effects for number of leaves per plant [Table 4] revealed that among parents, female AR 72 and GC 1 while male Farrukhabad local and HDM 4 were good general combiners as they displayed significant desirable gca effect [Table 5]. The variance due to gca and sca were found significant [Table 3]. This indicated that the character is governed by both additive and non-additive gene action. The sca variance was higher in magnitude than gca variance indicating this character is governed predominantly by non-additive gene effect suggesting involvement of non-additive gene action for the expression of number of leaves per plant [2, 4, 8, 14, 21].

3.6 Plant height: The estimates of gca effects for plant height [Table 4] revealed that among females GC 1 and among males Farrukhabad local and SK 49 exhibited positive significant gca effects and found to be good general combiner. Among, hybrids GCT 2 X Sel.15-16, Motihari Hemti X HDM 4 and GC 1 X HDM 4 showed highest positive sca effect [Table 5]. An examination of magnitude of gca and sca variance [Table 3] for plant height indicated that both σ2 gca and σ2 sca were highly significant, revealing that both additive and non-additive gene actions were involved for the expression of plant height [2, 8, 10, 11, 13, 15, 16].

3.7 Leaf length: The estimates of gca effect for leaf length [Table 4] revealed that among female parents GCT 2 and among male parents Farrukhabad local exhibited positive significant gca effect and were found to be good general combiner. Among hybrids, GCT 4 X SK 49, Motihari Hemti X HDM 4 and GC 1 X Black Queen exhibited positive sca effect [Table 5]. The estimate of both gca and sca variance was significant [Table 3] for leaf length, revealing that both additive and non-additive gene actions were involved for the expression of leaf length. However the sca variance was higher in magnitude than gca variance, which indicate the predominance of non-additive gene effect for the expression of this trait [1, 2, 3, 8, 10, 11, 13].

3.8 Leaf width: The estimates of gca effect for leaf width [Table 4] revealed that among female parents GCT 2 and male parents HDM 4 showed positive and significant gca effect. Among hybrids, GCT 2 X SK 49 and GC 1 X Black Queen exhibited significant and positive sca effect [Table 5]. The variance due to gca and sca effect were found significant [Table 3] for leaf width. This revealing that both additive and non-additive gene actions were involved for the expression of these traits. The sca variance was higher in magnitude than gca variance indicating the predominance of non-additive gene action for the expression of this trait [1-3, 13, 16].

3.9 Days to maturity: The estimate of gca effect for days to maturity [Table 4**]** revealed that the parents among females Motihari Hemti, AR 72 and among males Sel.15-16, HDM 4 exhibited negative but non-significant gca effects and were found to be good general combiner [Table 4]. Among hybrids, GCT 4 X Sel.15-16 showed highest negative but non significant sca effect (Table 4.5). The variance due to sca was found significant [Table 3], however the sca variance being substantially greater in magnitude than gca variance, which reveals the predominance of non-additive gene effect for the expression of this trait [1, 10-12, 21].

3.10 Nicotine content: The estimates of gca effect for Nicotine content [Table 4] revealed that among the female parent GCT 4 and GC 1 and among the male parent HDM 4 observed to be good combiner as they exhibited significant positive gca effect for Nicotine content. Among hybrids GCT 4 X Farrukhabad local, AR 72 X HDM 4 and GC 1 X Black Queen showed highest positive significant sca effect [Table 5]. The estimate due to gca and sca were found significant [Table 3] and the sca variance being comparatively higher in magnitude than gca variance for Nicotine content which indicated that character is governed by both additive and non-additive gene action, the predominant role of non-additive gene action for Nicotine content [8, 12-14, 21].

3.11 Total reducing sugar content: The estimates of gca effects for total reducing sugar per cent revealed that among female parents GC 1 and GCT 4 and among male parents Sel.15-16 observed to be the good general combiners as they exhibited significant positive gca effect for total reducing sugar content [Table 4]. Among hybrids, GC 1 X HDM 4, Motihari Hemti X HDM 4 and GCT 4 X Farrukhabad local exhibited significant positive sca effect [Table 5]. The estimate of both gca and sca variance were significant [Table 3] for total reducing sugar content, revealing that both additive and non-additive gene actions were involved for the expression of this straits. However the sca variance being substantially greater in magnitude than gca variance, which indicated that the role of non-additive gene action for the expression of this trait [8, 18, 21].

4. Discussions

Selection of the parents for hybridization programme is an important aspect in all crop improvement programmes. Therefore, in any sound breeding programme, the proper choice of parents based on their combining ability is a prerequisite. Accordingly, the present investigation was under taken to get an idea of the combining ability for yield and its components with a view to identify good combiners which may be used to create a population with favourable genes for various traits in tobacco.

General combining effects of parents [Table 6] indicated that none of the parents was found good general combiner for all the characters studied. Five parents *viz;* GC 1, AR 72, Motihari Hemti, Farrukhabad local and Sel.15-16 possessed significant gca effects for cured leaf yield. In addition to that GC 1 was also a good combiner for number of leaves per plant, plant height, Nicotine content and total reducing sugar content. While the parent, Farrukhabad local was also a good general combiner for number of leaves per plant, plant height and leaf length. The parent AR 72 also appeared as good general combiner for number of leaves per plant but average combiner for plant height leaf length and days to maturity and poor combiner for remaining characters. GCT 2 was a poor combiner for cured leaf yield, days to maturity, Nicotine content but was a good general combiner for leaf length, leaf width. The parent, GCT 4 was a good general combiner for cured leaf yield and No. of leaves per plant but a poor combiner for days to flowering, leaf width, Nicotine content and total reducing content.

The parent SK 49 was a good general combiner for days to flowering, plant height but poor combiner for leaf length. Though, parent HDM 4 was a poor combiner for cured leaf yield, plant height and Total reducing content it was a good general combiner for days to flowering, no. of leaves per plant, leaf width and Nicotine content. While the parent black queen was not a good general combiner for all characters but the poor combiner for cured leaf yield, days to maturity, plant height and Nicotine content. The potentiality of a parent in hybridization may be assessed by it's per se performance and gca effects. For the present study, these top ranking parents for per se performance presented in Table 4.8 and gca effects for different traits are presented in [Table 7]. The results revealed that most of the characters had relatively high degree of correspondence between per se performance and gca effects.

The information about three superior hybrids selected on the basis of per se performance and heterosis over mid parent, better parent and standard check for different characters has been presented in Table 4.7. A perusal of this table showed that best performing hybrids were found to be different from the best heterobeltiotic F1s for many of the characters. Therefore, while selecting a cross, one has to look both aspects i.e. the degree of heterosis exhibited and per se performance of the cross.

Specific combining ability effects [Table 5] indicated that top three cured leaf yielding hybrid GCT 4 X SK 49 (poor x average) also possessed highly significant sca effect as well as significant heterosis over mid parent and batter parent. While the second top high yielding hybrid GCT 4 X Black Queen (poor x poor) possessed highly significant sca effect as well as significant heterosis over mid parent and batter parent. The third top high yielding hybrid GC 1 X Sel.15-16 (good x good) also possessed significant sca effect as well as significant heterosis over mid parent.

In self-pollinated crops, sca effects are not much important as they are mostly related with non-additive gene effects which cannot be fixed in a pure line. However, if a cross-combination exhibited high sca effects as well as per se performance having at least one parent as good general combiner for a particular trait, it is expected that such cross-combinations would throw desirable transgressive segregants in later generations. Significant sca effects of those combinations involving good x good combiners showed the major role of additive type of gene effects, which is fixable. However, two good general combiners may not necessarily throw good segregants. Similarly, the superior crosses involving both the poor x poor general combiners, very little gain is expected from such crosses because high sca effects may dissipate with the progress towards homozygosity. These three top yielding crosses exhibited high per se performance having one of the parent with good gca for cured leaf yield could be evaluated further and utilized to get desirable segregants for improvement.

Considering the gca effects of parents involved for the expression of sca effects in a particular hybrid, the significant crosses may be grouped into 6 categories, viz. good x good, good x average, good x poor, average x average, average x poor and poor x poor, in which the parents belonged to either of the categories. However, the crosses involving high sca effects did not always involve parents with high gca effects, thereby suggesting the presence of intra allelic gene interactions. The sca effects of certain crosses in the undesirable direction could be due to the failure of desirable alleles of the parent to co-operate. As a result, a cross from good general combiner parents may exhibit poor sca effects. The results revealed that there was some degree of sca effects [Table 7] of hybrids as well as gca effects of parents for most of the traits. Hence, gca and sca effects and per se performance all play a role in manifestation of heterosis for various traits.

Table 1: List of parental lines used in the study with their Characteristics

Sr. No.	Parents	Characteristics
1	GC 1 (Gujarat Chewing 1)	Dark cast, Short internodes, resistance to drought and frost.
2	GCT 2 (Gujarat Chewing Tobacco 2)	Medium cast and high leaf potential.
3	AR 72	Light green colour with well distributed leaf.
4	GCT 4(Gujarat Chewing Tobacco 4)	High Nicotine, better spangling.
5	Motihari Hemti	Medium plant height, early maturity.
6	SK 49	Medium leaf and early maturity.
7	HDM4 (Highway Development Model 4)	Light green Colour, High yielder.
8	Farrukhabad Local	High yielder.
9	Black Queen	Well distributed leaf, High yielder.
10	Sel. 15-16	High yielder, taller plant.
11	AR 85 (Check)	Light green colour, high nicotine content, High yielder.

Table 2: Analysis of variance for various characters in tobacco

Sources of variation	d.f.	Cured leaf yield per plant	Days to flowering	No. of leaves per plant	Plant height	Leaf length	Leaf width	Days to maturity	Nicotine content	Total reducing sugar
Replications	2	8.56	19.72	0.24	4.26	19.14	7.33	2.56	0.020	0.004
Genotypes	35	2549.31**	135.27*	3.34**	153.69**	32.37**	40.15**	22.76*	0.34**	0.58**
Parents	9	3021.44**	427.03**	8.74**	141.86**	41.95**	54.02**	52.15*	0.23**	0.79**
Lines	4	2449.73**	897.00**	12.03**	60.65**	84.32**	85.70**	32.23	0.16**	0.22**
Testers	4	2427.83**	6.32	5.44**	41.79**	10.06	17.12*	59.90**	0.28**	1.06**
Lines *vs* Testers	1	6482.70**	230.18**	8.74**	866.17**	0.007	74.89**	100.81**	0.33**	1.99**
Hybrids	24	2051.89**	34.67**	1.58**	116.74**	22.87**	29.18**	9.92	0.38**	0.43**
Parents vs Hybrids	1	525.78**	54.44*	0.40	362.31**	149.73**	217.97**	80.56*	0.002**	0.67**
Check vs Hybrids	1	12662.03**	1.83	0.15	810.41**	38.64*	5.73	3.88	0.85	1.73**
Error	70	33.58	8.50	0.57	10.87	7.78	6.61	12.94	0.017	0.013

*, ** Significant at 5% and 1% levels, respectively.

Table 3: Analysis of variance and variance estimates of combining ability for various characters in tobacco

Sources of variation	d.f.	Cured leaf yield per plant	Days to flowering	No. of leaves per plant	Plant height	Leaf length	Leaf width	Days to maturity	Nicotine content	Total reducing sugar
Replication	2	6.40	5.59	0.22	0.69	38.78*	5.35	10.08	0.01	0.01
Hybrid	24	2051.89**	34.67**	1.58**	116.74**	22.87**	29.18**	9.92	0.38**	0.43**
Lines	4	2007.44**	27.77**	2.21**	27.51	21.29	33.06**	13.63	0.18**	1.61**
Testers	4	2212.31**	52.32**	1.17*	415.58**	38.81**	69.26**	8.89	0.09**	0.06**
L X T	16	2022.90**	31.98**	1.54**	64.34**	19.28**	18.19**	9.25*	0.50**	0.23**
Error	48	34.12	7.09	0.32	12.41	8.34	6.65	11.74	0.01	0.01
σ^2F	-	-1.03**	-0.28**	0.04**	-2.46	0.13	0.99**	0.29	-0.02**	0.09**
σ^2 M	-	12.63**	1.36**	-0.03*	23.42**	1.30**	3.40**	-0.02	-0.03**	-0.01**
σ^2 gca	-	5.8**	0.54**	0.005**	10.48**	0.72**	2.20**	0.14	0.025**	0.04**
σ^2sca	-	662.93**	8.30**	0.41**	17.31**	3.65**	3.85**	-0.83*	0.16**	0.07**
σ^2 sca/σ^2 gca	-	114.29	15.37	82	1.65	5.06	1.75	-5.92	6.4	1.75

*, ** Significant at 5% and 1% levels, respectively.

Table 5: Estimates of Specific combining ability (sca) effects of hybrids for various characters in tobacco

Hybrids/Traits	Cured leaf yield per plant	Days to flowering	No. of leaves per plant	Plant height	Leaf length	Leaf width	Days to maturity	Nicotine content	Total reducing sugar
GC 1 X SK 49	-8.99**	3.42**	-0.37	-0.11	0.23	0.78	0.77	0.14**	0.03
GC 1 X HDM 4	-9.65**	-4.50**	0.32	4.65**	-3.22**	-2.32	-0.63	-0.23**	0.52**
GC 1 X Farrukhabad L.	1.48	0.76	-0.16	4.11**	-2.45*	-3.46	1.17	-0.08	-0.37**
GC 1 X Black Queen	-5.52*	0.66	0.16	-7.34**	3.23**	3.43	-1.56	0.46**	-0.05
GC 1 X Sel.15-16	22.68**	-0.33	0.04	-1.31	2.20	1.57	0.24	-0.30**	-0.13**
GCT 2 X SK 49	14.08**	1.75	1.07**	-0.15	1.12	3.50	-0.89	-0.01	0.18**
GCT 2 X HDM 4	-1.92	0.83	0.03	-11.19**	-0.67	-1.14	0.37	0.03	-0.21**
GCT 2 X Farrukhabad	2.55	-0.70	-0.32	1.34	0.34	1.76	0.51	-0.43**	-0.07
GCT 2 X Black Queen	1.88	1.32	-0.66**	4.29**	-0.25	-2.36	-1.89	0.20**	-0.10**
GCT 2 X Sel.15-16	-16.59**	-3.20**	-0.12	5.72**	-0.55	-1.75	1.91	0.20**	0.20**
AR 72 X SK 49	-20.19**	-2.82**	-0.04	0.66	-2.82*	-2.75	-0.83	0.39**	0.07
AR 72 X HDM 4	22.48**	5.26**	0.99**	0.76	1.43	2.38	1.11	0.59**	-0.51**
AR 72 X Farrukhabad	-4.72*	1.66	-0.62**	-1.65	1.17	1.31	-2.09	-0.31**	0.02
AR 72 X Black Queen	-10.39**	-2.98**	-0.44*	1.37	-0.82	-1.20	1.17	-0.42**	0.19**
AR 72 X Sel.15-16	12.81**	-1.10	0.11	-1.13	1.05	0.27	0.64	-0.25**	0.23**
GCT 4 X SK 49	48.81**	2.79**	-0.01	-1.47	4.53**	0.65	2.37	-0.35**	-0.23**
GCT 4 X HDM 4	-31.52**	-1.20	-1.45**	1.07	-1.52	-1.02	0.31	-0.31**	-0.11**
GCT 4 X Farrukhabad	-14.72**	-3.13**	1.14**	-1.97	0.49	1.71	-0.23	0.88**	0.29**
GCT 4 X Black Queen	32.95**	-1.90	0.72**	0.61	-1.83	-1.84	1.37	-0.31**	0.13**
GCT 4 X Sel.15-16	-35.52**	3.44**	-0.40	1.77	-1.67	0.50	-3.83**	0.10*	-0.09*
Motihari Hemti X SK 49	-33.72**	-5.13**	-0.65**	1.08	-3.07**	-2.18	-1.43	-0.17**	-0.05
Motihari Hemti X HDM 4	20.61**	-0.38	0.11	4.71**	3.98**	2.12	-1.16	-0.09*	0.31**
Motihari Hemti X Farrukhabad	15.41**	1.42	-0.04	-1.83	0.45	-1.32	0.64	-0.06	0.13**
Motihari Hemti X Black Queen	-18.92**	2.91**	0.22	1.09	-0.33	1.97	0.91	0.07	-0.17**
Motihari Hemti X Sel.15-16	16.61**	1.19	0.36	-5.05**	-1.03	-0.59	1.04	0.24**	-0.21**
S.E. (Sij)	2.28	1.04	0.22	1.38	1.13	1.01	1.34	0.05	0.04

*, ** Significant at 5% and 1% levels, respectively

Table 6: Classification of parents with respect to general combining ability effects for various characters in tobacco

Parents									
1*	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
G	P	G	P	G	A	P	G	P	G
A	A	P	A	G	G	G	P	P	A
G	A	G	A	P	A	G	G	A	P
G	A	A	A	A	G	P	G	P	A
A	G	A	A	P	P	A	G	A	A
A	G	P	A	A	A	G	A	A	P
A	P	A	A	A	A	A	A	A	A
G	P	P	G	P	A	G	A	P	A
G	A	P	G	P	A	P	A	A	G

G = good combiner, A = average combiner and P = poor combiner

Table 7: Top three parents and F1S for combining ability estimates and parents with respect to general combining ability effects for various characters

Traits	Combining ability effects		
	General Combining Ability		Specific Combining Ability
	Females	Males	
Cured leaf yield	Motihari Hemti	Sel.15-16	GCT 4 X SK 49
	AR-72	Farrukhabad l.	GCT 4 X Black Queen
	GC-1	-	GC 1 X Sel.15-16
Days to flowering	Motihari Hemti	SK-49	Motihari Hemti x SK 49
	-	HDM-4	GC 1 X HDM 4
	-	-	GCT 2 X Sel.16-16
No. of leaves per plant	GC 1	Farrukhabad l.	GCT 4 X Farrukhabad l.
	AR 72	HDM 4	GCT 2 X SK 49
	-	-	AR 72 X HDM 4
Plant height	GC 1	Farrukhabad l.	GCT 2 X Sel.15-16
	-	SK 49	Motihari Hemti x HDM 4
	-	-	GC 1 X HDM 4
Leaf length	GCT 2	HDM 4	GCT 4 X SK 49
	-	-	Motihari Hemti x HDM 4
	-	-	GC 1 X Black Queen
Leaf width	GCT 2	HDM 4	GCT-2 X SK 49

	-	-	GC 1 X Black Queen
	-	-	AR 72 X HDM 4
Days to maturity	Motihari Hemti	Sel.15-16	GCT 4 X Sel.15-16
	AR 72	HDM 4	-
	GCT 4	-	-
Nicotine content	GCT 4	Black Queen	GCT 4 X Farrukhabad l.
	GC 1	Sel.15-16	AR 72 X HDM 4
	-	-	GC 1 X Black Queen
Total reducing sugar	GC 1	Sel.15-16	GC 1 X HDM 4
	GCT 4	-	Motihari Hemti x HDM 4
	-	-	GCT 4 X Farrukhabad l.

*1) GC 1, 2) GCT 2, 3) AR 72, 4) GCT 4, 5) Motihari Hemti, 6) SK 49, 7) HDM 4, 8) Farrukhabad, 9) Black Queen 10) Sel.15-16.

6. Conclusions

General combining effects of parents indicated that the parents was found good general combiner, average and poor combiner for different the characters studied. In this study significant and desirable estimates of variances due to specific combining ability (sca) differed significantly for all the characters under study indicating the importance of non-additive gene action for the inheritance of these traits. As variance due to both gca and sca were found significant for most of the character appeared to be under the influence of both additive and non-additive gene actions. The estimates of gca effects suggested those parents, GC 1, AR 72, Motihari Hemti and Sel.15-16 were good general combiners for cured leaf yield and its related attributes. The estimates of sca effects indicated that the cross GC 1, AR 72, Motihari Hemti and Sel.15-16 were the most promising for cured leaf yield and some of its related traits.

7. Acknowledgement: We cheering thanks acknowledge all support received from the Anand Agriculture University, Anand (Gujarat) for carrying out this come off. We are also grate thankful to guide and faculty member of institution for providing laboratory facilities.

8. Ethical approval: This article does only for research purposes and also do not use any other live things. This article does not contain any studies with human participants or animals performed by any of the authors.

9. References

1. Bhatt MM. Heterosis and combining ability in bidi tobacco (*N tabacum* L.) over environments. Ph.D. thesis submitted to Gujarat Agricultural University, Sardarkrushinagar, 1999.
2. Bhatt MM, Pathak HC, Patel JS. Combining ability analysis for yield and its components in bidi tobacco (N. tabacum L). Tobacco Research 2004; 30(2): 129-134.
3. Butorac J. Components of genetic variance of leaf parameters in burley tobacco Agriculture conspectus scientific 1999; 64:33-41.
4. Hanarnejad R, Shoai-Deylami M. Gene effects and combining ability of some quantitative and qualitative characteristics of tobacco (N. tabacum L.) Indian Journal Agriculture Sciences. 1997; 28: 121-145.
5. Jung SH, Hwang JK, Son SH. Analyses of inheritance of quantitative characters in a diallel cross of oriental tobacco varieties (*N. tabacum* L.), Journal of the Korean Society of Tobacco Science. 1982; 4(1):7-13.
6. Kempthorne O. An introduction to genetical statistics. The lowa State University press, Amer lowa, 1957, 545.
7. Kher HR, Pathak HC, Makwana MG, Patel JN. Combining ability studies for yield and yield components in bidi tobacco (N. tabacum L) over diverse cytoplasms. Tobacco Research 2001; 27(2):134-139.
8. Makwana MG. Generation mean analysis over environments in tobacco (N. tabacum L) Ph.D. thesis submitted to Anand Agricultural University Anand, 2006.
9. Makwana MG, Kher HR, Patel AD, Patel JN, Parmar DJ. Diallel study of yield and its components in bidi tobacco (N. L.). National Conference on Tobacco. Indian Society of Tobacco Science CTRI Rajahmundry Abstract 2005; B25:25.
10. Patel AD, Kingaonkar SK. Genetic analysis in tobacco (Nicotiana tabacum L) Tobacco Research 2006; 32(1):11-16.
11. Patel AD, Patel PA, Patel JS. Line x Tester study for yield and yield components in Bidi Tobacco (Nicotiana tabacum L) Tobacco Researchs 2006; 32(2):39-44.
12. Patel DA. Genetic studies in rustica tobacco (*Nicotiana rustica* L.). M.Sc. (Agri.) thesis submitted to Gujarat Agricultural University, Sardarkrushinagar, 1994.
13. Patel DA, Pathak HC. Gene effects for yield and quality in Rustica tobacco (*Nicotiana rustica* L) Tob Res 1996; 22(1):41-46.
14. Patel GP. Genetic variations in improved population of tobacco (Nicotiana tabacum L) M.Sc. (Agri.) thesis submitted to Gujarat Agricultural University Sardar-krushinagar, 1997.
15. Patel JN. Genetic analysis of important quantitative characters and seed oil yield in tobacco (Nicotiana tabacum L.). Ph.D. thesis submitted to Anand Agricultural University, Anand, 2005.
16. Patel PA. Heterosis and combining ability studies in tobacco (Nicotiana tabacum L.). M.Sc. (Agri.) thesis submitted to Gujarat Agricultural University, Sardar-krushinagar, 1998.
17. Patidar A. Diallel analysis for yield, its components and important quality traits in bidi Tobacco (Nicotiana tabacum L.) M.Sc. (Agri) thesis submitted to Anand Agriculture University, Anand, 2007.
18. Pawar SA. Line x Tester studies on morphological and seed oil yield traits in tobacco (Nicotiana tabacum L) M.Sc. (Plant breeding and Genetics) thesis submitted to Anand Agriculture University, Anand, 2010.
19. Rangaswamy BR. Ramesh S, Rudraradhya M, Vasuki N. Genetic and combining ability analysis of quantitative traits in FCV tobacco Tobacco Research 2002; 28:5-9.
20. Sprague GF, Tatum LA. General versus specific combining ability in single crosses of corn J Amer Soc Argon. 1942; 34:923-932.
21. Vankar HD. Heterosis and combining ability studies in bidi tobacco (Nicotiana tabacum L.) Crops Science, 2007; 10:437-440.