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Research Article

HETEROSIS STUDIES ON YIELD AND QUALITY PARAMETERS IN TOBACCO (*Nicotiana rustica* L.)

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Abstract- Tobacco (*Nicotiana tabacum* L.) is also the importance cash crops of India. Tobacco is one of the important commercial crops in the world. The data on heterosis calculated over mid parental value, better parent and standard check revealed superiority of some cross combinations. For cured leaf yield, the cross GC 1 X SK 49 showed significant positive heterosis over standard check, the cross Motihari Hemti X Sel.15-16, Motihari Hemti X HDM 4 and GCT 4 X SK 49 exhibited significant positive relative heterosis and heterobeltosis. A perusal of per se performance and heterosis indicated that hybrids GC 1 X SK 49, GCT 4 X SK 49, Motihari Hemti X Sel. 15-16 and GC 1 X Sel.15-16 were found promising for further evaluation and to exploit transgressive segregants. Heterosis is important for decide the direction of future breeding programme and to identify the cross combinations which are best for in conventional breeding designing.

Keywords- Tobacco, Heterosis, Heterobeltiosis, Inbreeding Depression, *Nicotiana spp.*

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Introduction

Tobacco is one of the valuable commercial growing crops in the India as well as world. The tobacco has various kinds on the based on quality and consumption purposes such as flue cured virginia, hookah, cigar type, lanka type bidi type etc. From these bidi tobacco is more widely grown in India and many other country e.g. Pakistan [15]. The quality in bidi tobacco is determine based on the nicotine content, spangle score, chloride content, reducing sugars and the ratios between reducing sugar to nicotine. The genetic work on the bidi tobacco not done very much. The tobacco mostly used for tobacco and as an insecticide, topical analgesic, anesthetic, narcotic, sedative, emetic; plant decoction as a wash against poison. The tobacco have some importance appearance e.g., Ritual, bright green leaves powder rubbed on the skin, over the forearm, temples, stomach, legs, for a ritual cleansing[CRC World Dictionary of Medicinal and Poisonous Plants]. In this connection this work has been carried out in Bidi Tobacco Research Station, Anand.

Tobacco is one of the important crops the status which it attained in India since 1930. There are 68 species of *Nicotiana*. Among them only two are cultivable species *viz*., *N. tabacum* L. and *N. rustica* L. Cultivation of *N. tabacumis* practiced throughout the world, but that of *N. rusticais* restricted to India, Russia and other Asian countries. Many countries involved in the cultivation of tobacco are e.g., Brazil, US, India, Zimbabwe, China, Malawi, Turkey, Indonesia and Argentina. The tobacco 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.

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. The material comprised of ten parents, their twenty five [Table-1] hybrids produced through line x tester mating system 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 heterosis will be estimated in term of three parameters, i.e., Relative Heterosis [10], Heterobeltiosis [2] and Standard heterosis [7].

Results

The results revealed that all the characters studied exhibited significant genotypic differences. The ANOVA [Table-2], was the mean sum of squares due to parents were highly significant for all the characters. This depicted the presence of great amount of genetic variability among the parents studied. Among the female parents, significant mean sum of squares for all the characters were observed except days to maturity. While among the male parents, highly significant sum of squares was observed for all the characters except days to flowering and leaf length. The female *vs* male comparison was found to be significant for most of the characters except leaf length. The analysis revealed that mean sum of squares due to parents vs. hybrids was significant form majority of the traits except number of leaves per plant. The mean squares due to check vs. hybrids were significant for cured leaf yield per plant, plant height, leaf length and total reducing sugar content. These results suggested that the differences may be due to better

combination of genes derived from the diverse parents for maximization of hybrid vigour for majority of the components. The analysis of variance revealed that mean sum of squares due to hybrids differed significantly for all the characters except days to maturity, which revealed the presence of great deal of variability among the hybrids with respect to yield and its components under study.

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

Sr. No.	Parents	Characteristics
Females		
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.
Males		
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 content
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										

Days to flowering

Early initiation of flowering is a desirable character in tobacco. The heterotic value ranged from -33.04 to 19.00 percent for hybrids over their mid parental value. Of these, best performing cross was AR 72 X SK 49 (-33.04%) followed by AR 72 X Black Queen (-27.41%) and AR 72 X Sel.15-16 (-27.24%). The value of heterobeltiosis varied from -8.32 % to 52.26 percent. The value of standard heterosis over standard check AR 85 ranged from -16.62 to 12.64 percent. Out of 2 hybrids exhibiting significant negative heterosis over AR 85 *viz*; Motihari Hemti X SK 49 (-16.62%) and GC 1 X HDM 4 (-12.38%). The results are in agreement with the findings of [11,14,17,19] for relative heterosis; [8,9,12,13] for relative heterosis and heterobeltiosis; [15,18,19] for relative heterosis, heterobeltiosis and standard heterosis [Table-3].

Number of leaves per plant

The heterotic value ranged from -19.33 % to 16.87 percent. Positive heterosis is desirable for the number of leaves which is directly associated with cured leaf yield. The crosses which showed positive and significant heterotic effect over mid parental value were GCT 2 X SK 49 (16.87%), GCT 2 X HDM 4 (16.22%) and GCT 4 X Farrukhabad local (14.76%). The heterobeltiosis ranged from -28.81 % to 14.12 percent. Significant positive heterosis was observed for 3 crosses, were GCT 2 X SK 49 (14.12%), GCT 4 X Farrukhabad local (12.57%) and GCT 4 X Black Queen (11.36%). The value of standard heterosis varied from -11.8 to 15.67 percent over standard check. Out of 25 crosses studied the best three *viz*; GCT 4 X Farrukhabad local (15.67%), GCT 4 X Black Queen (10.11%) and GCT 2 X SK 49 (8.93%) exhibited significant positive standard heterosis over AR 85. The results are in conformity with the results of [3,4] for relative heterosis, [8,11,13] for heterobeltiosis, [9,12,14] for relative heterosis and heterobeltiosis, [18] for relative heterosis, heterobeltiosis and standard heterosis [Table-3].

Plant height

The data revealed the minimum and maximum values of heterosis over mid parental value were -16.83 % to 33.00 percent. The crosses exhibiting significant and positive heterosis the best 3 crosses were GC 1 X Farrukhabad local (33.00%), GC 1 X HDM 4 (24.73%) and GCT 2 X Sel.15-16 (23.00%). The heterobeltiosis ranged from -24.19 to 17.38 percent. Out of 2 hybrids exhibiting significant negative heterosis over AR 85 *viz*; GCT 2 X Sel.15-16 (17.38%) and GC 1 X Farrukhabad local (10.82%). The value of standard heterosis over standard check ranged from -40.2 to -4.57 percent. The results are in conformity with [6,12,16,19] for relative heterosis and heterobeltiosis[Table-3].

Leaf length

The range of relative heterosis over mid parent was from -7.54 to 29.94 percent. The hybrids showed positive and significant relative heterosis over mid parent. Among these the best 3 were Motihari Hemti X HDM 4 (29.94%), Motihari Hemti X Farrukhabad local (20.27%) and Motihari Hemti X Black Queen (14.90%). The value of heterobeltiosis ranged from -11.45 to 20.71 percent. Only one hybrid *viz*; Motihari Hemti X HDM 4 (20.71%) showed positive and significant heterosis over better parent. The values of standard heterosis varied from -21.4 % to 2.77 percent. The results are in agreement with the findings of [3] and [1] for relative heterosis, [11] for relative heterosis, heterobeltiosis [Table-3].

Leaf width

The value for relative heterosis over mid parent ranged from -8.63 to 44.32 percent. The crosses showed positive and significant heterosis over mid parent. Were Motihari Hemti X HDM 4 (44.32%), AR 72 X HDM 4 (34.81%) and Motihari Hemti X Black Queen (21.66%). The value for heterosis over better parent ranged from -13.7 to 28.28 percent. 4 crosses were observed to have positive and significant heterosis over better parent. The crosses were AR 72 X HDM 4 (28.28%), Motihari Hemti X HDM 4 (25.50%) and GCT 2 X HDM 4 (12.06%). Standard heterosis over AR 85 ranged from -8.34 to 19.99 percent. Among all 25 crosses, the crosses were observed to have significant and positive heterosis over AR 85. Out of these, 3 best crosses were AR 72 X HDM 4(19.99%), GCT 2 X SK 49 (18.72 %) and Motihari Hemti X HDM 4 (17.38%).The findings are akin to the observations of [1,12] for relative heterosis and standard heterosis; [4,9,18,19] for relative heterosis, heterobeltiosis and standard heterosis[Table-4].

Table-3 *Percentage Heterosis in hybrid over mid parent (MP) and better parent (BP) and standard check (SC) for Cured leaf yield, Days to flowering, No. of leaves per plant, Plant height and Leaf length*

Genotypes Number	Cured leaf yield			Days to flowering			No. of leaves per plant			Plant height			Leaf length		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
1 x 6	-10.16**	-28.69**	5.65*	1.38	5.6	4.03	-6.48	-10.27*	-6.74**	21.57**	4.99	-17.14**	-1.9	-4.93	-10.08*
1 x 7	-17.87**	-38.65**	-45.58**	-13.35**	-8.28	-12.38*	6.58	-8.11	-4.55**	24.73**	7.95	-15.24**	-1.23	-8.68	-13.63**
1 x 8	-17.62**	-19.92**	-28.98**	0.34	2.2	5.15	-5.98	-6.49	-2.86**	33.00**	10.82*	-4.57	1.64	-1.69	-7.04
1 x 9	-19.02**	-30.88**	-38.69**	2.92	5.42	7.27	-2.79	-5.95	-2.27**	-11.96*	-24.19**	-39.76**	11.39*	8.68	2.78
1 x 10	22.44**	0	-11.31**	-2.15	2.62	-0.21	-9.24*	-9.73	-6.23	21.11**	8.94	-21.75**	10.98*	6.33	0.56
2 x 6	4.76	-12.50**	-31.98**	0.07	4.73	3.18	16.87**	14.12*	8.93**	10.04*	0.52	-20.66**	0.04	-4.1	-7.24
2 x 7	-15.99**	-34.32**	-48.94**	0	6.36	1.61	16.22**	6.17	-3.37	-16.83**	-23.85**	-40.20**	4.72	-4.17	-7.31
2 x 8	-20.57**	-23.42**	-35.87	-0.54	1.79	4.73	2.61	-3.28	-0.59**	16.52**	2.42	-11.80**	7.82	3.17	-0.21
2 x 9	-17.74**	-25.68**	-42.23**	6.34	9.44	11.36*	0.3	-2.89	-5.64**	0.25	-8.71	-27.45**	3.39	-0.22	-3.49
2 x 10	-9.76**	-22.27**	-39.58**	-5.93	-0.87	-3.6	-0.87	-6.56	-3.96**	23.00**	17.38**	-15.70**	4.52	-0.94	-4.18
3 x 6	-33.16**	-46.30**	-53.89**	-33.04**	-8.32	-9.69	-14.29**	-26.27**	-2.27**	9.82	0.97	-20.31**	-7.54	-9.57	-19.77**
3 x 7	-7.08*	-29.84**	-39.75**	-19.15**	12.87*	7.84	-1.08	-22.46**	2.78**	4	-4.15	-24.74**	12.35*	9.35	-7.24
3 x 8	-33.33**	-34.16**	-43.46**	-22.25**	3.57	6.57	-19.33**	-28.39**	-5.05**	9.50*	-3.15	-16.59**	12.25*	10	-2.78
3 x 9	-36.03**	-44.65**	-52.47**	-27.41**	-2.64	-0.93	-17.85**	-28.81**	-5.64	-6.86	-14.63**	-32.16**	4.14	1.16	-8.98
3 x 10	1.74	-15.84**	-27.74**	-27.24**	0.44	-2.33	-18.38**	-27.54**	-3.96*	7.6	3.4	-25.74**	10.63*	9.48	-5.16
4 x 6	49.24**	25.81**	-4.42	9.97*	10.77*	7.55	6.94	5.11	3.88**	9.97*	-3.27	-23.65**	6.53	6.15	-5.16
4 x 7	-25.66**	-41.40**	-55.48**	3.3	4.14	-0.51	1.29	-10.80*	-11.79	8.66	-4.21	-24.79**	1.23	-3.89	-13.51**
4 x 8	-19.69**	-23.42**	-35.87**	1.77	4.8	1.76	14.76**	12.57*	15.67	12.98**	-4.2	-17.50**	6.97	6.39	-4.95
4 x 9	20.25**	9.77**	-16.79**	7.32	9.9	6.7	12.32**	11.36*	10.11**	-4.8	-16.51**	-33.65**	-1.67	-2.01	-11.84*
4 x 10	-9.89**	-21.63**	-40.46**	15.93	16.01**	12.64*	-3.06	-4.2	-2.27**	18.02**	8.25	-22.25**	0.51	-1.01	-11.54*
5 x 6	5.28	1.36	-47.17**	-2.16	15.91*	-16.62**	-3.28	-4.71	-9.01**	7.32	3.38	-18.41**	-0.31	-11.45*	-21.44**
5 x 7	58.93**	51.65**	-26.86**	12.07*	30.45**	-6.15	11.71*	1.21	-6.23**	8.08	4.38	-18.05**	29.94**	20.71**	-3.07
5 x 8	22.89***	-3.16	-18.91**	19.00**	44.60**	4.03	0.57	-4.37	-1.68**	6.11	-1.89	-15.51**	20.27**	7.01	-5.43
5 x 9	2.55	-9.30*	-43.11**	26.12**	52.26**	9.54	3.55	1.16	-1.68**	-9.84	-13.43	-31.21**	14.41**	1.01	-9.12
5 x 10	68.87**	56.92**	-12.02**	18.80**	39.69**	0.49	-1.15	-6.01	-3.37	-3.03	-3.9	-29.72**	14.90**	3.13	-10.65*
Range	**-36.03 to 68.87**	**-46.3 to 56.92**	**-55.48 to 5.65**	**-33.04 to 19**	**-8.32 to 52.26**	**-16.62 to 12.64**	**-19.33 to 16.87**	**-28.81 to 14.12**	**-11.8 to 15.67**	**-16.83 to 33**	**-24.19 to 17.38**	**-40.2 to -4.57**	**-7.54 to 29.94**	**-11.45 to 20.71**	**-21.4 to 2.78**
S. E.	**4.15**	**4.8**	**4.8**	**2.08**	**2.4**	**2.4**	**0.54**	**0.62**	**0.62**	**0.23**	**0.27**	**0.27**	**0.19**	**0.23**	**0.23**

*, ** Significant at 5% and 1% levels, respectively, MP= Mid Parent, BP= Better Parent, SC= Standard Check

Table-4 *Percentage Heterosis in hybrid over mid parent (MP) and better parent (BP) and standard check (SC) for Leaf width, Days to maturity, Nicotine content and Total reducing sugar content*

Genotypes Number	Leaf width			Days to maturity			Nicotine content			Total reducing sugar content		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
1 x 6	2.89	1.09	8.42	1.3	1.83	0.51	5.56	-9.52**	-10.47**	27.74**	11.90**	-12.79**
1 x 7	10.42*	5.11	8.77	1.46	2.96	-1.29	5.19	-5.33	-16.28**	93.24**	73.22**	1.35
1 x 8	-5.42	-9.27	-6.11	2.75	2.89	1.29	4.35	-7.69*	-15.12**	8.73*	-5.85	-24.58**
1 x 9	8.62	7.56	13.53*	4.50*	9.12**	-1.03	31.75**	25.76**	-2.33	26.58***	12.23**	-15.15**
1 x 10	4.09	0.26	3.77	1.86	3.23	-0.78	2.36	-2.99	-23.55**	6.24	-16.63**	-14.48**
2 x 6	13.16**	10.70*	18.72**	0.52	1.32	-0.52	-7.28*	-16.67**	-17.44**	23.17**	0	-22.22**
2 x 7	17.24**	12.06*	14.96**	2.8	4.04	-0.26	5.63	0	-11.63**	32.32**	29.40**	-37.04**
2 x 8	12.25*	8.13	10.92	2.76	2.89	1.03	-15.86**	-21.79**	-28.20**	11.11**	-10.73**	-28.62**
2 x 9	-2.97	-4.33	0.97	4.79*	9.12**	-1.03	11.28**	10.45**	-12.79**	11.49**	-8.50*	-30.64**
2 x 10	-1.4	-4.63	-2.15	3.72	4.84*	0.77	11.94**	11.94**	-11.63**	9.43**	-19.44**	-17.17**
3 x 6	1.68	-9.11	-2.53	-2.93	-1.3	-1.55	7.69**	0	-1.16	18.89**	5.51	-17.85**
3 x 7	34.81**	28.28**	19.99**	-0.26	3.5	-0.78	26.53**	24.00***	9.59**	13.71**	0.6	-39.39**
3 x 8	17.28**	10.75	5.27	-2.82	-0.52	-2.07	-9.33**	-12.82**	-20.06**	17.07**	2.68	-17.85**
3 x 9	4.86	-5.61	-0.38	3.47	10.54**	0.25	-8.70**	-12.50**	-25.87**	27.58**	14.62**	-13.13**
3 x 10	9.6	3.09	-1.18	-0.91	2.69	-1.29	-2.16	-5.56	-20.06**	12.06**	-11.10**	-8.75*
4 x 6	-0.8	-6.44	0.35	1.17	1.57	0.51	-20.78**	-27.38**	-28.20**	-5.4	-19.29**	-37.04**
4 x 7	10.89*	10	4.57	0.8	2.43	-1.81	-8.97**	-12.00**	-22.38**	28.16**	18.16**	-35.02**
4 x 8	5.28	5.28	0.08	0.26	0.52	-1.03	25.68**	19.23**	9.59**	21.70**	2.68	-17.85**
4 x 9	-8.63	-13.7*	-8.34	5.45**	10.26**	0	-10.29**	-12.86**	-28.20**	15.85**	0	-24.24**
4 x 10	-2.4	-2.81	-6.83	-2.78	-1.34	-5.17*	5.11	2.86	-15.12**	-9.49**	-30.54**	-28.62**
5 x 6	10.12	-9.45	-2.88	-0.53	1.34	-2.58	-20.75**	-25.00**	-25.87**	-27.36**	-29.36**	-45.12**
5 x 7	44.32**	25.50**	17.38**	0.94	1.08	-3.1	-8.00**	-8.00*	-18.90**	8.32	-11.67**	-35.02**
5 x 8	17.31**	1.32	-3.69	2.26	3.49	-0.52	-12.42**	-14.10**	-21.22**	-18.16**	-21.45**	-37.04**
5 x 9	21.66**	0.68	6.27	6.50**	9.69**	-0.52	-3.55	-9.33**	-20.06**	-31.09**	-32.07**	-48.48**
5 x 10	14.67*	-1.31	-5.38	2.42	2.42	-1.55	2.82	-2.67	-13.95**	-39.25**	-47.89**	-46.46**
Range	**-8.63 to 44.32**	**-13.7 to 28.28**	**-8.34 to 19.99**	**-2.93 to 6.5**	**-1.34 to 10.54**	**-5.17 to 1.29**	**-20.78 to 31.75**	**-27.38 to 25.76**	**-28.2 to 9.59**	**-39.25 to 93.24**	**-47.89 to 73.22**	**-48.48 to 1.35**
S. E.	**0.18**	**0.2**	**0.2**	**0.25**	**0.29**	**0.29**	**0.9**	**1**	**0.1**	**0.82**	**0.94**	**0.94**

*, ** Significant at 5% and 1% levels, respectively, MP= Mid Parent, BP= Better Parent, SC= Standard Check

Days to maturity: The value of relative heterosis over mid parent ranged from -2.93 to 6.50 percent. The hybrids showed significant heterosis over mid parent but none of these found negative. The value of heterobeltiosis ranged from -1.34 to 10.54 percent. 6 hybrids showed significant heterosis over better parent but none of these found negative. Standard heterosis over AR 85 ranged from -5.17 to 1.29 percent. Out of 25 crosses studied, only one hybrid *viz*; GCT 4 X Sel. 15-16 (-5.17%) exhibited negative and significant standard heterosis over AR 85. The findings are akin to the observations of [15] for heterobeltiosis, standard heterosis. [12,18] for relative heterosis, heterobeltiosis and standard heterosis [Table-4].

Nicotine content: As higher Nicotine in leaf gives desired kick and satisfaction to the smokers, the positive heterosis is desirable for this trait. The data revealed that the heterotic values ranged from -20.78 to 31.75 percent over mid parent. The crosses showed significant and positive heterosis. Of these best performing crosses was GC 1 X Farrukhabad local (31.75%), AR 72 X HDM 4 (26.53%) and GCT 4 X Farrukhabad local (25.68%). The value of heterobeltiosis ranged from -27.38 to 25.76 percent. Of these best performing crosses were GC 1 X HDM 4 (25.76%), AR 72 X HDM 4 (24.00%) and GCT 4 X Farrukhabad local (19.23) showed positive and significant heterosis over better parent. Value for standard heterosis over AR 85 ranged from -28.2 to 9.59 percent. Only two hybrid AR 72 X HDM 4 (9.59) and GCT 4 X Farrukhabad local (9.59) showed positive and significant heterosis over AR 85. These results are in agreement with [16] for relative heterosis, [15] for heterobeltiosis and standard heterosis, [18,19] for relative heterosis, heterobeltiosis and standard heterosis [Table-4].

Total reducing sugar content: In tobacco, positive heterosis is desired for reducing sugar content. The data revealed that the heterotic value ranged from -39.25 to 93.24 percent. The crosses showed positive and significant heterosis over mid parent were GC 1 X HDM 4 (93.24%), GCT 2 X HDM 4 (32.32%) and GCT 4 X HDM 4 (28.16%).The heterotic value for heterobeltiosis ranged from -47.89 to 73.22 percent. Significant heterobeltiosis observed for 6 crosses, best 3 crosses which showed positive and significant heterosis were GC 1 X HDM 4 (73.22%), GCT 2 X HDM 4 (29.40%) and GCT 4 X HDM 4 (18.16%). Estimates of standard heterosis over AR 85 ranged from -48.48 to 1.35 percent. None of the crosses showed positive and significant standard heterosis over AR 85. These findings are close in agreements with the results of [16] for relative heterosis, heterobeltiosis, [5,12,18,19] for relative heterosis, heterobeltiosis and standard heterosis[Table-4].

Discussions

The cross GC 1 X SK 49 was found significantly superior for cured leaf yield (over standard check), plant height (over mid parent) and Total reducing sugar content (over mid parent and batter parent); GC 1 X HDM 4 for days to flowering (over mid parent and standard check), plant height (over mid parent), leaf width (over mid parent) and Total reducing sugar content (over mid parent and batter parent); The cross GC 1 X Farrukhabad local for Plant height (over mid parent and batter parent) and Total reducing sugar content (over mid parent); GC 1 X Black Queen for Leaf length (over mid parent), Leaf width, (over standard check), Nicotine content (mid parent and Batter parent) and Total reducing sugar content (over mid parent and Batter parent).

While the cross GC 1 X Sel.15-16 was found superior for cured leaf yield (over mid parent), Plant height and Leaf length (over mid parent); the cross GCT 2 X SK 49 was found superior for No. of leaves per plant, (over mid parent, Batter parent and standard check), plant height (over mid parent), Leaf width (over mid parent, Batter parent and standard check) Total reducing sugar content (over mid parent); the cross GCT 2 X HDM 4 was found significantly superior for No. of leaves per plant (over mid parent); leaf Width (over mid parent, Batter parent and standard check) and Total reducing sugar content (over mid parent and batter parent); GCT 2 X Farrukhabad local for plant height, Leaf width and Total reducing sugar content (over mid parent); the cross GCT 2 X Black queen Days to flowering (over standard check), Days to maturity and Nicotine content (mid parent and better parent), Total reducing sugar content (over mid parent); while the cross GCT 2 X Sel.15-16 for plant height and Nicotine content (over mid parent and better parent) Total reducing sugar content (over mid parent) was found significantly superior.

The cross AR 72 X SK 49 was found significantly superior for Days to flowering, Nicotine content and Total reducing sugar content (over mid parent); AR 72 X HDM 4 for Days to flowering, Leaf length (over mid parent), leaf width and Nicotine content (over mid parent, better parent and standard check) and Total reducing sugar content (over mid parent); while the cross AR 72 X Farrukhabad local was found superior for, plant height, leaf length, leaf width, total reducing sugar content (over mid parent); the cross AR 72 X Black Queen for days to flowering (over mid parent), Days to maturity (over, better parent); Total reducing sugar content (over mid parent and better parent) was found significantly superior; AR 72 X Sel.15-16 for days to flowering (over mid parent), leaf length, Total reducing sugar content (over mid parent).

The cross GCT 4 X SK 49 for cure leaf yield (over mid parent, better parent), No. of leaves per plant (over standard check), plant height (over mid parent); the cross GCT 4 X HDM 4 for leaf width (over mid parent) and reducing sugar content (over mid parent and better parent); the cross GCT 4 X Farrukhabad local was found significantly superior for No. of leaves per plant and Nicotine content (over mid parent, better parent and standard check), plant height (over mid parent) and reducing sugar content (over mid parent); GCT 4 X Black queen for cured leaf yield (over mid parent and better parent), No. of leaves per plant (over mid parent, better parent and standard check), days to maturity (over mid parent, better parent) and reducing sugar content (over mid parent); while the cross GCT 4 X Sel.15-16 was found significantly superior for plant height (over mid parent), days to maturity (over standard check).

While the cross Motihari Hemti X SK 49 was found significantly superior for Days to flowering (over standard check), leaf length (over mid parent and better parent), leaf width (over mid parent, better parent and standard check); while the cross Motihari Hemti X HDM 4 was found significantly superior for cured leaf yield (over mid parent and better parent), No. of leaves per plant (over mid parent) leaf length (over mid parent and better parent), leaf width (over mid parent, better parent and standard check); while the cross Motihari Hemti X Farrukhabad local was found significantly superior for cured leaf yield, leaf length, leaf width (over mid parent); while the cross Motihari Hemti X Black Queen was found significantly superior for leaf length, leaf width (over mid parent); as well as the cross Motihari Hemti X Black Queen was found significantly superior for cured leaf yield, leaf length, leaf width (over mid parent); while the cross Motihari Hemti X sel. 15-16 was found significantly superior for cured leaf yield (over mid parent and better parent), leaf length, leaf width (over mid parent).

It is, however, evidenced that not all yield contributing factors contribute equally towards heterosis for cured leaf yield. This was because the components compete for sum total of metabolic substances produced by the plant and the conditions favoring the development of one component may adversely affect the other component. Therefore to obtain maximum yield to a desired level of each component need to be known in a selection programme. The characters like Nicotine content and total reducing sugar content are the quality characters, which determine the acceptance by the consumers. The crosses, which exhibited significant desirable heterosis for these characters, can be utilized in breeding programme for quality improvement in tobacco.

Conclusion

The data on heterosis calculated over mid parental value, better parent and standard check revealed superiority of some cross combinations. For cured leaf yield, the cross GC 1 X SK 49 showed significant positive heterosis over standard check, the cross Motihari Hemti X Sel.15-16, Motihari Hemti X HDM 4 and GCT 4 X SK 49 exhibited significant positive relative heterosis, heterobeltosis. A perusal of per se performance and heterosis indicated that hybrids GC 1 X SK 49, GCT 4 X SK 49, Motihari Hemti X Sel.15-16 and GC 1 X Sel.15-16 were found promising for further evaluation and to exploit transgressive segregants.Heterosis is also useful to decide the direction of future breeding programme and to identify the cross combinations which are promising in conventional breeding programme. In the present study, heterosis over mid parental value, better parent as well as standard check AR 85 was estimated. While interpreting the results, positive effects were considered as favourable effects for all the characters excepts days

to flowering and days to maturity for which negative effects were considered favourable.

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