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GENETIC STUDIES IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.) I. HETEROTIC EFFECTS

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Abstract

Heterosis has been observed in many self fertilized species, including the cotton plant and it has been the subject of considerable study as a means of increasing its productivity. The objective of the present work was to determine the extension of heterosis over mid-parent, better parent and best parent for seed cotton yield/ha (SCYH) and other agronomic traits, as well as for fiber characters in 15 hybrids from 6 commercial varieties of cotton via., L_1 = 'Deltapine-16'; L_2 = 'Tamcot-SP-21'; L_3 = 'Cabuyare'; L_4 = 'Stoneville'; L_5 = 'Ospino' and L_6 = 'Acala-90-1'. The used statistical design was randomized complete blocks with 21 treatments (6 varieties and its 15 hybrids, excluding reciprocals) and three replications. Variance analysis were carried out and t-Student test was used to determine the differences among means (α = 0.10). There were no significant differences for better parent (HbBPC) in seed index. Significant HbBPC was found for days to blooming initiation; set flowers (SF); boll set; fruitful branches (FB); boll weight and SCYH. For fiber properties, significant HbBPC was found for fiber percentage; fiber length; fiber fineness and fiber strength. Significant heterosis over best parent (HbBPT) was only found for SF, FB and SCYH. Significant HbBPT was not found for fiber properties. Data are also given for heterosis over midparent values. These results demonstrated the presence of Hb for SCYH and other biometrical characters in cotton and the possibility of the agronomic use of this phenomenon in order to increase the productivity in this crop. On the other hand, these results showed that the Hb was mostly negative for fiber quality and that the hybrid L_3xL_4 with the biggest Hb for SCYH (58.52 %) and 2348.68 kg/ha had a Hb of -8.97 % for the fiber strength, with the smallest value (71 lb/inch^2). Those hybrid combinations that present a positive heterobeltiosis for SCYH and fiber quality be selected.

Introduction

Heterosis has been observed in many self fertilized species, including the cotton plant and it has been the subject of considerable study as a means of increasing its productivity, being even preferred for the exploitation of heterobeltiosis so that cotton hybrids for the commercial production should be superior to the best parent in the cross. On the other hand, the economic value and the textile use of any cotton type are determined by a group of physical properties of the fiber. The cross between two cotton varieties could produce hybrids with heterobeltiosis for a greater seed cotton yield/ha in combination with a better fiber quality. In India, hybrids have been released for their commercial exploitation, with high yields and good characteristics of the fiber.

Cotton is one of the crops of more importance in the agriculture of Venezuela and it is one of the commodities more exploited in the rainy season, providing occupation to the rural population almost during half of the year. On the other hand, the fiber and the seed are important raw materials in the manufacturing of clothes and oils, respectively, as well as of others industrial products (León *et al*., 1980). For the years 2003 and 2004, the volumes of cotton production were 12,932 and 22,446 t, respectively cultivated over 10,323 and 17,516 ha, respectively and seed cotton yields of 1,253 and 1,281kg/ha, respectively (FEDEAGRO, 2006).

One of the means for the improvement of the yields and other characteristics in cotton crop could be the use of hybrids. As it is known, the use of hybrid cultivars has represented a great advance in the development of the modern agriculture. Through the genetic breeding, using the hybridization technique, plants of different crops have been obtained with a better adaptation to certain environments, more productive, resistant and/or tolerant to some specific insects or diseases and, in general, plants with desirable agronomic characters to be cultivated commercially. However, actually the possibility of the hybrid production in cotton has been little diffused due to the scarce information and research and the high costs of obtaining of hybrids due to the nonexistence of commercial techniques for that. However, in India, some cotton hybrids with high yields and good fiber characteristics have been released for their commercial exploitation, due to the low cost of the manpower to carry out the hybridization in manual form.

For the production of hybrids in a crop, in first place, the heterosis or heterobeltiosis manifestation should be known. This condition is indispensable to start a genetic breeding program for obtaining of first generation hybrids for the commercial use. Heterosis and heterobeltiosis occur in many species of cultivated plants. In cotton, according to trials carried out by some researchers in the past eg., Ud-Din *et al*., (1980), Bahtt & Rao (1981), Tikka *et al*., (1980), and most recently by Ansari *et al*., (1993), Baloch *et al*., (1993), Soomro *et al*., (2000), Panhwar *et al*., (2002), Iqbal, *et al*., (2003), Wu *et al*., (2004), Desalegn *et al*., (2004) heterosis has been found for desirable agronomic characters as seed cotton yield, number of bolls/plant, boll size and fiber length and others. Unfortunately, there is little information about heterosis and heterobeltiosis in Venezuela, Gutierrez *et al*., (1998) estimated heterosis and heterobeltiosis for several yield and quality of fiber characteristics using five Upland type commercial cultivars of cotton which included two early: Lockett 77 and Tamcot SP 21, two intermediate: Cabuyare and Delta Pine 16 and one late: Acala Del Cerro and found that most of the crosses were superior to their parents for yield; being the most important those crosses that showed heterosis and heterobeltiosis for yield simultaneously with some of the quality of fiber characteristics such as Tamcot SP 21 x Delta Pine 16 and Acala Del Cerro x Cabuyare, the highest values of heterosis for yield were for Tamcot SP 21 x Cabuyare and Cabuyare x Delta Pine 16, also their values of heterosis and heterobeltiosis for length of fiber were high although not significant. All crosses were superior to Delta Pine 16 which is the most used commercial cultivar in the country

The objective of the present work was to determine the extension of the heterobeltiosis in relation to the best parent in the cross and better parent in the trial for seed cotton yield/ha and other agronomic characters, as well as, for fiber properties in 15 hybrids coming from 6 commercial varieties of cotton.

Materials and Methods

The experiment was carried out in Jusepín Town, where 6 commercial varieties of cotton viz., L_1 = ‘Deltapine-16’; L_2 = ‘Tamcot-SP-21'; L_3 = ‘Cabuyare'; L_4 = ‘Stoneville'; L_5 = ‘Ospino' and L_6 = ‘Acala-90-1' were used. The experiment consisted of two phases:

Phase I: This first phase, was denominated phase of crosses, it was carried out in the Estación Experimental de Sabana (Experimental Station of Savanna) of the Universidad de Oriente, Venezuela, located in the Table of Piedemonte of the plateau of the Oriental Plains, in a savanna soil previously cultivated. The preparation of the soil consisted of three passes of harrow, lime application of 1000 kg/ha 30 days before sowing. The experiment was fertilized with 15-15-15 in a dose of 600 kg/ha, applied in deep bands, urea was applied 30 days after sowing, in a dose of 200 kg/ha, applied in superficial bands. Two hills of plants were sown for each one of the used varieties. The distance between plants was 0.20 m and between hills was 1.0 m. The hills, with a length of 35.0 m were divided in 6 segments of 5.0 m each one, separated to each other by 1.0 m. One of the segments was dedicated for the self fertilization and intravarietal crosses and the five remaining hills were used to carry out the crosses with the other varieties, this with the purpose of obtaining the hybrid seeds, by means of diallel crosses excluding reciprocals to be used in the second phase.

The crosses began 36 days after sowing, following the methodology described by Poehlman (1981). The crosses were made one day before it was expected, the flowers opened up. For that, in first place, the corolla of the flower of the plant that would serve as female parent was cut, with a small scissor, then the anthers were eliminated (emasculation) being the stigma protected to avoid the possibility of cross pollination. The following day, in the morning, the pollination was carried out, collecting the male parent's pollen in a small piece of closed straw in one of its ends. This straw piece partially full with pollen was placed on the exposed stigma after removing the protector of the emasculated flower. To assure the pollination, the flower bracts were raised and they were placed surrounding the straw piece, getting together with a fine wire so that they stayed in their place. Finally, the cross was marked with a color tape in order to facilitate its identification. Approximately 40 crosses were carried out for segment with an approximate percentage of success of 75 % in agreement with that reported by Poehlman (1981).

For these crosses, there was a bigger emphasis in selected flowers located in the half third of the plant, which assure a bigger germination percentage and vigor (Arturi, 1984). The mature bolls from the crosses and from the self fertilization were harvested in two harvests, 119 and 135 days after sowing.

Phase II: The second phase or evaluation phase was carried out in the Estación Hortícola de Producción Vegetal (Horticultural Station of Crop Production of the Universidad de Oriente. Among the cultural practices carried out in this phase are: the preparation of the soil consisted of two passes of plow, three passes of harrow and lime application in dose of 1000 kg/ha, 30 days before sowing. The last pass of harrow was made one day before sowing, jointly with a pass to make the furrows. Three hills of the six commercial varieties of cotton and their 15 hybrid combinations were sown (excluding reciprocals) at a distance of 0.20 m between plants and 0.80 m between hills for an equivalent final population to 62500 plant/ha. Supplementary irrigation was made to meet the water requirements of the crop due to the absence of rains during the development of the crop. The cotton plants were fertilized with 15-15-15 in a dose of 600 kg/ha, placed in deep bands, urea was applied in superficial bands 30 days after sowing in a dose of 200 kg/ha. Weeds were controlled chemically using Round-up in dose of 4 l/ha in pre-sowing. H1-2000 was also applied in post-emergence in dose of 2 l/ha, 20 days after sowing. Two manual cleans were carried out, 35 and 82 days after sowing.

The experimental design was randomized complete blocks with three repetitions and 21 treatments (6 varieties and its 15 hybrids, excluding reciprocals). Each treatment was conformed by three hills of plants, the two outer two hills were considered as borders and the central hill was used for the evaluation of the different parameters. The obtained data were analyzed by means of the conventional analysis of variance. The three heterosis types were calculated by means of the formulas:

$$\mathbf{Het} = \frac{(\mathbf{F_1 - MP})}{\mathbf{MP}} * \mathbf{100}$$ over Mid-Parent Values

$$\mathbf{HbBPC} = \frac{(\mathbf{F_1 - BPC})}{\mathbf{BPC}} * \mathbf{100}$$ over better parent

$$\mathbf{HbBPT} = \frac{(\mathbf{F_1 - BPT})}{\mathbf{BPT}} * \mathbf{100}$$ over the best parent of the experiment

The heterosis values were also tested for significance to establish the difference of F1 hybrids means from their respective mid and better parents by applying t test with the following formula as quoted by Wynne *et al*., (1970).

$$t = \frac{(F_{1ij} - MP_{ij})}{\sqrt{\frac{3}{8} x EMS}}$$

Results

In Table 1, the means of different agronomic characters and fiber properties of 6 commercial varieties and their 15 hybrids are shown. In Table 2, the estimates of heterosis over mid-parent are shown for several agronomic characters and fiber properties of the cotton hybrids.

There was significant heterosis over mid-parent for all characters evaluated. All hybrids had positive heterosis over mid-parents for plant height and boll weight (three hybrids); number of fruit branches and number of set flowers (eight hybrids). All hybrids had negative heterosis over mid-parent for fiber content (four hybrids) and fiber strength (six hybrids). Of 15 F_1 hybrids, twelve had later blooming than its mid-parent value, two had earlier blooming and one had same blooming time. Eight hybrids had greater stem diameter and only one had lesser diameter over mid-parents. Two hybrids had lesser boll set and only one had greater boll set than its mid-parent. Six hybrids had positive heterosis and only one had negative heterosis for 100-seed weight. Two hybrids had positive heterosis and one had negative heterosis for fiber length and six hybrids had positive heterosis and five hybrids had negative heterosis for fiber fineness. Seed yield/ha presented positive heterosis for four hybrids and negative heterosis for one hybrid. Seed cotton yield/ha presented positive heterosis for three hybrids and negative heterosis for one hybrid.

Table 1. Means of several characters of 6 commercial varieties and 15 hybrids of Upland cotton (*Gossypium hirsutum* L.).

Varieties & Hybrids	Blooming initiation (days)	Plant height (cm)	Stem diameter (cm)	Number of fruit branches	Boll set (%)	Number of set flowers	100-Seed weight (g)	Boll weight (g)	Seed yield (kg/ha)	Seed cotton yield (kg/ha)	Fiber content (%)	Fiber length (inches)	Fiber strength (1000lb/inch^2)	Fiber fineness (mic.)
Deltapine 16	61.00	95.95	1.09	12.20	31.25	22.70	12.15	9.11	706.03	1093.45	34.85	1.03	76.00	4.10
Tamcot-SP-21	58.33	65.73	1.06	11.83	33.43	25.37	11.19	8.05	974.83	1523.34	35.91	1.03	76.33	3.90
Cabuyare	55.67	103.08	1.24	14.40	37.72	30.70	10.76	8.47	960.71	1481.63	35.03	1.05	78.00	4.17
Stoneville	61.00	105.77	1.22	15.77	26.16	30.07	11.40	8.65	881.32	1358.72	35.05	0.99	74.67	4.43
Ospino	61.33	84.48	1.16	12.20	30.59	27.27	10.13	8.60	901.57	1457.49	37.76	1.01	79.67	4.00
Acala 90-1	51.33	90.08	1.05	12.27	36.67	18.30	11.41	7.32	969.77	1637.71	39.93	1.06	79.33	4.47
DP 16 x TamSP21	55.67	103.72	1.43	17.87	32.03	37.77	12.54	9.59	1159.65	1871.74	37.65	1.02	73.33	4.47
DP 16 x Cabuy	60.67	103.57	1.39	20.00	28.60	39.20	12.10	8.89	1111.14	1733.68	33.72	1.01	77.00	4.10
DP16 x Stonev	62.67	109.78	1.48	19.23	29.54	39.53	11.42	8.95	1229.29	1896.21	35.07	1.04	72.67	4.27
DP 16 x Ospino	62.33	101.19	1.29	17.90	28.58	39.33	13.19	9.35	815.80	1268.70	35.13	1.08	75.00	4.40
DP 16 x Acala 90	62.33	105.43	1.25	17.07	30.36	32.40	11.66	8.76	852.02	1254.58	32.58	1.04	75.00	4.00
TamSP21 x Cabuy	61.00	85.84	1.19	13.70	37.30	27.60	12.08	7.94	1154.24	1787.08	35.44	1.01	72.00	4.03
TamSP21 x Stonev	62.67	71.67	1.01	11.80	33.06	22.90	11.57	8.18	952.06	1520.38	37.19	1.03	73.33	3.87
TamSPSP21 x Ospino	62.67	72.54	1.04	12.17	37.73	24.90	11.93	7.97	987.33	1593.67	38.02	1.04	80.00	4.23
TamSP21 x Acala 90	54.33	63.77	0.90	9.90	34.47	18.17	10.44	7.60	585.91	936.18	37.44	1.03	78.00	4.27
Cabuy x Stonev	62.00	118.65	1.63	19.25	23.30	45.77	11.89	9.08	1527.76	2348.68	35.07	1.06	71.00	4.07
Cabuy x Ospino	50.67	99.29	1.20	14.73	35.99	31.77	11.76	10.31	1044.31	1590.06	32.42	1.00	74.67	4.47
Cabuy x Acala 90	56.00	96.62	1.19	13.43	39.84	26.07	11.72	7.92	1046.46	1645.88	36.36	1.03	71.33	4.10
Stonev x Ospino	66.63	124.35	1.50	21.50	31.40	46.67	11.23	10.88	1067.67	1611.53	32.62	0.97	71.33	4.47
Stonev x Acala 90	66.33	130.01	1.45	18.80	27.34	40.67	11.13	10.40	762.44	1093.34	29.90	0.95	72.33	4.03
Ospino x Acala 90	70.33	82.41	1.03	11.53	30.36	22.33	11.41	8.10	702.61	1143.65	38.59	1.01	77.00	4.40

Table 2. Estimates (%) of Heterosis over mid-parent of several characters of 15 hybrids of Upland cotton (*Gossypium hirsutum* L.).

Hybrids	Blooming initiation (days)	Plant height (cm)	Stem diameter (cm)	Number of fruit Branches	Boll set (%)	Number of set flowers	100-Seed weight (g)	Boll weight (g)	Seed yield (kg/ha)	Seed cotton yield (kg/ha)	Fiber content (%)	Fiber length (inches)	Fiber strength (1000lb/inch^2)	Fiber fineness (mic)
DP 16 x TamSP21	-6.69	28.30	32.41	48.67	ns	57.11	7.45	ns	37.98	43.06	ns	ns	ns	11.75
DP 16 x Cabuy	3.99	ns	19.83	50.38	-17.05	46.82	ns	ns	33.33	ns	ns	ns	ns	ns
DP16 x Stonev	2.74	ns	27.59	37.55	ns	49.84	ns	ns	54.88	54.66	ns	ns	ns	ns
DP 16 x Ospino	1.91	ns	15.18	46.72	ns	57.44	18.40	ns	ns	ns	ns	5.88	ns	8.64
DP 16 x Acala 90	10.99	ns	16.82	39.46	ns	58.05	ns	ns	ns	ns	-12.86	ns	ns	-6.54
TamSP21 x Cabuy	7.02	ns	ns	ns	ns	ns	10.01	ns	ns	ns	ns	ns	-6.69	ns
TamSP21 x Stonev	5.04	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-6.97
TamSPSP21 x Ospino	4.75	ns	ns	ns	18.05	ns	11.91	ns	ns	ns	ns	ns	ns	7.09
TamSP21 x Acala 90	ns	ns	-15.09	ns	ns	ns	-7.61	ns	-39.74	-40.77	ns	ns	ns	ns
Cabuy x Stonev	6.27	ns	32.52	27.65	-27.05	50.66	7.31	ns	65.88	65.38	ns	3.92	-7.00	-5.35
Cabuy x Ospino	-13.88	ns	ns	ns	ns	ns	12.53	20.73	ns	ns	-10.93	ns	-5.28	9.56
Cabuy x Acala 90	4.67	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-9.32	-5.09
Stonev x Ospino	8.45	30.73	26.05	53.79	ns	62.78	ns	26.07	ns	ns	-10.41	ns	-7.57	5.92
Stonev x Acala 90	18.11	32.77	27.19	34.09	ns	68.20	ns	36.16	ns	ns	-22.01	-9.52	-6.06	-9.44
Ospino x Acala 90	24.85	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	3.77

ns : no significant (0.10)
Cells with values mean significant (0.10)

In Table 3, the estimates of heterosis are shown on the better parent (heterobeltiosis) and the best parent of the experiment for several agronomic characters and fiber properties of the cotton hybrids.

There were not significant heterobeltiosis on the better parent for seed index. All hybrids had positive heterosis over better parent for boll weight (three hybrids) and number of set flowers (six hybrids). All hybrids had negative heterosis over better parent for boll set (three hybrids); fiber content (four hybrids) and fiber strength (eight hybrids). Of 15 F_1 hybrids, 12 had later blooming than its mid-parent value, 2 had earlier blooming and 1 had same blooming time. Five hybrids had greater stem diameter and only one had lesser diameter over better parent. Two hybrids had smaller plants and only one had taller plants than its better parent. Five hybrids had positive heterosis and only one had negative heterosis for number of fruit branches. Six hybrids had negative heterobeltiosis and one had positive heterosis for fiber length and four hybrids had positive heterosis and seven hybrids had negative heterobeltiosis for fiber fineness. Seed yield/ha and seed cotton yield presented positive heterosis for one hybrid and negative heterosis for one hybrid.

Significant heterobeltiosis over the best parent was found for plant height; boll weight, seed yield/ha and seed cotton yield/ha (one hybrid each character); stem diameter (five hybrids); number of fruit branches (two hybrids) and number of set flowers (three hybrids). Significant heterobeltiosis over the best parent was not found for fiber properties.

Discussion

The extent of heterosis has often been measured in three ways vi., heterosis over mid-parent, better parent and the best parent. All three methods were followed in the present investigation and it was observed that the heterosis over mid-parent was conspicuous for all the characters. Table 4 shows the number of hybrids showing significant positive and negative heterosis for these three methods. Significant heterosis number was in the order mid-parent > better parent > best parent. Seed cotton yield had three hybrids with positive heterosis over mid-parent and only one hybrid over better and best parent. In cotton breeding programs, heterosis over better or best parent should be considered as a better measure of heterosis.

Earliness is one of the main objectives of the cotton breeding, it allows that harvest should be made before the crop suffers damages from unfavorable climatic conditions and it reduces the losses due to the attack of insects and diseases (Poelhman 1981). In this experiment, it was found that two of the hybrids were earlier in blooming than their mid-parent and better parent values. Sangwan & Yadava (1986) in a study of 30 crosses of *G. hirsutum* derived from crossing 15 varieties and lines as seed parent with 2 as pollen parents, reported that heterosis was observed for earliness (hybrids were early maturing).

It was found positive heterosis for the three methods evaluated in this report for plant height, stem diameter, number of fruitful branches and number of set flowers. These results agree with those obtained by others researchers. Mirza (1986) and Rauf *et al*., (2005) reported positive heterosis for plant height. Khan & Hydayat (1980), Ahmad *et al*., (1980) and Bhat & Rao (1981) found positive heterosis for number of fruitful branches in hybrids of first generation in similar studies, coming from diallel crosses.

Table 3. Estimates of Heterosis over better and best parent of several characters of 15 hybrids of Upland cotton (*Gossypium hirsutum* L.).

Hybrids	Blooming initiation (days)	Plant height (cm)	Stem diameter (cm)	Number of fruit branches	Boll set (%)	Number of set flowers	100-Seed weight (g)	Boll weight (g)	Seed yield (kg/ha)	Seed cotton yield (kg/ha)	Fiber content (%)	Fiber length (inches)	Fiber strength (1000lb/inch^2)	Fiber fineness (mic)
DP 16 x TamSP21	-4.56	ns	31.19	46.48	ns	48.88	ns	ns	ns	ns	ns	ns	ns	9.02
DP 16 x Cabuy	8.98	ns	ns	38.89	-20.86	ns	ns	ns	ns	ns	ns	-3.81	ns	ns
DP16 x Stonev	2.73	ns	21.31	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-3.61
DP 16 x Ospino	2.18	ns	ns	46.72	-20.52	44.22	ns	ns	ns	ns	ns	4.85	-5.86	7.32
DP 16 x Acala 90	21.43	ns	ns	39.12	ns	42.73	ns	ns	ns	ns	-18.41	ns	-5.46	-10.51
TamSP21 x Cabuy	9.57	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-3.81	-7.69	ns
TamSP21 x Stonev	7.44	-32.24	-17.21	-25.17	ns	ns	ns	ns	ns	ns	ns	ns	ns	-12.64
TamSPSP21 x Ospino	7.44	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	5.75
TamSP21 x Acala 90	5.84	-29.21	ns	ns	ns	ns	ns	ns	-39.90	-72.37	ns	ns	ns	-4.47
Cabuy x Stonev	11.37	ns	31.45	ns	-35.53	49.09	ns	ns	59.02	58.52	ns	ns	-8.97	-8.13
Cabuy x Ospino	-8.98	ns	ns	ns	ns	ns	ns	19.88	ns	ns	-14.14	-4.76	-6.28	7.19
Cabuy x Acala 90	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-10.08	-8.28
Stonev x Ospino	8.74	ns	22.95	36.33	ns	55.20	ns	25.78	ns	ns	-13.61	-3.96	-10.47	ns
Stonev x Acala 90	29.22	22.92	18.85	ns	ns	35.25	ns	20.23	ns	ns	-25.12	-10.38	-8.82	-9.84
Ospino x Acala 90	37.02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-4.72	ns	ns
Best Parent	ns	22.92	31.45	36.33	ns	52.02	ns	19.43	56.72	45.55	ns	ns	ns	ns
			20.97	26.82		49.09								
			19.35			32.48								
			16.94											
			15.32											

ns : no significant (0.10). Values mean significant percentages of heterobeltiosis (0.10)

Table 4. Number of hybrids showing significant positive and negative heterosis over mid-parent, better and best parent of several characters of 15 hybrids of Upland cotton (*Gossypium hirsutum* L.).

Character	Over mid-parent			Over better parent			Over best parent
	+	-	Total	+	-	Total	+
Blooming initiation (days)	12	2	24	12	2	14	0
Plant height (cm)	3	0	3	1	2	3	1
Stem diameter (cm)	8	1	9	5	1	6	5
Number of fruit branches	8	0	8	5	1	6	2
Boll set (%)	1	2	3	0	3	3	0
Number of set flowers	8	0	8	6	0	6	3
100-Seed weight (g)	6	1	7	0	0	0	0
Boll weight (g)	3	0	3	3	0	3	0
Seed yield (kg/ha)	4	1	5	1	1	2	1
Seed cotton yield (kg/ha)	3	1	4	1	1	2	1
Fiber content (%)	0	4	4	0	4	4	0
Fiber length (inches)	2	1	3	1	6	7	0
Fiber strength (10^3lb/inch^2)	0	6	6	0	8	8	0
Fiber fineness (mic)	6	5	11	4	7	11	0

\+ Positive heterosis
\- Negative heterosis

Heterosis for 100-seed weight and boll weight has been reported by several workers. Mirza (1986) in a study from a 7 x 7 diallel cross, involving 5 foreign and 2 local *Gossypium hirsutum* cultivars, revealed that positive heterosis for seed cotton yield, boll weight and 100-seed weight ranged from 6.20 to 235.22, 0.37 to 18.86 and 0.11 to 15.68% respectively. Zhou (1986) indicated that average heterosis for boll weight was 20.2 and 20.9 % in two upland cotton crosses and Rauf *et al*., (2005) reported that in case of boll weight, cross CIM-473 X NIAB-999 was on top and was followed by FVH-57 x NIAB-999 as far as heterosis is concerned. It was further noticed that the same crosses proved to be best in performance when compared with their better parents and Desalegn *et al*., (2004) found F_1 heterosis over the parental mean was of 13 % for boll weight. The results of seed index find support from Rauf *et al*., (2005), Desalegn *et al*., (2004) and Khan (1986) who observed considerable amount of heterosis for this character.

Heterosis was found significant for the three methods evaluated for seed cotton yield/ha and seed yield/ha. In similar studies, Krishnamurthy & Henry (1979) found positive effects of heterosis, compared with mid-parent values, for the seed cotton yield in 52 hybrids obtained from 13 varieties of *Gossypium hirsutum* with 4 varieties of *G. barbadense.* Also, Ud-Din *et al*., (1980) found heterotic effects up to 93.97 % on the mid-parent values for the character seed cotton yield. Garg & Kalsy (1988) indicated significant heterosis for seed cotton yield in a study of the parents and F_1's from a 9 x 9 diallel. Rauf *et al*., (2005) reported that out of the 20 crosses, most of the crosses manifested highly significant heterosis for yield of seed cotton and Desalegn *et al*., (2004) found that F_1 hybrids showed an overall yield advantage of the F_1 over the parental mean of 26.4%.

On the other hand, for the fiber properties, it was only found significant negative heterosis over mid-parent and better parent for fiber percentage and fiber strength, this result coincides with those reported by Marani (1968) who found that the fiber percentage in the F_1 hybrids, from diallel crosses of cotton, was lower than the mid-parents, also this result was reported by Desalegn *et al*., (2004). It was found significant negative and positive heterosis for the fiber length and fiber fineness. The heterosis manifestation for fiber length has been reported by Khan & Hidayat (1980) and Gesos & Pulatov (1980) in a similar study, also these two researchers worked with six cotton varieties and its 15 hybrids, finding sobredominance for the fiber length in 7 of 15 hybrids. Rauf *et al*., (2005), Desalegn *et al*., (2004) and Basal & Turgut (2003) in their studies noted varying amount of heterotic effect for fiber length.

These results demonstrated the presence of heterobeltiosis for the seed cotton yield/ha and other biometrical characters in cotton and the possibility of the agronomic use of this phenomenon in order to increase the productivity in this crop. On the other hand, these results showed that the heterobeltiosis was mostly negative for the quality of the fiber and that hybrid Cabuyare x Stoneville with the greater heterobeltiosis for seed cotton yield/ha (58.52%) and 2348.68 kg/ha had a heterobeltiosis of - 8.97% for the fiber strength, with the smallest value (71.000 lb/inch^2) but hybrid Deltapine 16 x Tamcot-SP-21 had 43.6 % of heterosis for seed cotton yield with no significant heterotic effect for fiber quality, except fiber fineness (11.75% positive heterosis). Gutierrez *et al*., (1998) indicated that the most interesting crosses were those where heterosis or heterobeltiosis for seed yield and for some fiber character and they found that hybrid Tamcot SP21 x Delta Pine 16 outyielded 26 % than mid parent value and had 6 % finer fibers that the best parent for this trait, similar results were found in this experiment. In conclusion, those hybrid combinations must be selected that present a positive heterosis or heterobeltiosis for seed cotton yield/ha and fiber quality.

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