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HETEROSIS AND COMBINING ABILITY IN SOME COTTON CROSSES IN TWO DIFFERENT ENVIRONMENTS:
1- Yield and yield components traits

Sorour, F.A.; M. S. Abdel- Aty; W.M.B. Yehia and H .M .K .Kotb
1-Agronomy Dept., Fac., of Agric., kafrel Sheikh. University.
2-Breeding Dept., Cotton Res., Institute, Agric., Res., Center, Egypt.

ABSTRACT

Two experiments were carried out at Sakha Agriculture Research Station, Cotton Research Institute, Agriculture Research Center, Egypt. The aim of this investigation was to study heterosis and combining ability for the most important traits of cotton (boll weight, seed cotton yield, lint yield, lint percentage, number of bolls per plant and seed index). Eight cotton genotypes 10229 x G.86, G.45, Pima S_1, Suven, TNB, CB.58, G. 70 and G. 93 were crossed in half diallel mating design in 2011 season to obtain 28 single crosses. These parents and their respective 28 F_1 crosses were evaluated in two planting dates (April and May) in a randomized complete blocks design in 2012 season.

The results obtained could be summarized as follows:-

1- Highly significant mean square values were obtained for genotypes, genotypes x dates, parents x dates, crosses x dates for all the studied traits.
2- The best general combiner for most of studied traits was parent (10229 x G. 86). Also the best general combiners for most of studied traits were crosses (10229 x G. 86) x Pima S_1, G.45 x G.70, CB.58 x G.70 and CB.58 x G.93
3- The parent (10229 x G. 86) had the best general combining ability for boll weight, seed cotton yield, lint yield and lint percentage under two sowing dates and their combined.
4- The crosses CB.58 x G.93 and G.45 x G.70 showed highly significant desirable specific combining ability for boll weight, seed cotton yield, lint yield and number of bolls per plant at two sowing dates and their combined.
5- Positive heterotic effects relative to the mid-parent were found for most of the traits in the crosses (10229 x G.86) x G.45, G.45 x Suven, G.45 x G.70, TNB x G.70 and C.B 58 x G.93. Also positive heterotic effects relative to the better parent were found for most of the traits in the crosses (10229 x G.86) x TNB, G.45 x Suven and G.45 x G.70 over two planting dates and their combined.
6- Dominance effects were important in the inheritance of boll weight, seed cotton yield and number of bolls per plant traits. The additive gene effects contribute the major portion of gene pool for lint yield, lint percentage and seed index traits.
7- Heritability estimates in narrow sense were low to high for all the studied traits, ranged from 32.17% for seed cotton yield to 91% for boll weight for the combined data.
8- From these results it could be concluded that the crosses CB.58 x G.93 and G.45 x G.70 appeared to be promising for late-planted tolerance therefore could be exploited in breeding program aiming to improve late-planting tolerance.

INTRODUCTION

Plant breeders are looking for desirable genes and gene complexes, and identification of promising individuals is very important in any breeding program. Diallel mating design is one of the tools which help the breeder to identify the potential genotypes and the promising recombination procedure by combining the parental individuals through GCA and SCA. In diallel mating design the parents are crossed in all possible combinations to identify parents as the best / poor general combiners through GCA and the specific crosses combinations through SCA. In combining ability, the entire genetic variability of each trait can be partitioned into GCA and SCA as defined by Griffing;s (1956), they stated that GCA effects a administer the additive type of gene action whereas SCA effects are showed due to genes which are non- additive (dominant or epistasis) in nature reported the importance of non-additive type of gene action for different cotton traits. (Abd El- Bary et al, 2008 a, Abd El-Hadi et al, 2005 a and b, Allam, 2003, Anisa et al 2004 and Basal and Turgut, 2005) However, El-Adly et al (2006), El-Debaby *et al* (1997), Hemaida et al (2006) and Iqbal et al (2005) stressed upon the appreciable degree of variance due to GCA and cleared that the mean square due to GCA and SCA were highly significant however the genetic variances due to SCA were greater than GCA for the yield traits showing the non-additive gene action. This study was carried out to study heterosis, gene action and combining ability in some cotton crosses under different environmental.

MATERIALS AND METHODS

The present investigation was carried out at sakha Agriculture Research Station, Cotton Research Institute, Agriculture Research Center, Egypt, during the two growing seasons of 2011 and 2012. Eight parents genotypes of wide divergent origin were used namely 10229 x G.86 (P_1) , G.45 (P_2) , Pima S1 (P_3) , Suven (P_4) , TNB (P_5) , C.B.58 (P_6) , G.70 (P_7) and G.93 (P_8) were crossed in a half diallel mating design to produce 28 F1 hybrids in 2011 season. The F1 hybrids and eight parents were growing in 2012 season in two dates {April (conventional planting date) and May (late-planting date)}.

A randomized complete blocks design with three replications was used in the two planting dates. Plot size one row, 4 m. long and 0.7 m. wide with 0.4 m. hill spacing. Hills were thinned to one plant per hill. The normal cultural practices for cotton production were performed at proper time. Ten plants were chosen at random from the middle row of each plot to estimate boll weight (gm.), seed cotton yield (gm.), lint yield (gm.), lint percentage, number of bolls per plant and seed index (gm.).

The ordinary analyses of variance for a randomized complete blocks design were done according Steel and Torrie (1960). General and specific combining ability estimates were computed according to Griffing;s (1956) method 2 model (1). The combined analysis of the two experiments (two planting dates) was done whenever homogeneity of variance was not significant.

Heterosis was calculated as the percentage of increase over both mid-parents (M.P) and better-parent (B.P) of each cross as follows:

Heterosis relative to mid-parent (M.P) % = $\frac{F_1 - \overline{M.P}}{\overline{M.P}}$ x 100

Heterosis relative to better parent (B.P) % = $\frac{F_1 - \overline{B.P}}{\overline{B.P}}$ x 100

Heritability was computed in both broad (H^2_b) and narrow senses (H^{-2}_n) as follow.

$$H^2_b\ \% = \frac{\sigma^2 G}{\sigma Ph} \times 100 = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 e} \times 100$$

$$H^2_n\ \% = \frac{\sigma^2_A}{\sigma^2_{Ph}} \times 100 = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_D + \sigma^2_e} \times 100$$

Where

H^2_b % = Heritability in broad sense

H^2_n% = Heritability in narrow sense

σ^2_G = Genetic variance

σ^2_{Ph} = Phenotypic variance.

σ^2_A, σ^2_D and σ^2_e are the additive, dominance and environmental component of variance, respectively.

RESULTS AND DISCUSSIONS

The analysis of variance for all studied traits for all genotypes is presented in Table (1). The results indicated that the mean squares of genotypes were highly significant indicating the presence of real genetic differences among them. These results were noticed for all the studied traits. The results also cleared that the mean square of parents and crosses also highly significant for all the studied traits. Also, genotypes x date, parents x date and crosses x date mean squares were highly significant for all studied traits.

Mean performance for parents and all crosses are presented in table 2. The results indicated that the highest parent was 10229 x G.86 (P_1) for boll weight , seed cotton yield per plant , lint cotton yield per plant , lint percentage at the two planting dates and combined data with the mean values of (3.55, 3.90, 3.73), (139.50, 149.73, 144.61), (56.97, 59.26, 58.11) and (40.80, 39.51, 40.15) respectively. While , the parent (P_2)

G.45 was the lowest mean performance for the boll weight, seed cotton yield per plant and lint yield in two planting dates and combined data, as well as in combined data for lint percentage with the mean values (3.02, 2.84, 2.93), (101.08, 90.26, 95.67), (34.94, 30.00, 32.47) and 33.58 respectively.

T1

T2

For number of bolls per plant the (P_6) CB.58 was the highest mean performance in the first date and combined with the mean values of 48.83 and 42.33 respectively, in addition to, the G.45 parent (P_2) was the lowest mean values for the same trait with the mean values 30.55, 24.63 and 27.59 in the two planting dates and combined data, respectively. Also , the (P_1) 10229 x G.86 was the highest mean value for seed index trait at the first date (11.79), behind , the (P_8) G.93 was the highest mean performance values for the same trait at the second date and combined with the mean values of 11.37 and 11.48, respectively.

For the crosses, the results also cleared that, the (10229 x G.86) x G.93 was the highest cross for boll weight at the second date and combined data with the mean values of 3.94 and 3.62. Also, the cross (10229 x G.86) x G.70 was the highest cross for lint percentage with 38.70 and 38.95. Behind, the TNB x G.70 cross was the highest mean for boll weight at the first date with 3.42g.

The results for seed cotton yield per plant cleared that the crosses (10229 x G.86) x Pima S_1, Pima S_1 x G.93 and CB.58 x G.93 were the highest crosses for first, second dates and combined data with the mean performance values 171.70, 170.61 and 161.09 respectively. Also, for the lint cotton yield per plant, the cross (10229 x G.86) x Pima S1 was the highest cross in the first date and combined data with the mean values 68.34 and 61.58, respectively. Although, (10229 x G.86) x G.70 was the highest cross for lint percentage at the second date and combined data with the mean values 38.70 and 38.95%, respectively.

For number of bolls per plant the cross Pima S_1 x G.93 was the highest cross at the combined data, but the lowest cross was G.70 x G.93 with the mean values 48.83 and 31.57. Also, the cross (10229 x G.86) x G.93 was the highest cross for seed index trait in the first date and combined data with the mean values of 12.22 and 11.99. Behind, the cross (10229 x G.86) x TNB was the highest mean in the second date with 11.95.

The estimates of general combining ability effects of parental varieties were obtained for yield and yield components and the results are presented in Table 3. The results indicated that positive general combining ability effect was found for most of studied traits. The comparison of the general combining ability effect of parent exhibited the parent 10229 x G.86 (P_1) was the best combiner for boll weight, lint cotton yield per plant and lint percentage at the first , second dates and combined data. As well as, for seed index at the second planting date. Also, the (P_3) Pima S_1 was the best combiner for seed cotton yield per plant and number of bolls per plant at the second planting date in addition to for lint yield in the second date and combined.

Specific combining ability effects (SCA) are given in Table 4. Significant positive SCA effects were obtained for some crosses indicating the presence of a considerable non- allelic gene effect. On the other hand, the significant negative estimates of SCA revealed the presence of undesirable types of epistasis in these combinations.

T3

T4

The highest posiive specific combining ability effects were found in the cross CB.58 x G.93 for boll weight in the first, second dates and combined data. Also, the cross G.45 x G.70 was the highest positive spcefic combining ability effects for seed cotton yield per plant and lint yield per plant at the second date and combined data. As well as, the cross Pima S_1 x suven was the highest positive specific combining ability effects at the first date and combined data for lint percentage. Although for number of bolls per plant the crosses Suven x G.93, Pima S_1 x G.93 and G.45 x G.70 were the highest positive specific combining ability effects at the first, second dates and combined data respectively. Also, the crosses G.45 x Pima S_1 and (10229 x G.86) x Suven were the highest positive specific combining ability effects for seed index in the first date and combined data respectively.

Heterosis has long been frequently observed in cotton especially in breeding program by hybridization. Useful heterosis expressed as the percentage of F_1 mean performance from mid - parents or better parent was observed for all traits studied. Heterosis values relative to mid- parents calculated and presented in table (5).

The amount of heterosis versus mid- parents for boll weight calculated and the results cleared that the TNB x G.70, G.45 x G.93 and CB. 58 x G.93 had the highest positive heterosis values with the mean of 10.67, 28.31 and 16.86 % for the first, second dates and combined data, respectively. On the other hand, the cross G.45 x G.70 was the highest positive heterosis values at the second date and combined for seed cotton yield (74.69 and 42.78) and lint cotton yield (84.13 and 43.86). Also, for lint percentage, the cross Pima S_1 x Suven was the highest positive heterosis values in first date and combined with the mean values 8.74 and 6.45%, respectively.

For number of bolls per plant showed 12, 8 and 12 crosses exhibited significant positive values of heterosis at the first, second dates and combined data, respectively. In the same time, the cross G.45 x G.70 was the highest positive heterosis values in second and combined data with the mean values of heterosis 44.65 and 26.22% respectively. Also, for seed index the results cleared that the crosses G.45 x Suven, (10229 x G.86) x Suven and (10229 x G.86) x G.45 were the best and the highest positive heterosis values in the first, second dates and combined data over the two planting dates with the mean values of heterosis 8.43 , 13.35 and 6.80% , respectively. These results are in agreement with those of, Abd EL- Bary et al (2008 a and b), Abd EL-Hadi (2005 a and b), EL-Mansy (2005), Allam (2003) , Ahmed et al (2006) , Baloch (2004) and Kalpande et al (2008) Soomro et al (2006), Saeed et al (2006) Nirania et al (2004) and Elangaimannan (2007).

The amounts of heterosis versus the better parent are calculated and the results are presented in Table (6). The results cleared that no one cross from all the crosses was the superior or the highest positive heterosis for all the studied traits. Also, the results cleared that for boll weight the crosses G.45 x G.93 was the highest positive hetrosis values for second date and CB. 58 x G.93 was the highest positive heterosis values for the first date and combined date , with the mean heterosis values 25.62 , 9.24 and 14.31% , respectively .

T5

T6

For , seed cotton yield per plant and lint yield per plant the cross G.45 x G.70 was the best and the highest positive heterosis values for the second date and the combined data over the two planting dates with the mean heterosis values 68.79, 34.28, 78.59 and 32.75%, respectively. On the other hand the cross Pima S_1 x Suven was the best and highest positive heterosis values for lint percentage at the first date and combined data over the two planting dates with the mean heterosis values 6.33 and 5.05% respectively. In the same time, for number of bolls per plant the cross G.45 x G.70 was the best cross and highest positive heterosis values with the mean values 40.88 and 21.59% respectively. Also, the crosses G.45 x Suven, (10229 x G.86) x TNB and (10229 x G.86) x G.45 were the best and the highest positive heterosis values for seed index at the first, second dates and the combined data over the two planting dates with the mean heterosis values is 6.22, 10.07 and 4.80%, respectively. These results are in agreement with those of, EL- mansy (2005) , Pole et al (2008) , McCarty et al (1996) , Soomro and Baloch (2005) , EL-Adl et al (2000) , Abd El-Hadi et al (2005 a and b)

The estimates of genetic variance components and heritability in broad and narrow senses were calculated and the results are presented in Table 7. The results indicated that, the additive genetic variances (σ^2A) were positive and larger than dominance genetic variances (σ^2D) for lint yield per plant at the first date and combined data, lint percentage at the first, second dates and combined data over the two planting dates and seed index at the first and combined data over the two planting dates. Also, the results cleared that the dominance variances (σ^2D) were positive and larger than additive genetic variance (σ^2A) for seed cotton yield per plant at the two planting dates and combined data over the two planting dates and the same results were obtained for number of bolls per plant. Also, the results cleared that the heritability in broad sense was larger than narrow sense and the heritability in broad sense ranged from 82.70% for seed index at the combined data to 98.53 % for boll weight at the combined data over the two planting dates. These results are in agreement with those of Many authers i.e. Abd El-Bary et al (2008a and b) , Abd El- Hadi et al (2005a and b) Ganapathy et al (2005) , Gaurav et al (2007) Iqbal et al (2005) and Mehetre et al (2004).

T7

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تقدير قوة الهجين والقدرة علي التالف في بعض هجن القطن المصري المنزرعة تحت بيئات مختلفة

١- المحصول ومكوناته

فؤاد عبد الحليم سرور * و محمد سعد عبد العاطي * و وليد محمد بسيوني يحيي و هيثم محروس كمال قطب****
*** قسم المحاصيل – كلية الزراعة – جامعة كفر الشخ**
**** معهد بحوث القطن – مركز البحوث الزراعية – مصر**

اجريت هذه الدراسة في محطة البحوث الزراعية بسخا ، معهد بحوث القطن وذلك لدراسة قوة الهجين والفعل الجيني الي جانب دراسة معامل التوريث بالمدي الواسع والمدي الضيق في بعض هجن القطن المصري الناتجة من التهجين نصف الدائري بين ثمانية اباء وهي ١٠٢٢٩ x جـ٨٦، جـ ٤٥، بيما س١، سيوفن، TNB، CB58، جـ٧٠ وجـ ٩٣ والتي تم زراعتها في الموسم الصيفي ٢٠١١ وتم التهجين بينها للحصول علي ٢٨ هجين في نظام تهجين نصف دائري وفي الموسم الصيفي الثاني ٢٠١٢ تم زراعة كل التراكيب الوراثية وهي ٢٨ هجين فردي بالإضافة للآباء الثمانية في تجربتين في ميعادين زراعة الأول في شهر ابريل والثاني في شهر مايو وتم اجراء جميع العمليات الزراعية المتبعة في مزرعة محطة البحوث الزراعية بسخا علي التجربتين وتم اخذ البيانات علي ٦ صفات للمحصول ومكوناته وتم تحليل البيانات وكانت النتائج كما يلي :-

١- اظهرت النتائج لدراسة التباين ان هناك اختلافات عالية المعنوية بين كل المواد الوراثية الموجودة تحت الدراسة وان كل من التفاعل بين المواد الوراثية ومواعيد الزراعة وبين الاباء ومواعيد الزراعة وما بين الهجن ومواعيد الزراعة كانت عالية المعنوية.
٢- بالنسبة لدراسة وتقدير المتوسطات اظهرت النتائج ان الاب الاول وهو ١٠٢٢٩ x جـ٨٦ كان الاعلي في متوسط كل الصفات تحت الدراسة بين كل الاباء وايضا من النتائج نستخلص ان الهجن (١٠٢٢٩ x جـ٨٦) x جـ٩٣ ، TNB x جـ٧٠، (١٠٢٢٩ x جـ٨٦) x بيماس١، CB.58 x جـ٩٣، بيما س١ x جـ ٩٣، (١٠٢٢٩ x جـ٨٦) x جـ٤٥ و (١٠٢٢٩ x جـ٨٦) x TNB كانت افضل واعلي الهجن في متوسطات الصفات تحت الدراسة بالمقارنة بباقي الهجن الفردية.
٣- بالنسبة لتقدير القدرة العامة علي التالف اظهرت النتائج ان الاب الاول (١٠٢٢٩ x جـ٨٦) كان الافضل وذو قدرة عامة علي التالف لمعظم الصفات الموجودة تحت الدراسة بالاضافة للأب الثالث بيما س١ كان ذو قدرة عامة علي التالف لصفات محصول القطن الزهر للنبات الي جانب متوسط عدد اللوز المتفتح علي النبات.
٤- اظهرت تقديرات القدرة الخاصة علي التالف ان الهجن CB.58 x جـ٩٣، جـ٤٥ x جـ٧٠، سيوفن x جـ٩٣، بيما س١ x جـ٩٣، جـ٤٥ x بيما س١ و (١٠٢٢٩ x جـ٨٦) x سيوفن كانت الاعلي والافضل للقدرة الخاصة علي التالف لمعظم الصفات الموجودة تحت الدراسة.
٥- بالنسبة لتقدير قوة الهجين علي اساس متوسط الاباء اظهرت النتائج ان الهجن TNB x جـ٧٠، جـ٤٥ x جـ٩٣ ، CB.58 x جـ٩٣، جـ٤٥ x سيوفن، (١٠٢٢٩ x جـ٨٦) x TNB و (١٠٢٢٩ x جـ٨٦) x جـ٤٥ كانت الافضل في قوة الهجين وذات قيم موجبة بالمقارنة بباقي الهجن تحت الدراسة.
٦- اظهرت النتائج بالنسبة لتقدير قوة الهجين علي اساس افضل الاباء ان الهجن جـ ٤٥ x جـ٩٣ ، CB58 x جـ٩٣ ، جـ٤٥ x جـ ٧٠ ، جـ٤٥ x سوفن ، (١٠٢٢٩ x جـ٨٦) x TNB و (١٠٢٢٩ x جـ٨٦) x جـ٤٥ كانت الاعلي والافضل بالنسبة لقيم قوة الهجين بالمقارنة بباقي الهجن.

٧- اظهرت النتائج لقياس اثر الفعل الجيني ان كلا من التباين الاضافي والتباين السيادي كانا يشتركان في توريث الصفات الموجودة تحت الدراسة وانه من خلال قياس وتقدير معامل التوريث يتضح ان معامل التوريث بالمدي الواسع كان اكبر من معامل التوريث بالمدى الضيق وان قيمة معامل التوريث بالمدي الضيق تراوحت بين ٣٢.١٧ % لمحصول القطن الزهرالي ٩١ % لوزن اللوزة فى التحليل التجميعى لميعادى الزراعة.

٨- ومن هذه النتائج يمكن التوصية بان الهجن CB.58 x جـ٩٣ و جـ٤٥ x جـ٧٠ يجب استغلالها فى برامج التربية التى تهدف لتحسين تحمل الزراعة المتاخرة.

قام بتحكيم البحث

أ.د / محمود سليمان سلطان — **كلية الزراعة – جامعة المنصورة**

أ.د / محمد شحاتة الكردى — **كلية الزراعة – جامعة كفر الشيخ**

Table 1: The mean squares of eight parents and F1 for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

S.O.V	d.f		Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	sin	com	d_1	d_2	Com.	d_1	d_1	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com
Replications	2		0.58**	0.79**		8462.4**	6291.9**		1672.2**	1314.45**		27.45**	35.64**		363.27**	181.93**		5.89**	6.62**	
Dates		1			5.33*			3819.6**			1007.29			44.74			2011.42			9.45
Ea		4			0.68			7377.13			1493.32			31.54			272.59			6.25
Genotypes	35	35	0.07**	0.22**	0.20**	1026**	1092.8**	1438.8**	194.42**	167.41**	258.67**	9.35**	6.22**	13.31**	75.33**	76.26**	93.22**	0.70**	1.24**	1.27**
Parents	7	7	0.09**	0.37**	0.38**	1047.8**	1312**	1971.54**	200.01**	285.09**	430.7**	13.91**	12.90**	22.10**	90.49**	29.12**	76.47**	0.80**	1.01**	0.96**
Crosses	27	27	0.06**	0.13**	0.12**	981.3**	961.8**	1164.2**	185.8**	124.89**	191.17**	8.35**	4.39**	11.03**	69.81**	90.34**	96.29**	0.68**	1.34**	1.39**
Parent versus crosses	1	1	0.06**	1.40**	1.02*	2080.6**	3093.6**	5124.1	388.17**	491.74**	876.85	4.61**	9.09**	13.33	118.31**	25.88*	127.43	0.35*	0.05	2.06
Genotypes x date		35			0.08**			679.9**			103.17**			2.27**			58.37**			0.67**
Parent x date		7			0.09**			388.3**			54.39**			4.72**			43.14**			0.84**
Crosses x date		27			0.06**			778.9**			119.52**			1.70**			63.86**			0.63**
Parent versus cross x date		1			0.44**			50			3.06			0.37			16.77			0.34
Eb	70	140	0.005	0.007	0.005	44.5	34.1	39.3	7.05	5.03	6.04	0.25	0.35	0.30	5.11	3.88	4.49	0.07	0.14	0.10

***, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively, d_1 and d_2, two planting dates.**

Table 2: The mean performances of eight parents and F1 for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

Genotypes	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.
10229 X G.86	3.55	3.90	3.73	139.50	149.73	144.61	56.97	59.26	58.11	40.80	39.51	40.15	39.26	37.54	38.40	11.79	10.86	11.32
G.45	3.02	2.84	2.93	101.08	90.26	95.67	34.94	30.00	32.47	34.53	33.18	33.85	30.55	24.63	27.59	10.49	11.31	10.90
Pima S_1	3.05	3.54	3.30	134.58	136.55	135.57	50.36	49.72	50.04	37.32	36.34	36.83	43.94	39.63	41.78	10.73	10.47	10.60
Suven	3.12	3.06	3.09	105.90	113.59	109.75	37.87	41.03	39.45	35.67	36.05	35.86	33.71	37.08	35.40	10.94	10.06	10.50
TNB	3.19	3.52	3.36	145.34	130.44	137.89	54.22	45.57	49.90	37.27	34.86	36.06	45.55	36.93	41.24	10.89	10.80	10.85
C.B58	3.10	3.21	3.16	151.63	115.10	133.37	52.17	40.94	46.55	34.37	35.54	34.95	48.83	35.84	42.33	10.99	9.71	10.35
G.70	2.98	3.22	3.10	120.43	96.80	108.61	44.89	31.92	38.40	37.22	32.84	35.03	43.50	29.47	36.49	10.26	10.94	10.60
G.93	3.07	2.96	3.02	115.66	99.96	107.81	40.20	35.08	37.64	34.75	35.08	34.91	37.46	33.03	35.25	11.59	11.37	11.48
(10299 X G.86) X G.45	3.39	3.51	3.45	147.20	129.80	138.50	55.22	47.26	51.24	37.51	36.31	36.91	43.40	36.85	40.12	11.96	11.78	11.87
(10299 X G.86) X pima S_1	3.31	3.85	3.58	171.70	147.30	159.50	68.34	54.81	61.58	39.78	37.16	38.47	56.16	37.47	46.81	10.74	11.56	11.15
(10299 X G.86) X Suven	3.24	3.80	3.52	153.90	114.16	134.03	61.30	41.61	51.45	39.77	36.39	38.08	47.54	29.99	38.76	10.94	11.86	11.40
(10299 X G.86) X TNB	3.33	3.86	3.60	149.15	117.78	133.46	59.87	44.33	52.10	40.02	37.44	38.73	44.63	30.42	37.53	11.62	11.95	11.79
(10299 X G.86) X C.B58	3.27	3.66	3.46	141.86	130.27	136.07	54.68	49.35	52.02	38.50	37.78	38.14	43.34	35.55	39.45	11.42	10.73	11.07
(10299 X G.86) X G.70	3.30	3.77	3.53	136.87	132.53	134.70	53.70	51.39	52.54	39.19	38.70	38.95	41.20	35.16	38.18	11.23	10.58	10.91
(10299 X G.86) X G.93	3.30	3.94	3.62	137.91	114.17	126.04	53.22	43.09	48.16	38.53	37.56	38.05	40.25	28.92	34.58	12.22	11.76	11.99
G.45 X Pima S_1	3.05	3.54	3.29	126.14	128.48	127.31	45.52	46.14	45.83	36.02	35.80	35.91	41.28	36.20	38.74	11.39	10.61	11.00
G.45 X Suven	3.03	3.47	3.25	118.30	124.73	121.51	43.39	44.97	44.18	36.57	36.00	36.29	38.93	35.90	37.41	11.62	10.74	11.18
G.45 X TNB	3.08	3.19	3.13	118.05	141.34	129.70	41.94	49.21	45.57	35.46	34.79	35.12	38.32	44.28	41.30	11.01	10.73	10.87
G.45 X C.B58	2.91	3.59	3.25	107.47	135.12	121.30	37.06	45.74	41.40	34.42	33.78	34.10	36.80	37.58	37.19	10.66	10.18	10.42
G.45 X G.70	3.14	3.65	3.40	128.30	163.39	146.01	44.96	57.00	50.98	34.99	34.87	34.93	39.77	45.69	42.73	10.90	10.34	10.62
G.45 X G.93	3.00	3.72	3.36	103.24	125.84	114.54	356.07	43.21	39.64	34.85	34.28	34.57	34.44	33.80	34.12	11.25	10.64	10.95
Pima S_1 X Suven	3.12	3.47	3.29	133.50	143.62	138.56	53.23	54.19	53.71	39.69	37.70	38.69	42.74	41.40	42.07	10.73	10.36	10.55
Pima S_1 X TNB	3.24	3.40	3.32	165.19	132.94	149.06	61.99	49.50	55.75	37.51	37.12	37.32	51.20	39.04	45.12	10.13	10.46	10.30
Pima S_1 X C.B58	3.03	3.43	3.23	144.70	131.09	137.89	53.01	47.09	50.05	36.52	35.82	36.17	47.71	38.19	42.95	10.66	10.23	10.45
Pima S_1 X G.70	3.17	3.61	3.39	133.21	143.28	138.24	49.62	52.99	51.30	37.15	36.90	37.02	41.95	39.65	40.80	10.30	10.16	10.23
Pima S_1 X G.93	3.13	3.32	3.23	132.58	170.61	151.59	47.33	61.11	54.22	35.61	35.80	35.71	42.18	55.49	48.83	11.31	10.26	10.79
Suven X TNB	3.06	3.45	3.26	142.33	135.07	138.70	51.71	48.63	50.17	36.19	35.99	36.09	46.54	38.99	42.77	11.07	10.08	10.58
Suven X C.B58	3.07	3.36	3.22	134.79	106.76	120.77	48.18	39.21	43.70	35.67	36.68	36.18	43.78	31.64	37.71	11.26	8.96	10.11
Suven X G.70	3.34	3.37	3.36	124.56	114.26	119.41	45.94	42.33	44.13	36.79	36.93	36.86	37.02	33.82	35.42	10.43	10.14	10.29
Suven X G.93	3.08	3.26	3.17	145.93	110.99	128.46	52.54	40.70	46.62	35.97	36.62	36.29	47.29	33.98	40.63	11.22	11.42	11.32
TNB X C.B58	3.39	3.49	3.44	168.68	140.99	154.84	61.46	49.39	55.42	36.41	34.99	35.70	50.24	40.44	45.34	10.76	9.82	10.29
TNB X G.70	3.42	3.68	3.55	136.00	103.72	119.86	52.17	37.70	44.94	38.26	36.31	37.28	39.71	28.01	33.86	11.21	10.35	10.78
TNB X G.93	3.24	3.25	3.25	152.32	116.89	134.60	56.06	41.13	48.60	36.67	35.08	35.87	46.90	35.86	41.38	11.59	10.31	10.95
C.B58 X G.70	3.23	3.39	3.31	111.09	111.95	111.52	40.43	39.12	39.77	36.27	34.95	35.61	34.19	32.95	33.57	10.67	10.53	10.60
C.B58 X G.93	3.39	3.83	3.61	163.05	159.14	161.09	56.26	56.02	56.14	34.49	35.15	34.82	48.19	41.55	44.87	11.20	10.94	11.07
G.70 X G.93	3.17	3.72	3.44	117.04	97.79	107.41	43.15	33.74	38.47	36.82	34.53	35.67	36.81	26.33	31.57	11.21	10.34	10.77
L S D. 0.05	0.11	0.14	0.12	10.84	9.49	10.32	4.31	3.64	4.04	0.81	0.96	0.90	3.67	3.20	3.49	0.43	0.61	0.52
0.01	0.15	0.18	0.14	14.43	12.64	12.16	5.75	4.85	4.77	1.08	1.28	1.06	4.89	4.26	4.11	0.57	0.81	0.61

Table 3: General combining ability effects of parental genotypes for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

Genotypes	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com.	d_1	d_2	Com
10229 X G.86	0.16**	0.27**	0.22**	10.28	4.64	7.46	7.03**	3.92*	5.48**	2.30**	1.67**	1.98**	1.17	-1.40	-0.12	0.41	0.61*	0.51
G.45	-0.10	-0.11	-0.10	-16.39**	-0.99	-8.69	-7.60**	-1.76	-4.68*	-1.30**	-1.15*	-1.23**	-3.98*	0.71	-1.63	0.02	0.18	0.10
Pima S_1	-0.05	0.02	-0.01	6.14	13.13**	9.64	2.98	5.41**	4.20*	0.51	0.53	0.52	2.59	3.53*	3.06	-0.29	-0.13	-0.21
Suven	-0.04	-0.12	-0.08	-4.97	-6.23	-5.60	-1.80	-1.74	-1.77	0.01	0.47	0.24	-0.94	-0.58	-0.76	-0.05	-0.21	-0.13
TNB	0.05	-0.01	0.02	10.76	1.05	5.91	4.37*	-0.01	2.18	0.32	-0.23	0.05	2.71	0.52	1.61	-0.04	-0.05	-0.05
C.B58	-0.01	-0.03	-0.02	6.01	0.64	3.33	0.54	-0.33	0.10	-1.09**	-0.35	-0.72	2.06	0.38	1.22	-0.10	-0.50	-0.30
G.70	0.01	0.02	0.01	-8.69	-7.86	-8.27	-3.03	-3.30	-3.16	0.20	-0.49	-0.14	-2.80	-2.49	-2.64	-0.31	-0.12	-0.22
G.93	-0.02	-0.05	-0.03	-3.14	-4.38	-3.76	-2.50	-2.19	-2.34	-0.95*	-0.45	-0.70	-0.82	-0.66	-0.74	0.36	0.22	0.29
LSD 0.05	0.11	0.14	0.12	10.84	9.49	10.32	4.31	3.64	4.04	0.81	0.96	0.90	3.67	3.20	3.49	0.43	0.61	0.52
LSD 0.01	0.15	0.18	0.14	14.43	12.64	12.16	5.75	4.85	4.77	1.08	1.28	1.06	4.89	4.26	4.11	0.57	0.81	0.61

***, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.**

Table 4.Estimates of specific combining ability for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

Genotypes	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.
(10299 X G.86) X G.45	**0.15****	**-0.15***	**0.01**	**18.34****	**-0.42**	**8.96**	**5.79****	**-0.58**	**2.61**	**-0.37**	**-0.17**	**-0.27**	**3.89***	**1.35**	**2.62**	**0.46***	**0.34**	**0.40**
(10299 X G.86) X pima S1	0.02	0.05	0.04	20.30**	2.97	11.63*	8.33**	-0.21	4.06*	0.10	-1.00*	-0.45	5.74**	-0.08	2.83	-0.45*	0.43	-0.01
(10299 X G.86) X Suven	-0.06	0.15*	0.05	13.61*	-10.81*	1.40	6.07**	-6.26**	-0.10	0.59	-1.71**	-0.56	4.97**	-4.23*	0.37	-0.49*	0.81**	0.16
(10299 X G.86) X TNB	-0.06	0.10	0.02	-6.87	-14.47**	-10.67*	-1.52	-5.26**	-3.39	0.53	0.03	0.28	-1.55	-4.90**	-3.22	0.19	0.75*	0.47
(10299 X G.86) X C.B58	-0.06	-0.08	-0.07	-9.40	-1.57	-5.49	-2.89	0.08	-1.41	0.41	0.49	0.45	-2.19	0.37	-0.91	0.04	-0.03	0.01
(10299 X G.86) X G.70	-0.06	-0.02	-0.04	0.30	9.18	4.74	-0.31	5.08**	2.39	-0.18	1.55**	0.68	0.84	2.85	1.84	0.07	-0.22	-0.08
(10299 X G.86) X G.93	-0.02	0.22**	0.10	-4.21	-12.66**	-8.43	-1.31	-4.32*	-2.81	0.30	0.38	0.34	-0.94	-5.22**	-3.08	0.38	-0.06	0.16
G.45 X Pima S1	0.01	0.13	0.07	1.41	-10.23*	-4.41	0.14	-3.20	-1.53	-0.06	0.46	0.20	0.36	-4.24*	-1.94	0.59**	-0.09	0.25
G.45 X Suven	0.01	0.20**	0.10	4.68	5.39	5.03	2.78	2.80	2.79	0.99*	0.72	0.85	1.54	-0.39	0.57	0.58**	0.13	0.35
G.45 X TNB	-0.06	-0.19**	-0.12*	-11.29*	14.71**	1.71	-4.83*	5.30**	0.23	-0.43	0.20	-0.12	-2.71	6.85**	2.07	-0.04	-0.05	-0.04
G.45 X C.B58	-0.16**	0.24**	0.04	-17.13**	8.90	-4.12	-5.88**	2.16	-1.86	-0.07	-0.69	-0.38	-3.57	0.29	-1.64	-0.32	-0.14	-0.23
G.45 X G.70	0.05	0.25**	0.15**	18.41**	45.67**	32.04**	5.58*	16.38**	10.98**	-0.79	0.54	-0.13	5.32**	10.31**	7.82**	0.13	-0.37	-0.12
G.45 X G.93	-0.07	0.39**	0.16**	-12.20*	4.64	-3.78	-3.84	1.49	-1.18	0.22	-0.08	0.07	-3.07	-2.44	-2.76	-0.19	-0.41	-0.30
Pima S1 X Suven	0.02	0.07	0.05	-2.65	10.15*	3.75	2.05	4.84*	3.45	2.29**	0.73	1.51**	-1.22	2.26	0.52	0.01	0.05	0.03
Pima S1 X TNB	0.05	-0.11	-0.03	13.31*	-7.81	2.75	4.65*	-1.59	1.53	-0.18	0.86	0.34	3.39	-1.21	1.09	-0.60**	-0.01	-0.31
Pima S1 X C.B58	-0.09	-0.06	-0.08	-2.43	-9.25	-5.84	-0.51	-3.67*	-2.09	0.23	-0.32	-0.05	0.76	-1.92	-0.58	-0.02	0.21	0.10
Pima S1 X G.70	0.02	0.07	0.05	0.78	11.44*	6.11	-0.33	5.19**	2.43	-0.43	0.89	0.23	-0.15	2.42	1.13	-0.17	-0.25	-0.21
Pima S1 X G.93	0.02	-0.15*	-0.07	-5.39	35.28**	14.94**	-3.16	12.21**	4.53*	-0.82*	-0.24	-0.53	-1.89	12.24**	5.17**	0.18	-0.49	-0.16
Suven X TNB	-0.13*	0.08	-0.02	1.56	13.69**	7.62	-0.86	4.70*	1.92	-1.02*	-0.22	-0.62	2.31	2.86	2.58	0.09	-0.30	-0.10
Suven X C.B58	-0.05	0.01	-0.02	-1.23	-14.21**	-7.72	-0.57	-4.39*	-2.48	-0.12	0.59	0.23	0.35	-4.32**	-1.99	0.34	-0.97**	-0.32
Suven X G.70	0.19**	-0.02	0.08	3.23	1.79	2.51	0.76	1.68	1.22	-0.30	0.98*	0.34	-1.44	0.69	-0.38	-0.28	-0.18	-0.23
Suven X G.93	-0.04	-0.08	-0.06	19.07**	-4.97	7.05	6.84**	-1.05	2.89	0.03	0.64	0.33	6.73**	-0.97	2.88	-0.16	0.77*	0.30
TNB X C.B58	0.17**	0.03	0.10	16.93**	12.73**	14.83**	6.55**	4.05*	5.30**	0.30	-0.41	-0.05	2.69	3.34*	3.02	-0.16	-0.27	-0.22
TNB X G.70	0.17**	0.18**	0.18**	-1.05	-16.04**	-8.55	0.83	-4.67*	-1.92	0.87*	1.06*	0.96*	-2.50	-6.14**	-4.32**	0.50*	-0.13	0.18
TNB X G.93	0.03	-0.19**	-0.08	9.72	-6.35	1.68	4.19	-2.35	0.92	0.42	-0.20	0.11	2.71	-0.19	1.26	0.21	-0.51	-0.15
C.B58 X G.70	0.06	-0.09	-0.02	-21.21**	-7.40	-14.30**	-7.09**	-2.93	-5.01**	0.28	-0.18	0.05	-7.38**	-1.15	-4.26**	0.01	0.50	0.26
C.B58 X G.93	0.24**	0.41**	0.32**	25.20**	36.31**	30.75**	8.22**	12.86**	10.54**	-0.35	-0.02	-0.19	4.56*	5.63**	5.09**	-0.13	0.57	0.22
G.70 X G.93	0.01	0.26**	0.13*	-6.11	-16.54**	-11.33*	-1.32	-6.40**	-3.86	0.68	-0.50	0.09	-1.88	-6.72**	-4.30**	0.09	-0.42	-0.16
LSD 0.05	0.11	0.14	0.12	10.84	9.49	10.32	4.31	3.64	4.04	0.81	0.96	0.90	3.67	3.20	3.49	0.43	0.61	0.52
LSD 0.01	0.15	0.18	0.14	14.43	12.64	12.16	5.75	4.85	4.77	1.08	1.28	1.06	4.89	4.26	4.11	0.57	0.81	0.61

***, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.**

Table 5: Heterosis relative to mid-parent (M.P) for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

Genotypes	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.
(10299 X G.86) X G.45	**3.42***	**4.21***	**3.82****	**22.37****	**8.17***	**15.28****	**20.16****	**5.91**	**13.14****	**-0.40**	**-0.08**	**-0.24**	**19.29****	**5.17**	**12.36****	**7.33****	**6.27***	**6.80****
(10299 X G.86) X pima S1	0.38	3.30*	1.93	25.29**	2.90	13.85**	27.34**	0.59	13.86**	1.85*	-2.02	-0.05	24.43**	-0.45	12.49**	-4.63**	8.39**	1.70
(10299 X G.86) X Suven	-2.89	9.11**	3.24*	25.43**	-13.29**	5.39	29.26**	-17.02**	5.47	4.03**	-3.67**	0.20	30.03**	-20.48**	4.37	-3.75*	13.35**	4.44*
(10299 X G.86) X TNB	-1.02	3.89*	1.55	4.72	-15.92**	-5.51	7.69*	-15.42**	-3.52	2.53**	0.69	1.63	5.24	-19.15**	-6.23	2.48	10.38**	6.34**
(10299 X G.86) X C.B58	-1.57	2.75	0.66	-2.54	-1.62	-2.10	0.21	-1.50	-0.61	2.43*	0.66	1.55	-1.59	-4.14	-2.75	0.23	4.34	2.18
(10299 X G.86) X G.70	0.99	5.82**	3.51**	5.31	7.52*	6.39	5.44	12.73**	8.88**	0.48	6.97**	3.60**	4.35	2.77	3.62	1.89	0.17	1.03
(10299 X G.86) X G.93	-0.31	14.79**	7.38**	8.10*	-8.55*	-0.14	9.55*	-8.64*	0.59	2.00*	0.72	1.36	8.59*	-19.72**	-5.11	4.51**	2.74	3.65
G.45 X Pima S1	0.43	10.89**	5.79**	7.05	13.29**	10.11**	6.72	15.75**	11.08**	0.27	3.01*	1.61	6.59	3.02	4.89	7.34**	-2.54	2.33
G.45 X Suven	-1.15	17.54**	8.01**	14.31**	22.37**	18.31**	19.17**	26.64**	22.86**	4.20**	4.01**	4.11**	15.71**	4.38	9.98*	8.43**	0.51	4.48*
G.45 X TNB	-0.88	0.28	-0.29	-4.19	28.08**	11.06**	-5.94	30.23**	10.66**	-1.22	2.27	0.47	-3.01	28.94**	11.85**	2.95	-2.94	-0.05
G.45 X C.B58	-5.01**	18.70**	6.78**	-14.95**	31.59**	5.92	-14.90**	28.97**	4.79	-0.06	-1.70	-0.88	-10.51**	11.20**	-0.72	-0.74	-3.09	-1.91
G.45 X G.70	4.60**	20.72**	12.70**	15.84**	74.69**	42.78**	12.63**	84.13**	43.86**	-2.46*	5.63**	1.42	10.76*	44.65**	26.22**	5.09**	-7.04**	-1.19
G.45 X G.93	-1.62	28.31**	12.98**	-4.73	32.31**	12.58**	-3.99	32.81**	13.09**	0.60	0.46	0.53	-3.03	3.26	-0.02	1.90	-6.14**	-2.17
Pima S1 X Suven	0.90	5.05**	3.04*	11.03**	14.83**	12.97**	20.66**	19.43**	20.03**	8.74**	4.15**	6.45**	9.86*	9.50*	9.68**	-0.91	0.93	-0.02
Pima S1 X TNB	3.66*	-3.75*	-0.27	18.02**	-0.42	9.02**	18.55**	3.88	11.56**	0.58	4.29**	2.39*	13.90**	3.49	9.14**	-6.26**	-1.61	-3.96
Pima S1 X C.B58	-1.66	1.60	0.05	1.11	4.18	2.55	3.41	3.87	3.63	1.89	-0.34	0.77	2.82	2.73	2.78	-1.83	1.44	-0.25
Pima S1 X G.70	4.91**	6.77**	5.89**	4.47	22.80**	13.23**	4.19	29.81**	16.01**	-0.32	6.67**	3.04**	-0.46	15.58**	6.74	-1.87	-5.11*	-3.51
Pima S1 X G.93	2.19	2.23	2.21	5.96	44.27**	24.57**	4.53	44.12**	23.67**	-1.17	0.25	-0.47	3.45	42.04**	21.57**	1.39	-6.07*	-2.30
Suven X TNB	-2.96	4.79**	1.00	13.30**	10.70**	12.02**	12.29**	12.30**	12.30**	-0.77	1.52	0.36	16.89**	5.35	11.32**	1.45	-3.36	-0.90
Suven X C.B58	-1.26	7.21**	2.99	4.68	-6.64	-0.64	7.02	-4.32	1.62	1.88	2.46*	2.17	5.97	-13.14**	-2.99	2.71	-9.37**	-3.02
Suven X G.70	9.39**	7.41**	8.39**	10.07*	8.62*	9.37*	11.01*	16.05**	13.37**	0.95	7.22**	3.99**	0.20	0.67	0.42	-1.59	-3.44	-2.51
Suven X G.93	-0.56	8.12**	3.72*	31.73**	3.95	18.09**	34.60**	6.95	20.95**	2.16*	2.97*	2.57*	32.50**	-4.03	14.31**	-0.38	6.58**	3.01
TNB X C.B58	7.65**	3.47*	5.49**	13.60**	14.84**	14.16**	15.54**	14.17**	14.93**	1.65	-0.60	0.53	5.46	11.15**	7.94*	-1.63	-4.23	-2.89
TNB X G.70	10.67**	9.33**	9.97**	2.34	-8.72*	-2.76	5.28	-2.68	1.79	2.73**	7.27**	4.89**	-7.48*	-16.17**	-11.29**	5.99**	-4.80	0.52
TNB X G.93	3.36*	0.28	1.79	16.72**	1.47	9.57**	18.75**	1.99	11.03**	1.82	0.33	1.09	12.87**	1.54	7.66	3.13	-6.99**	-1.90
C.B58 X G.70	6.31**	5.48**	5.88**	-18.33**	5.66	-7.82*	-16.69**	7.39	-6.36	1.34	2.22	1.77	-23.27**	-0.06	-13.40**	0.39	1.99	1.18
C.B58 X G.93	9.72**	24.01**	16.86**	22.00**	48.00**	33.59**	21.83**	47.37**	33.36**	-0.20	-0.46	-0.33	11.38**	19.47**	14.99**	-0.80	3.78	1.41
G.70 X G.93	4.62**	20.37**	12.57**	-0.85	-0.60	-0.74	1.44	0.88	1.19	2.31*	1.67	2.00	-5.45	-17.46**	-10.86**	2.58	-7.35**	-2.44
LSD 0.05	0.10	0.12	0.10	9.39	8.22	8.93	3.74	3.16	3.50	0.70	0.83	0.78	3.18	2.77	3.02	0.37	0.53	0.45
LSD 0.01	0.13	0.16	0.12	12.50	10.94	10.53	4.98	4.20	4.13	0.94	1.11	0.92	4.24	3.69	3.56	0.50	0.70	0.53

***, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.**

Table 6: Heterosis relative to better parent (B.P) for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
Genotypes	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.
(10299 X G.86) X G.45	-4.31**	-10.01**	-7.29**	5.52	-13.31**	-4.23	-3.07	-20.24**	-11.82**	-8.05**	-8.09**	-8.07**	10.49*	-3.86	3.40	1.41	4.16	4.80*
(10299 X G.86) X pima S1	-6.58**	-1.52	-3.93**	23.09**	-1.62	10.29**	19.96**	-7.50*	5.96	-2.48*	-5.95**	-4.19**	17.74**	-0.7	9.14*	-8.93**	6.45*	-1.56
(10299 X G.86) X Suven	-8.69**	-2.68	-5.54**	10.32*	-23.76**	-7.32*	7.59*	-29.79**	-11.46**	-2.51*	-7.89**	-5.15**	21.01**	-21.76**	-0.12	-7.24**	9.21**	0.65
(10299 X G.86) X TNB	-5.96**	-1.18	-3.45*	2.62	-21.34**	-7.71*	5.10	-25.18**	-10.34**	-1.90	-5.24**	-3.54**	-2.03	-20.62**	-9.01*	-1.41	10.07**	4.09
(10299 X G.86) X C.B58	-7.75**	-6.35**	-7.02**	-6.44	-13.00**	-5.91	-4.02	-16.72**	-10.50**	-5.64**	-4.39**	-5.02**	-11.22**	-7.26	-6.82	-3.17	-1.17	-2.21
(10299 X G.86) X G.70	-7.03**	-3.52*	-5.19**	-1.88	-11.49**	-6.86	-5.75	-13.28**	-9.59**	-3.93**	-2.06	-3.01**	3.02	-8.27	-1.19	-4.72*	-0.21	-2.19
(10299 X G.86) X G.93	-6.94**	0.96	-2.80	-1.14	-23.75**	-12.84**	-6.58	-27.28**	-17.13**	-5.56**	-4.93**	-5.25**	6.24	-24.55**	-8.97	3.62*	0.41	2.93
G.45 X Pima S1	-0.20	-0.09	-0.14	-6.28	-5.91	-6.09	-9.62*	-7.21	-8.42*	-3.49**	-1.48	-2.50*	-6.15	-6.03	-6.10	6.15**	-6.16*	0.92
G.45 X Suven	-2.84	13.29**	5.14**	11.71*	9.81*	10.72*	14.56*	9.62*	11.99*	2.54*	-0.14	1.19	15.13**	-3.15	5.57	6.22**	-5.01	2.57
G.45 X TNB	-3.61*	-9.46**	-6.68**	-18.78**	8.36*	-5.94	-22.66**	7.98	-8.67*	-4.86**	-0.2	-2.61*	-15.87**	19.90**	0.14	1.04	-5.13	-0.29
G.45 X C.B58	-6.32**	11.81**	2.90	-29.12**	17.39**	-9.05*	-28.95**	11.73*	-11.06**	-0.30	-4.97**	-2.44	-24.58**	4.85	-12.12**	-3.00	-9.94**	-4.37
G.45 X G.70	4.02*	13.66**	9.58**	6.54	68.79**	34.28**	0.16	78.59**	32.75**	-5.99**	5.09**	-0.29	1.39	40.88**	21.59**	3.94	-8.55**	-2.54
G.45 X G.93	-2.56	25.62**	11.27**	-10.74*	25.89**	6.24	-10.26	23.19**	5.32	0.28	-2.26	-1.00	-8.32	0.25	-4.26	-2.93	-6.42*	-4.66*
Pima S1 X Suven	-0.21	-2.07	-0.17	-0.80	5.17	2.21	5.69	32.07**	7.33	6.33**	3.73**	5.05**	-2.85	7.48	1.97	-1.86	-1.02	-0.47
Pima S1 X TNB	1.42	-3.97*	-1.17	13.65**	-2.65	8.10*	14.33**	8.61*	11.40**	0.51	2.16	1.32	11.95**	1.35	9.12*	-6.98**	-3.12	-5.06*
Pima S1 X C.B58	-2.41	-3.11	-2.08	-4.57	-4.00	1.72	1.62	15.01**	0.01	-2.15	-1.43	-1.79	-2.27	-0.84	1.47	-3.00	-2.23	-1.42
Pima S1 X G.70	3.69*	1.86	2.71	-1.02	4.93	1.97	-1.48	66.02**	2.52	-0.46	1.53	0.52	-4.64	2.95	-1.10	-4.01*	-7.16*	-3.52
Pima S1 X G.93	1.84	-6.10**	-2.10	-1.49	24.94**	11.82**	-6.02	74.20**	8.35*	-4.58**	-1.5	-3.06**	-4.11	33.17**	13.30**	-2.39	-9.82**	-6.07**
Suven X TNB	-4.01*	-2.10	-3.01	-2.08	3.55	0.58	-4.64	6.71	0.54	-2.91**	-0.16	0.07	1.83	5.11	3.51	1.25	-6.64*	-2.47
Suven X C.B58	-1.60	4.67*	1.92	-11.10**	-7.25	-9.44**	-7.64	-4.43	-6.14	0.02	1.74	0.89	-10.33**	-14.62**	-10.87**	2.46	-10.96**	-3.71
Suven X G.70	6.94**	4.83*	8.26**	3.43	0.59	8.80	2.34	3.16	11.86*	-1.16	2.44	2.79*	-7.85	-8.84*	0.05	-4.63*	-7.31*	-2.97
Suven X G.93	-1.32	6.40**	2.50	26.17**	-2.29	17.05**	30.71**	-0.81	18.17**	0.85	1.58	1.22	25.88**	-8.41	14.60**	-3.19	0.44	-1.39
TNB X C.B58	6.12**	-1.10	2.33	11.25**	8.09*	12.29**	13.35**	8.37*	11.08**	-2.32*	-1.56	-1.01	1.93	9.50*	6.55	-2.06	-9.05**	-5.10*
TNB X G.70	7.04**	4.54*	5.73**	-6.43	-20.49**	-13.08**	-3.78	-17.27**	-9.94**	2.66*	4.16**	3.38**	-12.82**	-23.93**	-17.80**	2.91	-5.42	-0.61
TNB X G.93	1.46	-7.70**	-3.35	4.80	-10.39**	-2.39	3.39	-9.75*	-2.61	-1.62	0.02	-0.53	2.97	-2.89	0.35	0.03	-9.35**	-4.62*
C.B58 X G.70	4.28*	5.43*	4.91**	-26.73**	-2.74	-16.38**	-22.50**	-4.44	-14.56**	-2.55*	-1.67	1.66	-29.97**	-8.07	-20.70**	-2.94	-3.75	-0.02
C.B58 X G.93	9.24**	19.19**	14.31**	7.53*	38.26**	20.79**	7.85	36.82**	20.59**	-0.75	-1.12	-0.39	-1.46	15.92**	5.90	-3.36	-3.81	-3.59
G.70 X G.93	3.06	15.65**	11.12**	-2.81	-2.17	-1.10	-3.86	-3.67	0.19	-1.09	-1.57	1.83	-8.65	-21.89**	-11.42*	-3.31	-9.11**	-6.18**
LSD 0.05	0.11	0.14	0.12	10.84	9.49	10.32	4.31	3.64	4.04	0.81	0.96	0.90	3.67	3.20	3.49	0.43	0.61	0.52
LSD 0.01	0.15	0.18	0.14	14.43	12.64	12.16	5.75	4.85	4.77	1.08	1.28	1.06	4.89	4.26	4.11	0.57	0.81	0.61

***, ** significant and highly significant at 0.05 and 0.01 probability levels, respectively.**

Table 7. The partitioning of the genetic variance for yield and yield components in two planting dates and their combined data in half diallel hybrids of cotton.

Genetic variance	Boll weight			Seed cotton yield			Lint yield			Lint percentage			Number of boll per plant			Seed index		
	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.	d1	d2	Com.
σ^2A	0.010	0.020	0.186	155.200	21.870	77.139	38.770	9.840	22.380	2.600	1.340	1.870	9.740	1.600	4.780	0.120	0.180	0.140
σ^2D	0.010	0.049	0.015	171.970	331.020	134.768	23.680	44.280	16.479	0.430	0.615	0.233	13.660	22.523	8.211	0.091	0.189	0.031
σ^2G	0.020	0.068	0.201	327.170	352.890	211.907	62.450	54.120	38.860	3.030	1.960	2.100	23.400	24.130	12.990	0.210	0.370	0.175
$\sigma^2{}_E$	0.002	0.002	0.003	14.840	11.353	27.902	2.351	1.678	4.245	0.080	0.117	0.116	1.702	1.292	2.544	0.024	0.046	0.036
$(\sigma^2D./\ \sigma A)^{½}$	1.000	1.580	0.280	1.050	3.890	1.320	0.780	2.120	0.860	0.170	0.680	0.120	1.180	3.750	1.310	0.880	1.030	0.470
σ^2ph	0.022	0.070	0.204	342.010	364.250	239.809	64.800	55.800	43.110	3.110	2.080	2.220	25.110	25.420	15.535	0.230	0.412	0.212
h^2_b	90.90	97.17	98.53	95.66	96.88	88.36	96.37	96.99	90.14	97.43	94.23	94.59	93.19	94.92	83.59	91.30	89.81	82.70
h^2_n	45.45	27.76	91.00	45.38	6.00	32.17	59.83	17.63	51.91	83.60	64.42	84.23	38.79	6.29	30.77	52.17	42.96	66.16