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Genetic Analysis of Seed Cotton Yield and its Attributes under Early and Late Plantings

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THIS RESEARCH was conducted to study the effects of late planting on the performance of Egyptian cotton sensitivity to environment, and gene actions that controlling seed cotton yield/plant (SCY/P) and related traits. Half diallel crosses of eight Egyptian cotton varieties were evaluated under early and late plantings. The analysis of variance indicated significant ($p \leq 0.01$) differences among entries (parents and crosses) for most traits. The reduction percentin seed SCY/P caused by the stress of late planting was 17.98 and 18.25 percent for the parents and hybrids; respectively. Stress susceptibility index indicated that five parents were tolerant for SCY/P to late planting. Fifteen out of the 28 hybrids showed tolerance in SCY/P to late planting. The diallel analysis of variance indicated that both additive and dominance effects of genes were involved in the inheritance of all traits. Generally, the regression coefficient "$b_{Wr/Vr}$" and the graphical analysis revealed that the inheritance of seed cotton yield/plant controlled by additive, dominance and epistatic effects of genes. The results of boll weight under the stress of late planting suggested the presence of additive, dominance and epistatic genes interaction. The genetic analysis of number of seeds/boll under late planting indicated no significance of the additive effects of genes "a item", however, the dominance item "b" was significant ($p \leq 0.01$). The non-additive effects of genes were reflected in the departure of narrow from broad sense heritability. Therefore, pedigree and recurrent selection breeding methods could be effective in isolating lines adapted to late planting.

Keywords: Egyptian cotton, Gene action, Late plantings, Seed cotton yield.

Introduction

Many reports emphasized the adverse effects of late sowing on yield and fiber properties, and mask any genetic improvement in cotton (Bauer et al. 1998; Bange & Milroy, 2004; Bange et al. 2008 and Pettigrew & Meredith 2009). The lack of understanding the effects of late sowing on genetics of yield and fiber properties of cotton is a great obstacle in improving new strains of cotton adapted to short-season production. Diallel analysis, as developed by Hayman (1954 and 1958), Jinks (1956) and Jinks & Hayman (1953), provides full information to identify superior parents and crosses for different traits. Several researchers (Luckett, 1989; Khan et al. 1995; Iqbal & Khan, 1996; Esmail et al., 1999; Mukhtar et al. 2000; Nadeem & Azhar, 2004; Basal & Turgut, 2005; Mohamed et al. 2009; Imran et al. 2012; Kumar et al. 2013; Raza et al. 2013; Simon et al. 2013; Soomro et al. 2006; Waqar et al. 2015 and Memon et al., 2016) pointed to the importance of genetic studies of the materials before selecting the desirable plant. Azhar & Khan (2005), Abbas et al. (2008), Abd El-Bary et al. (2008), Zangi et al. (2009), Palv (2009) and Darweesh (2010) reported that GCA effects were highly significant for number of bolls, seed cotton yield and lint percentage. They added that the general combining ability (GCA) variances were greater than specific combining ability (SCA) variances. Mohammed (2010) in *G. hirsutum* found that boll weight and number of open bolls were influenced by additive gene effects. While, seed cotton yield and number of sympodia were influenced by non-additive gene effects. Dewdar (2011), El-Kadi et al. (2011), Khan et al. (2011), Said (2011), Ali (2013) and Raza et al. (2013) revealed that there were noticeable differences between the parental genotypes for

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their positive significant GCA effects for most studied traits. In general, the magnitude of GCA mean squares was mostly greater than SCA mean squares expressed as GCA/SCA ratio, indicated that the magnitude of additive and additive × additive genetic effects were considerable in the inheritance of all characters compared to non-additive effects. Simon et al. (2013) found that GCA effects were higher than SCA effects for first fruiting nodes, in contrast in the case of days to first flower; suggesting that both additive and non-additive gene effects are playing an important role in inheritance of these characters. The current article was conducted to study the effects of late sowing date on the performance, and get detailed information concerning the genetic control of seed cotton yield/plant, number of bolls/plant, boll weight, seed index and number of seeds/boll of eight parent diallel cross of Egyptian cotton cultivars under early and late sowing dates.

Materials and Methods

Plant materials

This research was carried out at Shandaweel Res. Stn. Sohag, Cotton Res. Inst., ARC, during the summers of 2015 and 2016. The basic materials were eight Egyptian cotton varieties belong to *G. barbadense*, L. These varieties are shown in Table 1. The pure seeds of these varieties were obtained from the Cotton Research Institute, Agricultural Research Center at Giza, Egypt. The name, pedigree and the main characteristics of these varieties are presented in Table 1.

TABLE 1. The name, pedigree and the main characteristics of the varieties.

Genotypes	Pedigree	Characteristics
Giza 95	[(G.83 × (G.75 × 5844)) × G.80]	A new long-staple cotton variety, characterized by high yield-, high lint percentage, early maturity and heat tolerance (cultivated).
Giza 92	G84 (G74 x G68)	An extra-long staple variety, (cultivated).
Giza 90	Giza 83× Dandara	Long-staple variety for upper Egypt, high yield and lint percentage (cultivated).
Giza90×Aus	Giza 90 × Australian	Characterized by high yield and earliness (cultivated).
Giza 87	(G.77 × G.45A)	An extra-long staple (cultivated).
Giza 86	(G.77 × G.45B)	Long-staple variety, characterized by high yield
Giza 80	G. 66 × G. 73	Long-staple variety,characterized by high yield and lint percentage (cultivated).
Giza 45	G. 7×G. 28	An extra-long staple variety, (obsolete).

Reduction%=(early-late)/early.

Experimental design and field conditions

First season (2015)

The eight varieties were crossed in all possible combinations excluding reciprocals.

Second season (2016)

The parents and the 28 hybrids were sown on the 29th of March (early plating date) and on the 1st of May (late plating date) in a randomized complete block design with three replications for each treatment. Each plot consisted of one row, four-meterslong, 0.6m apart and 40cm between hills within a row. After full emergence, seedlings were thinned to one plant per hill. The recommended cultural practices were adopted throughout the growing season. The following data were recorded on each plot: 1) The seed-cotton yield/plant (SCY/P) was determined by dividing the total seed cotton yield of the two pickings by the number of plants. 2) The number of bolls/plant (NB/P); was counted during the two pickings. 3) The boll weight (BW); was estimated by taking the average weight of 25 bolls picked before the first picking from each plot. 4) The seed index (SI) was determined by weighing100 seeds.

Statistical analyses

The analysis of variance was performed in a randomized complete block design (RCBD) as outlined by Steel &Torrie (1980). Mean comparisons were calculated using revised L.S.D where :

$$R\,L\,S\,D\alpha = (t')\alpha^* \sqrt{(2MSE / r)}$$ (El Rawi & Khalafalla, 1980)

where t' is the t value from "minimum-average-risk t-table" at F-value of genotypes, genotypes df and experimental error df. Stress susceptibility index (SSI) was calculated according to the method of Fischer & Maurer (1978).

Yield of individual genotype was determined under stress (Yl) (late planting) and favorable (Ye) (early planting) conditions. Average yield of all genotypes under late (Xl) and early conditions (Xe) were used to calculate stress intensity (D) as:

$$D = 1 - Xl/Xe$$

The mean stress susceptibility index (SSI) of individual genotype was calculated as:

$$SSI = (1 - Yl/Ye)/D$$

Genotypes with average susceptibility or resistance to stress have "SSI" value of 1.0, values less than 1.0 indicate less susceptibility and great resistance to drought. Meanwhile, a value of SSI = 0.0 indicates maximum possible stress resistance (no effect of stress on yield). The diallel analysis was performed as outlined by Hayman (1954) and described by Mather & Jinks (1971)

Results and Discussion

Mean seed cotton yield/plant of the parents (Table 2) ranged from 66.33 for (G.87 extra-long) to 125.77 for (G90× Aus) with an average of 95.88g under early planting, and from 56.33 to 105.87 for (G90× Aus) with an average of 78.64g under late planting. Otherwise, the range of seed cotton yield/plant of the crosses was narrower than that in the parents, either under early or under late planting. Under early planting, the hybrids of seed cotton yield/plant ranged from 52.47 to 106.80 with an average of 75.55g, and from 47.13 to 86.80 with an average of 61.76g under late planting.

The reduction % in seed cotton yield/plant caused by the stress of late planting was 17.98% for the parents, and 18.25% for the crosses. Mohamed et al. (2009) noted reduction in seed cotton yield/plant of 42 and 37.4% for the parents and crosses; respectively, evaluated under optimum and drought conditions. Pettigrew & Meredith (2009) pointed to the adverse effects of late sowing on yield and fibers of cotton. The decrease in yield caused by late planting reached 29.79, 30.79 and 27.20% for females, males and crosses; respectively (Abdalla, 2014).

The results of SSI indicated that five parents (G.90x Aus, G.87, G.86, G.80 and G.45) were tolerant for SCY/P to late planting. Fifteen out of the 28 hybrids showed tolerance in SCY/P to late planting. The tolerant hybrids originated from one or both tolerant parents. These hybrids are promising to isolate new lines tolerant in SCY/P to late planting.

The reduction in boll weight reached 20.13 and 15.91% for the parents and hybrids; respectively. Mean of number of bolls/plant (Table 2) under early and late planting were comparable, and the reduction % in the parents was negative (-2.65).

Mean number of seeds/boll under late planting of the parental lines ranged from 16.43 for G.95 to 20.09 for G.45 with an average of 18.12g, and the reduction was 2.16%. The range of the F1- hybrids was 16.35 for G.87 × G.45 to 20.19 for G.80 × G.45 with an average of 18.19g, and the reduction was 3.50%. This is due to that the reduction % in boll weight of the parents was larger than that in seed cotton yield/plant. Furthermore, the reduction % in number of bolls/plant of the F1 hybrids was small (2.97%). The mean number of bolls of the parents ranged from 24.64 for G.92 to 46.67 for G.90 × Aus, and from 18.30 for G.87 × G.86 to 35.95 for G.95 × G.90 hybrid.

Mean seed index (Table 3) of the parental lines under early planting ranged from 9.30 to 10.87 with an average of 9.98g and from 8.07 to 9.30 with an average of 8.50g under late planting. Mean seed index of the F1- hybrids under early planting ranged from 8.50 to 10.30 with an average of 9.60g, and from 7.90 to 9.50 with an average of 8.69g under late planting. The reduction % in the F1's (9.47%) was less than that in the parents (14.82%) indicated that the hybrids were more stable than the parental lines in seed index.

TABLE 2. Mean seed cotton yield/plant, boll weight and number of bolls/plant, reduction % and stress susceptibility index (SSI);season 2016.

Genotype	SCY/P;g				BW;g			NB/P		
	Early	Late	Mean	SSI	Early	Late	Mean	Early	Late	Mean
G95	103.50	77.37	90.43	1.39	3.03	2.30	2.67	34.23	33.74	33.99
G92	77.70	61.03	69.37	1.18	3.20	2.47	2.83	24.34	24.94	24.64
G90	113.20	91.53	102.37	1.05	3.00	2.30	2.65	37.71	39.94	38.83
G90×Aus	125.77	105.87	115.82	0.87	2.80	2.20	2.50	45.29	48.05	46.67
G87	66.33	56.33	61.33	0.83	2.63	2.27	2.45	25.20	24.94	25.07
G86	104.30	85.73	95.02	0.98	3.43	2.53	2.98	30.58	33.99	32.28
G80	100.07	87.37	93.72	0.70	3.10	2.63	2.87	32.43	33.17	32.80
G45	76.20	63.90	70.05	0.89	2.60	2.33	2.47	29.38	27.30	28.34
Average	95.88	**78.64**	**87.26**		**2.98**	**2.38**	**2.68**	**32.40**	**33.26**	**32.83**
Reduction%		17.98				**20.13**			**-2.65**	
G95 × G92	87.67	77.37	82.52	0.65	3.10	2.90	3.00	28.30	26.85	27.57
G95 × G90	102.73	86.80	94.77	0.85	2.77	2.50	2.63	37.18	34.72	35.95
G95 × G90 × Aus	104.67	84.30	94.48	1.07	3.00	2.73	2.87	35.03	30.89	32.96
G95 × G87	75.47	72.20	73.83	0.24	3.20	2.67	2.93	23.68	27.28	25.48
G95 × G86	97.00	78.80	87.90	1.03	2.83	2.70	2.77	34.19	29.35	31.77
G95 × G80	72.70	63.73	68.22	0.68	3.00	2.47	2.73	24.25	25.99	25.12
G95 × G45	58.93	53.77	56.35	0.48	2.80	2.47	2.63	21.10	22.12	21.61
G92 × G90	77.87	76.13	77.00	0.12	2.90	2.50	2.70	26.91	30.44	28.68
G92 × G90 × Aus	99.30	60.90	80.10	2.13	2.83	2.43	2.63	35.29	25.34	30.32
G92 × G87	61.53	48.53	55.03	1.16	2.90	2.30	2.60	21.32	21.32	21.32
G92 × G86	62.37	48.50	55.43	1.22	3.00	2.33	2.67	20.98	21.12	21.05
G92 × G80	54.73	49.30	52.02	0.55	2.80	2.40	2.60	19.71	20.43	20.07
G92 × G45	53.77	48.17	50.97	0.57	2.93	2.23	2.58	18.36	21.73	20.05
G90 × G90 × Aus	106.80	73.20	90.00	1.73	2.97	2.47	2.72	36.07	29.86	32.97
G90 × G87	92.07	71.80	81.93	1.21	2.77	2.23	2.50	33.33	32.07	32.70
G90 × G86	73.20	56.20	64.70	1.28	3.10	2.57	2.83	23.61	21.93	22.77
G90 × G80	72.50	58.53	65.52	1.06	2.73	2.37	2.55	26.72	25.01	25.87
G90 × G45	61.80	53.23	57.52	0.76	2.77	2.30	2.53	22.34	23.21	22.78
G90 × Aus × G87	75.80	55.17	65.48	1.50	2.77	2.23	2.50	27.51	24.66	26.09
G90 × Aus × G86	74.50	57.10	65.80	1.29	2.73	2.23	2.48	27.50	25.57	26.53
G90 × Aus × G80	82.03	63.43	72.73	1.25	3.00	2.33	2.67	27.33	27.30	27.32
G90 × Aus × G45	100.60	71.80	86.20	1.58	2.73	2.23	2.48	36.84	32.27	34.55
G87 × G86	52.47	47.13	49.80	0.56	3.00	2.47	2.73	17.53	19.07	18.30
G87 × G80	61.37	54.73	58.05	0.60	2.93	2.43	2.68	21.05	22.51	21.78
G87 × G45	62.87	53.57	58.22	0.81	2.83	2.27	2.55	22.35	23.65	23.00
G86 × G80	63.97	53.43	58.70	0.91	2.93	2.47	2.70	21.81	21.78	21.80
G86 × G45	62.80	56.17	59.48	0.58	2.77	2.33	2.55	22.76	24.39	23.57
G80 × G45	63.83	56.00	59.92	0.68	2.87	2.47	2.67	22.34	22.69	22.51
Average	75.55	**61.76**	**68.65**		**2.89**	**2.43**	**2.66**	**26.26**	**25.48**	**25.87**
RLSD0.05	9.24	11.78				0.43		4.11	5.43	
RLSD0.01	12.09	15.49				0.57		5.32	6.93	
Reduction%		18.25				**15.91**			**2.97**	

Reduction%=(early-late)/early.

TABLE 3. Mean seed index and number of seeds/boll; season 2016.

Genotype	SI;g			NS/B		
	Early	Late	Mean	Early	Late	Mean
G95	9.50	8.77	9.13	18.83	16.43	17.63
G92	10.27	8.20	9.23	19.86	19.87	19.86
G90	9.87	8.23	9.05	18.67	17.72	18.19
G90 × Aus	9.30	8.13	8.72	18.01	16.75	17.38
G87	9.87	8.30	9.08	18.07	18.97	18.52
G86	10.87	9.03	9.95	19.04	17.53	18.28
G80	10.80	9.30	10.05	17.20	17.58	17.39
G45	9.40	8.07	8.73	18.46	20.09	19.28
Average	9.98	8.50	9.24	18.52	18.12	18.32
Reduction%		14.82			2.16	
G95 × G92	10.03	9.50	9.77	19.26	19.18	19.22
G95 × G90	9.47	9.10	9.28	17.85	17.26	17.56
G95 × G90 × Aus	8.50	7.90	8.20	21.26	21.58	21.42
G95 × G87	9.90	8.50	9.20	20.08	20.18	20.13
G95 × G86	10.30	9.37	9.83	16.57	18.52	17.55
G95 × G80	10.17	8.90	9.53	18.21	17.69	17.95
G95 × G45	9.53	8.90	9.22	18.23	17.79	18.01
G92 × G90	9.57	8.30	8.93	18.83	20.51	19.67
G92 × G90 × Aus	10.23	9.17	9.70	17.58	17.11	17.35
G92 × G87	9.60	8.60	9.10	20.34	18.35	19.34
G92 × G86	9.80	8.80	9.30	18.44	17.33	17.89
G92 × G80	9.63	8.50	9.07	18.06	18.33	18.20
G92 × G45	9.53	8.40	8.97	20.01	18.03	19.02
G90 × G90 × Aus	9.27	8.70	8.98	19.69	18.10	18.90
G90 × G87	9.83	8.43	9.13	18.14	17.88	18.01
G90 × G86	9.70	8.83	9.27	19.66	18.82	19.24
G90 × G80	9.67	8.97	9.32	17.36	16.81	17.09
G90 × G45	9.50	8.50	9.00	18.78	18.23	18.51
G90 × Aus x G87	9.43	8.50	8.97	18.55	17.22	17.88
G90 × Aus × G86	9.80	8.67	9.23	17.18	16.88	17.03
G90 × Aus × G80	9.30	8.53	8.92	19.20	17.37	18.29
G90 × Aus × G45	9.40	8.47	8.93	17.87	16.81	17.34
G87 × G86	9.30	8.53	8.92	20.59	18.54	19.56
G87×G80	9.80	9.10	9.45	19.15	17.59	18.37
G87 × G45	9.57	8.80	9.18	18.09	16.35	17.22
G86 × G80	9.33	8.67	9.00	19.00	17.85	18.42
G86 × G45	9.27	8.30	8.78	19.01	18.72	18.86
G80 × G45	9.27	8.30	8.78	20.74	20.19	20.47
Average	9.60	8.69	9.14	18.85	18.19	18.52
RLSD0.05	0.42	0.35			3.56	
RLSD0.01	0.55	0.45			3.03	
Reduction%	9.47			3.50		

Variance, mean, reduction% and stress susceptibility index

The analysis of variance (Tables 4 and 5) of seed cotton yield/plant, boll weight, number of bolls/plant, seed index and number of seeds/boll indicated significant ($p \leq 0.01$) differences among genotypes (parents and crosses) except for boll weight and number of seeds/boll under early planting date. Therefore, the diallel analysis was performed for these traits except for boll weight

and number of seeds/boll under early planting.

The diallel analysis of variance

The analysis of variance was done for the parents, F1- hybrids, and parents + F1- hybrids separately under early and late planting dates (not included). A comparison of the block interaction (Exp.error) for the parental families and for the F1- hybrids of the diallel set, showed insignificant differences between them (with 14 and 54 degrees of freedom). Therefore, EP = EF1 and both equal to the block interaction (Bt) mean squares for the 36 replicated families of the diallel (Mather & Jinks, 1971). The block interaction (Bt) was used in estimation of the genetic parameters of all traits. The genotypes mean squares (Tables 4 and 5) was significant ($p \leq 0.01$) for seed cotton yield/plant, number of bolls/plant and seed index under early and late planting, except for boll weight and number of seeds/boll which were significant ($p \leq 0.05$) under late planting. The diallel analysis of variance (Tables 4 and 5) indicated significant ($p \leq 0.01$) "a" and "b" items for all traits expect for "b" item of seed cotton yield/plant and "a" item for number of seeds/boll under late planting. The significance of "a" and "b" items indicated that both additive and dominance effects of genes were involved in the inheritance of the respective traits. The "b1" item mean square was significant for seed cotton yield/plant and number of bolls/plant under early planting, and seed index under both planting conditions. The "b1" item tests the mean deviations of the F1s from their mid–parental values. It is significant only if the dominance deviations of the genes are predominantly in one direction. The "b2" item was significant for seed cotton yield/plant under early planting, boll weight under late planting, number of bolls and seed index under both planting conditions. The "b2" item tests whether the mean dominance deviations of the F1 from their mid–parental values within each array differs over arrays. It will do so if some parents contain considerably more dominant genes than others. The "b3" item was significant for seed cotton yield/plant under early planting, boll weight under late planting, number of seeds/boll under late planting and number of bolls/plant and seed index under both planting dates. The "b3" component tests the part of dominance deviations that is unique to each F1. This component is equivalent to the specific combining ability of Griffing (1956) and others. These results are in general agreement with those reported by Mahdy (1982 a and b) in a full diallel analysis under two plant densities, and Mohamed et el. (2009) in a study of 6- parent diallel cross under normal and drought stress conditions.

The interpretation of Wr/Vr graph

The graphical analysis of seed cotton yield/plant is shown in Fig.1 and 2. The regression coefficient of Wr/Vr under early planting differed significantly from both of "1.0" and zero, and not from both under late planting (Table 4). This indicates that epistatic effects of genes were involved in the inheritance of seed cotton yield/plant. The regression line intercepted the Wr axe near the original point under early planting, indicating near complete dominance, which confirmed by the average degree of dominance (1.274) (Table 6). Otherwise, under late planting the intercept of regression line to the Wr axe was negative (-5.449) indicating over–dominance. The average degree of dominance (H1/D).5 was 1.885 (Table 6) confirming this result. The parent G.80 was located under the regression line and far from the limiting parabola causing over–dominance. Therefore, it could be concluded that the diallel analysis of variance and graphical analysis indicated that the epistatic gene effects were involved in the inheritance of seed cotton yield/plant.

The diallel analysis of variance of boll weight (Table 4) indicated that, mean squares of the entries was not significant under early condition. Therefore, the diallel analysis was not completed. Under late planting condition the regression coefficient of Wr/Vr was negative and significantly ($p \leq 0.01$) differed from unity but not from zero indicating the presence of epistatic gene interaction in the inheritance of boll weight.

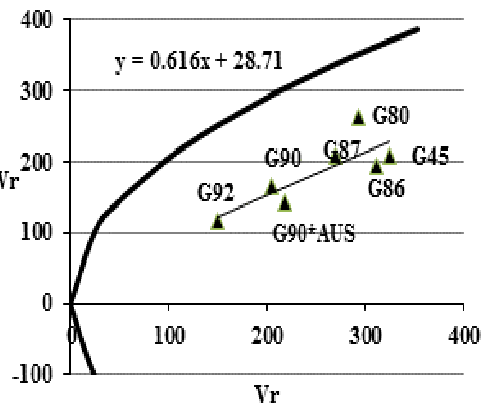

Fig. 1. D1 SCY

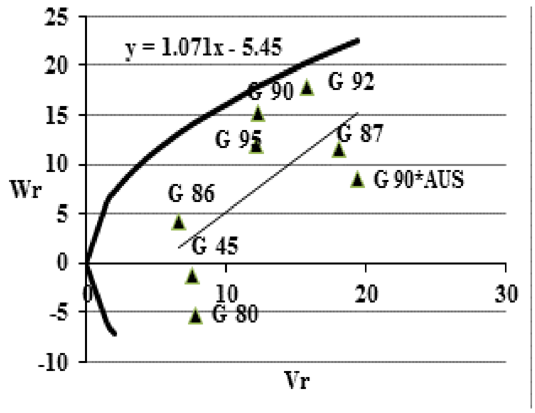

Fig. 2. D2 SCY

TABLE 4. Mean squares of the diallel analysis of variance in the F_1- generation at early (D1) and late (D2) planting dates for seed cotton yield/plant, boll weight and number of bolls/plant; season 2016.

Item	df	SCY/P;g		BW;g	NB/P	
		D1	D2	D2	D1	D2
Blocks(b)	2	68.73028	118.9729	0.158148	5.890994	41.95258
Genotypes	35	1138.449**	647.2253**	0.080275**	133.0579**	108.6351**
A	7	5589.750**	149.6049**	0.3291**	686.4554**	149.6049**
B	28	893.473**	55.8309	0.1002**	104.0335**	55.8309**
b1	1	8684.369**	26.7188	0.0537	789.4461**	26.7188
b2	7	525.878**	29.8072	0.1448**	35.9721**	29.8072*
b3	20	632.586**	66.3948	8.7335*	93.5843**	66.3948**
a*b	14	53.8303	67.9832	0.1003	18.1735	67.9832
b*b	56	71.7689	6.0957	6.5879	10.4122	6.0957
b1*b	2	23.3447	2.6907	7.9090	4.1369	2.6907
b2*b	14	89.1333	6.3445	6.0245	15.8172	6.3445
b3*b	40	68.1126	6.1788	7.0750	8.8342	6.1788
Error(Bt)	70	41.82247	60.95687	0.040815	7.754373	12.22428
r(p-,wr +vr)		0.073536	0.51086	0.26033	0.44472	0.51086
Wr+Vr		Ns	*	ns	ns	*
Wr-Vr		Ns	*	ns	ns	*
b from unity		*	Ns	**	*	ns
b form 0.0		*	Ns	ns	*	ns

*, ** Significant at 0.05 and 0.01 levels of probability; respectively, b from unity and from zero is the significant deviation of b Wr/Vr from unity and zero; respectively, r (p^-,wr +vr) is the correlation between the performance of the parents and Wr+Vr, ns= not significant.

The graphical analysis of number of bolls/ plant (Fig. 3, 4, 5 and Table 5) indicated partial dominance under early and over–dominance under late planting. The regression coefficient showed significant difference from unity and zero under early and not significant from both under late planting declaring the presence of epistatic effects of genes controlling number of bolls/plant.

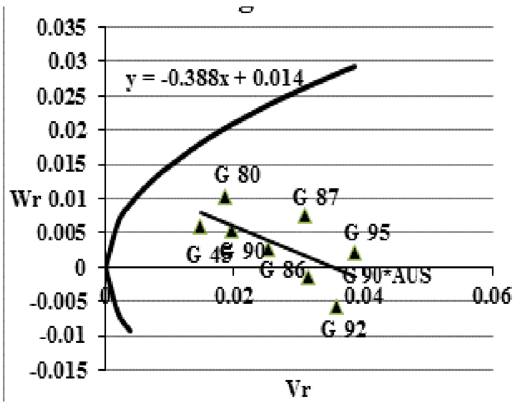

Fig. 3. D2 BY.

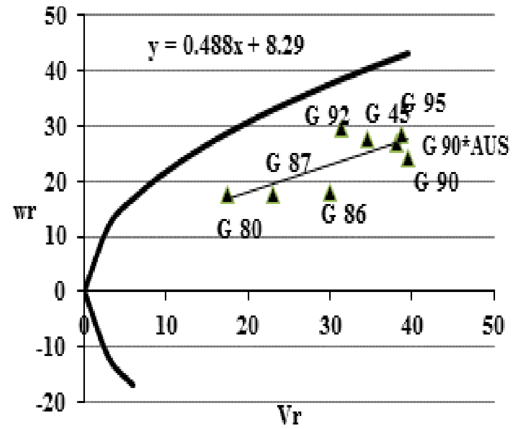

Fig. 4. D1 NB.

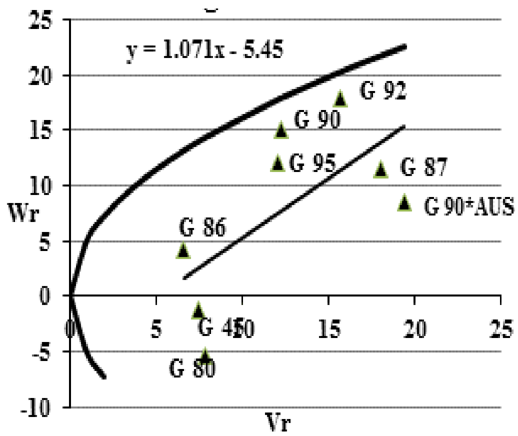

Fig. 5. D2 NB.

The graphical presentation of seed index (Fig. 6, 7 and Table 5) showed that under early planting the regression coefficient of Wr/Vr was not significant fromunity, but significant from zero, and Wr–Vr mean squares was not significant indicating the adequacy of the additive–dominance model for the data of seed index.

Furthermore, the intercept of the regression line to the Wr axe was negative and very small (-0.0473) indicating nearly complete dominance. However, under late planting, the regression coefficient was significant from both of zero and unity (Table 5) indicating the presence of non–allelic gene interaction and the inadequacy of additive – dominance model for seed index under late planting.

The graphical presentation of number of seeds/boll (Fig.8) under late planting indicated that the regression coefficient of Wr/ Vr was not significant from both of zero and unity showing non-allelic gene interaction. It could be concluded that the epistatic gene interactions were involved in the inheritance of seed cotton yield/plant, boll weight, number of bolls / plant under both planting conditions and for seed index and number of seeds/boll under late planting.

TABLE 5. Mean squares of the diallel analysis of variance in the F_1- generation at early (D1) and late (D2) planting dates for seed index and number of seeds/boll; season 2016.

Item	df	SI;g		NS /B
		D1	D2	D2
Blocks (b)	2	0.095926	0.04731	5.81
Genotypes	35	0.609235**	0.43681**	4.6605*
A	7	1.1902**	0.93861**	4.3281
B	28	0.8599**	0.67529**	9.1526**
b1	1	3.1435**	0.70126**	0.1041
b2	7	0.6351**	0.34089**	6.6056*
b3	20	0.8244**	0.79103**	10.4965**
a*b	14	0.1259	0.07952	7.7193
b*b	56	0.1324	0.10004	3.8761
b1*b	2	0.1597	0.01969	0.0402
b2*b	14	8.5157	0.06658	3.5200
b3*b	40	0.1470	0.11578	4.1926
Error (Bt)	70	0.075735	0.0526	2.5743
r (p-,wr +vr)		0.0172	0.453656	-0.0160
Wr + Vr		**	ns	ns
Wr - Vr		Ns	*	ns
b from unity		Ns	ns	ns
b form 0.0		**	ns	ns

*, ** Significant at 0.05 and 0.01 levels of probability; respectively, b from unity and from zero is the significant deviation.

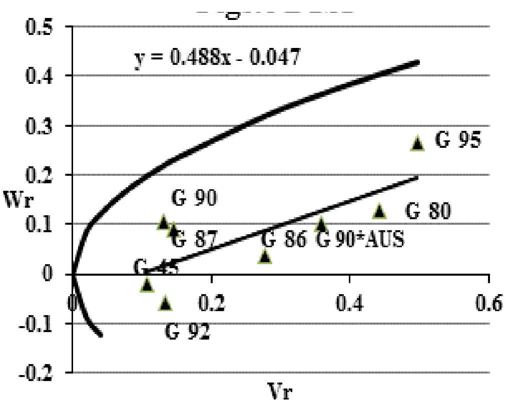

Fig. 6. D1 SI.

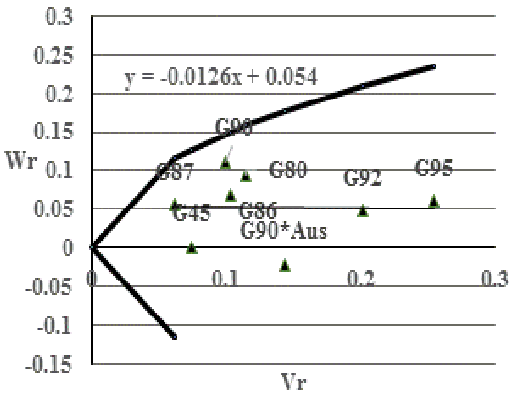

Fig. 7. D2 SI.

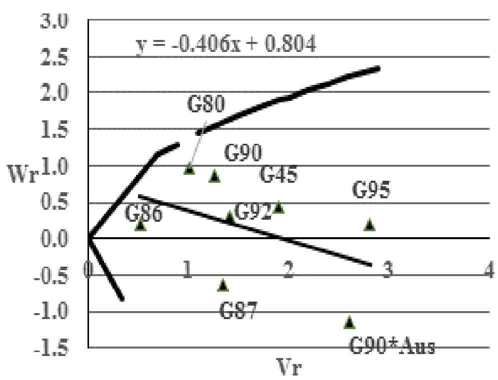

Fig. 8. D2 NS/B

Genetic parameters

The results of seed cotton yield/plant under early planting (Table 6) showed that the additive parameter "D" was significant ($p \leq 0.01$). Likewise, the dominance parameters "H1" and "H2" were significant ($p \leq 0.01$). These results indicated that both additive and non–additive effects of genes were involved in the inheritance of seed cotton yield/plant, and this is confirmed by the significant items "a" and "b" (Table 4). The "F" parameter was positive, but not significant from zero. Therefore, two alternatives are possible: either no genes exhibited dominance, or the dominant and recessive alleles were distributed equally among the parents. The former alternative must be rejected because the variance of "H1" and or "H2" were significantlydifferent from zero. Therefore, the later explanation must be the correct one. Furthermore, the KD/KR was nearly equal one (1.0459) indicating symmetrical distribution of dominance and recessive genes in the parents. The ŪV as an estimator of the average frequency of positive showed negative alleles (at loci exhibiting dominance) in the parents, and has a maximum value of 0.25; if unequal, it will be smaller. The estimate of UV of seed cotton yield under early planting was (0.2096) and showed slight departure from the theoretical value, and could be considered near the theoretical value (0.25) confirming the results of the insignificant "F" parameter and the ratio KD/KR. The slight departure of UV from the theoretical value may cause invalidity estimate of average degree of dominance (1.274) in which the intercept of regression line (Fig. 1) was positive indicating partial dominance. The slight difference between the intercept (= ¼(D-H)) and the average degree of dominance could be caused by two reasons. First, the intercept or ¼ (D-H) must be corrected for the environmental component. Second, the departure of UV from its theoretical value invalidates the average degree of dominance (Mather & Jinks, 1971). The high estimate of H1 and H2 respect to the "D" parameter (Table 6) and the significance of regression coefficient of Wr/Vr (Table 4) which indicate the presence of non–allelic interaction caused departure of narrow (0.5715) from broad sense heritability (0.8947). The parental mean (95.88g/plant) and the hybrids mean (75.55g/plant) indicated the absence of hybrids vigor in seed cotton yield/plant in this set of diallel crosses.

TABLE 6. Genetic parameters of seed cotton yield/plant, boll weight and number of bolls/plant of the diallel analysis; season 2016.

Item	SCY/P;g		BW;g	NB/P	
	D1	D2	D2	D1	D2
D±SE	376.81±43.62	-34.59±3.66	-0.0186±0.0128	38.95±5.73	14.13±3.66
H1±SE	612.11±100.28	-122.96±8.43	-0.0094±0.0294	57.02±13.18	11.05±8.43
H2±SE	513.31±87.24	-82.78±7.33	-0.0135±0.0256	54.09±11.46	13.15±7.33
F±SE	21.56±103.07	-70.08±8.67	-0.0304±0.0302	-13.13±13.54	3.01±8.67
UV	0.2096	0.1683259	0.35813	0.23713	0.29745
$(H1/D)^{1/2}$	1.274	1.885	0.711	1.209	0.884
h^2	0.57159	-0.06165	0.17551	0.56389	0.22543
H	0.8947	-0.6074	0.10119	0.84106	0.38962
KD/KR	1.0459	0.3009	-0.07002	0.75545	1.2737
Parents mean	95.88334	20.7625	2.37916	32.3956	20.7625
Hybrids Mean	75.54763	21.89049	2.42976	26.2643	21.8904

D1 and D2; early and late sowing dates; respectively, h^2 and H; narrow and broad sense heritability; respectively.

The genetic parameters of seed cotton yield/ plant under late planting conditions (Table 6) were negative because of the very large experimental error (Table 4). However, the “a” and “b” items were significant indicating the presence of additive and dominance effects. Furthermore, the significant of Wr-Vr mean squares, and the insignificance of regression coefficient of Wr/Vr from zero indicated non – allelic interaction. Generally, it could be concluded that the inheritance of seed cotton yield/plant under both planting conditions is controlled by additive, dominance and epistatic effects of genes.

The genetic parameters of boll weight under the stress of late planting were negative and insignificant because of the large experimental error. Furthermore, the regression coefficient of Wr/Vr was significant ($p \leq 0.01$) less than unity indicating that the epistatic genes interaction was operating in the inheritance of boll weight (Table 4). However, mean squares of “a” and “b” items were significant ($p \leq 0.01$). Generally, the results suggested that additive, dominance and epistatic genes interaction were involved in the inheritance of boll weight under the stress of late planting. The large experimental error resulted in unreliable genetic parameters, ratios and estimators.

The genetic parameters of number of bolls/ plant under early and late planting are showed in Table 6. The additive parameters “D” was significant under early and late planting. However, the dominance parameters; H1” and “H2” were significant under early planting only. The “F” parameter was not significant under early planting. The UV (0.2371) was near to the theoretical value, and the average degree of dominance (1.209) indicated over– dominance. However, the intercept of the regression line to Wr axe (Fig. 4) was positive indicating partial dominance. The difference between the two results is mainly due to that the ¼ (D-H) (intercept) should be corrected to the environmental component. Under late planting, the UV was not reliable because “H1” showed insignificant difference from zero. In consequence, the $(H/D)^{1/2}$ was not valid.

Narrow sense heritability ranged from (0.2254) under late to (0.5639) under early planting, and broad sense ranged from (0.3896) to (0.8411) under the respective conditions. Estimates of the ratio of dominant to recessive alleles in the parents (KD/KR) was less than one under early, and more than one under late planting. The regression coefficient of Wr/Vr (Table 6) indicated the presence of non–allelic gene interaction under both planting conditions. Parental and hybrid means indicated absence of heterotic effects in number of bolls/plant. Generally, it could be concluded that additive, dominance and epistatic effects of genes were involved in the inheritance of number of bolls/ plant.

The genetic analysis of number of seeds/ boll under late planting (Table 5) indicated insignificace of the additive effects “a item”, however, the dominance item “b” was significant ($p \leq 0.01$) indicating the presence of dominance effects of genes. The analysis of b Wr/Vr indicated the presence of epistatic effects of genes. Furthermore, the four genetic parameters “D, H1, H2 and F” (Table 7) were not significant and the H2 was larger than H1 which resulted in UV out of the theoretical limits “0.25”, in consequence the average degree of dominance became invalid. Amin et al. (1997), Ajmel et el. (1998) and Shakeel et el. (2001) found over – dominance in the inheritance of these traits. Ahmed et al. (2003) found that seed cotton yield was partially adequate to the additive, dominance model. Nadeem & Azhar (2004) did not find epistasis in the inheritance of seed cotton yield, number of bolls/ plant and boll weight. The dominance effects of genes were larger in the inheritance of seed cotton yield, number of bolls (Basal & Turgut, 2005). Rauf et el. (2006) found that specific combining ability was larger than general combining ability in the inheritance of seed cotton yield and number of bolls/plant. Mohamed et al. (2009) indicated non–additive for the same chracters under drought stress and vice versa under favorable conditions. Imran et al. (2012), Kumar et al. (2013), Simon et al. (2013) and Raza et al. (2013) came to the same conclusion. However, Memon et al. (2016) found that the gca variance was larger than that of sca, and the rank order for gca’s of the parents differed from F1 to F2

TABLE 7. Genetic parameters of seed index and number of seeds/boll of the diallel analysis; season 2016.

Item	SI;g		NS/B
	D1	D2	D2
D±SE	0.295±0.0503	0.164±0.0484	0.672±1.161
H1±SE	0.523±0.1158	0.390±0.1114	0.718±2.670
H2±SE	0.424±0.1007	0.346±0.0969	1.06±2.322
F±SE	0.3167±0.1190	0.145±0.1145	-0.6601±2.744
UV	0.2024	0.22178	0.37075
$(H1/D)^{1/2}$	1.332	1.5419	1.033
h^2	0.1765	0.1853	-0.0678
H	0.6569	0.6920	0.0328
KD/KR	2.3490	1.8022	0.3559
Parents mean	9.9833	8.5041	18.116
Hybrids mean	9.5964	8.6869	18.187

D1 and D2; early and late sowing dates; respectively, h^2 and H; narrow and broad sense heritability; respectively.

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التحليل الوراثي لمحصول القطن الزهر ومكوناته في مواعيد الزراعةالمبكرة والمتأخرة

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أجريت هذه التجربة لدراسة تأثير ميعادي الزراعة المبكر والمتأخر على أداء القطن المصري وطبيعة فعل الجين لصفة محصول القطن الزهر للنبات والصفات المرتبطة به. أجريت الهجن الدائرية المستقيمة بين ثمانية أصناف (طويله وفائقة الطول)، وقيمت الهجن والاباء تحت ميعادي الزراعة المبكر والمتأخر. أظهرت النتائج فروقاً معنوية (احتمال ١٪) بين التراكيب الوراثية لمعظم الصفات. وصل النقص في محصول القطن الزهر للنبات إلى ١٧,٩٨،١٨,٢٥ ٪ للآباء والجيل الأول على الترتيب. أظهرت النتائج ان خمسة اباء، ١٥ هجين كانت متحملة لتأثير الميعاد المتأخر. أكد تحليل التباين للهجن الدائرية أن التأثير المضيف وغير المضيف أشتركا في وراثة هذه الصفات. بصفة عامة، أشار التحليل البياني و معامل الانحدار (التباين على التغاير) إلى أن الفعل المضيف، الفعل السيادي والتفاعل بين الجينات موجود في وراثة محصول القطن الزهر للنبات. تشير النتائج إلى وجود الفعل المضيف والسيادي للجينات والتفاعل بين الجينات في وراثه وزن اللوزة تحت ميعاد الزراعة المتأخر. كما أشار التحليل الوراثي لعدد البذور للوزة تحت ميعاد الزراعة المتأخر إلى عدم معنوية الفعل المضيف بينما كان الفعل السيادي معنوياً. أدى الفرق الكبير بين التأثير المضيف وغير المضيف إلى فروق واضحة بين معامل التوريث بالمعنى العام والخاص. وبذلك فان طريقتي تسجيل النسب والانتخاب الدوري يمكن ان تكونا فعالتين في عزل سلالات تناسب الزراعة في الميعاد المتأخر من هذه الهجن.