4. RESULTS AND DISCUSSION

The present study was carried out to investigate the heterosis and type of gene action for yield and its components as well as the susceptibility to low nitrogen fertilizer by using six-parental diallel crosses of flax.

For better representation and discussion of the results obtained herein, it was preferred to outline the results into three parts, the first is heterosis and combining ability analysis for yield and its components, the second is concerned with genetic components of variation and the third is the fertilizer susceptibility index (FSI).

4.1. Heterosis and combining ability:

4.1.1. Analysis of variance and means:

The analysis of variance for each experiment (30 kg and 45 kg N/fed) and the combined analysis between them for all traits are presented in Table (6). Results indicated that nitrogen levels mean squares were significant for all studied traits.

Results in Table (7) presented the effect of nitrogen fertilizer levels on the studied traits. It is clear that all traits increased with 45 kg N/fed. This result might be attributed to the pronounced improvement in yield and yield components (seed and fiber). Similar results were recorded before by El-Farouk *et al.* (1983), Salama (1983), El-Ganayni *et al.* (1985), Hella *et al.* (1988), Mourad *et al.* (1988), Ghanem (1990), Nimje (1991), Salama (1991), El-Hindi *et al.* (1992), El-Shimey *et al.* (1993), Abd El-Fatah (1994), Esmail and Morsy (1994), Mohamed (1996), El-Sweify *et al.* (1997), Kineber *et al.* (1998), Rajesh *et al.* (1999), Singh and Verma (1999), Ash-Shormillesy (2001) and Awad *et al.* (2001).

Highly significant genotypes mean squares were obtained for all the studied traits in separate experiments as well as the combined analysis, indicating the wide diversity between the parental materials used in the present study. Significant genotypes x fertilizer nitrogen levels interaction mean squares were obtained for all the studied traits except number of seeds/capsule indicating that the tested genotypes varied from one nitrogen level to another and ranked differently from 30 to 45 kg N/fed

For number of seeds/capsule, significant genotypes mean squares along with insignificant genotypes x nitrogen levels interaction mean squares was detected. These findings, therefore, might revealed the high stability of the tested genotypes at both nitrogen levels. Also, it may reflect the minor role of the non additive type of gene action on the expression of this trait.

Results also, showed that mean squares due to parents were significant for all the studied traits. Significant mean squares due to interaction between parent and nitrogen levels were detected for the studied traits except plant height, oil percentage and number of seeds/capsule. These findings indicate that parental varieties and or lines differed in their mean performance in all traits under test. Also, it revealed that parents varied in their response to nitrogen levels in all traits except, plant height, oil percentage and number of seeds/capsule.

Table (6): Observed mean squares from ordinary analysis of variance for all the studied traits.

S.O.V.	d.f.		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Fer.	-	1			713.29**			819.01**			2.31**
Rep.	2	-	3.61	8.86		1.77	4.95		0.01	0.01	
Rep./Fer.	-	4			6.24			3.36			0.01
Genotypes	20	20	1000.16**	1021.17**	2002.36**	1006.34**	1386.27**	2362.60**	0.28**	0.10**	0.34**
Parents	5	5	1621.88**	1680.59**	3288.16**	1467.74**	1974.94**	3418.77**	0.18**	0.06**	0.20**
Crosses	14	14	841.46**	845.77**	1665.53**	907.97**	1257.59**	2132.92**	0.23**	0.06**	0.24**
Par. vs. Crossos	1	1	113.33**	179.54**	289.08**	76.53**	244.36**	297.20**	1.50**	0.93**	2.39**
Genotypes x Fer.	-	20			18.96**			30.01**			0.05**
Par. x Fer.	-	5			14.32			23.91**			0.04**
Cross. x Fer.	-	14			21.71**			32.63**			0.06**
Par.vs. cross x Fer.	-	1			3.79			23.69			0.03*
Error	40	80	5.00	8.96	6.98	4.19	9.38	6.78	0.01	0.01	0.01

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

Table (6): Cont.

S.O.V.	d.f.		Fiber length			Straw yield/plant (g)			Fiber yield		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Fer.	-	1			783.90**			888.14**			1.917**
Rep.	2	-	2.21	4.31	3.26	0.65	1.14		0.001	0.002	
Rep./Fer.	-	4						0.89			0.002
Genotypes	20	20	1040.81**	1425.08**	2435.14**	11.82**	46.39**	50.32**	0.028**	0.110**	0.117**
Parents	5	5	1510.20**	2034.14**	3519.14**	20.41**	73.59**	83.96**	0.052**	0.124**	0.153**
Crosses	14	14	942.51**	1291.78**	2201.26**	5.43**	28.26**	26.97**	0.015**	0.065**	0.069**
Par. vs. Crossos	1	1	70.03**	246.09**	289.34**	58.30**	164.23**	209.11**	0.095**	0.656**	0.625**
Genotypes x Fer.	-	20			30.75**			7.88**			0.021**
Par. x Fer.	-	5			25.20**			10.04**			0.023**
Cross. x Fer.	-	14			33.02**			6.72**			0.12**
Par.vs. cross x Fer.	-	1			26.79*			13.42**			0.126**
Error	40	80	3.97	9.39	6.68	0.35	0.51	0.43	0.001	0.002	0.001

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

Table (6): Cont.

S.O.V.	d.f.		No. of capsules/plant			No. of seed/capsule			1000-seed weight		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Fer.	-	1			5892.11**			1.35**			163.68**
Rep.	2	-	12.01	32.36**		0.03	0.02		0.12	0.24*	
Rep./Fer.	-	4			22.19*			0.02			0.18*
Genotypes	20	20	182.61**	434.59**	550.84**	2.53**	2.77**	5.27**	3.23**	7.01**	9.54**
Parents	5	5	284.58**	659.42**	896.32**	4.04**	3.63**	7.65**	6.23**	15.03**	20.08**
Crosses	14	14	66.46**	288.48**	277.20**	1.79**	2.22**	3.97**	1.49**	2.95**	3.94**
Par. vs. Crossos	1	1	1298.81**	1355.91**	2654.40**	5.33**	6.23**	11.54**	12.48**	23.74**	35.32**
Genotypes x Fer.	-	20			66.36**			0.04			0.70**
Par. x Fer.	-	5			47.69**			0.02			1.17**
Cross. x Fer.	-	14			77.74**			0.04			0.51**
Par.vs. cross x Fer.	-	1			0.31			0.02			0.90**
Error	40	80	5.36	5.78	5.57	0.06	0.10	0.08	0.09	0.06	0.07

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

Table (6): Cont.

S.O.V.	d.f.		Seed yield/plant (g)			Oil percentage		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Fer.	-	1			82.62**			22.73**
Rep.	2	2	0.05	0.18		1.75**	0.84	
Rep./Fer.	-	4			0.12			1.29**
Genotypes	20	20	0.66**	1.78**	1.78**	9.78**	16.31**	24.79**
Parents	5	5	0.90**	2.72**	2.94**	20.73**	27.16**	47.33**
Crosses	14	14	0.38**	0.88**	0.62**	6.12**	13.48**	17.97**
Par. vs. Crossos	1	1	3.41**	9.77**	12.36**	6.32**	1.83*	7.48**
Genotypes x Fer.	-	20			0.66**			1.31**
Par. x Fer.	-	5			0.68**			0.56
Cross. x Fer.	-	14			0.64**			1.62**
Par.vs. cross x Fer.	-	1			0.82**			0.67
Error	40	80			0.07	0.22	0.32	0.27

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

Table (7): The genotypes mean performance at two nitrogen levels as well as the combined analysis for all the studied traits.

Genotype	Plant height (cm)			Technical length (cm)			Stem diameter (mm)			Fiber length (cm)		
	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x1	88.87	90.64	89.76	61.30	63.13	62.22	2.40	2.82	2.61	59.31	60.85	60.08
2x2	75.89	84.90	80.40	51.79	56.48	54.13	2.37	2.78	2.58	49.72	54.28	52.00
3x3	119.14	121.66	120.40	94.49	101.52	98.01	2.18	2.69	2.44	92.33	99.08	95.71
4x4	105.09	112.32	108.71	83.10	92.40	87.75	2.48	2.76	2.62	81.00	90.39	85.70
5x5	53.90	56.20	55.05	35.87	34.67	35.27	2.92	3.02	2.97	32.73	31.37	32.05
6x6	75.98	78.41	77.19	49.36	50.08	49.72	2.41	2.62	2.51	46.53	46.84	46.69
1x2	119.55	121.88	120.72	94.52	102.02	98.27	2.59	2.87	2.73	92.41	99.61	96.01
1x3	90.09	93.61	91.85	71.64	73.67	72.65	2.84	2.91	2.88	69.04	70.58	69.81
1x4	105.29	114.48	109.89	77.35	93.90	85.63	2.77	2.92	2.85	75.31	91.97	83.64
1x5	68.97	73.48	71.23	41.94	48.48	45.21	3.26	3.36	3.31	38.73	45.57	42.15
1x6	77.30	82.02	79.66	53.46	54.31	53.89	2.66	3.01	2.84	50.81	51.65	51.23
2x3	99.39	106.24	102.82	77.31	85.04	81.17	2.46	3.06	2.76	74.68	82.63	78.66
2x4	102.85	103.77	103.31	76.77	86.02	81.40	2.68	3.02	2.85	74.93	83.88	79.41
2x5	66.68	71.76	69.22	42.54	43.59	43.06	2.98	3.18	3.08	39.23	40.59	39.91
2x6	83.74	84.88	84.31	56.85	57.35	57.10	2.32	2.91	2.62	54.68	55.52	55.10
3x4	120.23	124.13	122.18	98.20	107.73	102.97	2.74	2.86	2.80	96.23	105.80	101.02
3x5	84.92	85.16	85.04	53.99	64.43	61.71	3.13	3.20	3.17	56.14	61.58	58.86
3x6	79.89	87.33	83.61	56.60	65.20	60.90	2.67	3.11	2.89	54.07	62.57	58.32
4x5	76.23	87.28	81.76	53.76	53.49	53.63	3.15	3.16	3.15	51.10	50.70	50.90
4x6	88.91	101.59	95.25	68.61	76.47	72.54	2.60	3.00	2.80	66.40	73.74	70.07
5x6	77.68	78.78	78.23	47.82	49.38	48.60	3.14	3.18	3.16	45.32	46.26	45.79
L.S.D.0.05	3.69	4.94	4.29	3.38	5.05	4.23	0.13	0.13	0.13	3.29	5.06	4.20
0.01	4.94	6.61	5.69	4.52	6.76	5.60	0.17	0.18	0.17	4.40	6.77	5.57
r	0.66**	0.75**	0.71**	0.72**	0.76**	0.75**	0.80**	0.65**	0.85**	0.73**	0.77**	0.75**

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

r : Correlation coefficient between hybrid mean performance and mid-parent value.

Table (7): Cont.

Genotype	Straw yield/plant (g)			Fiber yield (g)			No. of capsules/plant			No. of seed/capsule		
	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x1	11.63	19.25	15.44	0.60	0.95	0.77	47.99	67.90	57.94	6.80	6.82	6.81
2x2	10.65	15.76	13.21	0.54	0.78	0.66	46.31	66.97	56.64	7.59	7.74	7.66
3x3	10.90	13.36	12.13	0.55	0.65	0.60	25.25	33.60	29.43	9.35	9.42	9.38
4x4	12.72	19.52	16.12	0.64	0.65	0.65	47.21	60.30	53.76	6.89	7.13	7.01
5x5	6.84	8.54	7.69	0.36	0.43	0.39	31.40	38.87	35.13	6.22	6.58	6.40
6x6	6.42	8.40	7.41	0.32	0.42	0.37	33.86	45.48	39.67	8.39	8.56	8.48
1x2	12.44	20.70	16.57	0.61	1.05	0.83	50.30	68.39	59.35	9.27	9.70	9.49
1x3	11.65	19.86	15.75	0.61	0.97	0.79	50.05	69.19	59.62	7.64	7.79	7.72
1x4	12.98	20.92	16.95	0.67	1.00	0.84	52.34	70.20	61.27	7.26	7.46	7.36
1x5	11.61	19.19	15.40	0.60	0.94	0.77	49.04	68.00	58.52	6.91	7.11	7.01
1x6	11.99	19.34	15.66	0.59	0.96	0.78	48.90	68.37	58.63	8.45	8.62	8.54
2x3	11.76	17.53	14.65	0.57	0.85	0.71	50.01	69.37	59.69	8.83	9.48	9.15
2x4	13.08	19.47	16.27	0.63	0.98	0.81	51.67	68.15	59.91	7.64	7.55	7.60
2x5	11.25	16.08	13.66	0.54	0.76	0.65	48.37	67.80	58.09	7.48	7.59	7.54
2x6	11.39	16.53	13.96	0.55	0.85	0.70	49.13	67.58	58.35	8.57	8.75	8.66
3x4	13.24	19.64	16.44	0.66	0.97	0.81	51.78	63.48	57.63	8.96	9.35	9.16
3x5	12.36	14.80	13.58	0.54	0.74	0.64	35.55	39.31	37.43	7.96	8.30	8.13
3x6	11.04	14.10	12.57	0.54	0.69	0.62	50.99	46.24	48.62	9.43	9.53	9.48
4x5	13.41	18.58	16.00	0.66	0.93	0.79	51.90	60.64	56.27	7.40	7.55	7.47
4x6	13.50	19.41	16.45	0.66	0.93	0.80	50.91	61.89	56.40	8.46	8.69	8.58
5x6	8.14	9.52	8.83	0.39	0.49	0.44	39.83	48.26	44.05	8.47	8.60	8.53
L.S.D.0.05	0.98	1.18	1.07	0.04	0.07	0.05	3.82	3.97	3.84	0.41	0.53	0.47
0.01	1.31	1.58	1.42	0.05	0.09	0.07	5.11	5.31	5.09	0.55	0.71	0.62
r	0.72**	0.90**	0.86**	0.79**	0.78**	0.80**	0.61*	0.82**	0.79**	0.73**	0.71**	0.73**

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r : Correlation coefficient between hybrid mean performance and mid-parent value.

Table (7): Cont.

Genotype	1000 seed weight (g)			Seed yield/plant (g)			Oil percentage		
	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x1	7.64	10.34	8.99	2.84	5.29	4.07	41.46	43.69	42.57
2x2	6.96	10.04	7.98	2.78	4.65	3.71	40.92	42.08	41.50
3x3	3.81	4.53	4.17	1.75	2.56	2.16	35.47	36.41	35.94
4x4	6.61	8.71	7.66	3.09	4.43	3.76	41.03	41.73	41.38
5x5	6.48	9.64	8.06	3.37	4.33	3.85	39.10	40.06	39.58
6x6	4.82	6.16	5.49	2.81	3.57	3.19	36.13	36.61	36.37
1x2	7.47	10.32	8.89	2.77	5.23	4.00	40.06	43.00	41.53
1x3	7.68	10.38	9.03	3.18	5.92	4.55	41.60	43.90	42.75
1x4	7.61	10.51	9.06	3.35	5.63	4.49	41.49	42.74	42.12
1x5	7.66	10.28	8.97	3.90	5.46	4.68	40.38	41.94	41.16
1x6	7.35	10.04	8.70	3.21	5.41	4.31	39.41	38.77	39.09
2x3	7.18	9.04	8.11	2.77	4.74	3.76	38.96	39.88	39.42
2x4	7.33	9.03	8.18	3.25	5.08	4.17	41.47	42.48	41.98
2x5	7.25	9.78	8.51	3.59	5.20	4.39	40.11	41.43	40.77
2x6	7.22	8.86	8.04	2.79	5.36	4.08	38.62	38.57	38.59
3x4	6.90	9.08	7.99	3.21	4.60	3.90	40.13	40.15	40.14
3x5	6.23	9.12	7.67	3.38	4.60	3.99	38.78	38.70	38.74
3x6	4.96	6.60	5.78	3.13	3.75	3.44	36.90	36.74	36.82
4x5	7.04	9.92	8.48	3.69	4.73	4.21	41.06	41.64	41.35
4x6	7.24	8.70	7.97	3.25	4.86	4.06	39.42	38.80	39.11
5x6	6.44	9.70	8.07	3.82	4.57	4.20	37.41	38.40	37.90
L.S.D.0.05	0.50	0.40	0.44	0.33	0.54	0.44	0.77	0.93	0.84
0.01	0.66	0.52	0.58	0.45	0.72	0.58	1.02	1.24	1.11
r	0.76**	0.78**	0.79**	0.62*	0.71**	0.70**	0.79**	0.84**	0.76**

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

r : Correlation coefficient between hybrid mean performance and mid-parent value.

The mean performances of the parental lines and/or varieties of flax at separate nitrogen levels as well as the combined data are presented in Table (7).

Data presented in Table (6), showed that crosses mean squares were significant for all the studied traits, revealing overall differences between these hybrids. Significant mean squares due to interaction between crosses and nitrogen levels were detected for all traits except number of seeds/capsule. Such results indicated that these hybrids varied in their response to environmental fluctuations.

The mean performances of F_1 hybrids in each nitrogen level and over both of them are presented in Table (7).

The varieties Ariane-R_3 (P_3) recorded the highest plant height, technical length and fiber length followed by variety S.strain$_1$ (P_4). While high values of plant height, technical length and fiber length of crosses were recorded by Ariane x S_1 (3x4) followed S.24191/1 x Giza 8 (1x2). This result indicated that parents No. P_3 (Arian) and P_4 (S.strain$_1$) contained the genes for tall plant height.

For fiber yield in gramme, the mean values for crosses ranged from 0.84 (1x4), S.2419/1 x S_1 to 0.44 (5x6) Gawhar x Bombay in the combined analysis. While, the mean values for parents ranged from 0.37 P_6 (Bombay) to 0.77 P_1 (S.2419/1) in the combined analysis. The highest values of fiber yield were detected in the combined analysis by (1x4) S.2419/1 x S_1 followed by (1x2) S.2419/1 x Ariane and then by (2x4) Giza 8 x S_1 and (3x4) Ariane x S_1.

Concerning straw yield/plant in grammes, the mean values for genotypes ranged from 7.41 (P_6) Bombay to 16.95 (1x4) S.2419/1 x S_1 in the combined analysis. The highest mean values were obtained by crosses (1x4) S.2419/1 x S_1, (1x2) S.2419/1 x Ariane, (4x6) S_1 x Bombay and (3x4) Ariane x S_1. This result indicated that P_1 (S.2419/1) and P_4 (S.strain$_1$) contained the genes controlling high fiber yield.

For number of capsules/plant, the mean values of genotypes ranged from 61.27 (1x4) S.2419/1 x S_1 to 29.43 for (P_3) Ariane in the combined analysis. The highest number of capsules were obtained by cross (1x4) S.2419/1 x S_1 but without significant superiority compared with (P_1) S.2419/1, (1x2) S.2419/1 x Giza 8, (1x3) S.2419/1 x Ariane-R_3, (1x5) S.2419/1 x Gawhar, (1x6) S.2419/1 x Bombay, (2x3) Giza 8 x Ariane, (2x4) Giza 8 x S_1, (2x5) Giza 8 x Gawhar, (2x6) Giza 8 x Bombay and (3x4) Ariane x S_1.

None of the hybrids, significantly, surpassed the highest parent in number of seeds/capsule, 1000-seed weight and oil percentage.

Concerning seed yield/plant in grammes, the mean values for genotypes ranged from 2.16 (P_3) Ariane to 4.68 cross (1x3) S.2419/1 x Ariane in the combined analysis. The highest mean value was obtained by cross (1x5) S.2419/1 x Gawhar but without superiority than crosses (1x3) S.2419/1 x Ariane, (1x4) S.2419/1 x S_1, (1x6) S.2419/1 x Bombay and (2x5) Giza 8 x Gawhar in the combined analysis. The high seed yield/plant in the previous crosses could be attributed to the high value of one or more of the yield components (no. of capsules/plant, no. of seeds/capsule and 1000-seed weight). It could be concluded that these crosses would be efficient and promising in flax breeding for improving seed yield/plant.

Correlation coefficient values between mid-parent and F_1 hybrids mean values for each of the studied traits are presented in Table (7). Significant positive correlation coefficient values were obtained for all the studied traits at two nitrogen levels as well as the combined analysis. Such result clarified good agreement between mid-parent values and F_1 performance. Consequently, the best performance of F_1 combination could be achieved by crossing between parental (lines or varieties) of high mean values.

4.1.2. Heterosis:

Mean squares for parents vs. crosses as an indication to average heterosis over all crosses was of appreciable magnitude in both experiments as well as their combined analysis for all investigated traits (Table, 6). Significant interaction mean squares between parents vs. crosses and nitrogen fertilizer levels were detected for all the studied traits except plant height, technical length, oil percentage, number of capsules/plant and number of seeds/capsule, indicating that the heterotic effects were affected by different nitrogen levels. For the exceptional traits, insignificant interaction between parent vs. crosses and nitrogen levels was detected. These results indicated that the heterotic effects were not affected by nitrogen level changes.

Heterosis expressed as the percentage deviation of F_1 mean performance from its mid- and better parent average values for all the studied traits at both nitrogen levels and averages of their combined are presented in Table (8).

For plant height, seven, five and six crosses expressed significant positive heterotic effects relative to mid-parent values at 30, 45 kg N/fed as well as with the combined analysis, respectively. While, two, one and two crosses from the previous crosses showed significant positive heterotic effects relative to better parent values in the same order. Significant positive heterotic effects, for plant height was previously detected by Krepkov and Michkina (1983), Ashry (1991), Heyland and Hemker (1991), wang *et al.* (1996) and El-Sweify (2002).

Regarding technical length, six, seven and eight parental combinations exhibited significant positive heterotic effects relative to mid-parent values at 30, 45 kg N/fed and with the combined analysis, respectively. While, three, two and one crosses expressed significant positive heterotic effects relative to better parent values in the same order. The best cross over both N-fertilizer levels was (1x2) S.2419/1 x Giza 8. Significant positive heterotic effects for technical length was reached before by Wang *et al.* (1996).

Concerning stem diameter, thirteen, fourteen and fourteen hybrids exceeded significantly mid-parent values at 30, 45 kg N/fed as well as with the combined average over them, respectively. Also, twelve, twelve and twelve hybrids showed significant positive heterotic effects relative to better parent values in the same order. Also, the other crosses at least were equal to their mid-parent or better than parent values. Significant

Table (8): Percentage of heterosis over both mid-parent and better parent at two nitrogen levels as well as the combined analysis for all studied traits.

Cross	Plant height						Technical length						Stem diameter					
	30 kg		45 kg		Combined		30 kg		45 kg		Combined		30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	45.12**	34.52**	38.86**	34.47**	41.88**	34.48**	67.17**	54.19**	70.57**	61.60**	68.94**	57.94**	8.37**	7.92**	2.50	1.77	5.41*	4.60
1x3	-13.38**	-24.38**	-11.81**	-23.06**	-12.59**	-23.71**	-8.04**	-24.18**	-10.52**	-27.43**	-9.31**	-25.88**	24.02**	18.33**	5.44**	13.19**	14.29**	10.35**
1x4	8.57**	0.19	12.81**	1.92	10.72**	1.08	7.13**	-6.92**	20.74**	1.62	14.20**	-2.42	13.53**	11.69**	4.66*	3.55	9.20**	8.78**
1x5	-3.39	-22.39**	0.082	-18.93**	-1.63	-20.64**	-13.67**	-31.58**	-5.86	-23.21**	-7.24	-27.34**	22.56**	11.64**	15.07**	11.26**	18.64**	11.45**
1x6	-6.22**	-13.02**	-2.96	-9.51**	-4.58*	-11.25**	-3.38	-12.79**	-4.06	-13.97**	-3.72	-13.39**	10.83**	10.37**	10.66**	0.19**	10.94**	8.81**
2x3	1.92	-16.58**	2.87	-12.67**	2.41	-14.60**	5.70**	-18.18**	7.65**	-16.23**	6.70**	-17.18**	7.90**	3.80	11.68**	0.28**	9.96**	6.98**
2x4	13.66**	-2.13	5.23*	-7.61**	9.25**	-4.97*	13.82**	-7.62**	15.56**	-6.91*	14.75**	-7.24**	10.74**	8.06**	9.03**	0.24**	9.62**	8.78**
2x5	2.74	12.14**	1.71	-15.48**	2.20	13.91**	-2.94	-17.86**	-4.35	-22.82**	-3.67	-20.45**	12.45**	2.06	9.66**	0.16*	11.19**	3.70
2x6	10.27**	10.21**	3.96	-0.024	7.01**	4.86	12.42**	9.77**	7.64	1.54	9.98**	5.49	-2.93	-3.73	7.78**	0.13*	3.15	1.55
3x4	7.23**	0.91	6.10**	2.03	6.65**	1.48	10.59**	3.93*	11.11**	6.12*	10.86**	5.06	17.60**	10.48**	4.76*	0.10	10.67**	6.87**
3x5	-1.85	-28.72**	-4.24	-30.00**	-3.07	-29.37**	-9.50**	-37.57**	-5.38	-36.54**	-7.40*	-37.04**	22.75**	7.19**	11.89**	0.18**	17.41**	6.73**
3x6	18.11**	-32.94**	-12.70**	-28.22**	-15.37**	30.56**	21.31**	-40.10**	-13.98**	-35.78**	-17.55**	-37.86**	16.59**	10.79**	16.92**	0.42**	17.00**	15.14**
4x5	-4.10*	-27.46**	3.58	-22.29**	-0.16	-24.79**	-9.63**	-35.31**	-15.82**	-42.11**	-12.81**	-38.88**	16.67**	7.88**	9.34**	0.14**	12.90**	6.06**
4x6	-1.80	-15.40**	6.53**	-9.55**	2.47	-12.37**	3.59	-17.44**	7.34*	-17.24**	5.54*	-17.33**	6.56**	7.88**	11.52**	0.24**	9.38**	6.87**
5x6	19.62**	2.24	17.04**	0.47	18.32**	1.35	12.23**	-3.12	16.55**	-1.40	14.38**	-2.25	18.05**	7.53**	12.77**	0.16**	15.33**	6.40**

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

Table (8): Cont.

Cross	Fiber length						Straw yield/plant						Fiber yield					
	30 kg		45 kg		Combined		30 kg		45 kg		Combined		30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	69.50**	55.81**	73.05**	63.70**	71.32**	59.80**	11.67**	6.97	18.22**	7.53*	15.71**	7.32*	7.02**	1.67	20.69**	10.53**	15.28**	7.79*
1x3	-8.94**	-25.23**	-11.73**	-28.77**	-10.37**	-27.06**	3.37	0.17	21.84**	3.17	14.21**	2.01	5.17*	1.67	21.25**	2.11	14.49**	2.60
1x4	7.36**	-7.03**	21.62**	1.75	14.75**	-2.40	6.57	2.04	7.89**	7.17*	7.41*	5.15	8.07**	4.69	25.00**	5.26	18.31**	9.09**
1x5	-15.84**	-34.70**	-1.17	-25.11**	-8.49*	-29.84**	25.79**	-0.17	38.06**	-0.31	33.22**	-0.26	26.42**	1.005	36.23**	-1.05	32.76**	0.129
1x6	-3.99	-14.33**	-4.09	-15.12**	-4.03	-14.73**	32.93**	3.10	39.94**	0.47	37.13**	1.43	28.26**	-1.67	39.13**	1.05	36.84**	1.30
2x3	5.14*	-19.12**	7.76**	-16.60	6.51*	-17.81**	9.09*	7.89	20.40**	11.23**	15.63**	10.91**	3.64	3.64	18.06**	8.97*	12.70**	7.58*
2x4	14.64**	-7.49**	15.95**	-7.20*	15.34**	-7.34**	11.99**	2.83	10.37**	-0.26	10.98**	0.93	6.78**	-1.56	36.11**	25.64**	24.62**	22.73**
2x5	-4.85	-21.10**	-5.23	-25.22**	-5.04	-23.25**	28.72**	5.63	32.35**	2.03	30.72**	3.41	20.00**	0.553	24.59**	-2.56	22.64**	-1.52
2x6	13.61**	9.98**	9.81*	2.29	11.67**	5.96	33.53**	6.95	36.84**	4.89	35.40**	5.68	27.91**	1.85	41.67**	8.97*	34.62**	6.06
3x4	11.03**	4.22*	11.67**	6.78*	11.38**	5.55*	12.11**	4.09	19.47**	0.62	16.35**	1.99	10.00**	3.13	49.23**	49.23**	28.57**	24.62**
3x5	-10.22**	-39.20**	-5.58	-37.85**	-7.86**	-38.50**	39.35**	13.40**	35.16**	10.78*	37.03**	11.95**	17.39**	-1.82	37.04**	13.85**	28.00**	6.67
3x6	-22.12**	-41.44**	-14.24**	-36.85**	-18.09**	-39.07**	27.48**	1.28	29.60**	5.54	28.66**	3.63	22.73**	-1.82	27.78**	6.15	26.53**	3.33
4x5	-10.15**	-36.91**	-16.72**	-43.91**	-13.54**	-40.61**	37.12**	5.42	32.43**	-4.82	34.45**	-0.74	32.00**	3.13	72.22**	43.08**	51.92**	21.54**
4x6	4.12*	-18.03**	7.46*	-18.42**	5.86*	-18.24**	41.07**	6.13	39.04**	0.56	39.88**	2.05	37.50**	3.13	72.22**	43.08**	56.86**	23.08**
5x6	14.36**	-2.60	18.28**	-1.24	16.31**	-1.93	22.78**	19.01*	12.40*	11.48*	16.95**	14.82*	14.71**	8.33	13.95*	13.95	15.79**	12.82*

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

Table (8): Cont.

Cross	No. of capsules/plant					
	30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	6.68	4.81	1.41	0.72	3.60	2.43
1x3	36.67**	4.29	36.34**	1.90	36.49**	2.90
1x4	9.96**	9.06*	9.52**	3.39	9.71**	5.75
1x5	23.56**	2.19	27.37**	0.15	25.74**	1.00
1x6	19.50**	1.90	20.60**	0.69	20.12**	1.19
2x3	39.77**	7.99	37.94**	3.58	38.72**	5.39
2x4	10.50**	9.45*	7.09*	1.76	8.53**	5.77
2x5	24.51**	4.45	28.13**	1.24	26.59**	2.56
2x6	22.58**	6.09	20.19**	0.91	21.18**	3.02
3x4	42.92**	9.68*	35.21**	5.27	38.57**	7.20*
3x5	25.53**	13.22*	8.47*	1.13	15.95**	6.55
3x6	72.56**	50.59**	16.95**	1.67	40.72**	22.56**
4x5	32.06**	9.93*	22.28**	0.56	26.62**	4.67
4x6	25.61**	7.84	17.02**	2.64	20.77**	4.91
5x6	22.07**	17.63**	14.41**	6.11	17.78**	11.04*

Cross	No. of seeds/capsule					
	30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	28.93**	22.13**	33.24**	25.32**	31.08**	23.89**
1x3	-5.33*	-18.29**	-4.06	-17.30**	4.69	-17.70**
1x4	6.14*	5.37	7.03*	4.63	6.51*	4.99
1x5	6.14*	1.62	6.12	4.25	6.21*	2.94
1x6	11.18**	0.72	12.09**	0.70	11.78**	0.71
2x3	4.25*	-5.56*	10.49**	0.64	7.39**	2.45
2x4	5.53*	0.66	1.48	-2.46	3.54	-0.78
2x5	8.41**	-1.45	6.01	-1.94	7.25*	1.57
2x6	7.26**	2.15	7.36*	2.22	7.31**	2.12
3x4	10.34**	-4.17	13.06**	-0.74	11.71**	-2.35
3x5	2.31	-14.87**	3.75	-11.89**	3.04	-13.33**
3x6	6.31**	0.86	6.01*	1.17	6.16**	1.07
4x5	12.98**	7.40*	10.06**	5.89	11.49**	6.56*
4x6	10.73**	0.83	10.70*	1.52	10.85**	1.18
5x6	15.87**	0.95	13.61**	0.47	14.65**	0.59

Cross	1000 seed weight					
	30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	2.33	-2.23	6.72**	-0.19	4.71*	-1.11
1x3	34.27**	0.52	39.52**	0.39	37.23**	0.45
1x4	6.88*	-0.39	10.28**	1.64	8.89**	0.78
1x5	8.50**	0.26	2.90	-0.58	5.16*	-0.22
1x6	17.98**	-3.80	21.70**	-2.90	20.17**	-3.23
2x3	33.46**	3.16	33.53**	0.44	33.39**	1.63
2x4	8.11*	5.32	1.92	0.33	4.60	2.51
2x5	7.89*	4.17	4.94**	8.78**	6.11*	5.58*
2x6	22.58**	3.74	16.89**	-1.56	19.29**	0.75
3x4	32.44**	4.39	37.16**	4.25	35.20**	4.31
3x5	21.21**	-3.86	28.63**	-5.39**	25.33**	-4.84
3x6	14.82**	2.91	23.37**	7.14*	19.67**	5.28
4x5	7.48*	6.51	8.18**	2.91	7.89**	5.21
4x6	26.57**	9.53*	16.94**	-0.12	21.13**	4.05
5x6	13.98**	-0.62	22.79**	0.62	19.03**	0.12

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

Table (8): Cont.

Cross	Seed yield/plant						Oil percentage					
	30 kg		45 kg		Combined		30 kg		45 kg		Combined	
	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP	H.MP	H.BP
1x2	-1.42	-2.47	5.23	-1.13	2.83	-1.72	-2.74**	-3.38**	0.26	-1.58	-1.21	-2.44**
1x3	38.26**	11.97*	50.64**	11.91*	46.30**	11.79*	8.16**	0.34	9.61**	0.48	8.89**	0.42
1x4	12.80*	8.41	15.84**	6.43	14.83**	10.32	0.58	0.07	0.07	-2.17*	0.33	-1.06
1x5	25.81**	15.73**	13.51**	3.21	18.18**	14.99**	0.25	-2.61**	0.14	-4.01**	0.20	-3.31**
1x6	13.43*	13.03*	22.12**	2.27	18.73**	5.90	1.57	-4.95**	-3.44**	-11.26**	-0.96	-8.13**
2x3	22.03**	-0.36	31.67**	1.94	28.33**	1.35	2.02*	-4.79**	1.61	-5.23**	1.81	-5.01**
2x4	10.92*	5.18	11.89*	9.25	11.50*	10.90	1.20	1.07	1.36	0.95	1.30	1.16
2x5	16.94**	6.53	15.81**	11.83*	16.14**	14.03*	0.25	-1.98*	0.88	-1.55	0.57	-1.76
2x6	-0.36	-0.71	30.41**	15.27*	18.26**	9.97	0.23	5.62**	-1.98	-8.34**	0.90	-7.01**
3x4	32.65**	3.88	31.43**	3.84	31.76**	3.72	4.92**	-2.19*	2.76**	-3.79**	3.83**	-3.00**
3x5	32.03**	0.30	33.33**	6.24	33.00**	3.64	4.00**	-0.82	1.20	-3.40**	2.60**	-2.12*
3x6	37.28**	11.39*	22.55**	5.04	28.84**	7.84	3.07**	2.13*	0.63	0.36	1.83	1.24
4x5	14.24**	9.50*	7.99	6.77	10.79*	9.35	2.47**	0.07	1.81	-0.22	2.15*	-0.07
4x6	10.17*	5.18	21.50**	9.71	17.00**	7.98	2.18*	-3.92**	-0.95	-7.02**	0.59	-5.49**
5x6	23.63**	13.35**	15.70**	5.54	19.32*	9.09	-0.56	-4.32**	0.16	-4.14**	-0.21	-4.25**

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

positive heterotic effects for stem diameter were recorded before by Ashry (1991).

For fiber length, eight parental combinations expressed significant positive heterotic effects relative to mid-parent values in both nitrogen levels and the combined analysis. While, three, two and two hybrids exhibited significant positive heterotic effects relative to better parent at 30, 45 kg N/fed as well as at the combined analysis, respectively. The two crosses (1x2) S.2419/1 x Giza 8 and (3x4) Ariane x Strain 1 gave significant positive heterotic effects relative to mid-parent or better parent values at both nitrogen levels as well as the combined analysis. Significant positive heterotic effects for fiber length were recorded before by Sallam *et al.* (1981), Krepkov and Michkina (1983), Ashry (1991) and Wang *et al.* (1996).

Regarding straw yield, thirteen, fifteen and fifteen parental combinations exceeded significantly mid-parent values at 30, 45 kg N/fed as well as at the combined analysis, respectively. Also, two, five and four crosses from the previous hybrids showed significant positive heterotic effects relative to better parent value in the same order. The crosses (5x6) Gawhar x Bombay, (3x5) Ariane x Gawhar and (2x3) Giza 8 x Ariane recorded the highest values of heterotic effects for this trait. Significant positive heterotic effects for straw yield were previously reported by Sallam *et al.* (1981), Singh *et al.* (1983), Wang *et al.* (1996) and El-Sweify (2002).

Concerning fiber yield, fourteen, fifteen and fifteen hybrids significantly exceeded mid-parent value at 30, 45 kg N/fed as well as at the combined analysis, respectively. While, nine and eight crosses from the previous hybrids exhibited significant positive heterotic effects relative to the better parent values in the same order. The crosses (3x4) Ariane x S_1 followed by (4x6) S_1 x Bombay and then by (2x4) Giza 8 x S_1 recorded the highest values of heterotic effects relative to the better parent values in the combined analysis. These crosses exhibited heterosis for one or more of traits contributing to fiber yield. The heterotic magnitude, however, differed from case to case. This finding agrees with general trend where the expression of heterosis for a complex trait could be explained on the basis of component interaction, as the numerical value recorded for a complex trait is always a function of its components. It could be concluded that these crosses would be efficient and prospective in flax breeding programs for improving fiber yield per plant. Significant positive heterotic effects relative to higher fiber yielding parent were also reached before by Heland and Hemker (1991) and Wang *et al.* (1996).

Concerning 1000-seed weight, fourteen, thirteen and fourteen crosses exhibited significant positive heterotic effects relative to mid-parent value at 30, 45 kg N/fed as well as with the combined analysis, respectively. While, one, two and one crosses exceeded significantly the better parent in the same order. Significant positive heterotic effects for 1000-seed weight were recorded by Singh *et al.* (1983), Dakhore *et al.* (1987) and Heyland and Hemker (1991).

For number of seeds/capsule, thirteen, ten and twelve parental combinations exhibited significant positive heterotic effects relative to mid-parent values at 30, 45 kg N/fed as well as with combined analysis, respectively. While two, one and two crosses expressed significant positive heterotic effects relative to the better parent value in the same order. The two crosses (1x2) S.2419/1 x Giza 8 and (4x5) S_1 x Gawhar recorded the highest values of heterotic effects for this trait in the combined analysis. The same trend of the present results was reported before by Singh *et al.* (1983) and El-Sweify (2002).

Concerning number of capsules/plant, all crosses exhibited significant positive heterotic effects relative to mid-parent values except cross (1x2) S.2419/1 x Giza 8 at both nitrogen levels as well as with the combined analysis. Also, seven, one and three crosses from the previous hybrids expressed significant positive heterotic effects relative to better parent at 30, 45 kg N/fed and the combined analysis, respectively. The three crosses (3x6) Ariane x Bombay followed by (5x6) Gawhar x Bombay and then by (3x4) Ariane x S_1 recorded significant positive heterotic effects relative to the better parent in the combined analysis. Significant positive heterotic effects relative to mid-parent or better parent values were recorded by Singh *et al.* (1983), Heyland and Hemker (1991), Wang *et al.* (1996) and El-Sweify (2002).

For oil percentage, seven, two and four crosses exhibited significant positive heterotic effects relative to the mid-parent values at 30, 45 kg N/fed as well as the combined analysis, respectively. While, the cross (3x6) Ariane x Bombay at 30 kg N/fed recorded significant positive heterotic effects relative to the better parent value. Similar results were also obtained by Heyland and Hemker (1991), Tolba (1991) and El-Sweify (2002).

Concerning seed yield/plant, thirteen, thirteen and fourteen crosses exhibited significant positive heterotic effects relative to mid-parent values at 30, 45 kg N/fed as well as the combined analysis, respectively. Also, seven three and three crosses from the previous crosses showed significant positive heterotic effects relative to better parent values in the same order. The crosses (1x3) S.2419/1 x Ariane, (1x5) S.2419/1 x Gawhar and (2x5) Giza 8 x Gawhar showed the desirable heterotic effects over both nitrogen levels for seed yield/plant. The previous crosses exhibited superiority in one or more of the traits contributing seed yield. The heterotic effects were different from one nitrogen level to another. This finding coincided with that reached before for significant genotypes by fertilizer mean squares (Table, 6). Significant positive heterotic effects relative to higher yielding parent were also reached before by Krepkov and Michkina (1983) and El-Sweify (2002).

4.1.3. Combining ability variance:

Analysis of variance for combining ability as outlined by Griffing's (1956) method 2 model I at each nitrogen levels as well as their combined average for all the studied traits is shown in Table (9).

The mean squares associated with general and specific combining abilities were significant for all traits at each nitrogen levels as well as the combined analysis, revealing that additive and non-additive gene effects were involved in determining the performance of single cross progeny. Also, results showed that all the traits expressed significant GCA/SCA ratios which exceeded the unity, indicating the predominance of additive and additive by additive gene action in the inheritance of each trait. These results were along the same line of those reported by Sprague and Tatum (1942), Wright (1985), El-Farouk *et al.* (1998), Prygun and Polonetskaya (1985), Dang *et al.* (1987), Ashry (1991), Tak (1994) and Stuthman and Stucker (1975).

The mean squares of the interaction between nitrogen levels and both types of combining ability were significant for all traits except with no. of seeds/capsule which showed insignificant GCA x nitrogen fertilizer and SCA x nitrogen fertilizer indicating that the magnitude of both additive and non-additive types of gene action varied from one nitrogen level to another.

For no. of seeds/capsule, insignificant mean squares of interaction between nitrogen levels and both types of combining ability were detected indicating that the magnitude of additive and non-additive types of gene action did not differ from one nitrogen level to another.

With the exception of 1000-seed weight, no. of capsules/plant, seed yield/plant and straw yield/plant, it is fairly evident that mean squares of SCA x nitrogen levels/SCA were much higher than GCA x nitrogen levels/GCA. Such results indicated that non-additive gene effects were much more influenced by the nitrogen fertilizer levels than additive genetic effects in these traits. Specific combining ability was tested by several investigators to be more sensitive to environmental changes than GCA (Gilbert, 1958; Shehata and Comstock, 1971; Patil and Chopde, 1981; Sallam *et al.* (1981; Marchenkov, 1984;

Table (9): Observed mean squares for general and specific combining ability from diallel cross analysis for all the studied traits at both nitrogen levels as well as the combined analysis.

S.O.V.	d.f.		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Genotypes	20	20	1000.16**	1021.17**	2002.37**	1006.34**	1386.27**	2362.60**	0.28**	0.10**	0.34
GCA	5	5	965.61**	1072.62**	2032.30**	1027.63**	1453.93**	2461.66**	0.23**	0.05**	0.24**
SCA	15	15	122.64**	96.31**	212.50**	104.72**	131.47**	229.49**	0.05**	0.03**	0.07**
Genotypes x Fer	-	20			18.96**			30.00**			0.05**
GCA x Fer	-	5			5.93*			19.90**			0.04**
SCA x Fer	-	15			6.45**			6.70**			0.01**
Error	40	80	1.67	2.99	2.33	1.40	3.12	2.26	0.00	0.00	0.00
GCA/SCA			7.87	11.14	9.56	9.81	11.06	10.73	4.46	1.78	3.46
GCAxFer/SCAxFer					0.92			2.97			3.58
GCAxFer/GCA					0.01			0.01			0.15
SCAxFer/SCA					0.03			0.03			0.15

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

Table (9): Cont..

S.O.V.	d.f.		Fiber length			Straw yield/plant (g)			Fiber yield		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Genotypes	20	20	1040.81**	1425.08**	2435.14**	11.82**	46.39**	50.32**	0.03**	0.11**	0.12**
GCA	5	5	1066.17**	1502.05**	2548.07**	9.26**	45.86**	46.57**	0.03**	0.09**	0.10**
SCA	15	15	107.19**	132.69**	232.93**	2.17**	5.33**	6.84**	0.00	0.02**	0.02**
Genotypes x Fer	-	20			30.75**			7.88**			0.02**
GCA x Fer	-	5			20.15**			8.54**			0.01**
SCA x Fer	-	15			6.95**			0.66**			0.00
Error	40	80	1.32	3.13	2.23	0.12	0.17	0.14	0.00	0.00	0.00
GCA/SCA			9.95	11.32	10.94	4.27	8.60	6.81	6.95	4.18	4.85
GCAxFer/SCAxFer					2.90			13.03			3.49
GCAxFer/GCA					0.08			0.18			0.16
SCAxFer/SCA					0.03			0.10			0.21

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

Table (9): Cont..

S.O.V.	d.f. Single	d.f. Comb.	No. of capsules/plant 30 kg	No. of capsules/plant 45 kg	No. of capsules/plant Com.	No. of seeds/capsule 30 kg	No. of seeds/capsule 45 kg	No. of seeds/capsule Com.	1000 seed weight 30 kg	1000 seed weight 45 kg	1000 seed weight Com.
Genotypes	20	20	182.61**	434.59**	550.84**	2.53**	2.77**	5.27**	3.23**	7.01**	9.54**
GCA	5	5	111.62**	404.84**	459.27**	2.30**	2.33**	4.62**	2.79**	6.43**	8.60
SCA	15	15	43.95**	58.20**	91.73**	0.36**	0.46**	0.80**	0.50**	0.97**	1.38**
Genotypes x Fer	-	20			66.36**			0.04			0.70**
GCA x Fer	-	5			57.19**			0.00			0.63**
SCA x Fer	-	15			10.43**			0.02			0.10**
Error	40	80	1.79	1.93	1.86	0.02	0.03	0.03	0.03	0.02	0.02
GCA/SCA			2.54	6.96	5.01	6.41	5.10	5.78	5.55	6.62	6.25
GCAxFer/SCAxFer					5.48			0.27			6.27
GCAxFer/GCA					0.12						0.07
SCAxFer/SCA					0.11						0.07

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

Table (9): Cont..

S.O.V.	d.f.		Seed yield/plant (g)			Oil percentage		
	Single	Comb.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
Genotypes	20	20	0.66	1.78**	1.78**	9.78**	16.31**	24.79**
GCA	5	5	0.51**	1.33**	1.22**	10.80**	18.94**	28.77**
SCA	15	15	0.12**	0.35**	0.39**	0.75**	0.94**	1.43**
Genotypes x Fer	-	20			0.66**			1.31**
GCA x Fer	-	5			0.62**			0.98**
SCA x Fer	-	15			0.09**			0.26**
Error	40	80	0.01	0.04	0.02	0.07	0.11	0.09
GCA/SCA			4.05	3.80	3.13	14.49	20.22	20.17
GCAxFer/SCAxFer					7.15			3.81
GCAxFer/GCA					0.51			0.03
SCAxFer/SCA					0.22			0.18

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

Rao and Singh, 1984; Prygun and Polonetskaya, 1985; Chung and Plonka, 1986; Dakhore *et al.*, 1987, Dang *et al.*, 1987 and Abo Kaied, 2002).

For 1000-seed weight and no. of capsules/plant, the ratio of mean squares of GCA x nitrogen levels/GCA and SCA x nitrogen levels/SCA were similar in magnitude, revealing that additive and non-additive gene action were similarly influenced by the nitrogen levels. However, with seed yield and straw yield/plant, the ratios of mean squares of GCAxnitrogen levels/GCA were much higher than SCA x nitrogen levels/SCA. This result indicates that additive genetic effects were much more influenced by the nitrogen levels.

4.1.4. General combining ability effects:

General combining ability effects ($\hat{g}_i$) of each parent for the studied traits at both fertilizer levels as well as the combined analysis are presented in Table (10). Such effects are being used to compare the average performance of each parent with other parents and its performance to select of parents (variety and/or lines) for further improvement.

High positive values would be interest for all the studied traits. The parental variety S.2419/1 expressed significantly positive $\hat{g}_1$ effects for all the studied traits except stem diameter and number of seeds/capsule at both fertilizer N-levels as well as the combined data, and seed yield/plant at 30 kg N level for stem diameter at both N fertilizer levels as well as the combined data and seed yield/plant at 30 kg N level, insignificant $\hat{g}_1$ effects were detected. However, it recorded significant negative $\hat{g}_1$ effects

Table (10): Estimates of general combining ability effects for studied parents in the F_1 generation at two nitrogen levels as well as the combined analysis for all studied traits..

Parent		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
S. 2419/1		2.34**	1.66**	2.00**	1.34**	1.52**	1.43**	-0.00	-0.01	-0.01
Giza 8		0.48**	0.60**	0.54*	0.10*	0.07	0.08	-0.14**	-0.03	-0.09**
Ariane-R_3		11.58**	10.79**	11.18**	12.62**	14.08**	13.35**	-0.09**	-0.04*	-0.06**
S. Strain-1		10.44**	12.80**	11.62**	11.27**	14.50**	12.88**	-0.00	-0.04**	-0.02**
Gawhar-552		-17.24**	-18.08**	-17.66**	-16.75**	-19.72**	-18.23**	0.32**	0.16**	0.24**
Bombay		-7.59**	-7.76**	-7.68**	-8.59**	-10.45**	-9.52**	-0.09**	-0.05**	-0.07**
L.S.D. (gi)	0.05	0.84	1.13	0.47	0.77	1.15	0.46	0.03	0.03	0.01
	0.01	1.13	1.51	0.62	1.03	1.54	0.61	0.04	0.04	0.02
L.S.D. (gi-gi)	0.05	1.31	1.75	0.76	1.20	1.79	0.75	0.04	0.05	0.02
	0.01	1.75	2.34	1.01	1.60	2.40	0.99	0.06	0.06	0.03
r		0.95**	0.97**	0.96**	0.95**	0.96**	0.96**	0.92**	0.91**	0.95**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation between parental mean performance and its $\hat{g}i$ effects.

Table (10): Con.

Parent		Fiber length (cm)			Straw yield/plant (g)			Fiber yield/plant (g)		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
S. 2419/1		1.42**	1.57**	1.50**	0.53**	2.71**	1.62**	0.04**	0.14**	0.09**
Giza 8		0.23	0.29	0.26	0.19	0.63**	0.41**	0.01	0.05**	0.03**
Ariane-R$_3$		12.66**	14.10**	13.38**	0.27*	-0.52**	-0.12*	0.01	-0.02*	-0.00
S. Strain-1		11.55**	14.80**	13.18**	1.50**	2.53**	2.01**	0.08**	0.06**	0.07**
Gawhar-552		-17.20**	-20.13**	-18.66**	-1.15**	-2.70**	-1.93**	-0.06**	-0.12**	-0.09**
Bombay		-8.65**	-10.63**	-9.64**	-1.35**	-2.64**	-1.99**	-0.07**	-0.11**	-0.09**
L.S.D. (gi)	0.05	0.75	1.15	0.46	0.22	0.27	0.12	0.01	0.02	0.01
L.S.D. (gi)	0.01	1.00	1.54	0.61	0.30	0.36	0.16	0.01	0.02	0.01
L.S.D. (gi-gi)	0.05	1.16	1.79	0.74	0.35	0.42	0.19	0.01	0.02	0.00
L.S.D. (gi-gi)	0.01	1.56	2.39	0.99	0.47	0.56	0.25	0.02	0.03	0.01
r		0.95**	0.96**	0.96**	0.98	1.00	1.00	0.98**	0.96**	0.97**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation between parental mean performance and its $\hat{g}i$ effects.

Table (10): Cont.

Parent		No. of capsules/plant			No. of seeds/capsule			1000 seed weight (g)		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
S. 2419/1		3.21**	7.91**	5.56**	-0.36**	-0.39**	-0.37**	0.72**	1.12*	0.92**
Giza 8		2.65**	7.32**	4.98**	0.12*	0.14*	0.13**	0.38**	0.22**	0.30**
Ariane-R_3		-4.01**	-7.73**	-5.87**	0.69**	0.73**	0.71**	-0.84**	-1.25**	-1.04**
S. Strain-1		4.01**	3.54**	3.77**	-0.31**	-0.32**	-0.32**	0.26**	0.75**	0.22**
Gawhar-552		-4.18**	-6.86**	-5.52**	-0.67**	-0.64**	-0.65**	0.04	0.60**	0.32**
Bombay		-1.68**	-4.17**	-2.93**	0.52**	0.48**	0.50**	-0.55**	-0.88**	-0.72**
L.S.D. (gi)	0.05	0.87	0.91	0.42	0.09	0.12	0.05	0.11	0.09	0.05
	0.01	1.17	1.21	0.56	0.13	0.16	0.07	0.15	0.12	0.06
L.S.D. (gi-gi)	0.05	1.35	1.40	0.68	0.15	0.19	0.08	0.18	0.14	0.08
	0.01	1.81	1.88	0.90	0.19	0.25	0.11	0.23	0.19	0.10
r		0.97**	0.99**	0.99**	0.98**	0.99**	0.99**	0.99**	0.99**	0.99**

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r : Correlation between parental mean performance and its ĝi effects.

Table (10): Cont.

Parent	Seed yield/plant (g)			Oil percentage		
	30 kg	45 kg	Com.	30 kg	45 kg	Com.
S. 2419/1	0.02	0.62**	0.32**	1.15**	1.89**	1.52**
Giza 8	-0.16**	0.20**	0.02	0.55**	0.87**	0.71**
Ariane-R_3	-0.35**	-0.57**	-0.46**	-1.17**	-1.30**	-1.23**
S. Strain-1	0.12**	0.05	0.09**	1.13**	0.84	0.98**
Gawhar-552	0.39**	-0.01	0.19**	-0.09	-0.04	-0.06
Bombay	-0.02	-0.28**	-0.15**	-1.58**	-2.26**	-1.92**
L.S.D. (gi) 0.05	0.08	0.12	0.05	0.18	0.21	0.09
L.S.D. (gi) 0.01	0.10	0.16	0.06	0.23	0.28	0.12
L.S.D. (gi-gi) 0.05	0.12	0.19	0.08	0.27	0.33	0.15
L.S.D. (gi-gi) 0.01	0.16	0.25	0.10	0.36	0.44	0.20
r	0.86**	0.98**	0.98**	0.97**	0.98**	0.97**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation between parental mean performance and its $\hat{g}i$ effects.

for number of seeds/capsule at both fertilizer N-levels as well as the combined analysis.

The parental variety Giza 8 was the best general combiner for 1000-seed weight, oil percentage and number of capsules/ plant, at both N-levels as well as the combined analysis, plant height in the combined analysis, fiber yield and straw yield at 45 kg N/fed and the combined analysis, and seed yield/plant at 45 kg N/fed. Also, it appeared insignificant or significantly negative $\hat{g}_I$ effects for other cases.

The parental variety Ariane (P_3) exhibited significantly positive g_i effect, for plant height, technical length, fiber length and number of seeds/capsule at both N-levels as well as the combined analysis. Also, it gave significantly negative or insignificant $\hat{g}_I$ effects for other traits.

The parental line strain$_1$ (P_4) expressed significantly positive $\hat{g}_i$ effects for plant height, technical length, 1000-seed weight, oil percentage, fiber yield, number of capsules/plant, and straw yield at both nitrogen fertilizer levels and the combined analysis, and seed yield/plant at 30 kg N/fed and the combined analysis. However, it had significantly negative or insignificant $\hat{g}_i$ effects for other traits. The parental variety Gawhar (P_5) seemed to be good combiner for stem diameter at both nitrogen levels as well as the combined analysis, while, it gave undesirable ($\hat{g}_i$) effects for other traits. Therefore, this parent was considered as a poor one for these traits.

The parental variety Bombay (P_6) expressed significantly positive ($\hat{g}_I$) effects for number of seeds/capsule at both nitrogen levels as well as the combined analysis. While, it was considered as a poor combiner for other traits.

The parental varieties Gawhar (P_5) and Strain 1 (P_4) expressed significantly positive $\hat{g}_l$ effects for plant height, fiber length compared to other parents at both nitrogen levels as well as the combined analysis. The two parental strains S.2419/1 (P_1) and Strain 1 (P_4) gave the highest $\hat{g}_i$ effects for number of capsules/plant, straw yield, oil percentage and fiber yield at both fertilizer levels as well as the combined analysis, also, significantly superior over other parents. Also, S.2419/1 seemed to be good combiner for 1000-seed weight and seed yield/plant showing significant superiority than other parents.

The two parental varieties Ariane (P_3) and Bombay (P_6) gave the highest $\hat{g}_i$ effects for number of seeds/capsule and it significantly differed than other parents.

In all traits, the values of ($\hat{g}_l$) mostly differed from one nitrogen level to another. This finding coincided with the detected significant GCA x fertilizer mean squares Table (9).

It is worth mentioning that good agreement between the parental performance and its ($\hat{g}_i$) effects was obtained for all traits (Table, 10). This finding indicates that intrinsic performance of parental varieties and/or lines gave a good index of their ($\hat{g}_i$) effects. Therefore, selection with the tested parental population for initiating any proposed breeding program could be practiced either on mean performance or ($\hat{g}_i$) effects basis with similar efficiency. Such agreement might add another proof to the preponderance of additive genetic variance in these cases.

4.1.5. Specific combining ability effects:

Specific combining ability effects for each cross at N_1 (30 kg N/fed), N_2 (45 kg N/fed) and the combined analysis are present of in Table (11).

For plant height, five, five and four crosses exhibited significantly positive ($\hat{S}_{ij}$) effects at N_1, N_2 and the combined analysis, respectively.

Tallness, if found in flax is favorable for increasing technical length, straw yield and fiber yield. The four crosses (1x2) S.2419/1 x Giza 8, (1x4) S.2419/1 x S_1, (3x4) Ariane x S_1 and (5x6) Gawhar x Bombay gave the highest S_{ij} effects in the combined analysis for this trait. In addition, the first three previous crosses (1x2) S.2419/1 x Giza 8, (1x4) S.2419/1 x S_1 and (3x4) Ariane x S_1 involved one or two good combiners for this trait. Hence, it could be concluded that the three crosses are valuable in breeding for increasing plant height.

For technical length, three, four and five crosses exhibited significantly positive S_{ij} effects at N_1, N_2 as well as the combined analysis, respectively.

For fiber length, three, four and six crosses exhibited significantly positive S_{ij} effects at N_1, N_2 as well as the combined analysis, respectively. The three crosses (1x2) S.2419/1 x Giza 8, (3x4) Ariane x Strain 1 and (5x6) Gawhar x Bombay gave significantly positive (S_{ij}) effects at both nitrogen levels as well as the combined analysis for this trait. Also, the first two crosses from the previously mentioned crosses involved one or two good combiners for this trait.

Table (11): Estimates of specific combining ability effects for crosses studied at two nitrogen levels as well as the combined analysis for all studied traits.

Cross		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x2		28.13**	26.26**	27.20**	28.68**	30.93**	29.81**	0.03	-0.06	-0.02
1x3		-12.41**	-12.19**	-12.31**	-6.72**	-11.43**	-9.08**	0.23**	-0.01	0.11**
1x4		3.91**	6.67**	5.29**	0.34	8.39**	4.37**	0.07	0.01	0.04
1x5		-4.73**	-3.45**	-4.09**	-7.05**	-2.8	-4.94**	0.24**	0.24**	0.24**
1x6		-6.05**	-5.23**	-5.64**	-3.69**	-6.26**	-4.97**	0.05	0.09*	0.07*
2x3		-1.26	1.49	0.12	0.19	1.40	0.80	-0.01	0.15**	0.07*
2x4		3.34**	-2.99	0.17	1.01	1.97	1.49	0.12**	0.11**	0.12**
2x5		-5.16**	-4.12*	-4.64**	-5.21**	-6.25**	-5.73**	0.10*	0.07	0.08**
2x6		2.26	-1.32	0.47	0.94	-1.76	-0.41	-0.15**	0.01	-0.07*
3x4		9.61**	7.19**	8.40**	9.92**	9.66**	9.79**	0.13**	-0.04	0.05
3x5		1.98	-0.90	0.54	-0.54	-1.28	0.57	0.19**	0.10*	0.15**
3x6		-12.70**	-9.06**	-10.88**	-11.82**	-7.93**	-9.88**	0.15**	0.22**	0.18**
4x5		-5.56**	-0.80	-3.18**	-5.16**	-10.78**	-7.97**	0.12**	0.07	0.10**
4x6		-2.54	3.19*	0.33	1.54	2.93	2.23*	-0.01	0.12**	0.06*
5x6		13.91**	11.26**	12.59**	8.76**	10.05**	9.40**	0.21	0.09*	0.15**
L.S.D.$_{sij}$	0.05	2.31	2.10	1.90	2.12	3.17	1.88	0.08	0.08	0.06
	0.01	3.09	4.14	2.52	2.83	4.24	2.49	0.11	0.11	0.08
L.S.D.$_{(sij-sik)}$	0.05	3.45	4.62	2.84	3.16	4.72	2.80	0.12	0.12	0.08
	0.01	4.62	6.18	3.76	4.23	6.32	3.71	0.16	0.16	0.01
L.S.D.$_{(sij-skl)}$	0.05	3.20	4.28	1.07	2.93	4.38	1.06	0.11	0.11	0.03
	0.01	4.28	5.72	1.42	3.92	5.85	1.40	0.15	0.15	0.04

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

Table (11): Cont.

Cross		Fiber length (cm)			Straw yield/plant (g)			Fiber yield/plant (g)		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x2		28.83**	30.82**	29.82**	0.34	0.68	0.51*	-0.00	0.04*	0.02
1x3		-6.97**	-12.03**	-9.50**	-0.54	0.98*	0.22	-0.01	0.04	0.01
1x4		0.40	8.67**	4.54**	-0.43	-1.01**	-0.72**	-0.01	-0.01	-0.01
1x5		-7.43**	-2.80	-5.11**	0.85**	2.49**	1.67**	0.06**	0.10**	0.08**
1x6		-3.90**	-6.22**	-5.06**	1.42**	2.58**	2.00**	0.06	0.12**	0.09**
2x3		-0.14	1.31	0.59	-0.09	0.74	0.32	-0.01	0.01	0.00
2x4		1.21	1.87	1.54	0.01	-0.37	-0.18	-0.01	0.07**	0.03*
2x5		-5.74**	-6.49**	-6.11**	0.83**	1.46**	1.14**	0.03**	0.02	0.03*
2x6		1.17	-1.07	0.05	1.16**	1.86**	1.51**	0.05**	0.10**	0.08**
3x4		10.08**	9.97**	10.03**	0.08	0.95*	0.52*	0.01	0.12**	0.06**
3x5		-1.26	0.68	-0.29**	1.86**	1.33**	1.59**	0.03**	0.07**	0.05**
3x6		-11.88**	-7.82**	-9.85**	0.74*	0.58	0.66**	0.04**	0.01	0.02*
4x5		-5.19**	-10.90**	-8.04**	1.68**	2.06**	1.87**	0.08**	0.18**	0.13**
4x6		1.57	2.65	2.11*	1.97**	2.83**	2.40**	0.89**	0.18**	0.13**
5x6		9.23**	10.10**	9.67**	-0.74*	-1.83**	-1.29**	-0.04**	-0.09**	-0.06**
L.S.D.$_{sij}$	0.05	2.22	3.17	1.86	0.62	0.74	0.47	0.02	0.04	0.02
	0.01	2.76	4.24	2.47	0.82	0.99	0.63	0.03	0.05	0.03
L.S.D.$_{(sij-sik)}$	0.05	3.08	4.73	2.78	0.92	1.10	0.71	0.03	0.06	0.03
	0.01	4.12	6.33	3.68	1.23	1.48	0.94	0.04	0.08	0.05
L.S.D.$_{(sij-skl)}$	0.05	2.85	4.38	1.05	0.85	1.02	0.27	0.03	0.06	0.01
	0.01	3.81	5.86	1.39	1.14	1.37	0.35	0.04	0.08	0.02

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

Table (11): Cont.

Cross		No. of capsules/plant			No. of seeds/capsule			1000 seed weight		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x2		-1.40	-6.37**	-3.88**	1.51**	1.75**	1.63**	-0.39*	-0.06	-0.23*
1x3		5.00**	9.49**	7.24**	-0.61**	-0.76**	-0.72**	1.04**	1.47**	1.26**
1x4		-0.73	-0.77	-0.75	0.07	-0.03	-0.05	-0.12	0.18	0.03
1x5		4.16**	7.43**	5.80**	-0.06	-0.07	-0.06	0.15	-0.48**	-0.17
1x6		1.52	5.11**	3.31**	0.29*	0.32	0.30**	0.43**	0.76**	0.60**
2x3		5.52**	10.26**	7.89**	0.02	0.40*	0.21*	0.88**	1.03**	0.96**
2x4		-0.83	-2.23	-1.53	-0.17	-0.47**	-0.32**	-0.06	-0.41**	-0.24*
2x5		4.06**	7.82**	5.94**	0.03	-0.11	-0.04	0.07	-0.09	-0.01
2x6		2.32	4.90**	3.61**	-0.07	-0.08	-0.08	0.63**	0.48**	0.56**
3x4		5.93**	8.15**	7.04**	0.58**	0.73**	0.66**	0.73**	1.11**	0.92**
3x5		-2.11	-5.61**	-3.86**	-0.07	0.01	-0.03	0.28	0.72**	0.50**
3x6		10.84**	-1.38	4.73**	0.22	0.11	0.16	-0.40*	-0.31*	-0.36**
4x5		6.22**	4.44**	5.33**	0.38**	0.31	0.34**	-0.01	0.10	0.05
4x6		2.73*	3.00*	2.87**	0.25	0.32	0.29**	0.78**	0.37**	0.58**
5x6		-0.15	-0.23	-0.19	0.61**	0.55**	0.58**	0.20	0.94**	0.57**
L.S.D.$_{sij}$	0.05	2.40	2.49	1.70	0.26	0.33	0.21	0.31	0.25	0.20
	0.01	3.21	3.33	2.25	0.35	0.44	0.27	0.41	0.33	0.26
L.S.D.$_{(sij-sik)}$	0.05	3.58	3.71	2.54	0.38	0.49	0.31	0.46	0.37	0.29
	0.01	4.78	4.97	3.36	0.51	0.66	0.41	0.62	0.49	0.39
L.S.D.$_{(sij-skl)}$	0.05	3.31	3.44	0.96	0.36	0.46	0.12	0.43	0.34	0.11
	0.01	4.43	4.60	1.27	0.48	0.61	0.16	0.57	0.45	0.15

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

Table (11): Cont.

Cross		Seed yield/plant(g)			Oil percentage		
		30 kg	45 kg	Com.	30 kg	45 kg	Com.
1x2		-0.23*	-0.34*	-0.29**	-1.16**	-0.13	-0.64**
1x3		0.38**	1.12**	0.75**	2.09**	2.93**	2.51**
1x4		0.08	0.20	0.14	-0.31	-0.36	-0.33
1x5		0.36**	0.10	0.23*	-0.21	0.28	-0.24
1x6		0.07	0.31	0.19	0.32	-1.23**	-0.46*
2x3		0.14	0.36*	0.25*	0.06	-0.06	-0.00
2x4		0.15	0.07	0.11	0.27	0.41	0.34
2x5		0.21*	0.25	0.23*	0.12	0.23	0.18
2x6		-0.17	0.68**	0.26*	0.12	-0.40	-0.14
3x4		0.30**	0.36*	0.33**	0.65**	0.24	0.45*
3x5		0.20	0.42*	0.31**	0.51*	-0.33	0.09
3x6		0.36**	-0.16	0.10	0.12	-0.07	0.03
4x5		0.04	-0.07	-0.02	0.51*	0.48	0.49**
4x6		0.01	0.32	0.17	0.36	-0.15	0.10
5x6		0.31**	0.10	0.21*	-0.45	0.33	-0.06
L.S.D.$_{sij}$	0.05	0.21	0.34	0.20	0.48	0.58	0.37
	0.01	0.28	0.45	0.26	0.64	0.78	0.49
L.S.D.$_{(sij-sik)}$	0.05	0.31	0.50	0.29	0.72	0.87	0.55
	0.01	0.42	0.67	0.39	0.96	1.16	0.73
L.S.D.$_{(sij-sk1)}$	0.05	0.29	0.46	0.11	0.66	0.80	0.21
	0.01	0.39	0.62	0.15	0.89	1.08	0.28

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

Eight, eight and eleven parental combinations expressed significantly positive ($\hat{S}_{ij}$) effects for stem diameter at N_1, N_2 as well as the combined analysis, respectively. The cross (1x5) S.2419/1 x Gawhar gave the highest $\hat{S}_{ij}$ effects in the combined analysis followed by (3x6) Ariane x Bombay and then by (3x5) Ariane x Gawhar.

Regarding straw yield, eight, nine and eleven parental combinations expressed significantly positive S_{ij} effects at N_1, N_2 as well as the combined analysis, respectively.

For fiber yield, eight, nine and ten hybrids exhibited significantly positive (S_{ij}) effects at N_1, N_2 as well as the combined analysis, respectively. For both traits, straw and fiber yields, the six crosses (1x5) S.2419/1 x Gawhar, (1x6) S.2419/1 x Bombay, (2x6) Giza 8 x Bombay, (3x5) Ariane x Gawhar, (4x5) S_1 x Gawhar and (4x6) S_1 x Bombay gave the highest S_{ij} effects in the combined analysis.

For number of capsules/plant, eight, nine and ten parental combinations expressed significantly positive ($\hat{S}_{ij}$) effects at N_1, N_2 as well as the combined analysis, respectively. The best combinations were (1x3) S.2419/1 x Ariane, (2x3) Giza 8 x Ariane and (3x4) Ariane x S_1. This result is logicaly expected where the parents S.2419/1, Giza 8, Ariane and Strain 1 were of D or O types.

Concerning, number of seeds/capsule, five, four and seven parental combinations exhibited significantly positive ($\hat{S}_{ij}$) effects at N_1, N_2 as well as the combined analysis, respectively. The best crosses were (1x2) S.2419/1 x Giza 8, (3x4) Ariane x S_1 and (5x6) Gawhar x Bombay, where they gave significantly positive S_{ij} effects at both N-levels as well as the combined analysis.

Regarding 1000-seed weight, seven, eight and eight parental combinations expressed significant positive ($\hat{S}_{ij}$) effects at N_1, N_2 as well as the combined analysis, respectively. The best combinations were (1x3) S.2419/1 x Ariane, (2x3) Giza 8 x Ariane and (3x4) ariane x S_1 at both N-levels and the combined analysis.

Regarding oil percentage, the crosses (1x3) S.2419/1 x Ariane, (3x4) ariane x S_1, (3x5) Ariane x Gawhar and (4x5) S_1 x Gawhar at N_1; (1x3) S.2419/1 x Ariane at N_2; and (1x3) S.2419/1 x Ariane, (3x4) ariane x S_1 and (4x5) S_1 x Gawhar in the combined analysis exhibited significantly positive ($\hat{S}_{ij}$) effects. The best cross was (1x3) S.2419/1 x Ariane which gave significantly positive S_{ij} effects at N_1, N_2 the combined analysis.

Concerning seed yield/plant, six, five and eight parental combinations expressed significantly positive S_{ij} effects at N_1, N_2 as well as the combined analysis, respectively. The best parental combinations were (1x3) S.2419/1 x Ariane, (1x5) S.2419/1 x Gawhar, (3x4) Ariane x S_1, (3x6) Ariane x Bombay and (5x6) Gawhar x Bombay at N_1; (1x3) S.2419/1 x Ariane, (2x6) Giza 8 x Bombay, (3x4) Ariane x S_1 and (3x5) Ariane x Gawhar at N_2; and (1x3) S.2419/1 x Ariane, (1x5) S.2419/1 x Gawhar (3x4) Ariane x S_1 and (3x5) Ariane x Gawahr, in the combined analysis. It could be concluded that the previous crosses seemed to be the best combinations since they had significant S_{ij} effects for more than one of seed yield components.

The best combinations were (1x3) S.2419/1 x Ariane, (2x3) Giza 8 x Ariane and (5x6) Gawhar x Bombay for seed yield/plant, (1x2) S.2419/1 x Giza 8, (1x6) S.2419/1 x Bombay, (3x6) Ariane x Bombay, (4x5) S_1 x Gawhar and (4x6) S_1 x Bombay for fiber yield and (1x5) S.2419/1 x Gawhar, (2x5) Giza 8 x Gawhar, (2x6) Giza 8 x Bombay, (3x4) Ariane x S_1 and (3x5) Ariane x Gawahr for both fiber and seed yields. The mentioned combinations might be of interest in breeding programs aiming to produce pure line varieties for high seed or fiber yields or both, whereas most combinations involved at least one good combiner for these propuse.

In most traits, the values of S_{ij} effects differed from one environment to another. This finding coincided with that reached above for significant SCA by environment mean squares (Table, 8).

The previous crosses that showed high ($\hat{S}_{ij}$) effects had only one good combiner. Such combinations would show desirable transgressive segregates providing that the additive genetic systems present in the good combiner as well as the complementary and epistatic effects present in cross act in the same direction to reduce undersirable plant characteristics and maximize the character in view. Therefore, the previous crosses might be of prime importance in breeding program for traditional breeding procedures.

4.2. Genetic components of variation:

Data were subjected to the diallel cross analysis produced by Hayman (1954a and b) for more information about the genetical behaviour of the agronomic characters under study. The computed parementers for all the studied traits are presented in Table (12).

Significant (D) values were detected for all the studied traits at both nitrogen levels. This finding confirms the results shown above by GCA mean squares in Table (9).

Significant values for the dominance component (H_1) were obtained for all the studied traits at both nitrogen levels. Values of (H_1) were larger in magnitude, than the respective (D) ones for stem diameter and seed yield/plant at both nitrogen levels, and no. of seeds/capsule and fiber yield/plant at 45 kg N/fed. Also, the quantity $(H_1/D)^{1/2}$ is a weighed estimate of the average degree of dominance at each locus. The values of $(H_1/D)^{1/2}$ were higher than the unity for these cases, indicating that the over dominance may be important as previously reported by Ashry (1991), Wang *et al.* (1996) and Foster (1998). This result also revealed that non-additive type of gene action was the most prevalent genetic components for these cases.

The values of (D) in most cross were larger in magnitude than the respective (H_1) ones, indicating that the additive and additive x additive types of gene effects were the most prevalent genetic components. Also, the ratio of $(H_1/D)^{1/2}$ was found to be less than unity, revealing the presence of partial dominance. Similar results were previously reported by Badwal *et al.* (1972), Doucet and Flipescu (1982), Rao and Singh (1985), Sharma *et al.* (1986), Rao and Sing (1987), Stapath *et al.* (1987) and Ashry (1991).

Table (12): Estimates of genetic components of variation in a diallel flax crosses for the studied traits at two nitrogen levels.

Components	Plant height (cm)		Technical length (cm)		Stem diameter (mm)	
	30 kg	45 kg	30 kg	45 kg	30 kg	45 kg
D	538.98±81.71 **	557.21±73.27 **	487.89±81.90 **	655.26±102.27 **	0.059±0.009 **	0.017±0.004 **
F	144.10±199.61	75.21±178.99	31.22±200.09	-21.33±249.84	-0.044±0.022 *	-0.006±0.011
H_1	528.13±207.42 *	402.22±185.99 *	456.27±207.92 *	558.22±259.62 *	0.159±0.023 **	0.081±0.011 **
H_2	436.95±185.30 *	341.05±166.15 *	369.46±185.74 *	461.21±231.92 *	0.124±0.020 **	0.074±0.010 **
h	23.57±124.72	37.13±111.83	15.78±125.01	51.10±156.10	0.323±0.014 **	0.200±0.007 **
E	1.65±30.88	2.98±27.69	1.36±30.96	3.06±38.65	0.002±0.003	0.002±0.002
$(H_1/D)^{1/2}$	0.990	0.850	0.967	0.923	1.644	2.208
$H_2/4H_1$	0.207	0.212	0.202	0.207	0.195	0.228
$K_D/K_R = \frac{(4DH_1)^{1/2}+F}{(4DH_1)^{1/2}-F}$	1.312	1.173	1.068	0.965	0.631	0.847
Heritability NS narrow semse	0.687	0.755	0.744	0.766	0.677	0.419
r	0.501	0.535	0.638	0.624	-0.974**	-0.804*
r^2	0.251	0.286	0.407	0.389	0.948	0.647

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r: Simple correlation between mean performance of parents and (Wr + Vr).

Table (12): Cont.

Components	Fiber length		Straw yield/plant		Fiber yield/plant	
	30 kg	45 kg	30 kg	45 kg	30 kg	45 kg
D	502.11±82.76**	675.00±102.13**	6.68±0.37**	24.35±0.99**	0.017±0.001**	0.041±0.005**
F	24.40±202.18	-27.23±249.50	3.27±0.90**	2.07±2.41	0.006±0.002**	0.002±0.011
H_1	466.52±210.09**	562.93±259.26*	6.53±0.93**	14.88±2.50**	0.012±0.002**	0.058±0.012**
H_2	379.78±187.68**	466.12±231.60*	5.90±0.83**	14.77±2.23**	0.011±0.002**	0.053±0.011**
h	14.41±126.32	51.48±155.88	12.53±0.56**	35.38±1.50**	0.020±0.002**	0.142±0.007**
E	1.30±31.28	3.05±38.60	0.12±0.14	0.18±0.37	0.000±0.000	0.001±0.002
$(H_1/D)^{1/2}$	0.964	0.913	0.989	0.782	0.836	1.195
$H_2/4\,H_1$	0.204	0.207	0.226	0.248	0.221	0.229
$K_D/K_R = \frac{(4\,D\,H_1)^{1/2}+F}{(4\,D\,H_1)^{1/2}-F}$	1.052	0.957	1.657	1.115	1.574	1.035
Heritability NS narrow semse	0.746	0.770	0.558	0.743	0.683	0.614
r	0.647	0.651	-0.990**	-0.988**	-0.993**	-0.941**
r^2	0.418	0.424	0.981	0.976	0.987	0.885

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r: Simple correlation between mean performance of parents and (Wr + Vr).

Table (12): Cont.

Components	No. of capsules/plant		No. of seed/capsule		1000 seed weight	
	30 kg	45 kg	30 kg	45 kg	30 kg	45 kg
D	92.97±11.28**	217.46±14.98**	1.33±0.20**	1.18±0.27**	2.05±0.13**	4.99±0.22**
F	62.00±27.056*	23.69±36.59	0.31±0.48	0.07±0.67	1.00±0.31**	2.78±0.53**
H_1	130.97±28.63**	178.76±38.02**	1.23±0.49*	1.54±0.70*	1.56±0.32**	3.23±0.55**
H_2	115.62±25.58**	175.46±33.97**	1.15±0.44*	1.50±0.62*	1.40±0.29**	2.69±0.49**
h	279.55±17.22**	291.64±22.86**	1.14±0.30**	1.33±0.42**	2.68±0.20**	5.12±0.33**
E	1.89±4.26	2.35±5.66	0.02±0.07	0.03±0.10	0.03±0.05	0.02±0.08
$(H_1/D)^{1/2}$	1.187	0.907	0.963	1.143	0.873	0.805
$H_2/4H_1$	0.221	0.245	0.234	0.243	0.225	0.208
$K_D/K_R = \frac{(4DH_1)^{1/2}+F}{(4DH_1)^{1/2}-F}$	1.782	1.128	1.271	1.051	1.777	2.060
Heritability NS narrow semse	0.429	0.681	0.641	0.586	0.613	0.665
r	-0.972**	-0.995**	-0.540	-0.619	-0.982**	-0.990**
r^2	0.944	0.989	0.291	0.383	0.965	0.981

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r: Simple correlation between mean performance of parents and (Wr + Vr).

Table (12): Cont.

Components	Seed yield/plant		Oil percentage	
	30 kg	45 kg	30 kg	45 kg
D	0.29±0.03**	0.87±0.11**	6.82±0.51**	8.94±0.95**
F	0.11±0.06*	0.35±0.27	2.50±1.25*	-0.08±2.32
H_1	0.38±0.07**	0.99±0.28**	2.91±1.30*	3.79±2.41*
H_2	0.30±0.06**	0.91±0.25**	2.14±1.16*	3.03±2.15*
h	0.73±0.04**	2.09±0.17**	1.31±0.78*	0.33±1.45
E	0.01±0.01	0.04±0.04	0.10±0.19	0.11±0.36
$(H_1/D)^{1/2}$	1.154	1.066	0.653	0.652
$H_2/4\,H_1$	0.197	0.231	0.184	0.200
$K_D/K_R = \frac{(4\,D\,H_1)^{1/2} + F}{(4\,D\,H_1)^{1/2} - F}$	1.414	1.465	1.783	0.986
Heritability NS narrow semse	0.589	0.530	0.801	0.849
r	-0.988**	-0.990**	-0.875*	-0.375
r^2	0.977	0.980	0.765	0.140

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r: Simple correlation between mean performance of parents and (Wr + Vr).

The overall dominance effects of heterozygous locisymbolized as (h^2) were estimated for all the studied traits (Table, 12). Significant (h^2) values were detected for all traits indicating that dominance was unidirectional. This finding confirms the results shown above by parent vs. crosses illustrated in Table (6).

The average frequency of negative vs. positive alleles in parental populations was detected by the ratio ($H_2/4H_1$). Values that deviate from one quarter were detected for stem diameter, oil percentage and seed yield/plant at 30 kg N-level, revealing that negative and positive alleles were unequally distributed among the parents. The same conclusion could also be drawn from estimating either (F) component or the corresponding proportion K_D/K_R.

Significant and negative correlation coefficient values between parental mean (Yr) and (Wr + Vr) for each array were obtained for stem diameter, no. of capsules/plant, seed yield/plant, straw yield/plant, 1000-seed weight and fiber yield at both nitrogen levels; and oil percentage at 30 kg N/fed. This indicates that the increasers genes were dominant over decreasers.

With the exception of stem diameter at 45 kg N/fed and number of capsules/plant at 30 kg N/fed., high to moderate heritability values in narrow sense were detected for all traits, indicating that most of genetic variance may be due to additive type of gene action. This finding supported the previous results of genetic components where (D) estimates had a high role for these cases. Consequently, selection could be useful in this respect. For the exceptional cases, both types of gene action (additive and non-additive) were most prevalent of the genetic variance.

4.3. Fertilizer susceptibility index (FSI):

4.3.1. Mean performance:

The mean performances of the six flax parents and their hybrids for most traits were used for estimating susceptibility to low nitrogen level by using three equations i.e. [$1-(Y_S/Y_N)/D$] (Fisher and Maurers, 1978), S/NS (Saulescu, *et al.*, 1995), [(NS-S)/NS] (Ali Dib *et al.*, 1990) (Table, 13).

Mean squares of (FSI) for genotypes were significant for all traits except number of seeds/capsule in the three methods and technical length by NS-S/NS only.

Significant (FSI) mean squares of parents were detected for all traits under study except oil percentage in the three methods, number of capsule in the first and second methods, and technical length in the third method.

The mean performances of the six parents of flax for FSI by the three methods are presented in Table (14). The susceptibility index was used to estimate relative stress injury because it accounted for variation in traits potential stress intensity.

Application of the performance of parents of the studied traits based on (FSI) over both fertilizer treatments 30 kg N/fed (low) and 45 kg N/fed (normal) (stress and non stress) indicated that the parental variety P_1 gave the desirable FSI for number of seeds/capsule, parent P_3 for 1000-seed weight, fiber length and

Table (13): Observed mean squares from ordinary analysis of variance for the fertilizer susceptibility index of all the studied traits in flax.

S.O.V.	d.f.	Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
Rep	2	0.187	0.001	0.001	0.175	0.003	0.004	0.041	0.001	0.0003
Genotype	20	1.625**	0.004**	0.004**	1.570**	0.009**	0.014	1.322**	0.011**	0.012**
Parents	5	1.321**	0.003*	0.003*	1.422*	0.008*	0.008	1.062**	0.006*	0.009**
Crosses	14	1.847**	0.005**	0.004**	1.601	0.009**	0.017	1.428**	0.013**	0.013**
Par x Cross	1	0.047	0.0004	0.001	1.876*	0.011*	0.004	1.147*	0.008	0.014**
Error	40	0.305	0.001	0.001	0.427	0.002	0.008	0.245	0.002	0.002

S.O.V.	d.f.	Fiber length (cm)			Straw yield/plant (g)			Fiber yield/plant (g)		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
Rep	2	0.125	0.003	0.008	0.001	0.005	0.003	0.009	0.004	0.004
Genotype	20	1.849**	0.010**	0.022**	0.205**	0.019**	0.021**	0.279**	0.027**	0.027**
Parents	5	1.819*	0.010**	0.043**	0.226**	0.023**	0.023**	0.491**	0.046**	0.046**
Crosses	14	1.801**	0.010**	0.012	0.204**	0.019**	0.021**	0.116**	0.011**	0.011**
Par x Cross	1	2.655*	0.015*	0.058**	0.108	0.015	0.011	1.496**	0.0150**	0.146**
Error	40	0.519	0.003	0.008	0.028	0.004	0.003	0.026	0.002	0.002

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

Table (13): Cont.

S.O.V.	d.f.	No. of capsules/plant			No. of seed/capsule			1000 seed weight		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
Rep	2	0.053**	0.030*	0.025	0.048	0.001	0.001	0.002	0.003	0.001
Genotype	20	0.527**	0.026**	0.034**	1.765	0.001	0.001	0.111**	0.008**	0.006**
Parents	5	0.149	0.005	0.037*	1.668	0.001	0.001	0.142**	0.009**	0.009**
Crosses	14	0.676**	0.034**	0.031**	1.922	0.001	0.001	0.105**	0.008**	0.006**
Par x Cross	1	0.332	0.017	0.063*	0.059	0.0001	0.0003	0.030	0.004	0.001
Error	40	0.117	0.006	0.012	2.951	0.002	0.002	0.031	0.002	0.001

S.O.V.	d.f.	Seed yield/plant			Oil percentage		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
Rep	2	0.003	0.002	0.001	0.047	0.019	0.001
Genotype	20	0.267**	0.033**	0.031**	4.006**	0.012	0.001**
Parents	5	0.255**	0.031**	0.030**	1.349	0.001	0.001
Crosses	14	0.288**	0.036**	0.033**	4.994**	0.017	0.002**
Par x Cross	1	0.035	0.004	0.004	3.452	0.002	0.001
Error	40	0.037	0.005	0.004	0.954	0.013	0.0003

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

Table (14): The genotypes mean performance based on FSI of the three methods for all the studied traits.

Genotype		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x1		0.30	0.98	0.02	0.37	0.97	0.03	1.64	0.85	0.15
2x2		2.07	0.89	0.11	1.13	0.92	0.08	1.62	0.85	0.15
3x3		0.42	0.98	0.02	0.93	0.93	0.07	1.98	0.88	0.18
4x4		1.27	0.94	0.07	1.32	0.90	0.10	1.11	0.90	0.10
5x5		0.81	0.96	0.04	-0.51	1.04	-0.04	0.35	0.97	0.03
6x6		0.59	0.97	0.03	0.19	0.99	0.01	0.88	0.92	0.08
1x2		0.38	0.98	0.02	0.95	0.93	0.07	1.07	0.94	0.10
1x3		0.63	0.96	0.04	0.25	0.98	-0.14	0.27	0.98	0.03
1x4		0.69	0.92	0.08	2.40	0.82	0.18	0.57	0.95	0.05
1x5		1.22	0.94	0.06	1.79	0.87	0.14	0.39	0.97	0.03
1x6		1.09	0.94	0.06	0.18	0.99	0.02	1.25	0.89	0.12
2x3		1.15	0.94	0.06	1.19	0.91	0.09	2.24	0.81	0.19
2x4		0.20	0.99	0.01	1.42	0.89	0.11	1.23	0.89	0.11
2x5		1.40	0.93	0.07	0.26	0.98	0.02	0.69	0.94	0.06
2x6		0.26	0.99	0.01	0.11	0.99	0.01	2.26	0.80	0.21
3x4		0.65	0.97	0.03	1.17	0.91	0.09	0.47	0.96	0.04
3x5		0.03	1.00	0.03	1.02	0.92	0.08	0.26	0.99	0.02
3x6		1.70	0.92	0.09	1.73	0.87	0.13	1.55	0.86	0.14
4x5		2.50	0.87	0.13	-0.05	1.01	-0.01	0.63	1.00	0.00
4x6		2.47	0.88	0.12	1.42	0.90	0.10	1.47	0.87	0.13
5x6		0.22	0.99	0.04	0.44	0.97	0.03	0.12	0.99	0.01
L.S.D.	0.05	0.91	0.05	0.05	1.08	0.08	0.15	0.82	0.07	0.07
	0.01	1.22	0.07	0.07	1.44	0.11	0.20	1.09	0.09	0.09
r		-0.07	-0.11	-0.34	0.30	0.307	0.168	0.34	0.35	0.39

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

r : Correlation coefficient between mid-parent and F_1-performance.

Table (14): Cont.

Genotype		Fiber length			Straw yield/plant			Fiber yield/plant		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x1		0.31	0.98	0.03	1.25	0.61	0.40	1.22	0.63	0.37
2x2		1.17	0.92	0.08	1.02	0.68	0.32	0.99	0.70	0.30
3x3		0.93	0.93	0.07	0.57	0.82	0.18	0.50	0.85	0.15
4x4		1.38	0.90	0.10	1.10	0.65	0.35	0.07	0.98	0.02
5x5		-0.69	1.05	-0.22	0.63	0.80	0.20	0.57	0.83	0.17
6x6		0.07	1.00	0.01	0.74	0.77	0.24	0.80	0.76	0.25
1x2		0.93	0.93	0.07	1.25	0.60	0.40	1.37	0.58	0.42
1x3		0.14	0.98	0.02	1.30	0.59	0.41	1.24	0.62	0.38
1x4		2.45	0.82	0.18	1.19	0.62	0.38	1.10	0.67	0.34
1x5		2.02	0.85	0.15	1.24	0.61	0.40	1.18	0.64	0.36
1x6		0.18	0.98	0.02	1.20	0.62	0.38	1.25	0.62	0.38
2x3		1.29	0.91	0.19	1.02	0.67	0.33	1.07	0.67	0.33
2x4		1.43	0.89	0.11	1.04	0.67	0.33	0.97	0.64	0.36
2x5		0.36	0.97	0.03	0.94	0.70	0.30	0.94	0.71	0.29
2x6		0.19	0.99	0.02	0.98	0.69	0.31	1.16	0.65	0.35
3x4		1.22	0.91	0.09	1.02	0.67	0.33	1.05	0.68	0.32
3x5		1.07	0.92	0.08	0.51	0.84	0.16	0.88	0.73	0.27
3x6		1.79	0.86	0.14	0.67	0.72	0.21	0.68	0.79	0.21
4x5		-0.08	1.01	-0.01	0.85	0.73	0.27	0.94	0.71	0.29
4x6		1.43	0.90	0.10	0.96	0.70	0.31	0.96	0.71	0.29
5x6		0.31	0.98	0.02	0.46	0.86	0.15	0.68	0.79	0.21
L.S.D.	0.05	1.19	0.08		0.28	0.11	0.26	0.26	0.08	0.08
	0.01	1.59	0.11		0.37	0.14	0.35	0.35	0.10	0.10
r		0.28	0.30	0.34	0.82**	0.77**	0.81**	0.58*	0.52*	0.51*

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation coefficient between mid-parent and F_1-performance.

Table (14): Cont.

Genotype		No. of capsules/plant			No. of seed/capsule			1000-seed weight		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x1		1.29	0.71	0.49	0.19	1.00	0.04	1.04	0.74	0.26
2x2		1.35	0.73	0.30	0.70	0.98	0.02	0.90	0.77	0.23
3x3		1.01	0.76	0.24	0.29	0.99	0.01	0.63	0.84	0.16
4x4		0.89	0.79	0.21	1.51	0.97	0.03	0.95	0.76	0.24
5x5		0.78	0.81	0.19	2.09	0.95	0.05	1.30	0.67	0.33
6x6		1.06	0.75	0.25	0.63	0.99	0.02	0.86	0.78	0.22
1x2		1.15	0.74	0.26	1.81	0.96	0.04	1.09	0.72	0.28
1x3		1.22	0.72	0.28	0.65	0.98	0.02	1.03	0.74	0.26
1x4		1.12	0.75	0.25	0.93	0.97	0.03	1.09	0.73	0.28
1x5		1.23	0.72	0.28	1.04	0.97	0.03	1.01	0.75	0.26
1x6		1.26	0.72	0.28	0.78	0.98	0.02	1.06	0.73	0.27
2x3		1.23	0.72	0.28	2.94	0.93	0.07	0.81	0.80	0.21
2x4		1.06	0.76	0.24	-0.64	1.01	-0.01	0.74	0.81	0.19
2x5		1.25	0.71	0.29	0.51	0.99	0.01	1.03	0.74	0.26
2x6		1.20	0.72	0.27	0.55	0.98	0.02	0.74	0.81	0.19
3x4		0.80	0.82	0.18	1.77	0.96	0.04	0.95	0.76	0.24
3x5		0.30	0.92	0.16	1.40	0.96	0.04	1.23	0.69	0.24
3x6		-0.48	1.11	-0.11	0.43	0.99	0.01	0.98	0.69	0.25
4x5		0.67	0.86	0.14	0.72	0.98	0.02	1.15	0.71	0.29
4x6		0.75	0.83	0.18	0.96	0.98	0.03	0.66	0.83	0.17
5x6		0.76	0.83	0.17	0.70	0.99	0.02	1.33	0.66	0.34
L.S.D.	0.05	0.56	0.13	0.18	2.84	0.07	0.07	0.29	0.08	0.06
	0.01	0.75	0.17	0.24	3.79	0.09	0.09	0.39	0.11	0.08
r		0.50	0.44	0.51	-0.26	-0.20	-0.21	0.48	0.31	0.50

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation coefficient between mid-parent and F_1-performance.

Table (14): Cont.

Genotype		Seed yield/plant			Oil percentage		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x1		1.36	0.54	0.46	2.51	0.95	0.05
2x2		1.18	0.60	0.40	1.46	0.97	0.03
3x3		0.91	0.69	0.31	1.31	0.97	0.01
4x4		0.88	0.74	0.30	0.74	0.98	0.02
5x5		0.65	0.78	0.22	1.16	0.98	0.02
6x6		0.61	0.79	0.22	0.64	0.99	0.01
1x2		1.37	0.53	0.47	3.50	0.93	0.07
1x3		1.36	0.54	0.46	2.56	0.95	0.05
1x4		1.19	0.60	0.40	1.41	0.97	0.03
1x5		0.83	0.72	0.28	1.64	0.96	0.04
1x6		1.19	0.59	0.41	-0.89	1.02	-0.02
2x3		1.21	0.59	0.41	1.17	0.98	0.02
2x4		1.05	0.64	0.36	1.05	0.98	0.02
2x5		0.91	0.78	0.31	1.75	0.97	0.03
2x6		1.41	0.52	0.47	-0.24	1.00	0.00
3x4		0.89	0.70	0.30	-0.11	1.00	0.00
3x5		0.77	0.74	0.26	-0.39	1.00	0.00
3x6		0.47	0.84	0.16	-0.33	0.70	0.00
4x5		0.64	0.78	0.22	0.18	0.99	0.01
4x6		0.97	0.67	0.33	-0.84	1.016	-0.01
5x6		0.47	0.84	0.16	1.30	0.98	0.03
L.S.D.	0.05	0.32	0.12	0.11		0.19	0.03
	0.01	0.42	0.16	0.14		0.25	0.04
r		0.78**	0.76**	0.80**	0.70**	-0.04	0.65**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation coefficient between mid-parent and F_1-performance.

fiber yield, parent (P_5) for technical length, fiber length, fiber yield, seed and straw yields in the three methods used in this study. However, the other parents showed undesirable (FSI) for all the studied traits.

Mean squares of hybrids were significant for all traits except technical length, oil percentage and fiber length in method 1, 2 and 3, respectively.

Fertilizer suceptability index values of 15 tested hybrids are presented in Table (14).

For plant height and stem diameter the crosses (2x4) Giza 8 x S_1, (3x5) Ariane x Gawhar and (5x6) Gawhar x Bombay gave desirable susceptibility index for stress of nitrogen fertilizer. While for technical length, the two crosses (1x3) S.2419/1 x Ariane and (4x5) S_1 x Gawhar gave the higher susceptibility index for low nitrogen fertilizer. Two crosses, namelly (3x5) Ariane x Gawhar and (3x6) Ariane x Bombay recorded desirable index for number of capsules/plant, the three crosses (2x4) Giza 8 x S_1, (2x6) Giza 8 x Bombay and (3x6) Ariane x Bombay for number of seeds/capsule, the three crosses (2x4) Giza 8 x S_1, (2x6) Giza 8 x Bombay and (4x6) S_1 x Bombay for 1000-seed weight, the six crosses (1x6) S.2419/1 x Bombay, (2x6) Giza 8 x Bombay, (3x4) Ariane x S_1, (3x5) Ariane x Gawhar, (3x6) Ariane x Bombay and (4x6) S_1 x Bombay for oil percentage, one cross (4x5) S_1 x Gawhar for fiber length, the three crosses (3x5) (Ariane x Gawhar, (3x6) Ariane x Bombay and (4x5) S_1 x Gawhar for seed yield/plant and fiber yield; and the two crosses (3x5) Ariane x Gawhar and (5x6) Gawhar x Bombay for straw yield in the three methods gave desirable susceptibility index for stress of nitrogen fertilizer. The hybrids which showed significant desirable FSI for seed, straw and fiber yields comprised P_5, which was classified above as being of a desirable (FSI) for these traits. Therefore, it could be concluded that P_5 had higher ability to transmit its desirable FSI to its hybrids.

Significant positive correlation coefficient values between mid-parent and F_1 hybrids mean values for each of the studied traits are presented in Table (14).

Desirable susceptibility index were obtained for seed, straw and fiber yields/plant in the three methods, oil percentage in the first and third methods. Such result clarified good agreement between mid-parent values and F_1 performance. Consequently, the best performance of F_1 combination could be achieved by crossing between parents of high (FSI).

Insignificant correlation values were detected for all the rest cases indicating that certain high and low parental lines/or varieties may produce outstanding F_1 hybrids in this concern.

Mean squares for parents vs. crosses as an indication to average heterosis over all crosses were insignificant for (FSI) in all traits in the three methods except stem diameter, fiber length and fiber yield in the three methods, technical length in the first and second methods, and number of capsules/plant in the third method (Table, 13).

4.3.2. Combining ability variance:

Analysis of variance for combining ability as outlined by Griffing's (1956) method 2 model I for FSI of all the studied traits, is presented in Table (15).

The mean squares associated with general combining ability GCA for (FSI) were significant for all traits except number of seeds/capsule in the three methods, and plant height and oil percentage in the third and second methods, respectively. The mean squares associated with specific combining ability of FSI were significant for all traits except number of seeds/capsule in the three methods, and number of capsules/plant, straw yield/plant and oil percentage in the second method. The mean squares associated with general combining ability were insignificant along with significant specific combining ability for FSI of plant height in the third method indicating that non-additive type of gene action was the more important part of the total genetic variability for this case. However, the mean squares of general combining ability were significant along with insignificant SCA for FSI in number of capsules/plant and straw yield/plant in the third and second method, revealing that additive type of gene action was the more important part of the total genetic variability. For other cases, the variances associated with GCA and SCA were significant for FSI. In such cases to get an idea about the predicated performance of single-cross progeny in each case, the relative size of general and specific combining ability mean squares may be helpful. Low GCA/SCA ratios of less than unity were detected for plant height in the three methods, indicating the predominance of non-additive gene action

Table (15): FSI observed mean squares for general and specific combining ability using the three methods for all the studied traits

S.O.V.	d.f.	Plant height (cm)			Technical length (cm)			Stem diameter		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
GCA	5	0.339**	0.001**	0.0008	0.658**	0.004**	0.003	0.901**	0.008**	0.009**
SCA	15	0.610**	0.002**	0.0014**	0.479**	0.003**	0.005*	0.287**	0.002**	0.002**
Error	40	0.102	0.004	0.0003	0.142	0.001	0.003	0.082	0.001	0.001

S.O.V.	d.f.	Fiber length (cm)			Straw yield/plant (g)			Fiber yield/plant (g)		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
GCA	5	0.750**	0.004**	0.013**	0.214**	0.020**	0.022**	0.200**	0.018**	0.018**
SCA	15	0.572**	0.003**	0.006**	0.020*	0.0021	0.002*	0.057**	0.006**	0.006**
Error	40	0.173	0.001	0.003	0.009	0.0014	0.0009	0.009	0.001	0.001

S.O.V.	d.f.	No. of capsules/plant			No. of seed/capsule			1000 seed weight		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
GCA	5	0.295**	0.013**	0.024**	0.249	0.0001	0.0002	0.086*	0.005**	0.005**
SCA	15	0.136**	0.007**	0.007	0.702	0.0004	0.0004	0.020*	0.002*	0.0012**
Error	40	0.039	0.002	0.004	0.984	0.0006	0.0005	0.010	0.001	0.0005

S.O.V.	d.f.	Seed yield/plant			Oil percentage		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
GCA	5	0.264**	0.032**	0.030**	2.731**	0.002	0.001**
SCA	15	0.031**	0.004*	0.003*	0.870**	0.005	0.0003**
Error	40	0.012	0.002	0.001	0.318	0.004	0.0001

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

in the inheritance of FSI of this trait. Results showed that the other cases expressed high GCA/SCA ratios, which exceeded the unity indicating the predominance of additive and additive by additive gene action in the inheritance of FSI of such cases.

4.3.3. General combining ability effects:

FSI estimates of GCA effects ($\hat{g}_i$) for individual parents of each trait are presented in Table (16).

The parental line S.2419/1 (P_1) expressed undesirable $\hat{g}_i$ effects of FSI for number of capsules/plant, seed yield/plant, fiber yield and straw yields/plant by the three methods. Also, it showed insignificant $\hat{g}_i$ effects for other traits.

The parental variety Giza 8 (P_2) expressed significant desirable $\hat{g}_i$ effects of FSI for 1000-seed weight in the three methods. On the other hand, it gave undesirable or insignificant $\hat{g}_i$ effects for the rest traits.

The parental variety Ariane-R_3 (P_3) expressed significant desirable $\hat{g}_i$ effects in the used three methods for plant height, no. of capsules/plant, straw yield/plant, 1000-seed weight and fiber yield. However, it was near the average for other traits. The parental line S.strain 1 (P_4) exhibited significant desirable $\hat{g}_i$ effects of FSI for fiber yield. While, it expressed the poorest $\hat{g}_i$ effects for FSI in other traits. The parental variety Gawhar-552 (P_5) expressed significant desirable $\hat{g}_i$ effects for FSI in stem diameter, seed yield/plant, straw yield/plant, 1000-seed weight and fiber length. Therefore, variety Gawhar-552 could be considered as an excellent parent in breeding programes aimed

Table (16): Estimates of general combining ability effects for the fertilizer susceptibility index of all the studied traits in flax.

Parent		Plant height (cm)			Technical length (cm)			Stem diameter		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
S. 2419/1		-0.259*	0.008	-0.010	0.051	-0.005	-0.009	-0.065	0.004	-0.004
Giza 8		0.104	-0.003	0.002	0.035	-0.003	0.009	0.420**	-0.040**	0.040**
Ariane R_3		-0.210*	0.013*	-0.012	0.165	-0.013	-0.001	0.175	-0.005	0.018*
S. $strain_1$		0.295**	-0.018**	-0.016**	0.388**	-0.028**	0.035*	-0.094	0.008	-0.013
Gawhar-552		0.039**	0.0001	0.004	-0.433**	0.032**	-0.026	-0.570**	0.053**	-0.056**
Bombay		0.030	0.0002	0.001	-0.205	0.016	-0.009	0.134	-0.020*	0.015
L.S.D. (gi)	0.05	0.21	0.012	0.012	0.246	0.018	0.033	0.186	0.015	0.016
	0.01	0.28	0.016	0.016	0.329	0.024	0.045	0.249	0.021	0.021
L.S.D. (gi-gi)	0.05	0.32	0.019	0.019	0.381	0.028	0.052	0.289	0.024	0.024
	0.01	0.43	0.025	0.025	0.510	0.037	0.069	0.386	0.032	0.032
r		0.35	0.60	0.56	0.92**	0.92**	0.91*	0.73	0.72	0.74

Parent		Fiber length			Straw yield/plant			Fiber yield/plant		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
S. 2419/1		0.046	-0.005	0.008	0.254**	-0.078**	0.080**	0.255**	-0.075**	0.074**
Giza 8		0.072	-0.005	0.020	0.078*	-0.022	0.024*	0.118**	-0.41**	0.041**
Ariane R_3		0.175	-0.013	0.028	-0.122**	0.032**	-0.038**	-0.075*	0.026**	-0.026**
S. $strain_1$		0.406**	-0.029**	0.032*	0.076*	-0.021*	0.024*	-0.17**	0.047**	-0.048**
Gawhar-552		-0.456**	0.033**	-0.073**	-0.173**	0.058**	-0.055**	-0.099**	0.033**	-0.033**
Bombay		-0.242	0.020**	-0.014	-0.112**	0.030*	-0.036**	-0.025	0.010	-0.008
L.S.D. (gi)	0.05	0.27	0.02	0.02	0.06	0.02	0.02	0.060	0.018	0.018
	0.01	0.01	0.36	0.03	0.09	0.03	0.03	0.081	0.024	0.024
L.S.D. (gi-gi)	0.05	0.01	0.42	0.03	0.098	0.04	0.03	0.093	0.027	0.027
	0.01	0.01	0.56	0.04	0.13	0.05	0.04	0.130	0.040	0.040
r		0.92**	0.94**	0.094**	0.97**	0.95**	0.97**	0.92**	0.92**	0.92**

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
r : Correlation between parental mean performance and its $\hat{g}_i$ effects.

Table (16): Cont.

Parent		No. of capsules/plant			No. of seed/capsule			1000 seed weight		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
S. 2419/1		0.240**	-0.053**	0.090**	-0.134	0.004	0.005	0.062	-0.013	0.018*
Giza 8		0.244**	-0.048**	0.043*	-0.009	-0.001	-0.002	-0.081*	0.023*	-0.018*
Ariane R_3		-0.192**	0.040	-0.043*	0.140	-0.003	0.001	-0.074*	0.013	-0.024**
S. $strain_1$		-0.057	0.012	-0.025	0.013	-0.0001	0.002	-0.045	0.014	-0.009
Gawhar-552		-0.109	0.022	-0.025	0.238	-0.007	0.005	0.184**	-0.044**	0.041**
Bombay		-0.126	0.027	-0.040	-0.248	0.007	-0.007	-0.046	0.007	-0.009
L.S.D. (gi)	0.05	0.129	0.028	0.041	0.647	0.016	0.015	0.066	0.018	0.014
	0.01	0.172	0.038	0.054	0.866	0.021	0.020	0.089	0.024	0.019
L.S.D. (gi-gi)	0.05	0.199	0.044	0.063	1.002	0.025	0.024	0.102	0.028	0.022
	0.01	0.267	0.059	0.084	1.340	0.033	0.031	0.137	0.038	0.029
r		0.81	0.73	0.91*	0.56	0.68	0.68	0.89*	0.82*	0.93**

Parent		Seed yield/plant			Oil percentage		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
S. 2419/1		0.236**	-0.085**	0.080**	0.839**	-0.004	0.017**
Giza 8		0.192**	-0.059**	0.064**	0.451*	0.005	0.008*
Ariane R_3		-0.031	0.005	-0.010	-0.126	-0.023	-0.005
S. $strain_1$		-0.035	0.015	-0.011	-0.418*	0.020	-0.006
Gawhar-552		-0.231**	-0.085**	-0.078**	0.034	0.011	0.002
Bombay		0.130**	0.039**	-0.045**	-0.780**	-0.009	-0.015*
L.S.D. (gi)	0.05	0.07	0.03	0.02	0.37	0.04	0.01
	0.01	0.10	0.04	0.03	0.49	0.06	0.01
L.S.D. (gi-gi)	0.05	0.11	0.04	0.04	0.57	0.07	0.01
	0.01	0.15	0.06	0.06	0.76	0.09	0.01
r		0.97**	0.96**	0.098**	0.93**	0.18	0.92**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
r : Correlation between parental mean performance and its $\hat{g}_i$ effects.

to release a high yielding (seed and fiber) variety under low nitrogen levels. The parental variety Bombay (P_6) gave significant desirable $\hat{g}_i$ effects of FSI for oil percentage and straw yield, but was near the average for other traits.

The three methods used to estimate FSI gave the same results for each parent in all traits.

4.3.4. Specific combining ability effects:

Specific combining ability of parental combinations which were computed for (FSI) for all traits, are presented in Table (17).

For FSI of plant height, the three crosses (2x4) Giza 8 x S_1, (2x6) Giza 8 x Bombay and (3x5) Ariane x Gawhar expressed significant desirable S_{ij} effects in the three methods. The first two crosses involving only one good combiner.

For FSI of technical length, the cross (1x3) S.2419/1 x Ariane gave significant desirable $\hat{S}_{ij}$ effects in the three methods. While, the cross (4x5) S_1 x Gawhar exhibited significant desirable S_{ij} effects in the first and second methods.

Regarding stem diameter, the two crosses (1x3) S.2419/1 x Ariane and (3x4) Ariane x S_1 expressed significant S_{ij} effects of FSI in the three methods.

The two crosses (1x5) S.2419/1 x Gawhar and (4x6) S_1 x Bombay and the cross (3x6) Ariane x Bombay expressed significant desirable S_{ij} effects of FSI in the three methods for 1000-seed weight and seed yield/plant, respectively. Also, the two crosses (1x6) S.2419/1 x Bombay and (4x5) S_1 x Gawhar exhibited significant negative S_{ij} effects and FSI in the first and third method.

Significant desirable S_{ij} effects of FSI in the three methods were exhibited by the crosses (1x3) S.2419/1 x Ariane and (4x5) S_1 x Gawhar for fiber length, and (1x3) S.2419/1 x Ariane and (3x4) Ariane x S_1 for straw yield.

From the previous results, the three methods used to estimate FSI were similar.

The previous crosses that showed desirable S_{ij} effect of FSI had one or two good combiners. Such combination, would show desirable transgressive segregates providing that the additive genetic system presents in the good combiner as well as the complementary of epistatic effects present in the cross act in the same direction to reduce undesirable plant characteristics and maximize the character in view. Therefore, the previous crosses might be of prime importance in breeding program for traditional breeding procedures to stress environments (low nitrogen fertilizer).

Stress tolerant genotypes, as defined by FSI values, need not have a high yield potential sine FSI provides a measure of tolerance based on minimization of yield loss under stress rather than on stress yield per season.

Genotypes identified as stress tolerant using FSI should posses tolerance mechanisms, which may need to be incorporated into germplasm with higher yield potential for development of high yielding, and stress tolerant cultivars.

Table (17): Estimates of specific combining ability effects of fertilizer susceptibility index for the studied crosses in all traits .

Cross		Plant height (cm)			Technical length (cm)			Stem diameter (mm)		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x2		-0.42	0.03	-0.03	0.02	-0.01	0.02	-0.34	0.06**	-0.03
1x3		-0.15	-0.01	0.01**	-0.81*	0.06*	-0.18**	-0.89**	0.06**	-0.08**
1x4		-0.30	-0.02	0.02	1.11**	-0.08**	0.09*	-0.32	0.02	-0.02
1x5		0.49	-0.02	0.02	1.33**	-0.10**	0.11*	-0.03	0.02	-0.004
1x6		0.36	-0.02	-0.01	-0.50	0.04	-0.02	0.13	-0.01	0.01
2x3		0.30	-0.02	0.02	0.15	-0.01	0.02	0.59*	0.06**	0.04*
2x4		-1.16**	0.06**	-0.06**	0.16	-0.01	0.01	-0.15*	0.01	-0.01
2x5		0.30	-0.02	0.01	-0.19	0.01	-0.02	-0.21	0.012	-0.014
2x6		-0.83**	0.04*	-0.04*	-0.56	0.04	-0.05	0.66*	-0.06**	0.06*
3x4		-0.39	0.03	-0.03	-0.22	0.02	-0.00	-0.66*	0.043*	-0.06*
3x5		-0.75*	0.04*	-0.02	0.45	-0.03	0.05	-0.40	0.03	-0.03
3x6		0.93**	-0.05**	0.04*	0.93**	-0.07**	0.09	0.19	-0.03	0.02
4x5		1.21**	-0.06**	0.05**	-0.85*	0.06*	-0.07	0.24	0.02	-0.02
4x6		1.19**	-0.06**	0.05**	0.40	-0.03	0.02	0.38	-0.03	0.04
5x6		-0.81**	0.04	-0.02	0.24	-0.02	0.01	-0.49	0.04*	-0.04
L.S.D.$_{sij}$	0.05	0.57	0.03	0.03	0.68	0.05	0.09	0.51	0.04	0.04
	0.01	0.76	0.05	0.04	0.90	0.07	0.12	0.69	0.06	0.07
L.S.D.$_{(sij-sik)}$	0.05	0.85	0.05	0.05	1.01	0.07	0.14	0.76	0.06	0.06
	0.01	1.14	0.07	0.07	1.35	0.10	0.18	1.02	0.08	0.09
L.S.D.$_{(sij-skl)}$	0.05	0.79	0.05	0.05	0.93	0.07	0.13	0.71	0.06	0.06
	0.01	1.06	0.06	0.06	1.25	0.09	0.17	0.95	0.08	0.08

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

Table (17): Cont.

Cross		Fiber length			Straw yield/plant (g)			Fiber yield		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x2		-0.04	0.002	-0.02	-0.03	0.01	-0.01	0.06	-0.01	0.02
1x3		-0.94*	0.07*	-0.08	0.22*	-0.06	0.07*	0.13	-0.04	0.04
1x4		1.15**	-0.08**	0.08	-0.085	0.02	-0.03	0.09	-0.02	0.02
1x5		1.58**	-0.12**	0.16**	0.21*	-0.07*	0.07*	0.09	-0.03	0.03
1x6		-0.48	0.03	-0.04	0.107	-0.03	0.03	0.09	-0.03	0.03
2x3		0.192	-0.012	0.079	0.112	-0.03	0.04	0.10	-0.02	0.02
2x4		0.099	-0.009	-0.005	-0.07	0.02	-0.02	0.09	-0.08**	0.08**
2x5		-0.104	0.004	0.03	0.09	-0.03	0.03	-0.01	0.01	-0.01
2x6		-0.50	0.034	-0.051	0.07	-0.02	0.02	0.13	-0.03	0.03
3x4		-0.214	0.016	-0.03	0.12	-0.03	0.04	0.37**	-0.11**	0.11
3x5		0.503	-0.036	0.07	-0.14	0.05	-0.05	0.12	-0.04	0.04
3x6		1.00**	-0.08**	0.06	-0.05	-0.04	-0.02	-0.15	0.04	-0.05
4x5		-0.88*	0.07*	-0.03	-0.01	-0.003	0.001	0.27**	-0.08**	0.08**
4x6		0.415	-0.03	0.02	0.05	-0.009	0.015	0.23**	-0.06*	0.06*
5x6		0.16	-0.01	0.05	-0.20*	0.072*	-0.07*	-0.13	0.04	-0.04
L.S.D.$_{sij}$	0.05	0.75	0.05	0.09	0.17	0.07	0.06	0.17	0.05	0.05
	0.01	1.00	0.07	0.12	0.23	0.09	0.07	0.22	0.07	0.07
L.S.D.$_{(sij-sik)}$	0.05	1.11	0.08	0.14	0.26	0.10	0.08	0.25	0.07	0.07
	0.01	1.49	0.11	0.18	0.35	0.13	0.11	0.33	0.10	0.10
L.S.D.$_{(sij-skl)}$	0.05	1.03	0.07	0.13	0.24	0.09	0.08	0.23	0.07	0.07
	0.01	1.38	0.10	0.17	0.32	0.12	0.10	0.31	0.09	0.09

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

Table (17): Cont.

Cross		No. of capsules/plant			No. of seeds/capsule			1000 seed weight		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x2		-0.28	0.054	-0.100	0.999	-0.024	0.015	0.13	-0.04*	0.03
1x3		0.23	-0.047	-0.001	-0.304	0.005	-0.014	0.06	-0.01	0.02
1x4		-0.01	0.004	-0.042	0.097	-0.007	-0.002	0.09	-0.03*	0.02
1x5		0.15	-0.031	-0.018	-0.013	0.001	-0.009	-0.21*	0.05*	-0.05*
1x6		0.20	-0.041	0.004	0.213	-0.005	-0.005	0.07	-0.01	0.013
2x3		0.23	-0.055	0.049	1.862*	-0.039	0.041	-0.01	0.01	0.003
2x4		-0.07	0.011	-0.008	-1.596	0.037	-0.036	-0.11	0.03*	-0.03
2x5		0.16	-0.044	0.037	-0.665	0.017	-0.016	-0.06	0.01*	-0.01
2x6		0.13	-0.041	0.039	-0.142	-0.002	0.002	-0.12	0.04*	-0.03
3x4		0.10	-0.020	0.021	0.666	-0.014	0.016	0.09	-0.02*	0.03
3x5		-0.35	0.073	-0.003	0.068	-0.006	0.008	0.13	-0.03*	-0.02
3x6		-1.11**	0.257**	-0.255**	-0.415	0.010	-0.009	0.12	-0.08**	0.04
4x5		-0.11	0.038	-0.037	-0.478	0.011	-0.009	0.03	-0.01	0.01
4x6		-0.01	0.003	0.009	0.241	-0.008	0.008	-0.23**	0.06*	-0.06**
5x6		0.05	-0.006	0.007	-0.240	0.009	-0.009	0.21*	-0.05*	0.06**
L.S.D.$_{sij}$	0.05	0.35	0.08	0.11	1.78	0.04	0.04	0.18	0.01	0.04
	0.01	0.47	0.11	0.15	2.38	0.06	0.06	0.24	0.07	0.05
L.S.D.$_{(sij-sik)}$	0.05	0.53	0.12	0.17	2.65	0.07	0.06	0.27	0.07	0.06
	0.01	0.71	0.16	0.22	3.55	0.09	0.08	0.36	0.10	0.08
L.S.D.$_{(sij-skl)}$	0.05	0.49	0.11	0.15	2.45	0.06	0.06	0.25	0.07	0.05
	0.01	0.65	0.14	0.21	3.28	0.08	0.08	0.34	0.09	0.07

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

Table (17): Cont.

Cross		Seed yield/plant(g)			Oil percentage		
		$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS	$1-(Y_S/Y_N)/D$	S/NS	NS-S/NS
1x2		-0.02	0.003	-0.007	1.28*	-0.04	0.02*
1x3		0.19	-0.06	0.064	0.91	0.01	0.02*
1x4		0.02	-0.011	0.006	0.06	-0.01	-0.001
1x5		-0.14	-0.042	-0.049	-0.16	-0.01	-0.002
1x6		0.12	-0.036	0.041	-1.88**	0.06	-0.04**
2x3		0.09	-0.035	0.029	-0.90	0.03	0.001
2x4		-0.07	0.008	-0.023	0.08	-0.014	0.003
2x5		-0.02	0.086*	-0.007	0.33	-0.013	0.002
2x6		0.38**	-0.135**	0.121**	-0.84	0.04	-0.014
3x4		-0.02	0.001	-0.006	-0.50	0.04	-0.008
3x5		0.07	-0.031	0.023	-1.23*	-0.49	-0.019*
3x6		-0.33**	0.117**	-0.112**	-0.35	-0.23**	-0.0004
4x5		-0.06	0.005	-0.021	0.364	0.010	-0.002
4x6		0.17	-0.061	0.058	-0.57	0.04	-0.012
5x6		-0.14	0.041	-0.048	1.11*	0.007	0.019*
L.S.D.$_{sij}$	0.05	0.20	0.07	0.07	1.01	0.12	0.02
	0.01	0.27	0.10	0.09	1.35	0.16	0.03
L.S.D.$_{(sij-sik)}$	0.05	0.30	0.11	0.10	1.51	0.18	0.03
	0.01	0.49	0.15	0.13	2.02	0.24	0.04
L.S.D.$_{(sij-skl)}$	0.05	0.28	0.10	0.09	1.40	0.16	0.03
	0.01	0.37	0.14	0.12	1.87	0.22	0.03

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