PERFORMANCE AND HETEROSIS OF SOME GRAIN SORGHUM LINES AND THEIR HYBRIDS UNDER DIFFERENT LEVELS OF NITROGEN.

Abd El-Mawgoud M. A.[*], E. A. Hassaballa[**], M. Z. El-Hefny[**] and M. M. El-Menshawi[*].

[*]Sorghum Res. Dept., Field Crop Res. Institute, A. R. C. Egypt.

[**]Agronmy Dept., Fac. Of Agric., Assiut Univ., Assiut, Egypt.

Abstract: Twenty four crosses were developed from eight cytoplasmic male sterile lines (CMS-Lines) and three restorer lines (R-Lines) at Shandaweel Agric. Res. Station, Sohag, Egypt, in 2009 season. Three experiments were conducted separately for each N level (the first experiment with 80 Kg N/Fed., the second experiment with 100 Kg N/Fed. and the third experiment with 120 Kg N/Fed.,). The twenty four crosses and their parental lines with the check (Shandaweel-6) were evaluated under the three levels of nitrogen in two locations at Shandaweel Agric. Res. Station, Sohag and at Arab El-Awammer Agric. Res. Station, Assiut in 2010 season. Data were recorded on days to 50% flowering, plant height (cm.), 1000-grain weight (g.) and grain yield / plant (g.).

The combined analyses of variance over the three levels of nitrogen at each of the two locations showed highly significant differences among nitrogen (N) levels and genotypes (G) and their interaction for all studied traits, except the genotype x nitrogen interaction was insignificant for days to 50% flowering at Shandaweel. The crosses (ATX 2-1 x Adv.11) and (ICSA-20 x Sel.9) had higher grain yield / plant than the check (Shandaweel-6) at Shandaweel location for the three levels of nitrogen, while the crosses (ATX 2-1 x Adv.11) and (Sh-13 x Adv.11) had higher grain yield / plant than the check (Shandaweel-6) at Arab El-Awammer location for the three levels of nitrogen. The cross (ATX 2-1 x Adv.11) had the highest positive significant heterosis for grain yield / plant for the three levels of nitrogen at Shandaweel and Arab El-Awammer locations and gave the highest yield / plant.

Key words: grain sorghum lines, hybrids, heterosis, levels of nitrogen.

Introduction

Sorghum [*Sorghum bicolo*r (L.) Moench] is often grown under nitrogen and water-limited conditions, but there is insufficient information on genotypic variation for grain yield and its components under stress conditions, **Kamoshita *et al.*, 2000.**

Nitrogen is the most important nutritive element for the production of cereals. It is mostly supplied to the soil in the form of inorganic fertilizers. A considerable portion of N fertilizer is lost through gaseous plant emissions, soil denitrification, surface runoff, ammonia volatilization, and leaching. This may lead to ground water, contamination **Raun and Johnson, 1999.** In contrast, the rates of N fertilizer in most developing countries are considerably low because of the limited access of fertilizers and the low or N stress tolerance are understood, **Maranville and Madhavan, 2002. Ragheb and Elnagar, 1997** found that sorghum genotypes had different response in yield and its components under different N levels. **Moran and Rooney 2003,** found a significant differences among hybrids for plant height, days to anthesis and grain yield under different N levels. **Al-Nagar *et al.*, 2006,** concluded that N levels and genotypes x N levels interactions were highly significant for all studied traits. **Hovny and El-Dsouky, 2007,** found that most of the crosses were earlier, taller, higher in 1000-grain weight and grain yield / plant than their parents under 50 and 100 Kg N/Fed. The aims of this study were to examined the expression some grain sorghum lines and their hybrids under different levels of nitrogen and obtain superior new hybrids adapted to the Shandaweel and Arab El-Awammer locations.

Materials and Methods

Eight grain sorghum cytoplasmic male sterile lines (CMS-lines) were crossed with three grain sorghum restorer lines (R-lines) at Shandaweel Agric., Res., Station, in 2009 season to develop twenty four crosses. The origin of the eight female lines is (two from USA, three from India and three from Egypt), while the male lines from Egypt. The three experiments were conducted separately for each N level (The first experiment with 80 Kg N/Fed., the second experiment with 100 Kg N/Fed. and The third experiment with 120 Kg N/Fed.,). The twenty four crosses and their parental lines with the check Shandaweel-6 (Sh-6) were evaluated under the three levels of nitrogen in the two locations, Shandaweel Agric., Res., Station, Sohag and at Arab El-Awammer Agric., Res., Station, Assiut in 2010 season. The dates of planting were 10^{th} and 23^{th} of June in 2010 at Arab El-Awammer with sandy soil

texture and Shandaweel with clay soil texture, respectively. Each experiment of three nitrogen levels was conducted with three replicates in Randomized Complete Block Design (RCBD). Each genotype was represented by a single row plot 4 m long and 60 cm apart. Sowing was done in hills spaced 20 cm and thinning was done two plants / hill after three weeks from sowing at both locations. The agriculture practices were followed as recommended except nitrogen treatments, through the growing season in both locations.

Three levels of nitrogen (80,100 and 120 Kg N/fed.) were added in two doses equally. The first does was added after 21 days from sowing, and the second does was added after 36 days from sowing at Shandaweel with clay soil. While in Arab El-Awamer with sandy soil the three levels of nitrogen were added in four doses by 1 : 1 : 2 : 3 ratio after 21, 32, 43 and 54 days from sowing, respectively. The physical and chemical characteristics of the soils were determined using the methods described by **Page, 1982**. The amount of total soil nitrogen was calculated and found to be 0.018 and 0.003 %, also PH were 7.79 and 8.65 at Shandaweel Agri. Res. Farm and Arab El-Awamer Agric. Res. Farm, respectively. Data were recorded on days to 50% flowering, plant height (cm.), 1000-grain weight (g.) and grain yield / plant (g.) with grain moisture adjusted to 14% moisture. Data on plot mean basis, of each location and combined over the three nitrogen levels were subjected to general analysis of variance for the Randomized Complete Block Design (R.C.B.D) according to **Gomez and Gomez, 1984.** Heterosis was calculated as the percent deviation of F_1 performance from the better parents, as described by **Bhatt, 1971.**

Results and Discussion

I- Analysis of variance

The analyses combined of variance over nitrogen levels at Shandaweel and Arab El-Awammer locations for days to 50% flowering, plant height, 1000-grain weight and grain yield / plant of thirty six grain sorghum genotypes (eleven parental lines, twenty four crosses and the check hybrid Shadaweel-6) are presented in (Table 1).

Highly significant differences among nitrogen levels were obtained at Shandaweel and Arab El-Awammer locations, indicating that the days to 50% flowering, plant height, 1000-

Table (1): Mean squares of thirty -six genotypes of grain sorghum over the three levels of nitrogen at Shandaweel locations.

Source of variation	D.F	Shandaweel location			
		Days to 50% Flowering	Plant height (cm.)	1000-Grain Weight (g.)	Grain yield/ Plant (g.)
Nitrogen Level (N)	2	1012.48**	5243.90**	249.66**	5529.76**
Rep/ N	6	20.32	27.99	15.08	1.01
Genotype (G)	35	87.14**	5185.82**	65.24**	1677.08**
Check vs LxT(S)	1	403.46**	16762.76**	85.34**	4501.85**
LxT Scheme (S)	34	77.84**	4845.32**	64.65**	1594.01**
Parents (P)	10	119.58**	2031.63**	35.82**	509.09**
Parents vs Crosses	1	990.10**	111785.8**	1497.07**	16289.18**
Crosses (C)	23	20.02**	1419.08**	14.90**	1426.78**
Females (F)	7	11.19**	2616.7**	25.41**	2857.38**
Males (M)	2	65.40**	6365.71**	10.13**	1215.03**
F x M	14	17.96**	113.61**	10.32**	741.741**
G x N	70	5.20	89.79**	3.61**	83.66**
Check vs LxT (S) x N	2	12.14	18.76	2.83**	60.09**
N x S	68	5.0	91.88**	3.64**	84.35**
N x P	20	4.0	188.64**	5.45**	33.44**
Nx C vs P	2	18.44**	85.19**	3.96**	43.16**
N x C	46	4.85	50.10**	2.83**	108.28**
N x F	14	3.40	45.83**	1.20**	96.49**
N x M	4	4.63	92.36**	2.57**	152.31**
N x Fx M	28	5.61	46.21**	3.69**	107.89**
Error	210	4.05	18.45	0.57	2.48

** **Significant at 0.01 probability levels.**

Table (2): Mean squares of thirty -six genotypes of grain sorghum over the three levels of nitrogen at Arab El-Awammer location.

Source of variation	D.F	Arab El-Awammer location			
		Days to 50% Flowering	Plant height (cm.)	1000-Grain Weight (g.)	Grain yield/ Plant (g.)
Nitrogen Level (N)	2	925.61**	5675.35**	292.97**	11134.9**
Rep/ N	6	6.11	21.08	0.88	1.29
Genotype (G)	35	28.14**	1145.02**	75.22**	733.46**
Check vs LxT(S)	1	1.01	294.35**	198.67**	29.56**
LxT Scheme (S)	34	28.94**	1170.04**	71.59**	754.16**
Parents (P)	10	25.31**	1552.73**	52.93**	240.01**
Parents vs Crosses	1	247.52**	18683.3**	1493.91**	9405.74**
Crosses (C)	23	21.01**	242.21**	17.86**	601.56**
Females (F)	7	30.36**	468.50**	31.28**	1145.76**
Males (M)	2	11.57*	224.76**	27.05**	1339.54**
F x M	14	17.68**	131.56**	9.84**	224.03**
G x N	70	11.70**	77.28**	37.61**	150.06**
Check vs LxT (S) x N	2	2.45	842.78**	1193.03**	171.60**
N x S	68	11.97**	54.77**	3.63**	149.43**
N x P	20	20.08**	63.50**	4.15**	227.26**
Nx C vs P	2	73.78**	242.73**	0.31	111.46**
N x C	46	5.762**	42.80**	3.54**	117.24**
N x F	14	6.716**	40.37**	2.71**	75.58**
N x M	4	14.11**	99.77**	3.26**	187.26**
N x Fx M	28	4.09	35.88**	4.01**	128.07**
Error	210	2.71	18.26	0.56	1.07

***,** Significant at 0.05 and 0.01 probability, respectively.**

grain weight and grain yield / plant responded differently to the quantity of nitrogen level. The mean squares for genotypes were highly significant at Shandaweel and Arab El-Awammer, indicating the presences of variability among crosses and their parents for the days to 50%flowering, plant height, 1000-grain weight and grain yield / plant. The genotype x nitrogen interactions were highly significant at Shandaweel and Arab El-Awammer, indicating that genotypes differently response of for nitrogen levels for the plant height, 1000-grain weight and grain yield / plant, while, for days to 50% flowering was insignificant at Shandaweel, but it was highly significant at Arab El-Awammer. These results are in harmony with those obtained by **Ragheb and Elnagar, 1997**, **Moran and Rooney, 2003** and **Al-Nagar *et al*., 2006.**

II-Means Performance.

1- Days to 50% flowering.

At Shandaweel (Table 2), the results showed that all crosses were highly significantly earlier than the check Sh-6 and some were earlier than parents under the combined average. While at Arab El-Awammer (Table 2) the results showed that all crosses except no.15 were highly significantly earlier than the check Sh-6 under the combined average. Also, the hybrids (ICSA-52 x Sel.9, Sh-2 x Sel.9 and ICSA-20 x Adv.11) were earlier under 120 Kg N level with an average of 68.00 and 89.00 days under Shandaweel and Arab El-Awammer, respectively. Moreover, the general combined average of genotypes at Shandaweel was earlier than at Arab El-Awammer, also the average of the check hybrid at Shandaweel was earlier than at Arab El-Awammer, because the weather conditions and soil texture are different in both locations. These results are in harmony with those obtained by **Al-Nagar *et al.*, 2006 and Hovny and El-Dsouky, 2007.** They reported that low N input delayed the flowering of sorghum genotypes.

2- Plant height (cm.).

At Shandaweel (Table 3), the results showed that all crosses were highly significantly taller than the check Sh-6 and some were taller than parents under the combined average. While at Arab El-Awammer (Table 3) the results showed that all crosses were highly significantly taller than the check Sh-6 and most of them were taller than parents under the combined average. Moreover, the hybrid (Sh-11 x Adv.11) was the tallest one under 120 Kg

Table(2): Mean performance of days to 50% flowering for grain sorghum genotypes under the three nitrogen levels and combined means at Shandaweel and Arab El-Awammer locations.

	No.	Genotypes	Days to 50 % flowering at Shandaweel				Days to 50 % flowering at Arab El-Awammer			
			80 N	100 N	120 N	Average	80 N	100 N	120 N	Average
F_1 Crosses	1	ATX 2-1 x Adv.11	76.00	71.67	71.00	72.89	95.67	91.33	90.67	92.56
	2	ATX 407 x Adv.11	78.33	73.33	72.33	74.66	99.67	93.33	92.33	95.11
	3	ICSA .TX -20 x Adv.11	79.33	74.00	71.00	74.78	97.33	94.00	91.33	94.22
	4	ICSA-20 x Adv .11	78.00	73.67	70.67	74.11	96.33	93.00	89.00	92.78
	5	ICSA-52 x Adv .11	77.67	72.67	72.00	74.11	96.33	95.00	91.67	94.33
	6	Sh-2 x Adv .11	77.67	75.67	75.00	76.11	98.33	92.67	91.33	94.11
	7	Sh-11 x Adv .11	78.00	72.00	69.33	73.11	98.67	93.00	91.00	94.22
	8	Sh-13 x Adv .11	74.00	71.00	68.33	71.11	95.67	91.00	91.00	92.56
	9	ATX 2-1 x Sel.9	75.33	72.67	70.33	72.78	91.33	91.00	89.33	90.56
	10	ATX 407x Sel.9	73.00	72.33	69.33	71.55	93.33	91.33	90.33	91.67
	11	ICSA .TX -20 x Sel.9	74.67	72.33	69.33	72.11	94.33	93.00	90.33	92.56
	12	ICSA-20 x Sel.9	76.67	72.33	70.33	73.11	94.33	91.33	90.33	92.00
	13	ICSA-52 x Sel.9	75.00	73.00	68.00	72.00	97.67	94.67	90.67	94.33
	14	Sh-2 x Sel.9	79.33	73.33	68.00	73.55	96.67	96.33	90.00	94.33
	15	Sh-11 x Sel.9	79.00	74.67	73.33	75.67	100.00	96.00	93.00	96.33
	16	Sh-13 x Sel.9	77.00	74.67	71.33	74.33	93.00	92.33	92.33	92.56
	17	ATX 2-1 x Sel.15	76.67	73.33	70.67	73.56	91.33	91.33	91.00	91.22
	18	ATX 407 x Sel.15	75.33	75.00	71.00	73.78	99.00	94.33	93.33	95.56
	19	ICSA .TX -20 x Sel.15	76.67	75.00	75.00	75.56	96.00	92.00	90.67	92.89
	20	ICSA-20 x Sel.15	77.33	75.67	71.67	74.89	99.33	94.00	94.00	95.78
	21	ICSA-52x Sel.15	78.33	73.67	72.67	74.89	91.67	91.67	91.67	91.67
	22	Sh-2 x Sel.15	78.33	74.33	72.33	75.00	97.33	95.33	92.67	95.11
	23	Sh-11 x Sel.15	80.67	76.33	70.00	75.67	96.33	94.67	91.00	94.00
	24	Sh-13 x Sel.15	80.33	76.33	74.00	76.89	96.67	92.33	92.00	93.67
		Mean	77.19	73.71	71.12	74.01	96.10	93.12	91.29	**93.50**
Females	25	BTX 2-1	75.00	72.00	71.00	72.67	95.00	93.00	91.00	93.00
	26	BTX 407	79.00	73.33	72.00	74.78	94.00	93.67	91.33	93.00
	27	ICSB .TX – 20	79.67	74.33	72.00	75.33	94.00	93.67	92.67	93.44
	28	ICSB-20	81.33	72.67	72.33	75.44	104.67	93.33	93.33	97.11
	29	ICSB-52	76.00	71.67	72.00	73.22	102.67	94.33	93.33	96.78
	30	Sh B 2	86.00	79.33	79.33	81.55	104.00	95.00	90.33	96.44
	31	Sh B 11	82.67	81.00	80.00	81.22	99.33	93.33	89.67	94.11
	32	Sh B 13	82.00	76.67	75.67	78.11	98.00	96.33	95.33	96.56
		Mean	80.21	75.13	74.29	76.54	98.96	94.08	92.12	**95.06**
Males	33	Adv .11	85.33	81.33	80.67	82.44	105.00	93.33	93.00	97.11
	34	Sel.9	83.67	78.33	78.00	80.00	102.67	94.67	91.67	96.33
	35	Sel.15	83.67	81.00	79.33	81.33	101.67	92.67	92.67	95.67
		Mean	84.22	80.22	79.33	81.26	103.11	93.56	92.44	**96.37**
		General mean	78.49	74.59	72.55	75.21	97.35	93.38	91.58	**94.10**
	36	Sh-6 (Hybrid check)	86.67	82.33	77.00	82.00	96.67	94.00	92.67	94.44

	Shandaweel 5%	Shandaweel 1%	Arab El-Awammer 5%	Arab El-Awammer 1%
R L.S.D nitrogen level (N)	1.25	1.79	0.68	0.98
R L.S.D genotypes (G)	1.73	2.26	1.42	1.85
R L.S.D N x G	6.16	9.04	2.70	3.55

Table (3): Mean performance of plant height (cm.) for grain sorghum genotypes under the three nitrogen levels and combined means at Shandaweel and Arab El-Awammer locations.

No.		Genotypes	Plant height at Shandaweel				Plant height at Arab El-Awammer			
			80 N	100 N	120 N	Average	80 N	100 N	120 N	Average
F_1 Crosses	1	ATX 2-1 x Adv.11	164.43	177.73	191.93	178.03	110.33	113.67	127.00	117.00
	2	ATX 407 x Adv.11	183.97	192.63	199.97	192.19	112.67	117.00	130.00	119.89
	3	ICSA .TX -20 x Adv.11	186.30	188.87	194.97	190.05	115.67	128.00	131.00	124.89
	4	ICSA-20 x Adv .11	176.97	185.97	191.63	184.86	112.67	129.67	137.00	126.45
	5	ICSA-52 x Adv .11	165.50	186.97	193.20	181.89	113.00	120.33	137.00	123.44
	6	Sh-2 x Adv .11	160.53	167.10	178.87	168.83	103.33	107.33	114.67	108.44
	7	Sh-11 x Adv .11	195.77	201.87	208.83	202.16	115.33	117.00	128.67	120.33
	8	Sh-13 x Adv .11	176.87	186.67	195.73	186.42	124.00	126.67	137.33	129.33
	9	ATX 2-1 x Sel.9	158.63	160.20	163.83	160.89	115.00	116.00	117.00	116.00
	10	ATX 407x Sel.9	175.63	176.63	179.77	177.34	117.33	124.00	125.00	122.11
	11	ICSA .TX -20 x Sel.9	155.97	169.73	169.73	165.14	109.00	121.00	126.67	118.89
	12	ICSA-20 x Sel.9	170.53	170.67	190.07	177.09	115.00	127.67	128.33	123.67
	13	ICSA-52 x Sel.9	170.77	179.77	181.10	177.21	118.00	128.33	130.67	125.67
	14	Sh-2 x Sel.9	154.90	155.53	161.10	157.18	111.00	111.33	121.67	114.67
	15	Sh-11 x Sel.9	191.20	192.30	196.63	193.38	115.33	129.33	134.33	126.33
	16	Sh-13 x Sel.9	169.57	180.00	188.40	179.32	111.00	121.33	125.67	119.33
	17	ATX 2-1 x Sel.15	153.60	154.40	158.50	155.50	105.00	116.33	116.67	112.67
	18	ATX 407 x Sel.15	159.97	174.40	178.73	171.03	114.67	122.67	126.33	121.22
	19	ICSA .TX -20 x Sel.15	161.00	163.30	176.10	166.80	113.33	117.67	129.33	120.11
	20	ICSA-20 x Sel.15	163.87	164.20	177.30	168.46	106.33	116.67	119.00	114.00
	21	ICSA-52x Sel.15	158.53	169.97	173.43	167.31	107.33	115.00	127.33	116.55
	22	Sh-2 x Sel.15	147.20	153.73	164.53	155.15	103.67	113.67	121.33	112.89
	23	Sh-11 x Sel.15	174.53	186.10	188.83	183.15	107.33	128.33	136.33	124.00
	24	Sh-13 x Sel.15	157.20	174.20	175.27	168.89	110.00	127.67	129.67	122.45
		Mean	168.06	175.54	182.44	175.34	111.93	120.69	127.42	120.01
Females	25	BTX 2-1	104.10	115.63	155.53	125.09	93.33	94.67	95.00	94.33
	26	BTX 407	122.50	124.10	133.53	126.71	94.33	95.33	97.33	95.66
	27	ICSB .TX – 20	119.40	121.50	124.77	121.89	92.00	95.33	98.67	95.33
	28	ICSB-20	115.63	117.20	121.07	117.97	94.00	94.67	99.33	96.00
	29	ICSB-52	123.87	124.07	131.63	126.52	93.00	100.33	109.00	100.78
	30	Sh B 2	134.07	140.20	148.53	140.93	96.67	98.00	119.00	104.56
	31	Sh B 11	164.33	171.07	174.40	169.93	129.00	138.00	157.00	141.33
	32	Sh B 13	136.20	139.97	165.63	147.27	96.00	100.00	102.33	99.44
		Mean	127.51	131.72	144.39	134.54	98.54	102.04	109.71	103.43
Males	33	Adv .11	141.97	144.00	144.97	143.65	100.33	101.67	108.00	103.33
	34	Sel.9	134.53	136.53	137.33	136.13	99.33	103.00	106.33	102.89
	35	Sel.15	123.50	126.63	128.87	126.33	102.33	102.33	107.33	104.00
		Mean	133.33	135.72	137.06	135.37	100.66	102.33	107.22	103.41
General mean			155.82	162.11	169.85	162.59	107.90	114.86	121.64	114.80
36		Sh-6 (Hybrid check)	114.97	117.07	124.43	118.82	94.33	97.33	119.33	103.66

	Shandaweel 5%	Shandaweel 1%	Arab El-Awammer 5%	Arab El-Awammer 1%
R L.S.D nitrogen level (N)	1.47	2.09	1.27	1.82
R L.S.D genotypes (G)	3.52	4.55	3.49	4.52
R L.S.D N x G	13.15	19.28	7.01	9.17

N level with an average of 208.83 cm. under Shandaweel conditions, while under Arab El-Awammer conditions the female line (Sh B 11) was the tallest one with an average of 157.00 cm. under120 Kg N level. Generally, the general combined of heights average of genotypes at Shandaweel was taller than at Arab El-Awammer, also the average of the check hybrid at Shandaweel was taller than at Arab El-Awammer because the weather conditions and soil texture are different in both locations. Similar results were obtained by **Hovny and El-Dsouky, 2007 and Abo-Zaid, 2007.** They reported that studied genotypes were shorter under low nitrogen level comparing with plant height of the same studied genotypes under optimum nitrogen level.

3-1000-grain weight (g.).

At Shandaweel (Table 4), the results showed that the 1000-grain weight of the cross (Sh-13 x Adv.11) was highly significant in weights than the check Sh-6 under the two levels of nitrogen 80 and 120 Kg N, while the cross (ICSA-52 x Sel.9) was highly significant than the check Sh-6 under the second level of nitrogen 100 Kg N. At Arab El-Awammer (Table 4), the results showed that the 1000-grain weight for all crosses were significantly more than the check Sh-6 under the combined average. Moreover, the hybrid (Sh-13 x Adv.11) was the highest one under 120 Kg N level with an average of 32.00 g. under Shandaweel conditions, while under Arab El-Awammer conditions the hybrid (Sh-13 x Sel.15) was the highest one with an average of 32.60 g. under 120 Kg N level. Generally, the average of the check hybrid at Shandaweel was higher for 1000-grain weight than at Arab El-Awammer, because the weather conditions and soil texture are different in both locations. These results are in harmony with those obtained by **Al-Nagar et al., 2006, Hovny and El-Dsouky, 2007 and Abo-Zaid, 2007.** They reported that under low N fertility the seed size of sorghum genotypes decreased.

4- Grain yield / plant (g.).

At Shandaweel (Table 5), the results showed that the grain yield / plant for all crosses were highly significant more than the check Sh-6 under the combined average. While, the crosses (ATX 2-1 x Adv.11) and (ICSA-20 x Sel.9) gave the highest yield under the three levels of nitrogen and their combined. Moreover, the cross (ICSA-20 x Sel.9) gave the highest yield under low level of nitrogen as well as high level.

Table (4): Mean performance of 1000-grain weight (gm.) for grain sorghum genotypes under the three nitrogen levels and combined means at Shandaweel and Arab El-Awammer locations.

No.		Genotypes	1000-grain weight at Shandaweel				1000-grain weight at Arab El-Awammer			
			80 N	100 N	120 N	Average	80 N	100 N	120 N	Average
F_1 Crosses	1	ATX 2-1 x Adv.11	23.87	27.47	28.27	26.53	23.20	24.13	24.80	24.04
	2	ATX 407 x Adv.11	25.87	28.47	28.60	27.64	24.47	28.20	31.13	27.93
	3	ICSA .TX -20 x Adv.11	24.13	26.13	29.27	26.51	23.73	27.47	27.60	26.27
	4	ICSA-20 x Adv .11	27.07	27.93	30.00	28.33	25.53	25.73	28.00	26.42
	5	ICSA-52 x Adv .11	25.67	26.40	28.13	26.73	27.07	28.20	29.13	28.13
	6	Sh-2 x Adv .11	25.27	25.47	25.87	25.53	24.00	25.13	29.13	26.09
	7	Sh-11 x Adv .11	24.33	28.20	29.13	27.22	27.93	28.13	28.13	28.07
	8	Sh-13 x Adv .11	29.67	30.27	32.00	30.64	26.93	29.13	30.60	28.89
	9	ATX 2-1 x Sel.9	26.67	27.00	29.67	27.78	25.73	27.87	29.07	27.56
	10	ATX 407x Sel.9	25.73	26.00	28.20	26.64	27.60	28.00	28.53	28.04
	11	ICSA .TX -20 x Sel.9	27.67	28.40	30.00	28.69	27.73	28.40	28.67	28.27
	12	ICSA-20 x Sel.9	26.47	27.73	28.07	27.42	27.40	28.87	30.67	28.98
	13	ICSA-52 x Sel.9	26.40	30.60	30.67	29.22	24.93	27.33	31.53	27.93
	14	Sh-2 x Sel.9	25.47	28.67	29.00	27.71	24.40	25.47	26.40	25.42
	15	Sh-11 x Sel.9	24.73	27.20	31.20	27.71	28.40	28.73	29.07	28.73
	16	Sh-13 x Sel.9	27.73	29.73	30.80	29.42	28.00	29.40	31.67	29.69
	17	ATX 2-1 x Sel.15	26.33	28.07	28.40	27.60	24.47	28.13	28.27	26.96
	18	ATX 407 x Sel.15	25.27	28.67	29.67	27.87	27.33	27.47	27.73	27.51
	19	ICSA .TX -20 x Sel.15	26.20	27.40	28.20	27.27	24.47	28.27	28.60	27.11
	20	ICSA-20 x Sel.15	24.27	29.33	29.60	27.73	24.40	28.33	28.53	27.09
	21	ICSA-52x Sel.15	28.67	29.07	29.40	29.04	25.60	27.07	30.73	27.80
	22	Sh-2 x Sel.15	25.40	27.47	27.73	26.87	27.13	28.00	31.33	28.82
	23	Sh-11 x Sel.15	24.40	24.67	24.87	24.64	25.07	28.13	30.80	28.00
	24	Sh-13 x Sel.15	28.00	28.80	29.20	28.67	28.40	31.20	32.60	30.73
		Mean	26.05	27.88	29.00	27.64	26.00	27.78	29.28	27.69
Females	25	BTX 2-1	18.07	20.20	21.27	19.84	20.40	20.67	21.40	20.82
	26	BTX 407	21.00	21.33	24.33	22.22	19.47	20.80	21.07	20.44
	27	ICSB .TX – 20	20.07	21.60	22.20	21.29	18.87	20.27	23.27	20.80
	28	ICSB-20	21.27	21.60	22.07	21.64	20.20	20.47	20.53	20.40
	29	ICSB-52	20.60	21.47	28.47	23.51	23.60	27.67	28.33	26.53
	30	Sh B 2	21.20	21.33	24.40	22.31	24.40	28.27	28.47	27.04
	31	Sh B 11	23.60	24.20	25.27	24.36	23.13	24.33	24.47	23.98
	32	Sh B 13	26.47	26.60	28.20	27.09	20.60	21.13	24.47	22.07
		Mean	21.53	22.29	24.53	22.78	21.33	22.95	24.00	22.76
Males	33	Adv .11	20.80	22.33	22.47	21.87	22.93	23.73	24.40	23.69
	34	Sel.9	22.33	23.47	24.20	23.33	22.00	24.40	28.67	25.02
	35	Sel.15	21.00	25.73	28.13	24.96	20.27	21.53	24.67	22.16
		Mean	21.38	23.84	24.93	23.39	21.73	23.22	25.91	23.62
General mean			24.62	26.26	27.63	26.17	24.57	26.29	27.78	26.21
36		Sh-6 (Hybrid check)	28.33	30.40	31.20	29.98	21.40	22.20	25.53	23.04
			5%		1%		5%		1%	
R L.S.D nitrogen level (N)			1.08		1.54		0.26		0.37	
R L.S.D genotypes (G)			0.62		0.80		0.61		0.79	
R L.S.D N x G			1.18		1.53		1.06		1.38	

Table (5): Mean performance of grain yield / plant (gm.) for grain sorghum genotypes under the three nitrogen levels and combined means at Shandaweel and Arab El-Awammer locations.

No.		Genotypes	Grain yield / plant at Shandaweel				Grain yield / plant at Arab El-Awammer			
			80 N	100 N	120 N	Average	80 N	100 N	120 N	Average
F_1 Crosses	1	ATX 2-1 x Adv.11	62.33	84.33	90.67	79.11	38.00	43.87	55.27	45.71
	2	ATX 407 x Adv.11	52.00	52.33	56.00	53.44	18.30	27.20	50.27	31.92
	3	ICSA .TX -20 x Adv.11	52.33	83.00	83.67	73.00	36.87	42.00	53.73	44.20
	4	ICSA-20 x Adv .11	61.33	70.00	70.33	67.22	26.53	35.33	67.07	42.98
	5	ICSA-52 x Adv .11	34.00	40.33	44.00	39.44	17.67	24.87	54.80	32.44
	6	Sh-2 x Adv .11	34.67	39.00	40.33	38.00	18.07	21.20	26.00	21.76
	7	Sh-11 x Adv .11	28.67	54.33	74.00	52.33	38.00	44.53	50.93	44.49
	8	Sh-13 x Adv .11	43.67	53.33	66.67	54.56	31.07	35.73	67.60	44.80
	9	ATX 2-1 x Sel.9	67.00	76.00	79.00	74.00	31.67	36.60	47.00	38.42
	10	ATX 407x Sel.9	64.00	71.67	83.33	73.00	24.80	27.87	29.40	27.36
	11	ICSA .TX -20 x Sel.9	68.00	75.00	76.33	73.11	27.33	33.67	54.20	38.40
	12	ICSA-20 x Sel.9	81.67	84.00	85.67	83.78	32.00	41.27	48.07	40.44
	13	ICSA-52 x Sel.9	56.67	59.67	60.00	58.78	15.87	21.20	29.73	22.27
	14	Sh-2 x Sel.9	48.33	57.00	68.00	57.78	17.13	18.80	28.53	21.49
	15	Sh-11 x Sel.9	39.00	44.67	45.00	42.89	15.47	25.93	31.20	24.20
	16	Sh-13 x Sel.9	51.33	62.67	62.67	58.89	16.80	26.20	37.20	26.73
	17	ATX 2-1 x Sel.15	61.33	64.00	78.67	68.00	37.80	38.93	42.13	39.62
	18	ATX 407 x Sel.15	49.33	70.67	78.67	66.22	16.93	24.00	26.20	22.38
	19	ICSA .TX -20 x Sel.15	57.00	62.00	63.33	60.78	33.07	38.27	50.13	40.49
	20	ICSA-20 x Sel.15	58.33	58.33	65.67	60.78	28.33	37.40	49.33	38.36
	21	ICSA-52x Sel.15	58.33	72.00	74.00	68.11	15.53	31.40	39.80	28.91
	22	Sh-2 x Sel.15	52.00	54.00	56.00	54.00	23.33	26.67	54.13	34.71
	23	Sh-11 x Sel.15	28.00	38.33	52.67	39.67	17.53	20.67	56.40	31.53
	24	Sh-13 x Sel.15	58.00	62.00	73.00	64.33	26.07	32.33	50.27	36.22
		Mean	52.81	62.03	67.82	60.88	25.17	31.50	45.81	34.16
Females	25	BTX 2-1	33.33	36.33	42.00	37.22	15.47	15.70	17.20	16.12
	26	BTX 407	35.00	47.00	47.33	43.11	15.47	18.27	18.80	17.51
	27	ICSB .TX – 20	33.67	35.67	36.33	35.22	15.00	15.00	28.80	19.60
	28	ICSB-20	25.00	33.33	44.67	34.33	12.67	15.80	55.47	27.98
	29	ICSB-52	45.00	57.00	65.00	55.67	14.07	19.33	46.13	26.51
	30	Sh B 2	39.00	46.00	59.00	48.00	13.20	20.40	56.00	29.87
	31	Sh B 11	42.33	50.33	51.67	48.11	13.87	18.33	27.67	19.96
	32	Sh B 13	39.00	42.33	46.00	42.44	13.60	15.73	20.07	16.47
		Mean	36.54	43.50	49.00	43.01	14.17	17.32	33.77	21.75
Males	33	Adv .11	39.33	49.00	56.33	48.22	16.07	20.67	29.00	21.91
	34	Sel.9	50.00	52.00	58.00	53.33	17.73	21.40	23.87	21.00
	35	Sel.15	46.33	54.67	60.00	53.67	27.20	30.20	30.67	29.36
		Mean	45.22	51.89	58.11	51.74	20.33	24.09	27.84	24.09
General mean			48.44	56.92	62.69	56.02	22.24	27.62	41.52	30.46
36		Sh-6 (Hybrid check)	28.33	29.00	42.66	33.33	12.93	25.40	30.53	22.95
			5%		1%		5%		1%	
R L.S.D nitrogen level (N)			0.27		0.39		0.31		0.44	
R L.S.D genotypes (G)			1.29		1.67		0.84		1.09	
R L.S.D N x G			2.23		2.89		1.47		1.90	

At Arab El-Awammer (Table 5), the results showed that the grain yield / plant for twenty crosses out of twenty four were significantly more than the check-6 under the combined average. The crosses (ATX 2-1 x Adv.11), (ICSA.-20 x Adv.11), (Sh-11 x Adv.11) and (Sh-13 x Adv.11) gave the highest yield under the three levels of nitrogen and their average. Moreover, the (ATX 2-1 x Adv.11) and (Sh-11 x Adv.11) gave the highest yield under the low level 80 Kg N. However, the hybrid (ATX 2-1 x Adv.11) was the highest one under 120 Kg N level with an average of 90.67 g. under Shandaweel conditions, while under Arab El-Awammer conditions the hybrid (Sh-13 x Adv.11) was the highest one with an average of 67.60 g. under 120 Kg N level. Moreover, the general combined average of genotypes at Shandaweel was higher for grain yield / plant than at Arab El-Awammer, also the average of the check hybrid at Shandaweel was higher for grain yield / plant than at Arab El-Awammer, because the weather conditions and soil texture are different in both locations. These results are in harmony with those obtained by **Al-Nagar et al., 2006, Hovny and El-Dsouky, 2007, Abo-Zaid, 2007 and Abd El-Mottaleb, 2009.**

III- Heterosis.

Heterosis for twenty four F_1 crosses were determined as a percentage of the better parent under the three levels of nitrogen at Shandaweel and Arab El-Awammer for all studied traits.

1-Days to 50% flowering:

At Shandaweel (Table 6) the highest negative heterosis values for days to 50% flowering were -9.76, -11.11 and -13.34 % under 80, 100 and 120 Kg N levels, respectively. The F_1 crosses (Sh-2 x Adv.11), (Sh-11 x Adv.11), (Sh-13 x Adv.11), (Sh-2 x Sel.9), (Sh-11 x Sel.9) and (Sh-2 x Sel.15) showed the highest negative values of heterosis over the best parent under the three levels of nitrogen. While, at Arab El-Awammer (Table 6) the highest negative heterosis values for days to 50% flowering were -9.84, -2.50 and -4.30 % under 80, 100 and 120 Kg N level, respectively. The cross (Sh-13 x Adv.11) showed the highest negative value of heterosis over the best parent under the three levels of nitrogen. Moreover, the results showed that this cross was earlier than the earliest parent under stress and normal conditions at both locations. This indicates that this cross will be useful for breeding programmes. Generally, negative and significant values of heterosis means indicated that theses crosses had

Table (6): Heterosis of twenty-four crosses for days to 50 % flowering under the three levels of nitrogen at Shandaweel and Arab El-Awammer.

No.	Genotypes	Days to 50 % flowering at Shandaweel			Days to 50 % flowering at Arab EL-Awammer		
		80 Kg N	100Kg N	120Kg N	80 Kg N	100Kg N	120Kg N
1	ATX 2-1 x Adv.11	1.33	-0.46	0.00	0.70	-1.79*	-0.37
2	ATX 407 x Adv.11	-0.85	0.00	0.46	6.03**	0.00	1.09
3	ICSA .TX-20 x Adv.11	-0.43	-0.44	-1.39	3.55**	0.71	-1.44
4	ICSA-20 x Adv.11	-4.09**	1.38	-2.30	-7.96**	-0.36	-4.30**
5	ICSA-52 x Adv.11	2.20	1.40	0.00	-6.17**	1.79*	-1.43
6	Sh-2 x Adv.11	-8.98**	-4.61**	-5.46**	-5.45**	-0.71	1.11
7	Sh-11 x Adv.11	-5.65**	-11.11**	-13.34**	-0.67	-0.36	1.49
8	Sh-13 x Adv.11	-9.76**	-7.40**	-9.70**	-2.38**	-2.50**	-2.15**
9	ATX 2-1 x Sel.9	0.44	0.93	-0.94	-3.86**	-2.15**	-1.83*
10	ATX 407 x Sel.9	-7.59**	-1.36	-3.71**	-0.71	-2.49**	-1.09
11	ICSA .TX-20 x Sel.9	-6.28**	-2.69*	-3.71**	0.35	-0.71	-1.46
12	ICSA-20 x Sel.9	-5.73**	-0.47	-2.77*	-8.12**	-2.14**	-1.46
13	ICSA-52 x Sel.9	-1.32	1.86	-5.56**	-4.87**	0.35	-1.09
14	Sh-2 x Sel.9	-5.19**	-6.38**	-12.82**	-5.84**	1.76*	-0.37
15	Sh-11 x Sel.9	-4.44**	-4.67**	-5.99**	0.67	2.86**	3.72**
16	Sh-13 x Sel.9	-6.10**	-2.61*	-5.74**	-5.10**	-2.47**	0.73
17	ATX 2-1 x Sel.15	2.23	1.85	-0.46	-3.86**	-1.44	0.00
18	ATX 407 x Sel.15	-4.65**	2.28	-1.39	5.32**	1.80*	2.19**
19	ICSA .TX-20 x Sel.15	-3.77**	0.90	4.17**	2.13**	-0.72	-2.16**
20	ICSA-20 x Sel.15	-4.92**	4.13**	-0.91	-2.30**	1.44	1.44
21	ICSA-52x Sel.15	3.07**	2.79*	0.93	-9.84**	-1.08	-1.08
22	Sh-2 x Sel.15	-6.38**	-6.30**	-8.82**	-4.26**	2.88**	2.58**
23	Sh-11 x Sel.15	-2.42*	-5.77**	-11.76**	-3.02**	2.16**	1.49
24	Sh-13 x Sel.15	-2.04	-0.44	-2.21	-1.36	-0.36	-0.72

***,** Significant at 0.05 and 0.01 probability, respectively.**

Table (6): Heterosis of twenty-four crosses for plant height under the three levels of nitrogen at Shandaweel Arab El-Awammer

No.	Genotypes	Plant height at Shandaweel			Plant height at Arab El-Awammer		
		80 Kg N	100Kg N	120Kg N	80 Kg N	100Kg N	120Kg N
1	ATX 2-1 x Adv.11	15.82**	23.42**	23.40**	9.967**	11.80**	17.59**
2	ATX 407 x Adv.11	29.58**	33.77**	37.94**	12.29**	15.08**	20.37**
3	ICSA .TX-20 x Adv.11	31.22**	31.16**	34.49**	15.29**	25.90**	21.30**
4	ICSA-20 x Adv.11	24.65**	29.15**	32.19**	12.29**	27.54**	26.85**
5	ICSA-52 x Adv.11	16.57**	29.84**	33.27**	12.62**	18.35**	25.69**
6	Sh-2 x Adv.11	13.07**	16.04**	20.43**	2.99	5.57**	-3.64*
7	Sh-11 x Adv.11	19.13**	18.00**	19.74**	-10.59**	-15.22**	-18.04**
8	Sh-13 x Adv.11	24.58**	29.63**	18.17**	23.59**	24.59**	27.16**
9	ATX 2-1 x Sel.9	17.91**	17.34**	5.34**	15.77**	12.62**	10.03**
10	ATX 407 x Sel.9	30.55**	29.37**	30.90**	18.12**	20.39**	17.56**
11	ICSA .TX-20 x Sel.9	15.94**	24.32**	23.59**	9.73**	17.48**	19.13**
12	ICSA-20 x Sel.9	26.76**	25.01**	38.40**	15.77**	23.95**	20.69**
13	ICSA-52 x Sel.9	26.94**	31.67**	31.87**	18.79**	24.59**	19.88**
14	Sh-2 x Sel.9	15.14**	10.93**	8.46**	11.74**	8.09**	2.24
15	Sh-11 x Sel.9	16.35**	12.41**	12.75**	-10.59**	-6.28**	-14.44**
16	Sh-13 x Sel.9	24.50**	28.60**	13.75**	11.74**	17.80**	18.19**
17	ATX 2-1 x Sel.15	24.37**	21.93**	1.91	2.60	13.68**	8.70**
18	ATX 407 x Sel.15	29.53**	37.72**	33.85**	12.05**	19.88**	17.70**
19	ICSA .TX-20 x Sel.15	30.36**	28.96**	36.65**	10.75**	14.99**	20.50**
20	ICSA-20 x Sel.15	32.69**	29.67**	37.58**	3.90*	14.01**	10.87**
21	ICSA-52x Sel.15	27.98**	34.23**	31.76**	4.88**	12.38**	16.82**
22	Sh-2 x Sel.15	9.79**	9.65**	10.77**	1.30	11.08**	1.96
23	Sh-11 x Sel.15	6.21**	8.79**	8.27**	-16.79**	-7.01**	-13.17**
24	Sh-13 x Sel.15	15.42**	24.46**	5.82**	7.49**	24.76**	20.81**

***,** Significant at 0.05 and 0.01 probability, respectively.**

favorable gene action for earliness. Similar results were obtained by **Al-Nagar et al., 2006 and Abo-Zaid, 2007.**

2-Plant height.

At Shandaweel (Table 6) the highest positive heterosis values for plant height were 32.69, 37.72 and 38.40% under 80, 100 and 120 Kg N levels, respectively. The twenty three F_1 crosses (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,22,23 and 24) had positive and highly significant heterosis under the three levels of nitrogen, which indicates that these crosses were taller than the tallest parent. While, at Arab El-Awammer (Table 6) the highest positive heterosis values for plant height were 23.59, 27.54 and 27.16% under 80, 100 and 120 Kg N levels, respectively. The sixteen F_1 crosses (1,2,3,4,5,8,9,10,11,12,13,16,18,19,21 and 24) had positive and highly significant heterosis for plant height under the three levels of nitrogen, which indicates that these crosses were taller than the tallest parent. The results showed that the sixteen crosses were taller than the tallest parent under stress and normal conditions at both locations. Generally, positive significantly heterotic values means that these crosses had favorable gene action for tallness. Similar results were obtained by **Hovny and El-Dsouky, 2007.**

3-1000-grain weight:

At Shandaweel (Table 7) the highest positive heterosis values for 1000-grain weight were 36.51, 30.40 and 33.53% under 80, 100 and 120 Kg N levels, respectively. The eighteen F_1 crosses (1,2,3,4,6,8,9,10,11,12,13,14,15,16,18,20,21 and 24) gave the highest positive and highly significant heterosis for 1000-grain weight under the three levels of nitrogen, which indicates that these crosses had higher 1000-grain weight than their best parent. While, at Arab El-Awammer (Table 7) the highest positive heterosis values for 1000-grain weight were 37.86, 44.89 and 32.16% under 80, 100 and 120 Kg N levels, respectively. The thirteen F_1 crosses (2,3,4,7,8,12,16,17,18, 19,20,23 and 24) had positive and highly significant heterosis for 1000-grain weight under the three levels of nitrogen, which indicates that these crosses had higher 1000-grain weight than their best parent. Moreover, the cross (Sh-13 x Sel.15) gave the highest positive and highly significant heterosis under the three levels of nitrogen at Arab El-Awammer. While the nine crosses (2,3,4,8,12,16,18,20 and 24) had positive and highly significant heterosis values under the three levels of nitrogen at Shandaweel and Arab El-Awammer. Generally, positive heterosis for 1000- grain weight indicating that these

Table (7):Heterosis of twenty-four crosses for 1000-grain weight under the three levels of nitrogen at Shandaweel and Arab El-Awammer locations.

No.	Genotypes	1000-grain weight at Shandaweel			1000-grain weight at Arab El-Awammer		
		80 Kg N	100Kg N	120Kg N	80 Kg N	100Kg N	120Kg N
1	ATX 2-1 x Adv.11	14.75**	22.99**	25.82**	1.16	1.69	1.64
2	ATX 407 x Adv.11	23.18**	27.47**	17.54**	6.69**	18.82**	27.59**
3	ICSA .TX-20 x Adv.11	16.02**	17.02**	30.27**	3.49**	15.73**	13.11**
4	ICSA-20 x Adv.11	27.27**	25.08**	33.53**	11.34**	8.43**	14.75**
5	ICSA-52 x Adv.11	23.40**	18.21**	-1.17	14.69**	1.93	2.82**
6	Sh-2 x Adv.11	19.18**	14.03**	6.01**	-1.64	-11.09**	2.34*
7	Sh-11 x Adv.11	3.11*	16.53**	15.30**	20.75**	15.62**	14.98**
8	Sh-13 x Adv.11	12.09**	13.79**	13.48**	17.44**	22.75**	25.07**
9	ATX 2-1 x Sel.9	19.41**	15.06**	22.59**	16.97**	14.21**	1.40
10	ATX 407 x Sel.9	15.22**	10.79**	15.89**	25.45**	14.75**	-0.47
11	ICSA .TX-20 x Sel.9	23.88**	21.02**	23.97**	26.06**	16.39**	0.00
12	ICSA-20 x Sel.9	18.51**	18.18**	15.98**	24.55**	18.31**	6.98**
13	ICSA-52 x Sel.9	18.21**	30.40**	7.73**	5.65**	-1.21	10.00**
14	Sh-2 x Sel.9	14.03**	22.16**	18.85**	0.00	-9.91**	-7.91**
15	Sh-11 x Sel.9	4.80**	12.40**	23.48**	22.77**	17.76**	1.40
16	Sh-13 x Sel.9	4.78**	11.78**	9.22**	27.27**	20.49**	10.46**
17	ATX 2-1 x Sel.15	25.40**	9.07**	0.95	19.94**	30.65**	14.59**
18	ATX 407 x Sel.15	20.32**	11.40**	5.45**	34.86**	27.56**	12.43**
19	ICSA .TX-20 x Sel.15	24.76**	6.48**	0.24	20.72**	31.27**	15.94**
20	ICSA-20 x Sel.15	14.11**	13.99**	5.21**	20.39**	31.58**	15.67**
21	ICSA-52x Sel.15	36.51**	12.96**	3.28**	8.47**	-2.17	8.47**
22	Sh-2 x Sel.15	19.81**	6.74**	-1.42	11.20**	-0.94	10.07**
23	Sh-11 x Sel.15	3.39*	-4.14**	-11.61**	8.36**	15.62**	24.86**
24	Sh-13 x Sel.15	5.79**	8.27**	3.55**	37.86**	44.89**	32.16**

***,** Significant at 0.05 and 0.01 probability, respectively.**

Table (7): Heterosis of twenty-four crosses for grain yield / plant under the three levels of nitrogen at Shandaweel and Arab El-Awammer locations.

No.	Genotypes	Grain yield / plant at Shandaweel			Grain yield / plant at Arab EL-Awammer		
		80 Kg N	100Kg N	120Kg N	80 Kg N	100Kg N	120Kg N
1	ATX 2-1 x Adv.11	58.48**	72.11**	60.95**	136.51**	112.26**	90.58**
2	ATX 407 x Adv.11	32.20**	6.80**	-0.59	13.90**	31.61**	73.33**
3	ICSA .TX-20 x Adv.11	33.05**	69.39**	48.52**	129.46**	103.22**	85.29**
4	ICSA-20 x Adv.11	55.93**	42.86**	24.85**	65.14**	70.96**	20.91**
5	ICSA-52 x Adv.11	-24.44**	-29.24**	-32.31**	9.96**	20.32**	18.79**
6	Sh-2 x Adv.11	-11.86**	-20.41**	-31.64**	12.45**	2.58	-53.57**
7	Sh-11 x Adv.11	-32.28**	7.95**	31.36**	136.51**	115.48**	75.63**
8	Sh-13 x Adv.11	11.02**	8.84**	18.34**	93.36**	72.90**	133.10**
9	ATX 2-1 x Sel.9	34.00**	46.15**	36.21**	78.58**	71.03**	96.92**
10	ATX 407 x Sel.9	28.00**	37.82**	43.68**	39.85**	30.22**	23.18**
11	ICSA .TX-20 x Sel.9	36.00**	44.23**	31.61**	54.14**	57.32**	88.19**
12	ICSA-20 x Sel.9	63.33**	61.54**	47.70**	80.45**	92.84**	-13.34**
13	ICSA-52 x Sel.9	13.33**	4.68**	-7.69**	-10.52**	-0.93	-35.55**
14	Sh-2 x Sel.9	-3.33*	9.62**	15.25**	-3.38	-12.15**	-49.05**
15	Sh-11 x Sel.9	-22.00**	-14.10**	-22.41**	-12.78**	21.18**	12.77**
16	Sh-13 x Sel.9	2.67*	20.51**	8.05**	-5.26*	22.43**	55.86**
17	ATX 2-1 x Sel.15	32.37**	17.07**	31.11**	38.97**	28.92**	37.39**
18	ATX 407 x Sel.15	6.47**	29.27**	31.11**	-37.75**	-20.53**	-14.57**
19	ICSA .TX-20 x Sel.15	23.02**	13.41**	5.56**	21.57**	26.71**	63.48**
20	ICSA-20 x Sel.15	25.90**	6.71**	9.45**	4.17**	23.84**	-11.06**
21	ICSA-52x Sel.15	25.90**	26.32**	13.85**	-42.89**	3.97**	-13.73**
22	Sh-2 x Sel.15	12.23**	-1.22	-6.67**	-14.22**	-11.70**	-3.33**
23	Sh-11 x Sel.15	-39.57**	-29.88**	-12.22**	-35.54**	-31.57**	83.91**
24	Sh-13 x Sel.15	25.18**	13.41**	21.67**	-4.17**	7.06**	63.91**

***,** Significant at 0.05 and 0.01 probability, respectively**.

crosses had bigger seed size and heavier seed weight more than better parent, also negative heterosis may be indicated that the seed number was high because there is a negative correlation between seed size and seed number similar results were obtained by **Al-Nagar et al., 2006 and Abo-Zaid, 2007.**

4- Grain yield / plant:

At Shandaweel (Table 7) the highest positive heterosis values for grain yield / plant were 63.33, 72.11 and 60.95% under 80, 100 and 120 Kg N levels, respectively. The fourteen crosses had positive and highly significant heterosis for grain yield / plant under the three levels of nitrogen, but five of them (ATX 2-1 x Adv.11, ICSA.TX-20 x Adv.11, ICSA-20 x Adv.11, ATX 2-1 x Sel.9 and ICSA-20 x Sel.9) gave the highest positive and highly significant heterosis for grain yield / plant under the three levels of nitrogen, which indicates that these crosses had higher grain yield / plant than their the best parent While at Arab El- Awammer (Table 7) the highest positive heterosis values for grain yield / plant were 136.51, 115.48 and 96.92 % under 80, 100 and 120 Kg N levels, respectively. The twelve F_1 crosses (1,2,3,4,5,7,8,9,10, 11,17 and 19) had positive and highly significant heterosis for grain yield / plant under the three levels of nitrogen , but five of them (1,3,7,8and 9) gave the highest positive and highly significant heterosis for grain yield / plant under the three levels of nitrogen, which indicates that these crosses had higher grain yield / plant than their best parent. Generally, the nine crosses (1,3,4,8,9,10,11,17 and 19) had positive and highly significant heterosis values under the three levels of nitrogen for grain yield / plant at both locations. Similar results were obtained by **Abo-Zaid, 2007 and Abd El-Mottaleb, 2009.**

Generally, the results indicated that increasing nitrogen level decreased days to 50% flowering and increased plant height, 1000-grain weight and grain yield / plant at both locations.

References

Abd El-Mottaleb, A.A. 2009. Heterosis and combining ability in grain sorghum (*Sorghum bicolor* (L.) Moench) under optimum and low level of nitrogen**.** Ph.D. Thesis, Fac. of Agric., El-Minia Univ., Egypt.

Abo-Zaid, Zeinab S.H. 2007. Studies on breeding of grain sorghum for tolerance to some stress conditions. Ph.D. Thesis, Fac. of Agric., Cairo Univ., Egypt.

Al-Nagar, A. M.; D.A. El-Kadi and Z..S.H. Abo-Zaid. 2006. Quantitative genetic parameters of grain sorghum traits contributing to low-N tolerance. Egypt. J. Plant Breed.,10: 79-102.

Bhatt, G.M. 1971. Heterotic performance and combining ability in diallel crosses among spring wheat's (*T. aestivem .L*) Australion J. Agric. Res. 22 :359-369.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons. New York. 2nd ed.

Hovny, M.R.A., M.M. El-Dsouky. 2007. Performance of some grain sorghum lines and their hybrids under optimum and low input nitrogen conditions. Assiut J.Agric. Sci., 38 : 67-90.

Kamoshita A.; R. C. Muchow; M. Cooper and S. Fukai. 2000. Genotypic variation for grain yield and grain nitrogen concentration among sorghum hybrids under different levels of nitrogen fertilizer and water supply. Crop Science; 40: 1295-1307.

Maranville, J. W. and S. Madhavan. 2002. Physiological adaptations for nitrogen use efficiency in sorghum. Plant and Soil ;245: 25-34.

Moran J. L. and W. L. Rooney.2003. Effect of cytoplasm on the agronomic performance of grain sorghum hybrids. Crop Science; 43: 777-781.

Page, A.L. 1982. Methods of soil analysis. Ed. Patr 2. Chemical and Microbiological properties. Agronomy J. of Am. Soc. Agron., Inc., Pub. Madison, Wise., U.S.A.

Ragheb H.M.A. and G. Elnagar. 1997. Response of grain sorghum to nitrogen fertilization and irrigation intervals. Assiut J. Agric. Sci.,; 28: 147-157.

Raun, W. R. and G. V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J., 91: 357-363.