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Role of some growth Characters in Improving the Drought Tolerance in Rice.

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ABSTRACT

The present investigation was carried out at the farm of the of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt, during 2014 and 2015 seasons to evaluate some growth and yield parameters in rice by using eight rice varieties under normal and drought conditions. The results indicated that, the parents Sakha 106, Giza178, Nerica4 and WAB880 and the crosses (Sakha106 × Giza177), (Sakha106 x Sakha102), (Giza178 × Giza177), (WAB880 × Nerica4) and (IRAT112 × Nerica4) were found to have the most desirable mean values under the two environments and their combined data. Genotypes, parents and the crosses mean squares and their interactions with environments were found to be highly significant for all studied characters. The most pronounced useful heterosis effects relative to the better parents for all characters were detected in the crosses (Sakha106× Giza 177), (IRAT170 × Nerica4),(Giza 177 × IRAT112),(Giza177 × Nerica4) and (Sakha102 × IRAT112) under the two environments and their combined data. Over dominance was detected in most crosses for plant height, number of tillers / plant, panicle length, relative water content and grain yield/plant. The values of potence ratio was less than unity in most crosses for days to heading, chlorophyll content, flag leaf area, flag leaf angle and leaf rolling. The results showed also high genetic variance for days to heading, plant height and flag leaf angle. However moderate values were obtained for chlorophyll content, flag leaf area and grain yield / plant, and low estimates of number of tiller/ plant, relative water content, panicle length and leaf rolling. High heritability values had been obtained for plant height, chlorophyll content, flag leaf area, flag leaf angle and grain yield / plant. The results obtained here indicates the relative importance of physiological parameters such as chlorophyll content, flag leaf area, flag leaf angle, relative water content and leaf rolling as selection criteria for drought tolerance. Also, the existence of significant amounts of genetic variation among the tested materials suggests their potential in breeding for water deficit tolerant rice genotypes.

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important agriculture food crops for more than half of the world`s population. Moreover, it is a very important cereal crop in Egypt for both consumption and export (Sharief *et al*., 2006). Egypt is facing two major challenges i.e. food security and water shortage, particularly in the terminal areas. Water shortage is a critical limiting factor in more than 30% of paddy fields in Egypt, where the developed varieties cannot perform well under water shortage. Therefore, the development of water stress tolerant genotypes that maintain good yield under drought is a priority area of research for sustainable rice production (AbdAllah, 2009).

Drought affects rice at morphological, physiological, and molecular levels where it reduces plant height, tiller numbers/ plant, panicle length, leaf area, increase sterility %, induce leaf rolling, reduce water potential, stomatal closure, dry matter accumulation and decrease photosynthetic capacity. Moreover, high temperature is often accompanied with low water supply, so the primary aim of rice breeding program is developing promising varieties tolerant to both types of stresses (Tester and Bacic 2005).

To increase the yield potential and to reduce the yield gap, improving varietal adaptability, yield potential and grain quality under stress are needed. Conventional plant breeding played important role in developing rice varieties tolerant to abiotic stresses, which is very complex due to the intricate interactions between stress factors that affect plant growth and development.

Rice breeders follow all breeding methods to improve characters of the newly developed varieties to cover the continuous changes in breeding objectives. The prior information about the varieties used are essential to plan a successful breeding program. The information about gene effects including additive and dominance gene effects, non-allelic gene interaction i.e. additive x additive, additive x dominance, and dominance x dominance are very important and essential to rice breeders for improving new rice varieties under both normal as well as adverse conditions. Generation mean analysis is a useful technique for estimating these genetic effects.

So, the present study was carried out to obtain information about gene action, genetic parameters and heritability for the studied traits in the tested parents and their respective crosses. The objective of current study was to estimate genetic components for vegetative and reproductive stage parameters of eight parental lines and their F_1 under normal and drought conditions.

MATERIALS AND METHODS

The present investigation was carried out at the farm of the of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt, during 2014 and 2015 seasons to evaluate eight rice varieties and their resultant crosses for growth characters and grain yield under normal and drought conditions. The characters studied were: days to heading (day), plant height (cm), number of tillers /plant, panicle length (cm), flag leaf area (cm^2), flag leaf angle, leaf rolling, chlorophyll content (SPAD), relative water content and grain yield / plant (g).

In 2014 season, seeds of the parental genotypes were sown at various planting dates in order to overcome differences in flowering time. Seedlings of each parent were individually transplanted in the permanent field in ten rows. Each row was five meters long and contained 25 hills. At flowering period, the eight parents were diallel crossed in all possible combinations without reciprocal giving a total of twenty eight crosses according to (Griffing's 1956), Method 2, Model 1. In 2015 season, seedlings of the parents and their F_1 crosses, of 30-days old, were transplanted in randomized complete blocks design with three replications. The rows were five meters long with 20 cm between rows and comprised 25 hills each of a single plant. The genotypes were grown under both normal and drought conditions (drought stress was imposed by using flush irrigation every 12 days). The amount of irrigation water applied was counted by flow meter. Weeds were chemically controlled by applying 2 liters Saturn/feddan, five days after transplanting. Nitrogen fertilizer was applied at recommended rate and time of application. The data were analyzed according to Griffing, 1956 method 2 model 1.

Heterosis relative to better parent was estimated according to Mather and Jinks (1982), as follows:

Heterosis over better-parent % (BP) = $(\overline{F_1} - \overline{B.P} / \overline{B.P}) \times 100$

Where, F_1 = Mean value of the first generation

B.P = Mean value of the better-parent.

L.S.D. values were calculated to test the significance of heterotic effects according to the following formula, suggested by Wynne *et al.* (1970):

$$\text{LSD for better-parent heterosis} = t_{0.01}^{0.05} \cdot (2MSe/r)^{1/2}$$

Where, MSe = The experimental error mean squares of the analysis of variance, r= Number of replications.The degree and nature of dominance (potence ratio) of the studied traits F1crosses was calculated as follows:

$$\text{potence ratio (p)} = \frac{\overline{F1} - \overline{M.P}}{\overline{H.P} - \overline{M.P}}$$

Where: M.P = mid parent value.

H.P = mean of high parent value.

F_1 = The mean of F_1 value.

Data of each character for each genotypes were analyzed separately by the analysis of variance, according to Panse and Sukhatme (1957. The genetic parameters mentioned blow, were computed according to formula suggested by Burton (1952) and Hansen *et al*. (1956) as follows.

$$\text{Genotypic variance (GV)} == \frac{M_1 - M_2}{r}$$

$$\text{Phenotypic variance (PV)} = GV + M_2 = M_1/r$$

$$\text{Genotypic coefficient of variance (GCV)} = \frac{\sqrt{GV}}{\bar{X}} \times 100$$

$$\text{Phenotypic coefficient of variance (PCV)} = \frac{\sqrt{PV}}{\bar{X}} \times 100$$

$\bar{X}$ =the general mean of the given character

$$\text{Heritability in the broad senses (HB \%)} = \frac{GV}{pv} \times 100$$

RESULTS AND DISCUSSION

Analysis of variance

Mean square estimates of the ordinary analysis and combining ability for characters under both normal and drought conditions and their combined data are presented in Table (1). Genotypes, parents, crosses and parent vs. crosses mean squares were found to be highly significant for all studied traits under both environments and their combined data, except leaf rolling under normal conditions. These results are in agreement with those obtained by Aidy *et al*., (2006) and Ghazy (2012). Genotypes × environments, parents × environments, crosses × environments and parent vs. crosses × environments mean squares were detected to be significant for these traits except flag leaf angle in the combined data. Parent vs. crosses × environment mean squares for plant height in the combined, parents × environments for panicle length in the combined data, indicating that the tested genotypes varied from each to other and ranked differently from stress to normal irrigation. These results are in agreement with those obtained by Aidy *et al*., (2006) and Ghazy (2012), who found that the genotypes differed significantly from one environment to another. Both general and specific combining ability variance were found to be highly significant for all characters studied at the two environments and their combined data. This would indicate the importance of both additive and non-additive genetic variance in controlling the performance of these vegetative traits except leaf rolling.

The results indicated that, mean squares estimates GCA × environments and SCA × environments were significant for all studied traits under the two environments and their combined data, except days to heading, panicle length, chlorophyll content and flag leaf angle in the combined data and SCA × environment mean square for days to heading, number of tillers / plant, panicle length, chlorophyll content, flag leaf angle and leaf rolling in the combined data. These results indicated that both additive and non-additive types of gene effects were involved and responsible for the expression of these traits. The GCA / SCA ratios were found to be great or higher than unity under all environments and their combined data for most traits, except plant height, number of tillers / plant, panicle length, leaf rolling, relative water content and grain yield / plant, where the ratio was less than unity. This might indicated that, additive gene action was important in the inheritance of the first trait and non-additive gene effects played the major role in the second one. These findings were in the some line with those obtained by Abd-Allah (2004) and Ghazy (2012) .

Mean performance

Mean performance of the parental genotypes and their F1 crosses under the two studied environments are presented in Table (2). For days to heading, the desirable mean values towards the earliness were obtained from the parents, Sakha106, Sakha102 and Giza177, and the crosses (Sakha106 × Sakha102), (Sakha106 × Giza177), (Sakha102 × Giza177), (Sakha102 × Giza178), (Giza178 × Giza177), and (Giza177 × IRAT170) under both normal and drought conditions and their combined data. With respect to plant height, the most desirable mean values towards dwarfing were obtained from the parents Giza178 and Giza177 and the crosses (Sakha106 × Giza177) and (Giza178 × Giza177) under both normal and drought conditions and their combined data. Concerning the number of tillers / plant (Table 2), the parents Sakha106 and Giza178 and the crosses (Sakha106 × Giza178), (Sakha106 × Giza177)and (Sakha102 × Giza178)gave the highest mean values of the number of tillers/plant and the values ranged from 12.30 to 25.50 tillers / plant under both normal and drought conditions and their combined data.

For panicle length (Table 2), the parents IRAT170 and Nerica4 and the crosses (Sakha106 × Sakha102), (Sakha106 × IRAT112), (Giza178 × Giza177), (Giza178 × IRAT170), (WAB880 × Nerica4) and (IRAT112 × Nerica4) gave the highest mean values under both normal and drought conditions and their combined data. For chlorophyll content (Table 2), the parents WAB880 and

Nerica4 and the crosses (WAB880 × IRAT112),(WAB880 × Nerica4) and (IRAT112 × Nerica4)gave the highest mean values and the values ranged from 44.90 to52.98 mg/g under both normal and drought conditions and their combined data. Concerning the flag leaf area (Table 2), the parents IRAT112 and Nerica4 and the crosses(Sakha106 × IRAT112), (Sakha106 × Nerica4), (Giza178 × IRAT112), (Giza177 × Nerica4), (WAB880 × Nerica4), (IRAT112 × Nerica4) and (IRAT170 × Nerica4) gave the highest mean values of the flag leaf area and the values ranged from 28.16 to 38.30 cm^2 under both normal and drought condition and their combined data.

Regarding the flag leaf angle (Table 2), the narrow flag leaf angle were recorded from the parents Giza178 WAB880, and Nerica4 and the crosses (Sakha102 × Giza178)), (Sakha106 × Giza178), (Giza178 × WAB880)and (WAB880 × Nerica4)while the wide flag leaf angle was detected from the other remaining parents and twenty two crosses under both normal and drought conditions and their combined data.

For leaf rolling (Table 2), the parents Sakha106 and Sakha102 and the crosses (Sakha106 × Sakha102), (Sakha102 × Giza177), (Sakha102 × WAB880), (Giza178 × Giza177) and (Giza177 × WAB880) gave the highest mean values and ranged from 1.31 to 6.77. For relative water content (Table 2), the parents WAB880 and Nerica4 and the crosses (WAB880 × IRAT112), (WAB880 × Nerica4) and (IRAT112 × Nerica4) gave the highest mean values of the relative water content and the values under both normal and drought conditions and their combined data. Concerning the grain yield / plant (Table 2), the parents Giza178 and the crosses (Sakha106 × Sakha102), (Sakha106 × Giza178), (Sakha106 ×WAB880) ,(Sakha106 × IRAT170), (Sakha102 × Giza178), (Giza178 × Giza177), (Giza178 × IRAT170) and (Giza177 × IRAT170) gave the highest mean values of the grain yield / plant and the values ranged from 28.40gto46.80g under both normal and drought condition and their combined data.

Table 1. Mean square estimates of the ordinary analysis and combining ability for characters under both normal and drought conditions and their combined data.

Source or variance	d.f		Days to heading (day)			Plant height (cm)			No of tillers / plant			Panicle length (cm)			Chlorophyll content (mg/ds^{-1})		
	Single	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
Replication (Rep)	2	…..	0.27	2.360	…..	3.98*	0.612	…..	2.55	0.632	…..	0.18	0.082	…..	0.42	0.162	…..
Environments(E)	…..	1	…..	….	547.85**	…..	….	1681.3**	…..	….	770.06**	…..	….	212.34**	…..	….	1264.74**
Rep. within E	…..	4	….	….	1.31	….	….	2.30	….	….	1.59	….	….	0.13	….	….	0.29
Genotypes (G)	35	35	53.99**	55.80**	106.12**	291.42**	260.04**	546.37**	25.51**	19.80**	40.71**	6.21**	9.83**	13.95**	41.35**	41.69**	79.91**
Parents (P)	7	7	114.11**	114.44**	225.54**	357.18**	288.09**	639.67**	40.40**	9.81**	40.01**	3.77**	6.00**	9.03**	76.75**	71.99**	143.53**
Crosses (C)	27	27	40.03**	37.48**	74.91**	249.23**	230.28**	474.41**	18.52**	13.40**	29.22**	4.32**	6.01**	8.00**	30.81**	28.96**	57.42**
P vs. C	1	1	10.23**	139.97**	112.95**	970.37**	867.14**	1836.0**	109.94**	262.43**	356.04**	74.17**	139.93**	208.92**	78.00**	173.07**	241.73**
G × E	…..	35	…..	….	3.67**	…..	….	5.09**	…..	….	4.59**	…..	….	2.09**	…..	….	3.13**
P × E	…..	7	….	….	3.01**	….	….	5.60**	….	….	10.20**	….	….	0.74	….	….	5.21**
C×E	…..	27	…..	….	2.60**	…..	….	5.09**	…..	….	2.71**	…..	….	2.33**	…..	….	2.36**
P vs. C × E	…..	1	…..	….	37.26**	…..	….	1.45	…..	….	16.33**	…..	….	5.17*	…..	….	9.35**
Error	70	140	1.61	1.52	1.57	1.34	1.69	1.52	0.98	0.77	0.87	0.23	0.23	0.23	0.57	0.59	0.58
G.C.A	7	7	207.53**	199.69**	134.42**	1029.4**	896.51**	639.75**	79.39**	35.66**	34.67**	5.21**	13.28**	5.44**	172.73**	152.01**	107.46**
S.C.A	28	28	15.61**	19.82**	10.61**	106.92**	100.92**	67.72**	12.04**	15.84**	8.30**	6.46**	8.97**	4.45**	8.50**	14.11**	6.43**
G.C.A × E	…..	7	…..	…..	1.32	…..	…..	2.23*	…..	…..	3.68**	…..	…..	0.73	…..	…..	0.78
S.C.A × E	…..	28	…..	…..	1.20	…..	…..	1.56*	…..	…..	0.99	…..	…..	0.69	…..	…..	1.11
Error	70	140	0.54	0.51	0.52	0.45	0.56	0.51	0.33	0.26	0.29	0.08	0.08	0.08	0.19	0.20	0.19
G.C.A/ S.C.A	…..	…..	1.37	1.03	1.33	0.97	0.89	0.95	0.68	0.23	0.43	0.08	0.15	0.12	2.08	1.09	1.72

Table 1. Cont.

Source or variance	d.f		Flag leaf area (cm^2)			Flag leaf angle			Leaf rolling			Relative water content			Grain yield / plant (g)		
	Single	Comb.				N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
Replication (Rep)	2	…..	0.69	0.042	…..	1.09	0.911	…..	0.02	0.004	…..	0.05	0.417	…..	0.30	0.22	…..
Environments(E)	…..	1	…..	….	2289.28**	…..	….	430.93**	…..	….	253.00**	…..	….	5374.01**	…..	….	4541.70**
Rep. within E	…..	4	….	….	0.37	….	….	1.00	….	….	0.01	….	….	0.23	….	….	0.26
Genotypes (G)	35	35	40.04**	64.86**	99.23**	193.57**	189.03**	381.59**	0.63	3.88**	1.80**	49.60**	84.41**	43.91**	57.57**	46.29**	64.47**
Parents (P)	7	7	81.41**	147.98**	222.02**	349.61**	319.06**	668.24**	0.51	8.38**	2.42*	84.64**	162.25**	76.54**	119.50**	51.51**	119.54**
Crosses (C)	27	27	30.03**	45.63**	70.37**	142.45**	146.91**	288.22**	0.67	2.67**	1.66*	41.59**	47.55**	30.67**	42.23**	20.56**	32.74**
P vs. C	1	1	20.80**	2.51	18.88**	481.30**	416.06**	896.18**	0.34	4.95*	1.34	20.41**	534.55**	173.03**	38.37**	704.29**	535.73**
G × E	…..	35	…..	….	5.68**	…..	….	1.01	…..	….	2.70*	…..	….	90.09**	…..	….	39.39**
P × E	…..	7	….	….	7.37**	….	….	0.43	….	….	6.48**	….	….	170.35**	….	….	51.46**
C×E	…..	27	…..	….	5.28**	…..	….	1.15	…..	….	1.68*	…..	….	58.47**	…..	….	30.06**
P vs. C × E	…..	1	…..	….	4.43**	…..	….	1.19	…..	….	3.95*	…..	….	381.94**	…..	….	206.93**
Error	70	140	0.51	0.46	0.49	0.87	0.54	0.71	0.01	0.02	0.02	0.73	0.60	0.66	0.41	0.23	0.32
G.C.A	7	7	171.15**	258.32**	140.13**	783.67**	762.42**	514.95**	0.643	13.261**	1.779	189.28**	196.16**	29.42**	223.86**	45.50**	57.49**
S.C.A	28	28	7.26**	16.50**	6.31**	46.04**	45.68**	30.26**	0.626	1.529	0.307	14.68**	56.47**	10.94**	16.00**	46.48**	12.49**
G.C.A × E	…..	7	…..	…..	3.02**	…..	…..	0.41	…..	…..	2.856**	…..	…..	99.06**	…..	…..	32.30**
S.C.A × E	…..	28	…..	…..	1.61*	…..	…..	0.32	…..	…..	0.411	…..	…..	12.77**	…..	…..	8.34**
Error	70	140	0.17	0.15	0.16	0.29	0.18	0.24	0.005	0.007	0.006	0.24	0.20	0.22	0.14	0.08	0.11
G.C.A/ S.C.A	…..	…..	2.41	1.58	2.28	1.71	1.68	1.71	0.103	0.871	0.590	1.31	0.35	0.27	1.41	0.10	0.46

N: normal conditions. S: drought conditions. Comb.: combined data.
*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 2. Mean performance of the parental genotypes and their F_1 crosses for characters studied under normal and drought conditions and their combined data.

Genotypes	Days to heading (day)			Plant height (cm)			No of tillers / plant			Panicle length (cm)			Chlorophyll content (mg/ds^{-1})		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
Sakha 106	93.40	88.21	90.81	108.70	103.95	106.33	20.41	12.30	16.36	22.20	20.20	21.20	42.50	34.61	38.55
Sakha 102	92.44	87.48	89.96	110.27	102.78	106.53	19.40	11.23	15.32	23.10	19.53	21.32	43.18	39.38	41.28
Giza178	105.87	98.43	102.15	98.07	94.31	96.19	22.84	16.10	19.47	22.10	20.33	21.22	43.84	37.08	40.46
Giza177	93.33	89.43	91.38	100.77	97.88	99.33	17.43	13.10	15.27	21.30	18.33	19.82	38.28	32.36	35.32
WAB 880	103.55	98.63	101.09	119.10	114.15	116.63	14.50	10.53	12.51	23.10	20.47	21.78	51.40	44.93	48.16
IRAT 112	106.50	101.33	103.92	120.70	116.94	118.82	13.20	11.87	12.53	22.23	18.80	20.52	47.99	44.45	46.22
IRAT 170	102.06	98.27	100.17	129.67	121.28	125.47	12.70	10.60	11.65	23.27	21.40	22.33	40.59	37.45	39.02
Nerica 4	105.33	102.76	104.04	120.93	114.72	117.83	15.17	11.50	13.34	25.03	22.77	23.90	52.32	44.90	48.61
Sakha 106*Sakha 102	95.52	93.03	94.28	112.40	108.80	110.60	21.41	17.90	19.66	25.20	24.67	24.93	41.12	39.72	40.42
Sakha 106*Giza178	105.83	100.50	103.17	112.74	103.40	108.07	23.27	18.97	21.12	24.73	23.23	23.98	45.08	42.04	43.56
Sakha106*Giza177	96.23	93.21	94.72	100.81	96.86	98.84	24.67	17.60	21.14	21.83	19.20	20.52	46.09	41.45	43.77
Sakha106*WAB 880	103.46	97.34	100.40	121.20	116.60	118.90	21.32	17.61	19.46	23.05	20.25	21.65	49.38	45.42	47.40
Sakha106*IRAT 112	100.17	98.29	99.23	121.84	115.66	118.75	17.90	15.80	16.85	26.23	24.03	25.13	46.58	40.24	43.41
Sakha 106*IRAT 170	98.17	96.67	97.42	130.13	122.48	126.31	19.03	13.47	16.25	23.47	22.37	22.92	42.89	37.41	40.15
Sakha 106*Nerica 4	97.28	95.50	96.39	121.14	114.26	117.70	17.90	14.30	16.10	24.27	22.43	23.35	49.44	45.28	47.36
Sakha 102*Giza 178	96.83	94.67	95.75	108.03	105.25	106.64	25.50	20.10	22.80	24.03	23.87	23.95	45.38	40.31	42.85
Sakha 102*Giza 177	95.11	92.14	93.63	110.57	103.17	106.87	20.17	16.87	18.52	23.53	21.07	22.30	44.69	40.40	42.55
Sakha 102*WAB 880	102.17	100.33	101.25	120.55	115.84	118.20	19.23	15.53	17.38	24.83	22.80	23.82	48.92	43.71	46.31
Sakha 102*IRAT 112	104.50	99.83	102.17	119.31	110.78	115.05	18.50	14.37	16.43	24.23	22.00	23.11	49.62	45.60	47.61
Sakha 102*IRAT 170	98.33	95.38	96.86	131.23	122.71	126.97	17.37	13.57	15.47	23.89	22.13	23.01	43.66	38.70	41.18
Sakha 102*Nerica 4	103.33	101.50	102.42	118.21	112.85	115.53	20.23	16.37	18.30	24.27	23.10	23.68	49.08	44.67	46.88
Giza 178*Giza 177	96.24	94.83	95.54	94.94	90.77	92.86	22.93	18.40	20.67	26.30	22.50	24.40	43.40	38.31	40.86
Giza 178*WAB 880	103.33	97.67	100.50	124.40	118.45	121.43	19.93	17.83	18.88	24.90	24.83	24.87	49.23	44.42	46.82
Giza 178*IRAT 112	105.44	102.67	104.06	119.28	117.87	118.57	15.10	13.90	14.50	24.27	23.40	23.83	48.99	43.50	46.25
Giza 178*IRAT 170	106.25	105.21	105.73	131.50	127.46	129.48	19.70	17.90	18.80	27.65	23.50	25.58	42.90	39.88	41.39
Giza 178*Nerica 4	106.67	104.66	105.66	126.26	119.57	122.92	20.27	18.97	19.62	24.33	26.00	25.17	48.25	44.84	46.55
Giza 177*WAB 880	100.50	98.20	99.35	121.52	115.80	118.66	19.70	15.03	17.36	25.57	22.03	23.80	45.64	39.50	42.57
Giza 177*IRAT 112	100.50	97.55	99.03	118.31	114.52	116.42	18.20	15.10	16.65	25.20	22.90	24.05	46.24	40.85	43.54
Giza 177*IRAT 170	96.33	94.67	95.50	129.31	123.76	126.53	16.20	12.57	14.39	24.90	23.50	24.20	42.36	38.73	40.55
Giza 177*Nerica 4	98.46	95.76	97.11	121.88	115.66	118.77	16.70	13.37	15.03	24.43	22.97	23.70	47.86	43.07	45.46
WAB 880*IRAT 112	104.67	101.33	103.00	126.10	119.17	122.64	17.57	14.83	16.20	25.83	23.07	24.45	52.58	48.97	50.78
WAB 880*IRAT 170	101.16	98.19	99.68	127.80	122.31	125.06	16.83	11.77	14.30	24.77	22.63	23.70	46.82	40.02	43.42
WAB 880*Nerica 4	103.17	101.41	102.29	128.32	121.05	124.69	18.97	16.47	17.72	26.93	24.60	25.77	52.98	48.62	50.80
IRAT 112*IRAT 170	102.44	100.83	101.64	131.87	127.81	129.84	17.13	14.93	16.03	24.23	22.20	23.22	45.35	41.99	43.67
IRAT 112*Nerica 4	105.50	103.34	104.42	121.90	116.39	119.14	18.87	16.33	17.60	25.17	24.90	25.03	51.54	46.49	49.01
IRAT 170*Nerica 4	101.80	97.92	99.86	129.05	122.66	125.86	18.17	15.40	16.79	25.93	22.93	24.43	51.51	44.14	47.83
LSD 0.05	2.06	2.00	2.00	1.88	2.11	1.97	1.61	1.42	1.49	0.78	0.77	0.76	1.23	1.25	1.22
LSD 0.01	2.73	2.66	2.63	2.49	2.80	2.58	2.13	1.89	1.96	1.04	1.02	1.00	1.63	1.66	1.60

Table 2. Cont.

Genotypes	Flag leaf area (cm^2)			Flag leaf angle			Leaf rolling			Relative water content			Grain yield / plant (g)		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
Sakha 106	27.85	20.42	24.13	wide	wide	wide	1.37	6.57	3.97	86.84	61.05	73.95	43.63	22.52	33.08
Sakha 102	23.31	16.55	19.93	wide	wide	wide	1.56	6.77	4.16	85.35	59.73	72.54	40.23	21.72	30.98
Giza178	29.32	22.68	26.00	Narrow	Narrow	Narrow	2.13	3.75	2.94	92.42	75.65	84.04	46.50	30.85	38.68
Giza177	27.35	18.65	23.00	wide	wide	wide	1.35	6.43	3.89	91.36	62.34	76.85	36.40	20.93	28.67
WAB 880	35.48	29.73	32.61	Narrow	Narrow	Narrow	2.32	3.14	2.73	81.33	78.56	79.95	33.80	28.05	30.93
IRAT 112	36.05	33.39	34.72	Wide	Narrow	Wide	2.20	3.33	2.77	79.63	73.73	76.68	29.09	22.34	25.71
IRAT 170	33.70	26.48	30.09	Wide	Wide	Wide	2.17	3.50	2.83	78.63	72.70	75.67	32.20	25.48	28.84
Nerica 4	38.30	35.66	36.98	Wide	Narrow	Narrow	2.23	3.20	2.72	80.85	73.04	76.94	30.72	18.03	24.38
Sakha 106*Sakha 102	26.03	20.30	23.17	Wide	Wide	Wide	1.55	6.40	3.98	85.44	62.77	74.11	44.35	31.11	37.73
Sakha 106*Giza178	28.34	22.64	25.49	Narrow	Narrow	Narrow	2.05	4.97	3.51	86.46	68.58	77.52	43.96	30.29	37.12
Sakha106*Giza177	27.30	16.36	21.83	Wide	Wide	Narrow	1.17	3.30	2.23	89.57	69.78	79.67	40.37	28.66	34.51
Sakha106*WAB 880	31.47	25.40	28.44	Wide	Wide	Narrow	1.88	3.06	2.47	83.68	78.31	81.00	37.65	35.67	36.66
Sakha106*IRAT 112	35.20	30.65	32.93	Wide	Wide	Wide	2.11	4.43	3.27	81.32	76.76	79.04	36.24	30.96	33.60
Sakha 106*IRAT 170	29.34	22.58	25.96	Wide	Wide	Wide	1.12	4.10	2.61	80.64	75.81	78.23	40.64	33.45	37.04
Sakha 106*Nerica 4	35.76	29.66	32.71	Narrow	Wide	Wide	2.14	4.97	3.55	82.77	77.91	80.34	36.02	29.41	32.71
Sakha 102*Giza 178	27.32	19.77	23.55	Wide	Narrow	Narrow	2.05	4.20	3.13	89.61	67.32	78.47	46.80	29.48	38.14
Sakha 102*Giza 177	27.87	17.75	22.81	Wide	Wide	Wide	3.87	5.10	4.49	92.39	71.28	81.83	41.40	28.34	34.87
Sakha 102*WAB 880	33.57	27.97	30.77	Narrow	Wide	Narrow	1.31	5.73	3.52	82.66	78.90	80.78	36.42	30.76	33.59
Sakha 102*IRAT 112	32.77	27.61	30.19	Narrow	Wide	Wide	2.10	4.20	3.15	81.82	76.94	79.38	34.09	29.29	31.69
Sakha 102*IRAT 170	30.05	26.62	28.34	Wide	Wide	Wide	2.13	4.40	3.27	82.45	74.58	78.51	37.75	31.47	34.61
Sakha 102*Nerica 4	34.39	26.12	30.25	Wide	Wide	Wide	2.01	4.57	3.29	80.85	74.86	77.86	38.55	29.70	34.12
Giza 178*Giza 177	29.40	21.19	25.30	Narrow	Wide	Narrow	2.02	5.33	3.68	93.57	78.17	85.87	45.45	28.40	36.92
Giza 178*WAB 880	33.87	27.92	30.90	Narrow	Narrow	Narrow	2.31	3.12	2.72	83.64	76.65	80.15	36.94	31.57	34.25
Giza 178*IRAT 112	35.20	29.29	32.24	Wide	Wide	Wide	2.10	3.20	2.65	84.07	78.57	81.32	32.51	27.79	30.15
Giza 178*IRAT 170	31.46	25.23	28.35	Wide	Wide	Wide	2.00	3.04	2.52	80.15	74.85	77.50	38.84	32.03	35.44
Giza 178*Nerica 4	32.34	27.19	29.77	Wide	Wide	Wide	2.13	3.13	2.63	82.31	75.35	78.83	36.98	28.94	32.96
Giza 177*WAB 880	33.13	27.20	30.16	Narrow	Wide	Wide	2.27	5.17	3.72	82.29	76.55	79.42	39.49	20.10	29.80
Giza 177*IRAT 112	35.44	24.04	29.74	Wide	Wide	Wide	2.10	3.77	2.94	79.39	73.32	76.36	33.70	29.33	31.51
Giza 177*IRAT 170	30.80	25.29	28.05	Wide	Wide	Wide	2.13	4.17	3.15	82.76	78.62	80.69	39.74	32.03	35.89
Giza 177*Nerica 4	36.17	29.70	32.94	Wide	Wide	Narrow	2.13	4.34	3.24	84.86	78.38	81.62	35.98	30.52	33.25
WAB 880*IRAT 112	35.22	28.86	32.04	Narrow	Wide	Wide	2.27	3.31	2.79	80.38	77.37	78.87	34.86	29.86	32.36
WAB 880*IRAT 170	34.65	26.34	30.49	Wide	Wide	Narrow	2.16	3.31	2.73	80.36	76.54	78.45	36.42	31.85	34.13
WAB 880*Nerica 4	35.59	29.29	32.44	Narrow	Narrow	Wide	2.15	3.15	2.65	83.08	79.50	81.29	34.13	28.43	31.28
IRAT 112*IRAT 170	34.79	28.77	31.78	Wide	Wide	Wide	2.01	3.23	2.62	80.15	73.19	76.67	33.61	27.70	30.65
IRAT 112*Nerica 4	36.45	28.16	32.30	Wide	Wide	Wide	2.09	3.03	2.56	81.79	75.56	78.68	34.34	28.94	31.64
IRAT 170*Nerica 4	35.40	30.85	33.13	Wide	Wide	Wide	2.10	3.27	2.68	79.71	72.24	75.97	36.97	30.62	33.80
LSD 0.05	1.16	1.10	1.12	-	-	-	0.20	0.24	0.22	1.39	1.26	1.30	1.04	0.78	0.90
LSD 0.01	1.54	1.46	1.46	-	-	-	0.26	0.32	0.29	1.84	1.67	1.71	1.37	1.03	1.18

N: normal conditions. S: drought conditions. Comb.: combined data.

Heterosis over better parent:

The data presented in (Table 3) shows heterosis over better parents (BP %) for studied characters under normal and drought conditions and their combined data. for heading date, hybrid combinations (Sakha106 × Sakha102), (Sakha106 × Giza 177) and (Giza 178 × Giza 177)) showed significant and desirable heterotic effects over better parents. Significant desirable heterosis for earliness were reported by Hassan *et al.,* (2016) and Ghazy (2017). With respect to plant height, the cross (Giza 178 × Giza 177) had highly significant negative heterosis of the better parent at the two environments and their combined data. The results are in harmony with the findings reported by Abd El-Lattef *et al.,* (2008), Bagheri (2010), and Hassan *et al.,* (2016). The data also showed that the crosses (Sakha106× Giza 177), (Wab880 × IRAT112), (Wab880 × Nerica4), (IRAT112 × IRAT170), (IRAT112 × Nerica4) and (IRAT170 × Nerica4) had highly significant positive better parent heterosis for number of tillers / plant under both environments and their combined data. In agreement with this, significant heterosis for this trait was also found by Ahmed (2004, and Bagheri (2010). For panicle length, the crosses (Sakha106 × Sakha102), (Sakha106 × Giza178), (Sakha106 × IRAT112), (Wab880× IRAT112), and (Giza 177 × IRAT112) recorded highly significant positive better parent the two environments and their combined data. The values ranged from 9.09% to 22.09 % as the percentage deviations of F_1 mean performances from better parents.

With respect to chlorophyll content, the crosses (Sakha106 × Giza177), ((Sakha106 × Giza178) and (Giza177 × IRAT170) had significant positive heterosis as a deviation from better parents at the two environments and their combined data and their values ranged from 2.84 % to 19.77 %.. For flag leaf area, (Table 3) the crosses (Sakh102 × Wab880), (Sakha102 × IRAT112), (Sakha102 × IRAT170), (Sakha102 × Nerica4) and (Giza177 × Nerica4) had significant positive heterosis as a deviation from better parents at the two environments and their combined data. For flag leaf angle, the crosses (Sakha106 × Sakha102), (Sakha106× Giza177), (Giza178 × Giza177) and (Wab880 × IRAT112) had highly significant positive hetrotic effects as deviation from the better parent at non-stress, stress and their combined data. Similar results were obtained Nevame *et al.,* (2012) and Ghazy (2017).

With regard to Leaf rolling, the crosses (Sakha102 × Giza177), (Sakha106 × Giza177), and (Giza178 × IRAT170) recorded highly significant negative heterosis under stress conditions. These results were in agreement with those obtained Ghazy (2017). Regarding relative water content, the crosses were (Sakha106 × Giza177), (Sakha102 × Giza 177), (Giza177 × IRAT170) and (Giza177 × Nerica4) had highly significant positive hetrotic effects as deviation from the better parent at stress and combined data. These results were in agreement with those obtained by Sedeek (2006) and Ghazy (2017). Concerning the grain yield / plant, the crosses (Giza177 × IRAT170), (Wab880 × IRAT170), (IRAT112 × IRAT170), (IRAT112 × Nerica4) and (IRAT170 × Nerica4) had highly significant positive better parent heterosis at the two environments and their combined data. The heterosis values ranged from 4.37% to 29.56% .Significant heterotic effect for grain yield were also found by) Ushakumar *et al.,* (2014), and Ghazy (2017).

Table 3. Percentage of heterosis over better parents (BP%) for studied characters under normal and drought conditions and their combined data.

Crosses	**Days to heading** (day)			**Plant height** (cm)			**No of tillers / plant**			**Panicle length** (cm)			**Chlorophyll content** (mg/ds^{-1})		
	N	**S**	**Comb.**	**N**	**S**	**Comb.**	**N**	**S**	**Comb.**	**N**	**S**	**Comb.**	**N**	**S**	**Comb.**
Sakha 106*Sakha 102	3.33**	6.35**	4.80**	3.40**	5.86**	4.02**	4.87	45.52**	20.15**	9.09**	22.09**	16.97**	-4.77**	0.86	-2.08
Sakha 106*Giza178	13.31**	13.93**	13.61**	14.95**	9.65**	12.35**	1.87	17.85**	8.47*	11.41**	14.23**	13.02**	2.84*	13.37**	7.66**
Sakha106*Giza177	3.10**	5.66**	4.31**	0.04	-1.04	-0.49	20.85**	34.34**	29.21**	-1.65	-4.97*	-3.23	8.46**	19.77**	13.54**
Sakha106*WAB 880	10.77**	10.35**	10.56**	11.50**	12.17**	11.83**	4.43	43.13**	18.98**	-0.22	-1.06	-0.61	-3.94**	1.10	-1.59
Sakha106*IRAT 112	7.24**	11.42**	9.27**	12.09**	11.26**	11.69**	-12.31**	28.42**	3.01	17.99**	18.94**	18.54**	-2.93*	-9.46**	-6.07**
Sakha 106*IRAT 170	5.10**	9.58**	7.28**	19.72**	17.82**	18.79**	-6.76	9.46	-0.66	0.86	4.52*	2.61	0.92	-0.10	2.90
Sakha 106*Nerica 4	3.68**	8.26**	6.14**	10.28**	9.91**	10.69**	-16.56**	16.23**	-1.58	-3.06	-1.49	-2.32	-5.51**	0.85	-2.57*
Sakha 102*Giza 178	4.75**	8.22**	6.43**	10.16**	11.60**	10.86**	11.62**	24.85**	17.09**	4.04*	17.38**	12.35**	3.51*	2.36	3.79*
Sakha 102*Giza 177	2.88*	5.33**	4.07**	9.73**	5.40**	7.60**	3.93	28.77**	20.91**	1.88	7.85**	4.61*	3.51*	2.60	3.07*
Sakha 102*WAB 880	10.52**	14.69**	12.55**	9.33**	12.70**	10.96**	-0.89	38.29**	13.47**	7.50**	11.40**	9.33**	-4.83**	-2.71	-3.84**
Sakha 102*IRAT 112	13.04**	14.12**	13.57**	8.20**	7.78**	8.00**	-4.67	21.10**	7.29	4.88**	12.61**	8.42**	3.40**	2.59	3.01*
Sakha 102*IRAT 170	6.37**	9.03**	7.66**	19.01**	19.38**	19.19**	-10.48*	20.81**	0.99	2.66	3.43	3.03	1.10	-1.73	-0.25
Sakha 102*Nerica 4	11.78**	16.03**	13.84**	7.20**	9.79**	8.45**	4.28	42.36**	19.48**	-3.06	1.46	-0.91	-6.19**	-0.51	-3.57**
Giza 178*Giza 177	3.12**	6.03**	4.55**	-3.19**	-3.75**	-3.47**	0.39	14.33**	6.15	19.00**	10.66**	15.00**	-1.01	3.32	0.97
Giza 178*WAB 880	-0.21	-0.78	-0.58	26.84**	25.60**	26.23**	-12.74**	10.75*	-3.03	7.79**	21.34**	14.15**	-4.22**	-1.14	-2.78*
Giza 178*IRAT 112	-0.40	4.31**	1.87	21.62**	24.99**	23.27**	-33.88**	-13.65**	-25.52**	9.15**	15.08**	12.33**	2.10	-2.13	0.06
Giza 178*IRAT 170	4.11**	7.06**	5.56**	34.08**	35.16**	34.61**	-13.76**	11.22*	-3.43	18.84**	9.81**	14.51**	-2.14	6.50**	2.29
Giza 178*Nerica 4	1.27	6.33**	3.44**	28.74**	26.79**	27.78**	-11.25**	17.85**	0.78	-2.80	14.20**	5.30**	-7.78**	-0.13	-4.25**
Giza 177*WAB 880	7.68**	9.81**	8.72**	20.60**	18.31**	19.47**	13.02**	14.68**	13.73**	10.68**	7.65**	9.26**	-11.21**	-12.08**	-11.62**
Giza 177*IRAT 112	7.68**	9.08**	8.38**	17.41**	16.99**	17.20**	4.42	15.21**	9.81*	13.34**	21.81**	17.57**	-3.65**	-8.10**	-5.87**
Giza 177*IRAT 170	3.22**	5.85**	4.51**	28.33**	26.43**	27.39**	-7.06	-4.04	-5.76	7.03**	9.81**	8.37**	4.36**	3.44*	3.92*
Giza 177*Nerica 4	5.50**	7.08**	6.27**	20.96**	18.16**	19.58**	-4.19	2.01	-1.53	-2.40	0.88	-0.84	-8.53**	-4.08**	-6.48**
WAB 880*IRAT 112	1.08	2.74**	1.89	5.88**	4.40**	5.15**	21.17**	25.00**	29.27**	11.83**	12.70**	12.24**	2.30	9.00**	5.43**
WAB 880*IRAT 170	-0.88	-0.08	-0.49	7.31**	7.15**	7.23**	16.09**	11.07	14.30*	6.45**	5.76**	6.12**	-8.92**	-10.92**	-9.85**
WAB 880*Nerica 4	-0.37	2.82**	1.19	7.74**	6.04**	6.91**	25.02**	43.23**	32.87**	7.59**	8.05**	7.81**	1.26	8.21**	4.50**
IRAT 112*IRAT 170	0.37	2.60*	1.47	9.25**	9.30**	9.27**	29.80**	25.84**	27.93**	4.15*	3.74*	3.96*	-5.49**	-5.52**	-5.51**
IRAT 112*Nerica 4	0.16	1.98*	0.48	0.99	1.45	1.12	24.34**	37.64**	31.98**	0.53	9.37**	4.74**	-1.50	3.53*	0.82
IRAT 170*Nerica 4	-0.26	-0.36	-0.31	6.71**	6.92**	6.81**	19.73**	33.98**	25.87**	3.58*	0.70	2.21	-1.55	-1.69	-1.61

Table 3. Cont.

Crosses	Flag leaf area (cm^2)			Flag leaf angle			Leaf rolling			Relative water content			Grain yield/plant (g)		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
Sakha 106*Sakha 102	-6.51**	-0.56	-3.99	17.68**	11.57**	14.76**	13.11	-2.54	0.17	-1.60*	2.81**	0.22	1.64	38.13**	14.06**
Sakha 106*Giza178	-3.34	-0.20	-1.97	28.67**	19.77**	24.41**	49.03**	32.44**	19.27**	-6.45**	-9.35**	-7.76**	-5.48**	-1.80	-4.01**
Sakha106*Giza177	-1.97	-19.87**	-9.54**	22.19**	14.97**	18.73**	-13.58	-48.70**	-42.61**	-1.96*	11.94**	3.68**	-7.47**	27.26**	4.35**
Sakha106*WAB 880	-11.31**	-14.56**	-12.79**	95.28**	95.42**	95.34**	36.65**	-2.65	-9.58*	-3.64**	-0.32	1.31	-13.70**	27.15**	10.84**
Sakha106*IRAT 112	-2.36	-8.22**	-5.17**	77.23**	75.85**	76.57**	53.64**	33.00**	18.25**	-6.35**	4.11**	3.08**	-16.94**	37.48**	1.59
Sakha 106*IRAT 170	-12.96**	-14.73**	-13.74**	73.40**	70.15**	71.84**	-18.20*	17.25**	-7.77*	-7.14**	4.28**	3.38**	-6.86**	31.30**	12.00**
Sakha 106*Nerica 4	-6.62**	-16.82**	-11.54**	42.83**	85.66**	81.99**	34.18**	55.21**	30.74**	-5.03**	6.68**	4.42**	-24.78**	30.58**	-1.10
Sakha 102*Giza 178	-6.83**	-12.84**	-9.45**	26.21**	26.00**	26.11**	31.69**	12.00**	6.29	-3.04**	-11.01**	-6.63**	0.65	-4.42**	-1.37
Sakha 102*Giza 177	1.93	-4.83	-0.81	24.28**	30.70**	27.34**	186.91**	-20.73**	15.29**	1.12	14.35**	6.49**	2.91*	30.48**	12.57**
Sakha 102*WAB 880	-5.39**	-5.93**	-5.64**	65.86**	77.99**	71.63**	-16.06*	82.40**	28.94**	-3.15**	0.43	1.05	-9.48**	9.64**	8.43**
Sakha 102*IRAT 112	-9.11**	-17.33**	-13.06**	105.39**	119.33**	112.02**	34.90**	26.00**	13.86**	-4.13**	4.36**	3.52**	-15.26**	31.11**	2.30
Sakha 102*IRAT 170	-10.83**	0.55	-5.82**	63.17**	65.40**	64.23**	37.04**	25.83**	15.36**	-3.40**	2.58**	3.76**	-6.16**	23.52**	11.74**
Sakha 102*Nerica 4	-10.20**	-26.77**	-18.19**	75.40**	80.14**	77.66**	29.12**	42.71**	21.04**	-5.27**	2.49**	1.18	-4.18**	36.74**	10.16**
Giza 178*Giza 177	0.26	-6.57**	-2.72	13.17**	8.64**	11.00**	49.38**	42.22**	25.00**	1.24	3.33**	2.18**	-2.27*	-7.93**	-4.53**
Giza 178*WAB 880	-4.54**	-6.10**	-5.25**	46.45**	46.07**	46.27**	8.29	-0.64	-0.55	-9.50**	-2.44**	-4.63**	-20.57**	2.33	-11.44**
Giza 178*IRAT 112	-2.38	-12.30**	-7.15**	51.50**	58.55**	54.88**	-1.41	-4.00	-4.22	-9.03**	3.85**	-3.23**	-30.09**	-9.92**	-22.05**
Giza 178*IRAT 170	-6.65**	-4.71*	-5.79**	66.32**	66.07**	66.20**	-6.10	-13.16**	-11.07**	-13.28**	-1.07	-7.78**	-16.48**	3.84**	-8.38**
Giza 178*Nerica 4	-15.55**	-23.75**	-19.50**	60.16**	60.42**	60.29**	0.01	-2.08	-3.13	-10.94**	-0.40	-6.19**	-20.47**	-6.18**	-14.77**
Giza 177*WAB 880	-6.64**	-8.52**	-7.50**	43.21**	49.41**	46.18**	67.90**	64.37**	36.14**	-9.92**	-2.57**	-0.66	8.48**	-28.34**	-3.66*
Giza 177*IRAT 112	-1.71	-28.01**	29.25**	61.57**	65.20**	63.38**	55.56**	13.20**	34.38**	-13.10**	-0.55	-6.82**	-7.42**	31.29**	11.93**
Giza 177*IRAT 170	-8.60**	-4.49*	-6.80**	59.12**	61.93**	60.47**	58.02**	19.16**	11.24**	-9.41**	8.13**	5.00**	9.17**	25.74**	24.44**
Giza 177*Nerica 4	-5.55**	-16.71**	-10.93**	51.21**	48.72**	50.02**	57.53**	35.73**	19.08**	-7.12**	7.32**	6.08**	-1.16	45.83**	15.99**
WAB 880*IRAT 112	-2.31	-13.57**	-7.72**	13.06**	12.87**	12.97**	3.18	5.30	2.20	-1.17	-1.52	-1.34	3.13*	6.44**	4.63**
WAB 880*IRAT 170	-2.34	-11.42**	-6.48**	14.94**	13.89**	14.43**	-0.46	5.30	0.12	-1.20	-2.58**	-1.88*	7.75**	13.52**	10.37**
WAB 880*Nerica 4	-7.07**	-17.88**	-12.28**	14.95**	17.29**	16.07**	-3.58	0.11	-2.45	2.14*	1.20	1.68*	0.98	1.34	1.14
IRAT 112*IRAT 170	-3.50*	-13.86**	-8.48**	19.37**	21.38**	20.34**	-7.23	-3.00	-5.24	0.65	-0.73	-0.01	4.37**	8.71**	6.29**
IRAT 112*Nerica 4	-4.82**	-21.04**	-12.64**	2.61	4.29**	3.41	-5.00	-5.21	-5.71	1.16	2.49**	2.25**	11.78**	29.56**	23.04**
IRAT 170*Nerica 4	-7.56**	-13.50**	-10.42**	4.33*	3.58*	3.97*	-3.08	2.08	-1.23	-1.42	-1.09	-1.26	14.82**	20.19**	17.19**

N: normal conditions. S: drought conditions. Comb.: combined data.
*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Potence ratio:

Potence ratio values (data not shown) exceeded unity in eight crosses, indicating the presence of over-dominance for days to heading at the two environments and their combined data. The crosses (Sakha106 × Giza178), (Sakha102 × WAB880) and (IRAT170 × Nerica4) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data, while partial dominance was found in the remaining crosses, since the potence ratio values were less then unity . Similar results were obtained by Ghazy (2017). For plant height, twelve crosses were found to be controlled by over-dominance since potence ratio values were more than unity at the two environments and their combined data. The five crosses (Sakha106 × IRAT170), (Sakha106 × Nerica4), (Sakha102 × Giza177), (Giza177 × IRAT170) and (Giza177 × Nerica4) were controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data, while partial dominance was found in the remaining crosses, since the potence ratio values were less then unity .

Concerning number of tillers / plant (data not shown) twenty-one crosses were controlled by over-dominance since potence ratio values were more than unity at stress and combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were were less then unity at non- stress and combined data. For panicle length, twenty-two crosses controlled by over-dominance since potence ratio values were more than unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at non- stress and combined data. Similar results were obtained by Hassan *et al*., (2016).

For chlorophyll content (data not shown) the potence ratio values were more then unity for eight crosses indicating the presence of over-dominance at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at non- stress and combined data. Concerning flag leaf area, potence ratio values were more then unity for crosses (Sakha106 × Giza177) and (WAB880 × IRAT112) indicating the presence of over-dominance at the two environments and their combined data. The cross (WAB880 × Nerica4) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at the two environments and their combined data. For flag leaf angle, the potence ratio values were more than unity for eleven crosses indicating the presence of over-dominance at the two environments and their combined data. The crosses (Sakha102× IRAT112), (Giza177 × Nerica4), (IRAT112 × IRAT170), (Sakha102 × Nerica4) and (Sakha106 × Nerica4) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at the two environments and their combined data. Similar results were obtained by Ghazy (2017).

Concerning leaf rolling seven crosses controlled by over-dominance since potence ratio values were more than unity at the two environments and combined data. The cross

(Giza178 × WAB880) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at the two environments and their combined data. For relative water content, the potence ratio values were more than unity for fourteen crosses indicating the presence of over-dominance at the stress and combined data. The cross (Sakha102 × Nerica4) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less then unity at the two environments and their combined data. For grain yield / plant, nineteen crosses controlled by over-dominance since potence ratio values were more than unity under stress and combined data. The cross (WAB880 × Nerica4) controlled by complete dominance since the potence ratio values were near unity at the two environments and their combined data. While, the other remaining crosses controlled by partial dominance since the potence ratio values were less than unity at the two environments and their combined data. Similar results were obtained by Hassan *et al*., (2016).

Genetic parameters:

The data presented in Table 10and 11 showed high genetic variance for days to heading (34.85),plant height (181.62) and flag leaf angle (126.96).However moderate values were obtained for chlorophyll content, flag leaf area and grain yield / plant 26.44,32.91and 21.38,respectively. Low estimates of 13.28, 14.42, 4.57, and 0.59, respectively, for, number of tiller/ plant, , relative water content, panicle length and Leaf rolling .Among the trails Plant height, number of tiller / plant, chlorophyll content, flag leaf area , flag leaf angle and grain yield / plant had markedly high phenotypic coefficients of variability compared to the correspondent genetic coefficient of variability, indicates the effect of environmental factors. On the other hand, the remaining traits showed close values for PCV and GCV indicating high heritable variance. The heritable portion of the variation could be found out with the help of heritability estimates. High heritability values Table (10and 11) had been obtained for plant height (99.17), chlorophyll content (97.85), flag leaf area (98.54) ,flag leaf angle (99.45) and grain yield / plant (98.54).These results are in agreed with those obtained by Abd El-Lattef *et al*., (2008), and Ghazy (2012)

The results obtained here indicates the relative importance of physiological parameters such as chlorophyll content, flag leaf area, flag leaf angle, relative water content and leaf rolling as selection criteria for drought tolerance. Also, the existence of significant amounts of genetic variation among the tested materials suggests their potential in breeding for water deficit tolerant rice genotypes.

Table 4. Estimates of genetic variance, phenotypic variance, genetic coefficient of variance, phenotypic coefficient of variance, and heritability in broad sense for characters studied over three environments and their combined data.

S. O. V	Days to heading (day)			Plant height (cm)			No of tillers / plant			Panicle length (cm)			Chlorophyll content (mg/ds^{-1})		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
G.V	17.46	18.09	34.85	96.69	86.11	181.62	8.18	6.34	13.28	1.99	3.20	4.57	13.59	13.70	26.44
P.V	19.07	19.61	36.42	98.03	87.81	183.13	9.16	7.11	14.15	2.22	3.43	4.80	14.16	14.29	27.02
G.C.V	4.14	4.35	5.95	8.25	8.17	11.58	15.17	16.72	21.49	5.80	8.00	9.16	7.91	8.86	11.64
P.C.V	4.39	4.53	6.08	8.31	8.25	11.63	16.06	17.70	22.19	6.13	8.28	9.38	8.11	9.05	11.77
H.B	91.56	92.24	95.70	98.63	98.07	99.17	89.31	89.23	93.84	89.60	93.43	95.25	95.98	95.86	97.85

Table 4. Cont.

	Flag leaf area (cm^2)			Flag leaf angle			Leaf rolling			Relative water content			Grain yield / plant (g)		
	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.	N	S	Comb.
G.V	13.18	21.47	32.91	64.23	62.83	126.96	0.20	1.28	0.59	16.29	27.94	14.42	19.06	15.35	21.38
P.V	13.69	21.93	33.40	65.10	63.37	127.67	0.22	1.31	0.61	17.02	28.53	15.08	19.46	15.58	21.70
G.C.V	11.26	18.01	19.80	20.87	22.28	30.46	21.79	27.07	24.63	4.82	7.17	4.82	11.58	13.74	13.97
P.C.V	11.48	18.20	19.94	21.01	22.37	30.54	22.56	27.31	25.01	4.93	7.24	4.93	11.71	13.84	14.07
H.B	96.25	97.91	98.54	98.66	99.15	99.45	93.31	98.28	96.97	95.72	97.90	95.60	97.91	98.53	98.54

N: normal conditions. S: drought conditions. Comb: combined data. G.V= Genetic variance P.C.V= Phenotypic coefficient of variance P.V= Phenotypic variance H.B= Heritability in broad sense G.C.V= Genetic coefficient of varianc

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دور بعض صفات النمو في تحسين تحمل الجفاف في الارز

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تم إجراء هذا البحث في مزرعة مركز بحوث وتدريب الأرز ، سخا ، كفر الشيخ ، مصر ، خلال مواسم ٢٠١٤ و ٢٠١٥ باستخدام ثمانية أنواع من الأرز لصفات النمو ومحصول الحبوب تحت كل من الظروف الطبيعية وظروف الجفاف. أوضحت النتائج أن أفضل قيم مرغوبة لمتوسط الصفات لصفات النمو ومحصول الحبوب من الاباء سخا ١٠٦ ,جيزة ١٧٨ ,نيريكا ٤ , واب ٨٨٠ و الهجن سخا١٠٦×سخا ١٠٢ ,سخا١٠٦× جيزة١٧٧, جيزة ١٧٨× جيزة واب ٨٨٠ × نيريكا ٤ , إرات ١١٢ × نيريكا ٤ تحت كل من الظروف الطبيعية وظروف الجفاف. أظهر تحليل التباين إختلافات عالية المعنوية بين جميع التراكيب الو راثية الآباء والهجن الخاصة بها ومعظم تفاعلاتها مع الظروف البيئية المدروسة فى جميع البيئات. أظهرت نتائج قوة الهجين مقارنة بالأب الأفضل لكل الصفات أن أفضل الهجن لصفات النمو ومحصول الحبوب سخا١٠٦× جيزة١٧٧ ,إرات١١٢ ×نيريكا٤ , جيزة١٧٧× إرات١١٢ ,جيزة ١٧٧ × نيريكا ٤ ,سخا ١٠٢ ×إرات ١١٢ تحت كل من الظروف الطبيعية وظروف الجفاف. بالنسبة لطبيعة ودرجة السيادة أظهرت النتائج وجود سيادة فائقة فى معظم الهجن لصفة ارتفاع النبات ,عدد الفروع / نبات, طول السنبلة, محتوي الماء النسبي ومحصول الحبوب لكل نبات. وأظهرت النتائج سيادة جزئية في معظم الهجن لصفة عدد الايام حتي التزهير ,محتوي الكلروفيل ,مساحة ورقة العلم ,زاوية ورقة العلم والتفاف الاوراق. اظهر التباين الوراثي ارتفاعا في صفة عدد الايام حتي التزهير , طول النبات ,زاوية ورقة العلم وكان معتدلا في القيم لصفة محتوي الكلورفيل في الورقة ,مساحة ورقة العلم ومحصول الحبوب لكل نِبات. بينما كان منخفض لصفة عدد الفروع لكل نبات ,محتوي الماء النسبي ,طول السنبلة والتفاف الاوراق . وبالنسبة لصفة عدد الفروع لكل نبات ,محتوي الكلورفيل في الورقة ,مساحة ورقة العلم,زاوية ورقة العلم ومحصول الحبوب لكل نبات كان فيهم معاملات التباين المظهري عالية مما يدل علي تأثير العوامل البيئية.وبالنسبة للصفات المتبقية كان فيها معامل التباين المظهري قريب من معامل التباين الوراثي مما يدل علي التأثير في التباين الوراثي . وتم الحصول علي قيم عالية في درجة التوريث في صفة ارتفاع النبات ,محتوي الكلورفيل ,مساحة ورقة العلم ,زواية ورقة العلم ومحصول الحبوب لكل نبات. تشير النتائج التي تم الحصول عليها إلى الأهمية النسبية للصفات الفسيولوجية مثل محتوى الكلوروفيل ، مساحة ورقة العلم ، زاوية ورقة العلم ، محتوى الماء النسبي والتفاف الأوراق كمعايير اختيار لتحمل الجفاف. أيضا ، فإن وجود كميات كبيرة من التباين الوراثي بين المواد التي تم اختبارها يشير إلى إمكاناتها في التكاثر من أجل التراكيب الوراثية للأرز التي تتحمل عجز الماء.