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Utilization of New African Rice Varieties for Breeding Egyptian Cultivars Tolerant to Water Deficit

Elgamal, W. H.*; W. F. Ghidan and A. M. Elmoghazy
Rice Research and Training Center, Field Crops Research Institute, Agricultural Research Center, Egypt
***Corresponding author's email: elgamal.rrtc@gmail.com**

ABSTRACT

Breeding rice for abiotic stress tolerance is very important objective for rice breeders. Significantly reduce in yield due to drought-stress in most world countries, especially suffering from water lace as well as Egypt. Evaluating combining ability effects would provide valuable information that can be used for developing new drought tolerant lines. This study was conducted at Sakha Agricultural Research Station during 2014 to 2016 rice growing seasons to determine combining ability and gene action for grain yield and other important traits to identify the superior varieties/parents and crosses under both drought and optimum conditions. Six F_1 hybrids were generated by crossing four rice genotypes in a half diallel mating scheme in addition to their six F_2 populations after self-pollination. The four populations (P_1, P_2, F_1 and F_2) for all the six crosses were evaluated in a replicated field trial under drought and normal conditions. Drought stress significantly decreased the mean values of all the studied traits for parents and their hybrids compared with the control condition. Significant differences were observed among parents and their hybrids for most traits under both research conditions. General combining ability (GCA) and specific combining ability (SCA) means squares were highly significant for grain yield and most traits under test environments. The non-additive gene action played an important role in the inheritance of most studied traits. The parental genotypes NERICA3 and NERICA4 appeared to be the best general combiners for earliness and grain yield. The cross combinations; Giza178×NERICA3; Giza178×NERICA4 and NERICA3×NERICA4 in both F_1 and their F_2 generations were distinguished as specific combiners for grain yield and other related traits under normal and drought conditions. These results emphasized by positive heterosis over high parents followed by high values of inbreeding depression. Hence, these hybrids would be valuable in rice breeding for improving grain yield under drought stress condition.

Keywords: Rice, NERICA, Drought, Combining ability, Heterosis.

INTRODUCTION

Rice (*Oryza sativa* L.) is the main food crop for over one-half of the world's population (Yuan, 2014). By the year 2030, the world population is expected to reach approximately eight billion (Fageria, 2007). Hence, it will be necessary to increase rice production by 40% to meet the growing world population. Drought is one of the major constraints that effects on rice production worldwide. It is estimated that 50% of the world rice production are affected more or less by drought (Boumanet *et al.,* 2005). Rice occupies about 22% of the total cultivated area in Egypt during summer season and it consumes about 20% of the total water resources. Due to the limited water resources in Egypt and increasing population, the total water requirements for rice crop caused a big problem. Some of rice cultivated areas, especially which located at the end of the terminal canals suffer from shortage of irrigation water during different growth stages, which are considered to be one of the most serious constraints to rice production in Egypt (Abd Allah *et al*., 2010). Development of new rice promising lines tolerant to drought or water deficit is the most straightforward way to overcome this problem.

NERICA's rice varieties are very important resources for biotic and abiotic stress conditions which derived from inter-specific crossing between *Oryza sativa* and *Oryza glaberrima* from the African Rice Center in Bouake, Ivory Coast (Somadoet *al.,* 2008). These varieties have a good gene pool to improve our cultivars. NERICA's Genotypes are new materials and promising to be utilized as a source for water deficit tolerance in Egypt

To design an effective breeding program for developing drought tolerance cultivars, knowledge and understanding the type of gene action controlling the inheritance of different traits is important. Diallel analysis is the choice of providing such detailed genetic information about type of gene action (Lonnquit and Gardner 1961). This information helps in emphasizing on the breeding strategy, either selection when GCA effects are important; inbreeding followed by cross breeding when SCA effects are predominant; or selection followed by hybridization if both are important; because GCA effects are attributed to the preponderance of genes with additive effects and SCA indicates the predominance of genes with non-additive effects (Sharma, 1994). Parents of the best potentiality transmit the high yielding ability or improved earliness and level of drought tolerance traits to their progeny of new combinations, are those exhibiting the highest GCA effects. Whereas, the highest SCA effects combinations demonstrate the exploitation of heterosis concept. Proper choice of parents on the basis of their combining ability status for putative drought tolerant attributes as well as yield contributing traits and selection in a typical target environment will help in combining complex traits such as productivity and drought tolerance (Muthuramu *et al.,* 2010). In view of the above, the main objectives of the present study were to assess genetic parameters and combining ability for agronomic, yield and yield component characters under drought-stress and normal conditions. In addition, to identify the most desirable genotypes for the rice breeding program under these conditions.

MATERIALS AND METHODS

Plant Materials and Designation:

The present study was conducted at the experimental farm of the Agricultural Research Station, Sakha, Kafr El-Sheikh, Egypt. During 2014to 2016 successive rice growing seasons, four rice genotypes namely; Giza 177 and Giza 178 (Egyptian varieties characterized as Early, semi dwarf and high yielding varieties), while NERICA3 and NERICA4 are inter-specific varieties derived from two following crosses CG

14 (*O. glaberrima*) ×WAP 450-1-B-P-28-HB (*Oryza sativa* L.) and CG 14 ×WAP 450-1-B-P-91-HB.These parents represented a wide range of diversity, were crossed in a half diallel mating design to produce six F_1's in the 2014 growing season. Part of the six F_1's seeds were sowing and transplanting during 2015 summer season for self-pollination to getting six F_2 populations. All the genotypes (four parents, six F_1's and their six F_2 populations) were evaluated in two experiments in the 2016 rice growing season. The first experiment was normally irrigated with continuous flooding (normal condition). The second was irrigated every 12 days without any standing water (drought-stress condition). Each experiment was designed in a Randomized Complete Block Design (RCBD) with three replications. Each genotype of parents and F_1 was planted in three rows per replicate, while the F_2 population planted in 10 rows. The row was five meters long with the spacing 20 × 20 cm between rows and plants within rows. All the recommended agronomic and plant protection practices were uniformly followed throughout the crop growth period for raising ideal crop stand.

Traits Measurements:

Data were recorded on ten individuals guarded plants for parents and F_1 plants, while 100 individuals were observed in F_2 data record per replicate. The studied traits were; days to heading (day), root thickness (mm), plant height (cm), leaf rolling score, number of panicles/plant, spikelet fertility (%) and grain yield/plant (g). Leaf rolling score was recorded by visual estimation based on method by De Datta*et al.,* (1988).

Data Analysis:

The analysis of variance for each experiment (normal and stress conditions) was done according to Steel and Torrie (1980). Combining ability analysis was performed according to Griffing (1956) method 2 model 1. Heterosis over high parent was estimated as a percent increase or decrease in F_1's over the better parent (Heterosis) as F_1-BPx100/BP (Liang *et al.,* 1971), where F_1 is mean of F_1's, BP is mean of the better parent for each cross. Inbreeding depression was expressed as percent decrease observed in F_2 over F_1 as F_1-F_2x100/F_1, where F_2 is mean of F_2's.

RESULTS AND DISCUSSION

Analysis of variance:

Analysis of variance showed that the mean squares due to genotypes, parents and crosses were highly significant for all studied traits under normal conditions except for leaf rolling score in case of F1and under drought-stress conditions except for spikelet fertility % in case of F2 (Table 1). This indicates the presence of sufficient genetic variability among the genotypes, which is considered adequate for further biometrical assessment. Mean squares due to parents vs. crosses were significant and highly significant for the studied traits under both conditions except for leaf rolling score in case of F2. These results revealed good scope for the manifestation of heterosis in all the studied traits (Jayasudha and Sharma, 2009; Rahimi *et al*., 2010; El-Mowafi *et al*., 2012 and Sanghera and Hussain 2012).

Table 1. Mean square estimates of both ordinary and combining ability analysis for all the studied traits under normal and stress conditions.

S.O.V	d. f.		Days to heading (day)		Root thickness (mm)		Plant height (cm)		Leaf rolling score		No. of panicles/plant		Spikelet fertility (%)		Grain yield/plant (g)	
			N	S	N	S	N	S	N	S	N	S	N	S	N	S
Replications	2	F_1	0.233	0.700	0.002	0.000	0.533	1.300	0.70	0.533	0.475	0.033	1.902	2.025	0.400	0.562
		F_2	0.233	3.233*	0.000	0.001	1.408	1.758	0.533	0.400	0.0583	1.858	0.544	34.58	3.280*	4.103
Genotypes	9	F_1	41.76**	72.16**	0.163**	0.204**	195.9**	424.4**	3.052**	11.02**	38.53**	22.17**	185.1**	54.90**	151.8**	126.3**
		F_2	44.68**	53.44**	0.147**	0.165**	185.7**	381.9**	5.185**	10.90**	30.67**	14.24**	186.0**	89.58	60.72**	70.74**
Crosses (c)	5	F_1	12.10**	83.46**	0.035**	0.064**	12.35**	172.5**	0.855	2.888**	23.38**	3.666**	89.56**	93.64**	149.1**	95.55**
		F_2	11.83**	23.78**	0.061**	0.038**	30.03**	59.45**	5.033**	3.955**	26.83**	5.600**	39.49**	99.32	85.31**	48.99**
Parents (p)	3	F_1	30.30**	45.11**	0.234**	0.286**	114.4**	271.6**	6.75**	26.11**	34.68**	17.90**	110.9**	8.634*	36.95**	115.7**
		F_2	30.30**	45.11**	0.234**	0.286**	114.5**	271.5**	6.75**	26.11**	34.68**	17.90**	110.9**	8.634	36.94**	115.7**
P vs C. (h)	1	F_1	224.4**	96.80**	0.589**	0.648**	1358**	2142**	2.938**	6.422**	125.8**	127.5**	885.7**	0.004**	510.7**	312.2**
		F_2	252.1**	226.7**	0.315**	0.440**	1178**	2325**	1.25	0.022	37.81**	46.51**	1143**	283.7*	9.090**	44.43**
GCA	3	F_1	4.346**	1.222**	0.088**	0.124**	22.91**	103.6**	2.457**	9.333**	23.04**	4.174**	19.26**	5.118**	25.36**	75.07**
		F_2	18.37**	11.41**	0.106**	0.105**	44.67**	57.34**	3.543**	9.630**	23.98**	7.008**	16.68**	20.73	0.386**	53.66**
SCA	6	F_1	18.71**	35.47**	0.038**	0.040**	86.52**	160.4**	0.298**	0.844**	7.748**	9.000**	82.94**	24.89**	63.25**	25.64**
		F_2	7.938**	21.01**	0.021**	0.030**	70.53**	162.3**	0.821**	0.637*	3.346**	3.621**	84.66**	34.42	30.17**	8.542**
Error	18	F_1	0.418	0.441	0.001	0.001	0.348	1.263	0.441	0.533	0.605	0.478	1.325	2.381	0.873	2.558
		F_2	0.492	0.529	0.001	0.000	0.584	1.045	0.496	0.548	0.355	0.682	2.204	48.94	0.776	3.292
GCA/SCA		F_1	0.232	0.034	2.315	3.100	0.264	0.645	8.244	11.054	2.973	0.463	0.232	0.204	0.400	2.927
		F_2	2.358	0.054	5.047	3.500	0.633	0.353	4.315	15.117	7.166	1.935	0.197	0.602	0.013	6.282

***, ** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.**
N= Normal and S= Stress condition

General (GCA) and specific (SCA) combining ability mean squares were highly significant for all the studied traits under normal conditions while under drought-stress conditions GCA and SCA mean squares were significant and highly significant for all the studied traits except for spikelet fertility % in case of F2. These results would indicate the importance of both additive and non-additive gene effects in the inheritance of such traits. The ratio of GCA/SCA was less than unity for days to heading, plant height, spikelet fertility % under both environments and grain yield/plant under normal irrigation, while GCA/SCA ratio was more than unity for root thickness, leaf rolling, no. of panicles/plant under both environments and grain yield/plant under drought conditions. These results indicated that the non-additive gene effects played a major role in the genetic expression of these traits, while the inheritance of the expected traits was mainly controlled by additive gene effects. This finding is consistent with those reported for rice hybrids evaluated under similar environments (El-Mowafi *et al*., 2005; Gaballah 2009 and Hadifa 2012). However, these findings are in contrary with those of Sanghera and Hussain 2012 and El-Hity *et al*., 2015.

Mean performance:

Drought-stress caused great reductions in most of the studied traits compared with normal conditions (Table 2). Moreover, rice genotypes greatly differed in their responses under both conditions for all the studied traits. Water stress delayed for days to heading for all studied combinations, except Giza 178 x NERICA3 and NERICA3×NERICA4in case of F_1. The two parents Giza 177 and NERICA 4 and the cross combinations (Giza 177×NERICA4) and (Giza 178×NERICA 3) in both F_1 and F_2 generations exhibited the desirable mean values towards the earliness under both normal and water stress conditions. Delayed flowering under drought is associated with an apparent delay in floral development when stress occurs between panicle initiation and pollen meiosis (from 30 to 10 days before heading) (Lafitte *et al*., 2004). With respect to plant height, the two parents Giza177 and NERICA 3 and the two crosses (Giza 177×Giza178) and (Giza177×NERICA 3) scored the desirable mean values towards dwarfing under both environments. There was significant reduction in plant height under water stress condition in the most of rice genotypes studied. Water stress greatly suppresses cell expansion and cell growth due to lower turgor pressure, the reduction in plant height is associated with a decline in cell enlargement under water stress (Kamoshita*et al.,* 2008). Concerning leaf rolling score, the two parents NERICA 3 and NERICA 4 as well as the crosses (Giza 177 × NERICA 4); (Giza 178 × NERICA 4) and (NERICA 3 × NERICA 4) gave the lowest score desirable for this trait under normal irrigation and water stress conditions in both F_1 and F_2 generations, indicating that these genotypes could be considered as a good candidate for drought tolerance. For number of panicles/plant, that all F_1 and F_2 generations for most crosses gave the highest values compared with their parents under normal and stress conditions. The parental genotype Giza178 gave the highest mean values of number of panicles/plant under normal condition while the parent NERICA 4 gave the highest value under drought conditions and the crosses (Giza177× Giza178); (Giza178 × NERICA 3) and Giza178× NERICA 4) gave the highest mean values for number of panicles/plant in F_1 and F_2 generations under both normal and water stress conditions. For spikelets fertility %, the parental variety Giza177 recorded the highest mean value under normal condition while the parent NERICA4 recorded the highest value under drought condition and the cross combinations (Giza 177 × NERICA 4); (Giza178 × NERICA 3) and (Giza 178 × NERICA 4) recorded the highest desirable mean values for number of panicles/plant under both environments. Regarding root thickness, the two parents; NERICA4 and NERICA3 gave the thickest root values under both conditions and the crosses (Giza178 × NERICA 3); (Giza 178 × NERICA 4) and (NERICA 3 × NERICA 4) recorded the highest desirable values of root thickness in F_1 and F_2 generations under both normal and stress conditions. The grain yield is the important trait for breeders and producers, the values of grain yield /plant under normal conditions showed by the parents Giza 178 and Giza 177 while, NERICA 3 and NERICA 4 gave the high yield/plant under drought stress. All the studied crosses gave higher values of grain yield /plant under normal condition in both F_1 and F_2 generations while, some of studied crosses exhibited high yielding under drought conditions, i.e. (Giza 177 × NERICA 4); (Giza178 × NERICA 3); (Giza 178 × NERICA 4) and (NERICA 3 × NERICA 4)in both F_1 and F_2 generations. These results indicate the role of NERICA3 and NERICA4 as a donor for yielding ability under drought or water stress conditions with Egyptian verities combinations even in F_1 or F_2 generations. From previous studies by Abd Allah *et al.,* 2010; Abd El-Maksoud *et al.,* 2013 and Elgamal 2013 on drought effects on traits mean values insured that drought effects on rice traits by negative effects but the best genotype which has a narrow variance between normal conditions and drought stress.

General combining ability (GCA) effects:

Identification of parents for improvement of the trait in question necessitates the assessment of GCA effects for the studied traits, which presented in Table 3. Results indicated that NERICA4 was the best parent for all studied traits of the parents, which present high significant positive values of GCA for all traits under study for both conditions in F_1 and F_2 generations, except for leaf rolling score, days to heading and spikelets fertility, followed by Giza 178 which recorded positive values of GCA for No. of panicles/plant and spikelets fertility under normal and drought conditions in addition to grain yield /plant in both F_1 and F_2 generations under normal conditions. The parent Giza 177 was the best general combiner for early heading and plant height, which identified as good combiners for developing short stature genotypes under both environments in F_1 and F_2 generations, while the parental genotype NERICA3 recorded high significant positive GCA values for root thickness under both conditions in F_1 and F_2 generations and for grain yield /plant under drought conditions. Sharma (2006); El-Mowafi *et al.,*(2012) and El-Hity *et al.,*(2015) reported similar results during previous studies on GCA.

Table 2. Mean performance for parents and their F_1's and F_2's for all the studied traits under normal and stress conditions.

Genotypes		Days to heading (day)		Root thickness (mm)		Plant height (cm)		Leaf rolling score		No. of panicles/plant		Spikelet fertility (%)		Grain yield/plant (g)	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 177		93.67	96.33	1.13	1.15	94.00	68.83	3.67	7.00	15.33	9.00	94.50	73.50	39.07	20.52
Giza 178		100.33	104.67	1.17	1.20	109.33	86.33	1.67	5.67	19.67	12.67	91.00	72.33	41.22	21.55
NERICA3		100.00	103.67	1.63	1.68	102.83	83.83	0.67	1.67	11.83	11.33	86.96	73.00	33.37	30.89
NERICA 4		96.33	99.33	1.63	1.73	104.33	89.00	0.33	1.00	13.33	14.83	80.33	76.20	35.56	32.53
Giza 177 ×	F_1	105.33	105.67	1.47	1.52	114.00	90.67	1.67	3.67	23.67	15.33	71.33	66.18	40.36	24.14
Giza 178	F_2	106.67	110.67	1.33	1.50	115.67	94.50	1.00	5.00	20.83	15.67	70.33	63.10	38.00	23.09
Giza177 ×	F_1	102.67	112.00	1.67	1.63	116.00	90.33	1.00	3.67	17.33	17.00	73.14	72.00	37.87	27.93
NERICA3	F_2	104.67	109.33	1.57	1.65	109.67	100.00	3.67	4.33	15.00	12.33	76.33	62.67	38.27	24.37
Giza177 ×	F_1	102.67	104.00	1.72	1.75	119.17	108.67	1.00	3.00	16.83	15.17	80.33	78.33	40.15	34.11
NERICA4	F_2	101.00	103.33	1.62	1.65	115.67	105.67	1.00	3.00	15.00	13.67	80.33	61.72	34.18	30.33
Giz178 ×	F_1	100.33	95.67	1.70	1.77	117.00	106.33	1.00	3.00	21.83	17.00	86.17	82.00	53.63	37.67
NERICA3	F_2	102.33	104.67	1.65	1.75	120.50	102.50	1.00	5.00	17.67	15.33	74.67	70.83	33.43	30.43
Giza178 ×	F_1	102.33	106.33	1.77	1.88	114.67	99.67	1.00	3.00	22.00	17.33	77.33	71.67	49.97	35.67
NERICA4	F_2	103.67	106.00	1.70	1.80	116.00	94.50	0.33	3.00	21.00	15.83	78.60	75.67	36.00	33.37
NERICA3 ×	F_1	105.67	104.33	1.75	1.90	118.33	98.00	0.00	1.00	16.33	15.00	74.33	72.23	52.35	37.96
NERICA4	F_2	102.67	105.67	1.73	1.78	114.50	100.67	0.33	2.33	14.50	14.17	73.30	70.90	48.39	30.47
L.S.D 0.01	F_1	1.489	1.529	0.111	0.053	1.358	2.588	1.529	1.681	1.792	1.591	2.651	3.554	1.642	3.681
	F_2	1.615	1.676	0.083	0.032	1.760	2.355	1.622	1.705	1.372	1.902	3.419	3.613	2.029	4.177
L.S.D 0.05	F_1	0.966	0.993	0.071	0.034	0.882	1.682	0.993	1.092	1.164	1.034	1.723	2.309	1.067	2.392
	F_2	1.049	1.088	0.053	0.020	1.143	1.530	1.048	1.107	0.891	1.235	2.221	2.346	1.318	2.715

N=Normal condition and S= Stress condition.

Table 3. Estimates of GCA effects for parental genotypes for all studied traits under normal irrigation and water stress conditions.

Parents		Days to heading (day)		Root thickness (mm)		Plant height (cm)		Leaf rolling score		No. of panicles/plant		Spikelet fertility (%)		Grain yield/plant (g)	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 177	F_1	-1.111**	-0.277**	-0.116**	-0.151**	-2.833**	-5.805**	0.833**	1.333**	-0.152	-1.125**	1.015**	-0.868**	-2.528**	-4.015**
	F_2	-1.000**	-0.972**	-0.133**	-0.141**	-3.472**	-4.388**	1.055**	1.222**	-0.097	-1.291**	2.136**	-2.579**	0.361**	-3.289**
Giza 178	F_1	0.667**	0.167**	-0.092**	-0.090**	1.527**	1.472**	0.167**	0.777**	2.792**	0.431**	1.519**	-0.701**	2.456**	-1.844**
	F_2	1.278**	1.472**	-0.094**	-0.083**	3.166**	0.250**	-0.222**	0.889**	2.791**	0.791**	0.403**	0.718	0.225**	-1.513**
NERICA 3	F_1	0.667**	0.556**	0.094**	0.093**	0.305**	0.361**	-0.444**	-0.889**	-1.652**	-0.097	-0.025	0.585**	-0.315**	2.279**
	F_2	0.667**	0.861**	0.105**	0.100**	-0.167**	1.444**	-0.056	-0.667**	-1.875**	-0.486**	-0.826**	0.073	-0.361**	1.357**
NERICA 4	F_1	0.222**	-0.444**	0.114**	0.148**	1.000**	3.972**	-0.556**	-1.222**	-0.986**	0.791**	-2.508**	0.985**	0.388**	3.580**
	F_2	-0.944**	-1.361**	0.122**	0.125**	0.472**	2.694**	-0.778**	-1.444**	-0.819**	0.986**	-1.713**	1.787**	0.101	3.446**
S. E(gi)	F_1	0.132	0.135	0.006	0.004	0.120	0.229	0.135	0.149	0.158	0.141	0.234	0.314	0.190	0.326
	F_2	0.143	0.148	0.007	0.002	0.156	0.208	0.143	0.151	0.121	0.168	0.303	1.428	0.179	0.370

***, ** Significant at 5% and 1% levels, respectively.**
N=Normal condition and S= Stress condition.

Specific combining ability (SCA) effects:

Estimates of SCA in studying combinations; $F_1$and F_2 generations of the studied traits under both normal irrigation and drought-stress conditions are shown in Table 4. The best hybrid combinations reflected that the highest significant values of SCA effects, the cross combinations (Giza178 × NERICA 3) for earliness; (Giza 177 × Giza178) and (Giza177× NERICA 4)for leaf rolling, where recorded the highest negative values of SCA effects under both normal and drought conditions in F_1 and F_2 generations. These results agreed with Elgamal (2007) results on other rice combinations. On the other hand, the high positive values of SCA effects indicate good results of some traits such as grain yield/plant, No. of panicles/plant and spikelets fertility (%) in addition to root thickness. The all cross combinations showed high significant positive values for root thickness and No. of panicles/plant except on hybrid (NERICA 3 × NERICA 4).Four cross combinations (Giza177× NERICA 4); (Giza178× NERICA3); (Giza178× NERICA4) and (NERICA 3 × NERICA 4) showed good results for grain yield/plant under both conditions in F_1 and F_2 generations, respectively. These superior crosses would be practical interest in breeding programs in developing new rice varieties under water stress conditions. Most of the top grain yield performing combinations observed to be constituted from crosses with both or one parent exhibiting significant GCA effects. This is consistent with the notion that parental selection for crop improvement programs can't be based on SCA effects alone, but in association with GCA effects of the parents involved (Abd El-Maksoud *et al.,* 2013; Abd El-Hadi *et al.,* 2014 and Elgamal*et al*., 2015).

Heterosis and inbreeding depression:

Estimation of heterosis over better parent values and inbreeding depression are presented in Table 5. Out of six crosses tested, no crosses recorded negative significant heterosis for days to heading and plant height under both normal and drought conditions except the cross(Giza 178 x NERICA 3) for days to heading in case of drought conditions with high significant negative heterosis values, which are preferred in rice breeding. Two of six crosses (Giza 177 x NERICA 4) and (Giza 178 x NERICA 3) recorded positive significant heterosis for spikelets fertility % under drought conditions due to higher genetic variation between the parents. For root thickness all crosses recorded positive highly significant heterosis values under both normal and drought conditions except the two crosses;(Giza 177 x NERICA3) and (Giza 177 x NERICA 4). For leaf rolling all cross combinations recorded high significant positive values under drought conditions except the two crosses (Giza 177 x Giza 178) and (NERICA 3 x NERICA 4). Regarding to No. of panicles/plant the scored results showed significant and high significant heterosis for the crosses (Giza 178 x NERICA 4) and (Giza 177 x Giza 178) under both normal and drought conditions. Three crosses (Giza 178 x NERICA 3);(Giza 178 x NERICA 4) and (NERICA 3 x NERICA 4) recorded significant positive heterosis for grain yield /plant under normal and drought conditions Mirarab *et al.,*(2011); El-Refaee and Abdulmajid (2011) and Elgamal (2013) got similar results when they studied the heterosis over the better parents on rice F_1's under drought conditions.

For Inbreeding depression in F_2's means the results showed high positive values for most studied traits under both conditions following the high heterosis values, which might be due to the dominance gene action in the inheritance of various traits. Among the different traits highest inbreeding depression value was observed in leaf rolling (66%) under normal condition followed by grain yield/plant (38.89%) under normal condition; No. of panicles/plant (29.41%) under drought condition; spikelets fertility% (13.92) under drought condition and root thickness (7.53%) under normal irrigation condition. Reddy (2004); Elgamal (2013) and Venkanna*et al.,* (2014) studied the heterosis in F_1 followed by inbreeding depression in F_2 and reported the similar results in the case of inheritance of study traits, with the importance of non-additive gene action for grain yield and yield components in rice.

Table 4.Estimates of SCA effects for all studied traits under normal and stress conditions.

Hybrids		Days to heading (day)		Root thickness (mm)		Plant height (cm)		Leaf rolling score		No. of panicles/plant		Spikelet fertility (%)		Grain yield/plant (g)	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 177	F_1	4.844**	2.578**	0.112**	0.136**	4.272**	2.900**	-0.533**	-1.711**	2.144**	1.544**	-12.74**	-5.995**	-1.727**	-0.318
×Giza 178	F_2	5.255**	5.800**	0.044**	0.135**	6.005**	6.105**	-1.167**	-0.911**	1.722**	2.683**	-12.84**	-5.031**	0.562**	0.035
Giza177 ×	F_1	2.178**	8.522**	0.125**	0.070**	7.494**	4.011**	-0.588**	-0.044	1.255**	3.905**	-9.390**	-1.461**	-2.345**	-0.658
NERICA3	F_2	3.866**	5.078**	0.078**	0.102**	3.838**	10.911**	1.333**	-0.022	0.555**	0.627**	-5.61**	-4.819**	0.732**	-1.156**
Giza177 ×	F_1	3.067**	1.522**	0.156**	0.131**	9.966**	18.40**	-0.477**	-0.378**	0.422**	1.016**	0.280	4.472**	0.535**	4.526**
NERICA4	F_2	1.811**	1.300**	0.111**	0.076**	8.200**	14.82**	-0.611**	-0.577**	-0.500**	0.489**	-0.730	-7.483**	-3.330**	2.652**
Giza178 ×	F_1	-1.933**	-8.256**	0.134**	0.142**	4.133**	12.40**	0.078	-0.156	2.144**	2.183**	3.130**	8.372**	9.134**	6.870**
NERICA3	F_2	-0.744**	-2.033**	0.122**	0.143**	7.033**	8.272**	-0.056	0.978**	0.333**	1.544**	-5.550**	0.050	-3.840**	2.629**
Giza178 ×	F_1	0.956**	3.411**	0.181**	0.203**	1.105**	2.122**	0.188	0.178	2.644**	1.627**	-3.220**	-2.361**	4.697**	3.608**
NERICA4	F_2	2.200**	1.522**	0.155**	0.168**	1.894**	-0.977**	-0.333**	-0.244	2,611**	0.572**	-0.730	3.169	-2.302**	3.896**
NERICA3	F_1	4.289**	1.022**	-0.021**	0.036**	5.994**	1.566**	-0.200	-0.156	1.422**	-0.178	-4.680**	-3.081**	9.919**	1.775**
× NERICA4	F_2	1.811**	1.800**	-0.011	-0.032**	3.727**	3.994**	-0.167	0.644**	0.778**	0.100	-4.790**	-0.953	10.874**	-2.095**
S. E(Sij)	F_1	0.319	0.328	0.016	0.011	0.291	0.556	0.328	0.361	0.384	0.341	0.569	0.762	0.462	0.790
	F_2	0.347	0.359	0.017	0.006	0.377	0.505	0.348	0.366	0.294	0.408	0.733	3.458	0.435	0.897

***, ** Significant at 5% and 1% levels, respectively.**
N=Normal condition and S= Stress condition.

Table 5. Estimation of heterosis over better parent (H%) and inbreeding depression (ID%) foe all studied traits under normal (N) and stress (S) conditions.

Hybrids		Days to heading (day)		Root thickness (mm)		Plant height (cm)		Leaf rolling score		No. of panicles/plant		Spikelet fertility (%)		Grain yield/plant (g)	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S
Giza 177 x	H%	12.46**	9.69**	20.00**	21.05**	20.63**	33.66**	0.00	-54.49**	13.56**	21.05**	-24.51**	-9.96**	-1.60	12.02*
Giza 178	ID%	-1.90	-3.77	7.53	0.67	-1.75	-5.56	-50.00	-66.67	12.50	-6.67	4.11	4.55	5.00	4.17
Giza177 ×	H%	9.61**	16.26**	2.395	-3.070*	22.75**	33.66**	33.00	54.49**	10.87	51.47**	-22.60**	-2.04	-4.86	-9.58**
NERICA3	ID%	-1.94	2.68	6.63	-0.61	5.17	-11.11	-50.00	-66.67	11.76	29.41	-1.33	16.00	0.00	14.29
Giza177 ×	H%	9.61**	7.96**	5.232**	1.142	26.10**	60.20**	67.00	66.67**	9.78	2.25	-14.99**	2.80*	4.31	5.80
NERICA4	ID%	0.98	0.96	5.95	5.71	4.17	2.75	0.00	0.00	11.76	13.33	0.00	13.92	15.00	11.76
Giz178 ×	H%	0.33	-7.72**	4.117*	5.084**	13.78**	26.84**	33.00	44.33**	5.93	34.21**	-5.31**	12.33**	30.12**	21.82**
NERICA3	ID%	-3.00	-9.47	2.37	1.69	-2.56	3.74	0.00	-33.33	10.00	11.76	12.79	13.25	38.89	21.05
Giza178 ×	H%	6.23**	7.05**	7.909**	7.978**	9.73**	15.44**	66.00	66.67**	11.86*	16.85*	-15.02**	-5.95**	21.06**	9.65**
NERICA4	ID%	-1.96	0.00	2.86	0.00	-0.87	6.00	66.00	-50.00	4.55	11.11	-1.30	-5.63	28.00	8.33
NERICA3	H%	9.69**	5.03**	6.857**	8.947**	15.07**	16.90**	0.00	0.00	22.50**	1.12	-14.52**	-5.21**	47.22**	16.69**
x NERICA4	ID%	2.83	-1.92	0.00	2.12	3.39	-3.06	0.00	0.00	12.50	6.67	1.35	2.78	7.69	21.05
LSD H%	1%	1.053	1.082	0.079	0.037	0.960	1.830	1.082	1.189	1.267	1.260	1.875	2.513	1.522	2.605
	5%	0.684	0.703	0.051	0.024	0.624	1.189	0.703	0.773	0.823	0.732	1.218	1.636	0.989	1.692

***, ** Significant at 5% and 1% levels, respectively.**
N=normal condition and S= stress condition.
H%= heterosis over better parentandID= inbreeding depression.

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إستخدام أصناف أرز أفريقيه جديده في تحسين تحمل نقص المياه للأصناف المصريه المنزرعه

وليد حسن الجمل ، وليد فؤاد غيضان و أشرف محمد المغازي

مركز البحوث الزراعيه- معهد بحوث المحاصيل الحقليه- قسم بحوث الأرز

تربية الأرز لتحمل الظروف البيئيه القاسيه تعد هدف مهم جدا بالنسبة لمربي الأرز. يحدث نقص معنوي للمحصول نتيجة لظروف الجفاف في معظم دول العالم ومصر خاصة حيث انها تعاني من فقر مائي. تقييم القدره علي التآلف سوف يقدم ويتيح معلومات يمكن أن تستخدم في تطوير سلالات جديدة متحمله للجفافقي الأرز. الدراسه المقدمه أقيمت في المزرعه البحثيه لمركز البحوث والتدريب في الارز بسخا – كفرالشيخ خلال الأعوام من ٢٠١٤ الي ٢٠١٦ و تهدف إلي تحديد القدره علي التآلف والفعل الجيني لصفة المحصول وبعض الصفات المرتبطه بها وتحديد أحسن الآباء والهجن تحت ظروف الجفاف والظروف المثاليه.ستة هجن في الجيل الأول تم الحصول عليها من خلال نظام التزاوج النصف دائري بين أربعة أباء مختلفه بالإضافه الي ستة عشائر من الجيل الثاني عن طريق التلقيح الذاتي لهجن الجيل الاول . كل العشائر الأربعة (الأب الاول والأب الثاني والجيل الأول والجيل الثاني) الخاصه بالستة هجن تم تقييمها في تجربه حقليه للجفاف مقارنة بالظروف الطبيعيه.ظروف الجفاف أثرت بالنقص المعنوي في متوسطات قيم كل الصفات المدروسه للآباء والهجن مقارنة بالظروف الطبيعية.قيم متوسطات المربعات لكل من القدره العامه والخاصه علي التآلف كانت عالية المعنويه لصفة المحصول ومعظم الصفات المدروسه تحت ظروف التجربه.تأثير الفعل الجيني الغير اضافي يلعب الدور الأهم في توريث معظم الصفات المدروسه.الأبين NERICA 3 و NERICA 4 كانا أحسن الآباء محصولا تحت ظروف الجفاف ولهما أكثر قدره عامه علي التآلف بينما كانت الهجن Giza178×NERICA3 وGiza178×NERICA4 وNERICA 3×NERICA4 هم اكثر الهجن للقدره الخاصه علي التآلف بالنسبه الي صفة المحصول و الصفات المتعلقه به تحت الظروف العاديه و ظروف الجفاف لكل من الجيل الأول والجيل الثاني وتأكدت هذه النتائج من خلال القيم العاليه لقوة الهجين مقارنة بأحسن الآباء متبوعة بقيم عاليه للتدهور الناتج في الجيل الثاني نتيجة للتربية الداخليه. لذلك فإن هذة الهجن سوف تكون متاحه لإستخدامها في برنامج التهجين لتحسين صفات المحصول تحت ظروف الجفاف.