J. Plant Production, Mansoura Univ., Vol. 6 (1): 11 - 28, 2015

PERFORMANCE, GENETIC VARIABILITY, AND TRAITS ASSOCIATION OF HYBRID RICE UNDER NORMAL AND DROUGHT ENVIRONMENTS

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ABSTRACT

The present study was carried out at the Experimental Farm, Faculty of Agriculture, Kafrelsheikh University, Egypt during 2011, 2012 and 2013 seasons. Three elite hybrid rice combination namely; IR64608 A x Giza 181, IR64608 A x Gz.1368-5-4 and IR64608 A x Suweon 287R were produced (in 2011) and evaluated beside their four parents (3 pollen parents and the iso genic maintainer of the CMS line IR64608 A) a long with seventeen rice cultivars/ or lines. Such genotypes including 7 of the most commercial rice cultivars, 3 drought tolerant rice varieties, six elite maintainers and IET 1444. All the materials (24 rice genotypes) were grown under two irrigation treatments; drought stress (irrigation every 12 days) and irrigation every 6 days through two successive seasons of 2012 and 2013. The aim of this investigation was to study the response of elite hybrid rice combinations to drought stress compared with a large number of Egyptian and exotic rice cultivars /varieties having a wide range of drought tolerance, determine the association between grain yield and the other agronomic characters under water stressed and non-stressed environments as well as estimate the range of drought susceptibility index for grain yield for the genotypes under study and to sheds light on phenotypic and genotypic coefficients of variability, heritability and genetic advance from selection. The genotypic variance (σ^2 G) was highly significant for all the studied traits, indicating wide range of genetic variability among rice genotypes. Also, the variance due to irrigation treatments (σ^2 T) was highly significant for all characters. Furthermore, G x T interaction was highly significant for all characters except for 1000-grain weight, indicating that the genotypes interacted considerably with environmental changes and 1000-grain weight was more genotypically controlled. The three hybrid rice genotypes involved in this study surpassed all the other genotypes in grain yield, number of panicles/ plant, number of grains/ panicle, number of spikelets/ panicle and panicle length. This was true under drought stress and over the two treatments. The hybrid rice IR64608 A x Suweon 287R recorded the most desirable estimates of grain yield (4.82 and 2.83 ton/fed.), number of grains/ panicle (231 and 160) and number spikelets/ panicle (255 and 205) under normal and drought stress, respectively. Grain yield was significantly correlated with each of panicle length, number of spikelets/ panicle and number of grains/ panicle under stressed and non-stressed environments. While, it was significantly correlated with days to 50% heading under drought stress and with number of panicles/ plant under higher moisture environment. The estimates of PCV was maximized in case of sterility percentage (42.9%) followed by number of panicles/ plant, while GCV values were maximized in case of number of panicles/ plant. The differences between PCV and GCV was high for number of grains/ panicle and grain yield, indicating the influence of environment on them but such differences were low in case of the other traits. High broad sense heritability estimates was recorded for days to 50% heading (94.3%), number of panicles/ plant (93.7%), panicle length (89.47%) and number of spikelets/ panicle (86.55%). The desirable genetic gain from selection was found to be associated with high heritability estimates in case of number of panicles/ plant and number of spikelets/ panicle. Moroberekan, Hexi 41B, IET1444, IR68884 B, WAB 878 and IRAT 170 detected the lowest DSI values however, their grain yield was still low compared with the hybrids and most of the other genotypes under drought stress.

INTRODUCTION

Rice is the most important grain crop worldwide, especially in developing countries for direct human food consumption. Drought stress is a serious limiting factor in rice production and yield stability in the world (Dwivedi and Pandey, 2012). So, rice researchers should improve both water management system and rice characteristics (Tota and Lam, 2011). Rice used about 30% of the fresh water used for agricultural crops worldwide, exploring ways to reduce water use for rice production is essential for sustainable crop production of the world facing water scarcity (Molden *et al*., 2010).

The effect of drought varies with the variety, degree and duration of stress (Dwivedi and Pandey, 2012). There is a lack of information on the response of hybrid rice varieties to drought stress or under water saving crop management. Genetic improvement in drought tolerance in rice is the key to save water of sustainable agriculture (Sangram *et al*., 2011). Breeding strategy in rice mainly depends upon the degree of association among characters as well as its magnitude and nature of variation (Zahid *et al*., 2006). Grain yield was positively correlated with each of number of panicles/ plant, number of grains/ panicle (Bughio *et al*., 2009, Yan *et al*., 2011 and Ramanjaneyulu *et al*., 2014); plant height, panicle length (Aditya and Bhartiya, 2013 and Shabier *et al*., 2013) and heading date (Lakshmi *et al*., 2014 and Sarker *et al*., 2014). High heritability estimates coupled with high genetic advance was detected for number of grains/ panicle, number of panicles/ plant and grain yield (Bughio *et al*., 2009). Yadav *et al*. (2010) reported that plant height, seed yield, grain weight and number of spikelets/ panicle had heritability estimates associated with high genetic advance. Medium to high heritability estimates were observed for days to 50% heading, 1000-grain weight, number of panicles/ plant (Idris and Mohamed, 2013). Days to flowering and plant height showed high heritability under water stress condition (Sellammal *et al*., 2014). Genotypic (GCV) and phenotypic (PCV) coefficient of variability are useful in detecting the amount of variability among genotypes (Idris *et al*., 2012). The coefficient of variability in rice has been investigated by many researchers (Lal and Chauhan, 2011; Devi *et al*., 2012; Seyoum *et al*., 2012 and Ganapati *et al*., 2014). Some of these studies showed that the highest GCV and PCV, heritability and genetic advance were recorded for number of grains/ panicle, grain yield and 1000-grain weight (Bhadru *et al*., 2012). The main objectives of this investigation were to:

1-Study the response of elite hybrid rice combinations to drought stress compared with a large number of Egyptian and exotic rice varieties having a wide range of drought tolerance.

2-Determine the association between grain yield and the other agronomic characters under water stressed and non-stressed environments.

3-Estimate the range of drought susceptibility index for grain yield for the genotypes under study as well as to sheds light on phenotypic and genotypic coefficients of variability, heritability and genetic advance from selection

MATERIALS AND METHODS

The present study was conducted during 2011, 2012 and 2013 seasons at the experimental farm, Faculty of Agriculture, Kafrelsheikh University, Egypt. Twenty four rice genotypes were involved in this study. Such genotypes comprises three elite hybrid rice combinations namely; IR64608 A x Giza 181, IR64608 A x Gz.1368-5-4 and IR64608 A x Suweon 287R beside their parents (4 parents) as well as three drought tolerance genotypes (kindly provided by RRTC, Egypt; IRAT 170, Moroberekan and WAB 878) along with 7 of the most commercial rice cultivars; Sakha 101, Sakha 102, Sakha 104, Sakha 105, Sakha 106, Giza 177 and Giza 178. The remaining genotypes including IET 1444 rice variety and six maintainer lines viz. Hexi 41 B, Yimi 15 B, Hexi 35 B, Dian Yu B, IR68884 B and D297 B (kindly provided by Prof. El-keredy, Agronomy Department Faculty of Agriculture, Kafrelsheikh University, Egypt). Suitable amount of F_1 hybrid seed for the aforementioned hybrids were produced in summer 2011 through crossing between the cytoplasmic male sterile line IR64608A with the respective pollen parents of the hybrids.

The evaluation experiment was conducted during two successive seasons of 2012 and 2013. Sowing date was on 1 and 3 May in the two seasons, respectively. Thirty days old seedlings of each genotype were transplanted individually in seven rows, five meters long and 20 cm among hills and rows. Two irrigation treatments were applied; the first, flush irrigation every twelve days without standing water after irrigation (As a drought stress environment) and the second was watering every six days (as a treatment not significantly differed from normal irrigation and take less amount of water). A randomized complete block design with three replications was applied for each water treatment. The stress was applied after two weeks from transplanting till harvest. All standard agronomic recommendations were followed. Observations were recorded on an individual plant basis for nine characters namely; number of days to 50% heading, plant height, panicle length, number of spikelets/ panicle, number of grains/ panicle, sterility percentage, number of panicles/ plant, 1000- grain weight. While, grain yield was determine from the total weight of grain from each plot (the five inner rows) and then converted to calculate grain yield (ton/ fed).

Analysis of variance was conducted for each season according to Snedecor and Cochran (1967). The variances of the error from separate analysis of the data were subjected to homogeneity test (Bartlett, 1937). The combined analysis was computed for the data of the two seasons according to Cochran and Cox (1957). Phenotypic and genotypic coefficients of variability were estimated according the method stated by Burton (1952). The phenotypic correlation as well as the expected genetic advance from selection was estimated according to Johnson *et al*., (1955). Broad sense heritability over irrigation treatments was calculated following Singh and Chaudhary (1985). Drought Susceptibility index (DSI) was calculated according to the formula of Ali et al., (1990):

DSI = NS-S/NS, where:

NS: is yield under normal conditions, S: is yield under drought conditions. Duncan's multiple rang test was used for the comparison between environments means (Duncan, 1955).

RESULTS AND DISCUSSION

Response of hybrid rice to drought stress:

a) Irrigation treatments:

As shown in Table (1), irrigation treatments had highly significant effects on all the studied characters. Subjecting rice genotypes to drought stress resulted in unfavorable effects on all the studied traits except plant height, as it reduced plant height by about 10 cm averaged over 24 rice genotypes and two years. Prolonged irrigation intervals from 6 to 12 days reduced grain yield from 3.5 to 2.16 ton/fed., 1000-grain weight from 23.5 to 22.7 g, number of panicles/plant from 14.7 to 13.5, number of grains/ panicle from 124.4 to 104.7 and panicle length from 22.3 to 21 cm.

The reduction in growth, grain yield and yield related characters under drought stress may be due to decreasing the activity of meristimic tissue, reduction in net photosynthetic availability by reducing leaf area and increasing stomatal resistance as well as decreasing in enzymes and photochemical activities (Sinha *et al*., 1982). Similar decreases in plant characters due to drought stress were also obtained by Adhikary *et al*. (1999), kumar *et al*. (2007) and Sellammal et al. (2014).

b) Varietal differences and interaction:

Rice genotypes differed from each other in their performance in all the studied traits (Table 1). WAB 878, Moroberekan and the hybrid rice IR64608 A x Suweon 287R recorded significantly the highest number of days to 50% heading (128, 127 and 120 days for the aforementioned genotypes, respectively). On the other hand, Sakha 105 rice cultivar was the earliest genotypes as it headed after 95 days from sowing. The differences among rice genotypes for heading date may be due to genetic variability. Heading date was significantly affected by the interaction between genotypes and water treatments (Table 2). The mean value of heading date was maximized in case of WAB 878 under high moisture conditions, while such estimates was maximized in case of Moroberekan under drought conditions.

Giza 178 rice cultivar recorded significantly the shortest plant stature (80.3 cm) compared with the other genotypes followed by D297 B (Table 1). On contrary, Moroberekan and IR68884 B recorded the tallest plants. Plant height was significantly affected by the interaction between rice genotypes and water treatments. D297 B gave the minimum value for plant height under drought stress while, Giza 178 detected the shortest plant height compared with the other genotypes under watering every 6 days (Table 2).

Rice genotypes were significantly differed in their panicle length. The maximum values was recorded for the three hybrid rice combinations with a value of 27.8 cm for IR64608 A x Giza 181, 27.3 cm for IR64608 A x Gz.1368-5-4 and 26.4 cm for IR64608 A x Suweon 287R (Table 1). IR64608 A x Giza 181 recorded the longest panicles under high moisture treatment;

28.5 cm (Table 2). While, such estimates were minimized in case of Dian Yu B. However, the hybrid rice IR64608 A x Gz.1368-5-4 exhibited the longest panicles under drought stress (27.5 cm). These results were in accordance with those reported by El-Keredy *et al*. (2007).

Highly significant differences among rice genotypes were detected for number of spikelets/ panicle and number of grains/ panicle (Table1). IR464608 A x Suweon 287 R revealed significantly the most desirable estimates, 230.3 and 195.5 for the aforementioned two traits respectively. The previous results were in general agreement with those of El-Keredy *et al*. (2003). The interaction between rice genotypes and water treatments was significant for number of spikelets/ panicle and number of grains/ panicle (Table 2). Generally, the three hybrid rice combinations detected the most favorable estimates for these two traits under drought stress and normal environments. The hybrid rice IR64608 A x Suweon 287R gave the most desirable number of spikelets/ panicle (255.7) and grains/ panicle (231) under non-stressed environment while, such estimates were 205 and 160, under drought stress, for number of spikelets/ panicle and number of grains/ panicle, respectively.

Large variations among rice genotypes were detected for sterility percentage. IR64608 A x Giza 181 rice hybrid and IRAT 170 recorded higher sterility percentage compared with the other genotypes while, Giza 177 and Giza 178 rice cultivars revealed the most desirable value of sterility percentage; 5.82% and 6.3%, respectively (Table 1). Under high moisture conditions (watering every 6 days), Gz.1368 rice variety recorded the most favorable value for sterility percentage (4.4%) while, under water stress conditions the most desirable estimates were recorded for Giza 177 and Giza 178; 6.7 and 7.0%, respectively (Table 2).

Rice genotypes were significantly differed in their number of panicles / plant. IR64608 A x Giza 181 and IR64608 A X Gz. 1368-5-4 revealed significantly the highest number of panicles/ plant (21.3 and 20.2, respectively). The maximum number of panicles/ plant was recorded for IR64608 A x Giza 181 (22.3) under watering every 6 days while, it was minimized in case of Moroberekan under drought stress (Table 2). Large variation among rice genotypes were detected for 1000-grain weight (Table 1). IR64608 B and IRAT 170 recorded the heaviest 1000-grain weight (25.7g) followed by Sakha 105 (25.4 g) and Giza 177 (25.3 g) as a mean of two irrigation treatments. However, the interaction between genotypes and water treatment was not significant for 1000-grain weight, indicating that 1000-grain weight was more genotypically controlled. As shown in Table (1), the three hybrid rice combinations were the most desirable for grain yield. Such estimates were maximized in case of the hybrid rice IR64608 A x Suweon 287R (3.82 ton/fed.) followed by IR64608 A x Gz.1368 (3.56 ton/fed.) and IR64608 A x Giza 181 (3.39 ton/fed).

Table (1): Means of grain yield and its related characters beside drought susceptibility index (DSI) as influenced by irrigation treatments and genotypes over the two seasons.

Variable	Days to 50% heading (day)	Plant height (cm)	Panicle length (cm)	Number of spikelets/ panicle	Number of grains/ panicle
Irrigation treatments (T)					
6 days	110.2b	98.7a	22.3a	138.8a	124.4a
12 days	110.6a	88.9b	21.0b	126.1b	104.7b
F. test	**	**	**	**	**
Genotypes (G)					
IR64608 A x R1	119.5	94.1	27.8	183.1	143.5
IR64608 A x R2	116.5	95.7	27.3	168.2	155.0
IR64608 A x R3	120.0	103.4	26.4	230.3	195.5
Giza 181 (R1)	113.5	89.1	25.0	132.3	108.8
Gz1368-5-4 (R2)	109.0	88.5	18.8	101.0	92.9
Suweon 287R (R3)	117.0	84.0	23.0	130.0	108.8
IR64608 B	116.5	88.5	23.3	144.2	120.8
Sakha 101	110.5	83.7	21.2	118.0	103.0
Sakha 102	102.5	98.1	20.0	110.0	97.8
Sakha 104	106.0	92.1	18.3	121.2	101.9
Sakha 105	95.5	86.3	18.9	111.8	95.0
Sakha 106	97.5	84.6	18.2	101.0	86.5
Giza 177	100.5	97.5	20.0	99.1	93.3
Giza 178	106.5	80.3	22.1	136.8	128.2
IRAT 170	114.5	89.4	21.0	115.8	90.7
Moroberekan	127	119.5	23.2	128.6	106.3
WAB 878	128	82.6	23.6	135.5	117.5
Hexi 41 B	111.5	108.1	20.9	138.4	120.2
Yimi 15 B	113.0	95.4	19.5	112.6	102.0
Hexi 35 B	105.5	101.6	18.3	142.9	128.2
Dian YU B	108.5	101.2	17.0	143.3	127.8
IR68884 B	99.5	113.3	24.0	141.5	121.3
D297 B	102.5	81.7	21.9	112.5	95.8
IET 1444	109.0	91.7	20.2	121.0	108.1
F. test	**	**	**	**	**
L.S.D. (0.05)	0.9	3.8	1.0	10.8	8.2
Interaction (G x T)	**	**	**	**	**

R1= Giza 181 R2 = Gz.1368-5-4 R3 = Suweon 287R
****: Significant at 0.01 level of probability.**

Table (1): continue.

Variable	Sterility (%)	Number of panicles/ plant	1000-grain weight (g)	Grain yield (ton/fed.)	DSI
Irrigation treatments (T)					
6 days	10.1b	14.7a	23.5a	3.51a	-
12 days	16.4a	13.5b	22.7b	2.16b	0.38
F. test	**	**	**	**	
Genotypes (G)					
IR64608 A x R1	21.6	21.3	23.9	3.39	0.44
IR64608 A x R2	8.0	20.2	22.7	3.56	0.42
IR64608 A x R3	15.8	17.6	24.4	3.82	0.41
Giza 181 (R1)	17.9	19.8	22.9	2.78	0.32
Gz1368-5-4 (R2)	8.0	18.4	21.7	3.1	0.46
Suweon 287R (R3)	16.3	19.7	19.6	2.29	0.46
IR64608 B	16.2	14.4	25.7	2.88	0.32
Sakha 101	12.8	11.7	24.9	3.11	0.52
Sakha 102	11.2	12.7	24.9	2.86	0.36
Sakha 104	16.3	12.1	24.2	2.48	0.32
Sakha 105	15.2	11.8	25.4	2.68	0.44
Sakha 106	14.6	10.2	24.1	2.40	0.46
Giza 177	5.82	11.8	25.3	2.58	0.46
Giza 178	6.3	17.4	18.8	2.90	0.42
IRAT 170	19.4	12.1	25.7	2.67	0.29
Moroberekan	17.4	5.6	23.9	2.34	0.13
WAB 878	13.3	11.1	20.7	2.67	0.27
Hexi 41 B	12.0	10.5	23.8	2.71	0.19
Yimi 15 B	9.5	16.2	23.2	2.51	0.55
Hexi 35 B	10.3	12.4	22.9	3.24	0.35
Dian YU B	10.9	11.1	23.0	2.71	0.48
IR68884 B	14.2	8.1	21.1	2.42	0.27
D297 B	15.2	16.3	21.3	2.76	0.46
IET 1444	10.7	15.6	19.9	3.21	0.26
F. test	**	**	**	**	
L.S.D. (0.05)	1.7	1.5	1.3	0.22	
Interaction (G x T)	**	*	ns	**	

R1= Giza 181 R2 = Gz.1368-5-4 R3 = Suweon 287R

***, ** and ns: Significant at .05 and .01 levels of probability and not significant, respectively**

Table (2): Means of the studied characters as influenced by the interaction between rice genotypes and irrigation treatments (data over two seasons).

Variable	Days to 50% heading (day)		Plant height (cm)		Panicle length (cm)		Number of spikelets/ panicle	
	Irrigation treatments (day)		Irrigation treatments (day)		Irrigation treatments (day)		Irrigation treatments (day)	
	6	**12**	**6**	**12**	**6**	**12**	**6**	**12**
IR64608 A x R1	117	122	98.6	89.7	28.5	27.0	187.7	178.5
IR64608 A x R2	116	117	100.0	91.3	27.0	27.5	190.7	145.7
IR64608 A x R3	118	122	108.1	98.7	26.5	26.2	255.7	205.0
Giza 181 (R1)	113	114	97.3	80.8	25.6	24.4	139.3	125.3
Gz1368-5-4 (R2)	107	111	102.0	75.0	19.2	18.3	102.0	100.1
Suweon287R (R3)	114	120	95.0	73.0	23.8	22.2	137.3	122.7
IR64608 B	117	116	94.0	82.9	24.3	22.6	146.0	142.3
Sakha 101	110	111	90.0	77.4	21.9	20.5	124.0	112.0
Sakha 102	101	104	103.8	92.5	20.7	19.3	114.7	105.3
Sakha 104	106	106	97.7	86.5	18.0	18.6	130.1	112.3
Sakha 105	95	96	94.7	78.0	20.4	17.3	123.7	100.0
Sakha 106	97	98	88.2	81.1	18.7	17.6	107.3	94.7
Giza 177	100	101	95.1	99.9	21.5	18.0	105.6	92.5
Giza 178	108	105	84.2	76.5	22.6	21.6	139.2	134.4
IRAT 170	116	113	93.8	85.0	21.3	20.6	114.0	117.6
Moroberekan	126	128	125.1	113.9	23.4	23.0	131.0	125.9
WAB 878	130	126	85.0	80.1	23.2	23.9	136.3	134.7
Hexi 41 B	112	111	107.7	108.4	21.5	20.3	139.8	136.9
Yimi 15 B	114	112	96.9	94.0	21.3	17.6	118.1	107.0
Hexi 35 B	108	103	105.1	98.2	19.4	17.2	150.8	135.0
Dian YU B	109	108	103.6	98.8	17.6	16.4	150.3	136.3
IR68884 B	101	98	115.9	110.7	25.0	23.0	141.7	141.3
D297 B	100	105	91.0	72.4	23.5	20.2	120.0	105.0
IET 1444	110	108	95.0	88.3	20.9	19.4	126.7	115.3
L.S.D. (0.05)	1.0		5.3		1.3		15.3	

R1= Giza 181 **R2 = Gz.1368-5-4** **R3 = Suweon 287R**

Table (2): continue.

Variable	Number of grains/ panicle		Sterility (%)		Number of panicles/ plant		Grain yield (ton/fed.)	
	Irrigation treatments (day)		Irrigation treatments (day)		Irrigation treatments (day)		Irrigation treatments (day)	
	6	**12**	**6**	**12**	**6**	**12**	**6**	**12**
IR64608 A x R1	151.0	136.0	19.5	23.7	22.3	20.2	4.35	2.43
IR64608 A x R2	178.0	132.0	6.7	9.2	20.9	19.5	4.50	2.62
IR64608 A x R3	231.0	160.0	9.6	21.9	18.0	17.2	4.82	2.83
Giza 181 (R1)	117.0	100.7	16.0	19.7	20.0	19.5	3.30	2.25
Gz1368-5-4 (R2)	97.4	88.3	4.4	11.6	18.8	18.0	4.01	2.18
Suweon287R (R3)	119.0	98.7	13.2	19.4	20.1	19.8	2.98	1.60
IR64608 B	130.0	111.7	10.9	21.5	15.0	13.8	3.43	2.32
Sakha 101	111.7	94.3	9.9	15.7	12.2	11.2	4.19	2.02
Sakha 102	105.0	90.7	8.4	14.0	13.2	12.1	3.48	2.23
Sakha 104	118.5	85.3	8.9	23.8	14.5	9.6	2.95	2.00
Sakha 105	108.0	82.0	12.5	17.9	12.7	10.8	3.43	1.93
Sakha 106	96.3	76.7	10.2	19.0	12.0	8.3	3.11	1.68
Giza 177	100.3	86.3	5.0	6.7	11.5	12.0	3.34	1.81
Giza 178	131.3	125.0	5.6	7.0	18.0	16.7	3.66	2.13
IRAT 170	94.7	86.7	16.9	21.8	12.0	12.1	3.12	2.22
Moroberekan	109.7	103.0	16.5	18.2	5.9	5.3	2.50	2.18
WAB 878	119.3	115.7	12.5	14.1	11.4	10.7	2.98	2.35
Hexi 41 B	126.3	114.0	7.3	16.7	10.2	10.8	3.00	2.42
Yimi 15 B	111.0	93.0	6.0	13.0	16.0	16.3	3.46	1.56
Hexi 35 B	137.3	119.0	8.8	11.8	14.0	10.8	3.93	2.55
Dian YU B	139.3	116.3	7.3	14.6	12.6	9.6	3.57	1.85
IR68884 B	126.7	116.0	10.6	17.9	9.0	7.2	2.77	2.10
D297 B	109.7	82.0	8.4	22.0	15.7	16.8	3.59	1.93
IET 1444	116.3	99.9	8.1	13.2	16.2	15.0	3.69	2.72
L.S.D. (0.05)	11.5		2.4		2.1		0.32	

R1= Giza 181 **R2 = Gz.1368-5-4** **R3 = Suweon 287R**

High grain yield of hybrid rice genotypes may be attributed to large panicles, high number of grains/ panicle and high number of tillers bearing panicles. The interaction between rice genotypes and irrigation treatments was significant for grain yield. The hybrid rice IR64608 A x Suweon 287R gave the highest grain yield (4.82 and 2.83 ton/fed), under normal and drought environments, respectively (Table 2). While, such estimates were minimized in case of Yimi15 B under drought stress. Similar decrease in grain yield due to drought stress was obtained by Sorour *et al*. (1998). Previous results showed that the hybrids were superior to their parents under dry and wet seasons, indicating substantial heterosis in hybrids (Young and Virmani, 1990).

As shown in Table (1), large variation among rice genotypes was recorded for drought susceptibility index (DSI). The results showed that Yimi 15B, Sakha 101 and Dian Yu B exhibited the highest estimates of DSI, 55, 52 and 48% for the previous genotypes, respectively. These results indicating that such genotypes were more affected by water stress. On other side, Moroberekan, Hexi 41B, IET1444, IR68884 B, WAB 878 and IRAT 170 detected the lowest DSI values; 13, 19, 26, 27, 27, and 29%, for the aforementioned genotypes, respectively indicating that these genotypes were more tolerant to drought stress. However, the low estimates of DSI for the aforementioned genotypes, their grain yield was still low compared with the hybrids and most of the other genotypes under drought stress. This may be due to their low yield potentiality under normal irrigation. These results were in general agreement with those reported by Gaballah (2009).

Genetic parameters:

Estimates of variance components, phenotypic (PCV) and genotypic (GCV) coefficient of variability, heritability and genetic advance from selection are presented in Table (3).

The genotypic variance (σ^2 G) were highly significant for all the studied traits, indicating the presence of wide range of genetic variability among rice genotypes. Also, the variance due to irrigation treatments (σ^2 T) was highly significant for all traits. The genotype by environment interaction was significant for all the studied traits except 1000-grain weight, indicating that the genotypes interacted considerably with environmental changes. The non-significant G x T interaction for1000-grain weight indicates that such trait might be genotypically controlled and affected slightly with environmental changes. The estimates of PCV were maximized in case of sterility percentage (42.9%) followed by number of panicles/ plant (30.1%), indicating that these traits might be more genotypically controlled and it would be possible to achieve further improvement from them. GCV estimates ranged from 7.8% for days to 50% heading to 29.1% for number of panicles/ plant. Generally, the phenotypic coefficient of variability was higher than genotypic coefficient of variability. The small differences between PCV and GCV indicating less environmental influence on the expression of differed traits. Previous results showed that the highest genotypic coefficient of variation was detected for sterility percentage followed by grain yield (Mehetre *et al*., 1996). Previous results showed that the maximum PCV and GCV were exhibited by number of spikelets/ panicle followed by number of productive tillers/ panicle (Devi *et al*., 2012).

Heritability estimates in broad sense were high in case of heading date (94.3%), number of panicles/ plant (93.7%), 1000-grain weight (92.9%), panicle length (89.47%) and number of spikelets/ panicle (86.55%). Similar results were reported by Akhtar *et al*. (2011) who reported that the heritability estimates was found to be highest for number of grains/ panicle and heading date. Vice-versa, heritability estimates was moderate for sterility percentage, grain yield, plant height and number of grains/ panicle; 38.7, 41.7, 60.0 and 67.7%, respectively. These results were in accordance with those of Yadav *et al*. (2010). They reported that test weight and number of spikelets/ panicle exhibited high heritability estimates. Previous studies showed that grain yield revealed low heritability estimates (Surek and Korkut, 1998). Other studies illustrated that heritability estimates were high for 1000-grain weight and moderate for number of spikelets/ panicle while, grain yield detected low heritability estimates (El-Mowafi and Abou Shousha, 2003).

The expected genetic advance from selection, as percentage of mean, were maximized in case of number of panicles / plant (58.2%) followed by number of spikelets/ panicle (41.7%), sterility percentage (39.28%) and number of grains/ panicle (35.7%). Such high value may be interpreted that rice genotypes involved in this study have large variation in the previous trait. This may also ensured by high phenotypic coefficient of variability, therefore the improvement of these traits through selection is an important way to achieve further improvement. The desirable genetic gain from selection was found to be associated with high heritability estimates in case of number of panicles/ plant and number of spikelets/ panicle, indicating the major role of additive gene action and the possibility of improving these traits by selection. Also, high heritability estimates coupled with moderate genetic advance was detected for panicle length, indicating the involvement of additive and non-additive type of gene action and postponement of selection programs for the improvement of these traits (Bughio *et al*., 2009). It may be worth to note that high heritability estimates is not always associated with high genetic gain. The aforementioned results were, in general, harmony with those reported by Jakkrit *et al*. (2013). They found that number of fertile grains/ panicle and number of spikelets/ panicle revealed the highest genetic advance from selection. High heritability estimates along with high genetic advance was recorded for number of spikelets/ panicle (Ghosh and Sharma , 2012). Basak and Ganguli (1996) Found high genetic advance combined with high genotypic coefficient of variation (GCV) and high heritability estimates for number of filled grains/ panicle and number of spikelets/ panicle. Furthermore, Sellammal *et al*. (2014) noted that days to 50% flowering showed high heritability estimates under the severe stress conditions.

Correlation:

Correlation among different traits of rice may be useful indicator for indirect selection programs. It help plant breeder to identify traits that have more, little or no importance in crop breeding based on selection program. Breeding strategy in rice mainly depends upon the degree of association among characters as well as its magnitude and nature of variation (Zahid *et* *al*., 2006). The phenotypic correlation coefficient between grain yield and the eight characters on one hand, and among the all the studied characters themselves on the other hand, are presented in Table (4). It is clear from the results that grain yield was significantly and positively correlated with each of panicle length, number of spikelets/ panicle and number of grains/ panicle under both high moisture and drought stress conditions. Such values were (0.29, 0.47), (0.62, 0.66) and (0.66, 0.67) for non-stressed and stressed conditions for the aforementioned traits, respectively. Indicating that such traits are of a great importance toward grain yield either under high moisture or under water stress conditions. Furthermore, grain yield was positively correlated with days to 50% heading under drought condition and with number of panicles/ plant under watering every 6 days.

Previous results showed that the association between grain yield and each of heading date, plant height, panicle length and number of panicles/ plant were significant with positive values (Babar *et al*., 2007). Previous investigations reported that grain yield was positively correlated with each of number of panicles per square meter (Miller *et al*., 1991), number of panicles/ plant (Ashvani *et al*., 1997), number of filled grains/ panicle (Samonte *et al*., 1998) and number of spikelets/ panicle and panicle length (Geethadevi *et al*., 2000). Similar results reported that grain yield was positively correlated with each of number of panicles/ plant, number of grains/ panicle (Bughio *et al*., 2009, Yan *et al*., 2011 and Ramanjaneyulu *et al*., 2014); plant height, panicle length (Aditya and Bhartiya, 2013 and Shabier *et al*., 2013) and heading date (Lakshmi *et al*., 2014 and Sarker *et al*., 2014).

Heading date was significantly associated with positive value with panicle length, number of spikelets/ panicle and number of grains/ panicle under both irrigation environments as well as with sterility percentage (under high moisture conditions) and number of panicles/ plant (under drought stress).

Other inter character correlation revealed that plant height was positively and significantly correlated with number of spikelets/ panicle and number of grains/ panicle. This was true under both environments. On the other hand, it was negatively correlated with number of panicles/ plant under both water treatment, indicating that shorter cultivars produced more panicles/ plant and this may be contribute directly to higher grain yield.

Panicle length was positively and significantly correlated with each of number of spikelets/ panicle, number grains/ panicle/ panicle, sterility percentage and number of panicles/ plant. This was true under stressed and non-stressed conditions.

Positive association was detected between number of spikelets/ panicle with number of grains/ panicle and number of panicles/ plant under both water environment and with sterility percentage under drought stress.

Table (3): Estimates of variance components, phenotypic (PCV), and genotypic (GCV) coefficients of variability, broad sense heritability (h^2bs) and genetic advance (Δ g) for all the studied traits (data over two seasons).

Parameters	Days to 50% heading	Plant height (cm)	Panicle length (cm)	Number of spikelets/ panicle	Number of grains/ panicle	Sterility (%)	Number of panicles/ plant	1000-grain weight (g)	Grain yield (ton/fed.)
Mean ($\bar{X}$)	110.40	93.8	21.60	132.5	114.6	13.29	14.07	23.10	2.83
σ^2 G	74.20**	102.1**	8.84**	833.4**	583.5**	4.07**	4.10**	3.84**	0.15**
σ^2 T	0.08**	47.7**	0.94**	80.23**	192.5**	19.83**	0.70**	0.29**	0.10**
Σ^2 GT	4.39**	20.3**	0.48**	49.30**	85.9**	6.49**	0.43*	ns	0.11**
PCV	8.03	13.9	14.51	23.42	25.6	42.90	30.10	8.80	21.20
GCV	7.80	10.8	13.72	21.79	21.1	16.60	29.10	8.50	13.70
(h^2bs)	94.30	60.0	89.47	86.55	67.7	38.70	93.70	92.90	41.70
(Δ g)	17.23	16.2	5.80	55.30	40.9	5.22	8.19	3.89	0.52
(Δ g (%)	15.60	17.3	26.75	41.70	35.7	39.28	58.20	16.90	18.21

***, ** and ns: Significant at .05 and .01 levels of probability and not significant, respectively.**

Table (4): Phenotypic simple correlation coefficient among the studied characters under drought stress (D) and normal (N) irrigation treatments over 24 rice genotypes and two years.

Characters	Treat.	1	2	3	4	5	6	7	8	9
1- Grain yield	N		0.01	-0.12	0.29*	0.62**	0.66**	-0.16	0.59**	0.07
	D		0.31**	0.23	0.47**	0.66**	0.67**	0.08	0.15	-0.11
2- Heading date	N			0.14	0.44**	0.39**	0.32**	0.39**	0.09	-0.16
	D			0.05	0.65**	0.51**	0.46**	0.23	0.30**	-0.07
3- Plant height	N				0.10	0.26*	0.24*	0.11	-0.33**	0.13
	D				0.05	0.30*	0.34**	-0.07	-0.49**	0.19
4- Panicle length	N					0.59**	0.51**	0.42**	0.39**	-0.12
	D					0.68**	0.64**	0.25*	0.43**	-0.20
5- Number of spikelets/ panicle	N						0.98**	0.19	0.38**	-0.10
	D						0.94**	0.31**	0.25*	-0.12
6- Number of grains/ panicle	N							0.001	0.38**	-0.03
	D							0.004	0.26*	-0.24*
7- Sterility (%)	N								-0.02	0.10
	D								-0.04	0.26*
8- Number of panicles/ plant	N									-0.26*
	D									-0.35**
9- 1000 grain weight	N									
	D									

Number of grains/ panicle was positively correlated with number of panicles/ plant under stressed and non-stressed conditions (0.38 and 0.26, respectively). While, it was negatively associated with 1000-grain weight under drought stress. This may be true that increasing number of grains/ panicle might be reversely reflected on the weight of grains.

Association between sterility percentage and 1000-grain was positive and significant under water stress. On the other hand, number of panicles/ plant was negatively correlated with 1000-grain weight under both environments. This may be due to their compensatory relationship. These results were in general agreement with those obtained by Shabier *et al*. (2013), Sarker *et al*. (2014) and Ramanjaneyulu *et al*. (2014).

From the aforementioned results, it could be concluded that, the hybrid rice genotypes seemed to be superior compared with their parents, traditional commercial rice cultivars and drought tolerant varieties under study. This was true not only under normal irrigation but also under drought stress. The three hybrid rice genotypes involved in this study surpassed all the other genotypes in grain yield, number of panicles/ plant, number of grains/ panicle, number of spikelets/ panicle and panicle length under both environments. The hybrid rice IR64608 A x Suweon 287R recorded the most desirable estimates of grain yield (4.82 and 2.83 ton/fed.), number of grains/ panicle (231 and 160) and number spikelets/ panicle (255 and 205) under normal and drought stress, respectively compared with the other genotypes. Moroberekan, Hexi 41B, IET1444, IR68884 B, WAB 878 and IRAT 170 detected the lowest DSI values; However, their grain yield was still low compared with the hybrids and most of the other genotypes under drought stress.

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دراسة الاداء و الاختلافات الوراثية و معامل الارتباط المظهرى للمحصول و الصفات المتعلقة به فى الارز الهجين تحت الظروف العادية و ظروف الجفاف

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اجريت هذه الدراسة بقسم المحاصيل بكلية الزراعة جامعة - كفر الشيخ و نفذت التجارب الحقلية بالمزرعة التجريبية للكلية خلال اعوام ٢٠١١ و ٢٠١٢ و ٢٠١٣ . و اشتملت هذه الدراسة على ٢٤ تركيب وراثى تمثل ٣ تراكيب وراثية من الارز الهجين (انتجت بذورها عام ٢٠١١) و هى IR64608A x Giza181 و IR64608A x Gz.1368-5-4 و IR64608A x Suweon287R الي جانب الاباء الخاصة بهذه الهجن (ثلاثة اباء مذكرة بالاضافة الى السلالة المحافظة على السلالة IR64608A) و سبعة من اصناف الارز الاكثر انتشارا على النطاق التجاري و ثلاثة من اصناف الارز المستوردة المتحملة للجفاف و ستة من السلالات المتميزة من السلالات المحافظة على الخصوبة (maintainer lines) بالاضافة للصنف IET1444 و تم تقييم هذه التراكيب الوراثية خلال عامى ٢٠١٢ و ٢٠١٣ تحت نظامين من الرى، الاول و يمثل معاملة جفاف و هو الرى كل ١٢ يوم، و الثانى الرى كل ٦ ايام. و يهدف هذا البحث الى دراسة استجابة الارز الهجين لنقص الماء مقارنة بعدد كبير من الاصناف و السلالات ذات المدى الواسع من القدرة على تحمل الجفاف و دراسة الارتباط بين محصول الحبوب و الصفات الاخرى موضع الدراسة و كذلك بين هذه الصفات و بعضها البعض تحت الظروف العادية و ظروف نقص الماء, الى جانب دراسة معامل الحساسية للجفاف للمحصول فى التراكيب الوراثية المختلفة بالاضافة لتقدير معامل الاختلاف المظهرى و الوراثى و درجة التوريث و التقدم الوراثى من الانتخاب. و كانت اهم النتائج المتحصل عليها ما يلى:

كانت قيم التباين الوراثى و البيئى و كذلك التفاعل بينهما عالية المعنوية لجميع الصفات تحت الدراسة ما عدا التفاعل بين البيئة و الوراثة لصفة وزن الالف حبة ، دليلا على وجود مدى واسع من الاختلافات الوراثية بين الاصناف و السلالات موضع الدراسة، و ان الاصناف تستجيب بطريقة مختلفة للتغيرات البيئية و ان العوامل الوراثية ربما تكون الاكثر اهمية فى التعبير عن صفة وزن الالف حبة.

اظهرت النتائج تفوق تراكيب الارز الهجين على الاصناف و السلالات الاخرى فى صفات المحصول و عدد الداليات/ نبات و عدد الحبوب بالدالية و عدد السنيبلات بالدالية و كذلك طول الدالية و قد ظهر هذا التفوق تحت ظروف الجفاف و الظروف العادية.

سجل الهجين IR64608A x Suweon287R افضل القيم لصفات محصول الحبوب (٤.٨٢ و ٢.٨٣ طن/فدان) و عدد الحبوب بالدالية (٢٣١ و ١٦٠) و كذلك عدد السنيبلات بالدالية (٢٥٥ و ٢٠٥) تحت الظروف العادية و ظروف الجفاف على التوالى مقارنة بالتراكيب الوراثية الاخرى.

اظهرت النتائج وجود ارتباط معنوى موجب بين صفة محصول الحبوب و كل من عدد الحبوب بالدالية و عدد السنيبلات بالدالية و طول الدالية فى كل من البيئتين، كذلك كان هناك ارتباط معنوى موجب بين محصول الحبوب و صفة تاريخ الطرد تحت ظروف الجفاف و مع صفة عدد الداليات/ نبات تحت الظروف العادية.

سجلت صفة العقم اعلى القيم لمعامل الاختلاف المظهرى (٤٢.٩%) و تلاها صفة عدد الداليات لكل نبات و قد سجلت الاخيرة اعلى القيم لمعامل الاختلاف الوراثى.

كانت الفروق بين معامل الاختلاف المظهرى و الوراثى كبيرة بالنسبة لصفتى عدد الحبوب بالدالية و محصول الحبوب فى حين كانت هذه الفروق قليلة فى حالة الصفات الاخرى دليلا على التاثير الواضح للبيئة فى التعبير عن تلك الصفتين.

سجلت صفة عدد الايام من الزراعة حتى طرد ٥٠% من النباتات لدالياتها و عدد الداليات/ نبات و طول الدالية و عدد السنيبلات بالدالية اعلى القيم للمكافئ الوراثى (٩٤.٣ و ٩٣.٧ و ٨٩.٤٧ و ٨٦.٥% للصفات السابقة عل التوالى).

اظهرت النتائج ان القيم العالية للمكافئ الوراثى كانت مصحوبة بالقيم العالية للتقدم الوراثى من الانتخاب لصفتى عدد الدليات/ نبات و عدد السنيبلات/ دالية.

سجلت السلالتين Yimi 15B و Dian YuB بالاضافة للصنف Sakha 101 اعلى القيم لمعامل الحساسية للجفاف (٥٥ و ٥٢ و ٤٨% على التوالى) دليلا على حساسيتها الشديدة لنقص الماء، فى حين سجلت التراكيب الوراثية Moroberekan وHexi 41B و IET1444 و IR68884B و WAB878 و IRAT 170 اقل القيم له (١٣ و ١٩و ٢٦ و ٢٧ و ٢٧ و ٢٩% على التوالى) مما يدل على انها اكثر تحملا للجفاف. و على الرغم من القيم المنخفضة لمعامل الحساسية للجفاف للتراكيب الوراثية السابقة الا ان محصولها من الحبوب ما زال اقل من محصول تراكيب الارز الهجين الثلاث و معظم السلالات و الاصناف الاخري موضع الدراسة.