

Effect of Soil Water Deficit on Yield and Its Components at The Different Growth Stages in Rice (*Oryza sativa*)

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TWENTY FIVE rice (*Oryza sativa*) genotypes were evaluated under normal (continues flooding) and drought (irrigation every 12 days) conditions at the experimental farm of the Rice Research and Training Center, Sakha, Kafrelsheikh, Egypt during 2011 and 2012 to study the genetic variability, phenotypic correlation as well as identify the desirable genotypes that could be used as donors in rice breeding program. Combined analysis of variance was performed for data collected on number of panicles plant⁻¹, 100-grain weight (g), sterility percentage (%), grain yield plant⁻¹ (g), Harvest index (%) and water use efficiency (WUE) (kg/m³). Highly significant differences were observed among the genotypes for all studied traits. Genotype × Environment mean squares were highly significant for all the examined traits. The genotypes GZ 1368-S-5-4, Morobrekan, GZ 5121-5-2, WAB 878 and Goari were recorded the best performing entries under the drought conditions for grain yield plant⁻¹ (g) (31.38, 30.98, 29.73, 28.99 and 29.25 g) and some of its related traits and could be used as donors to enhance such traits. Among the studied traits grain yield plant⁻¹ (g) and harvest index (%) had the highest genotypic and phenotypic variances. WUE recorded the lowest genotypic and phenotypic variances under both conditions. The phenotypic coefficient of variability (PCV%) was higher than genotypic coefficient variability (GCV%) under both normal and drought conditions for the all traits indicating the existence of wide genetic variability in these genotypes and that selection to improve such traits could be practiced effectively in the segregating populations after crossing among them. High estimating values of heritability were observed in all the examined traits under the normal and drought conditions except for harvest index under drought stress condition. Highly significant and positive correlation coefficient was determined between grain yield plant⁻¹ and most of the yield attributes under the normal and drought conditions.

Keywords: Normal and drought conditions, Water deficit, Rice (*Oryza sativa*), Grain yield, Yield components, Water stress, Heritability, Water use efficiency.

Drought remains one of the most serious problems in agriculture, rice (*Oryza sativa*) as a submerged crop, is more susceptible to drought stress than other plant species. Shortage of irrigation water is one of the major obstacles for increasing rice production not only in Egypt, but also at the worldwide. According to statistical data, about 50% of the world rice production is affected more or less from the drought conditions (Bouman *et al.*, 2005). In Egypt, rice crop is one of the major water consuming crops and continuous flooding is the only method of irrigation. Rice covered area in Egypt 700000 ha (FAO, 2013). Some rice varieties cultivated areas which are located at the end of the irrigation canals in the northern part of the Nile Delta suffer from shortage of irrigation water that cause drought conditions at the different growth stages, which are considered to be one of the most serious constraints to rice production in Egypt (Abd Allah *et al.*, 2009). Most of cultivated rice varieties are considered as drought sensitive crop varies with stage of growth (Abdel Hafez *et al.*, 2013). Drought mainly influences grain yield by limiting seed numbers, by either influencing the amount of dry matter produced by the time of flowering or by directly influencing pollen or ovule function, which leads to decreased seed set. Secondly, drought influences seed filling mainly by limiting the assimilate supply, leading to smaller seed size and lower yields (Prasad *et al.*, 2008). Drought stress near heading has been shown to reduce grain yield in rice cultivars by inhibiting processes such as anther dehiscence (Liu *et al.*, 2006) and panicle exertion (Ji *et al.*, 2005 and Pantuwan *et al.*, 2002). Furthermore, water deficit also increases the formation of reactive oxygen species (ROS), resulting in lipid peroxidation, protein denaturation and nucleic acid damage with severe consequences affecting the overall metabolism (Hansen *et al.*, 2006). All of these and these kind factors are responsible for the reduction of grain yield under the drought conditions. The main objective of this study was to identify tolerant genotypes to drought conditions depending on some traits associated with drought tolerance to use them as donors in the rice breeding program (s).

Materials and Methods

The present study was carried out at the experimental farm of Sakha Research Station, Kafrelsheikh, Egypt during the 2011 and 2012. Total, 25 genetically diversified rice (*Oryza sativa*) cultivars were used in this study. Seeds were obtained from the Rice Research and Training Center, Field Crops Research Institute, Agriculture Research Center, Egypt.

Field experiments

In 2011 and 2012, seeds of the each cultivar's were sown in the nursery, then they (seedlings) were transplanted into two adjacent experimental fields. The first one was normally irrigated (continuous flooding) and the second one drought was irrigated every 12 days. After thirty days from the sowing, seedlings of each genotype were individually transplanted into their permanent field(s) in seven rows. Each row was five meters long and contained 25 hills with one plant/hill. The soil of experiment was clay in texture containing 1.7-1.55 meq.L⁻¹ of N, 14.8-14.02 ppm for P, 15.50-14.80 meq.L⁻¹ for K, 1.36-1.39% organic

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matter and the pH was 8.15-8.25 as the mean of two seasons. Each experiment was designed in a randomized complete block design (RCBD) with three replications. Package of recommendation for rice growing was applied. Data were taken for these parameters: number of panicles plant⁻¹, 100-grain weight (g), sterility (%), grain yield plant⁻¹ (g), harvest index (%) and water use efficiency (WUE) (kg/m³).

$$\text{Water use efficiency WUE} = \frac{\text{Yield (kg/ feddan)}}{\text{water consumptive use (m}^3\text{/feddan)}}$$

Statistical analysis

The obtained data were statistically analyzed for analysis of variance according to Gomez & Gomez (1984) by using computer statistical software of MSTAT-C. Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). The combined analysis was calculated over the two years and also, for the two environs (normal and drought conditions). Before the calculations of the combined experiments, the error variance of the experiments was tested for the homogeneity of variance as described by Bartlett (1937), the genetic parameters were computed according to formula suggested by Burton (1952) and Hansen *et al.* (1956), and the correlation coefficients between the traits were fixed using Pearson's correlation coefficients.

Results and Discussion

Analysis of variance

Combined analysis of variance for grain yield plant⁻¹ (g) and its components over the two years are presented in Table 1. Year's mean squares were found not significant for all the studied traits except for sterility percentages (%). Environs' mean squares were obtained highly significant and this result is showing that the drought stress has significant effect on the all traits. Drought stress significantly decreased the mean values for all the evaluated traits except sterility percentages. Increased spikelet sterility of rice under water deficit condition at flowering stage has been reported by Liu *et al.* (2006) and Jongdee *et al.* (2002).

Genotypes mean squares were highly significant for all the studied. This indicates the existence of a high degree of genetic variability in the material to be exploited in breeding program, and that also reflected the broad ranges observed for each trait.

Significant differences for the number of panicles plant⁻¹ were detected among genotypes at each environment to the GZ 1368-S-5-4, Giza 178 and Giza 182 were recorded the highest mean values (21.37, 21.05 and 20.28) over all the environments for number of panicles plant⁻¹ while the Sakha 103 and Giza 177 were gave the lowest mean values (15.44 and 15.72) in Table 1.

TABLE 1. Means and combined analysis of variance for yield and its component characters over two years.

Factor	Number of panicles plant ⁻¹	Sterility (%)	100- grain weight (g)	Grain yield plant ⁻¹ (g)	Harvest index (%)	Water use efficiency (kg/m ³)
Year (Y)						
Season 2011	17.728	10.972a	2.433	30.754	28.196	0.624
Season 2012	17.890	10.861b	2.432	30.825	28.345	0.625
F test	ns	*	ns	ns	ns	ns
Environment						
Normal	20.044a	7.920b	2.567a	37.438a	34.968a	0.645a
Drought	15.573b	13.914a	2.297b	24.141b	21.573b	0.604b
F test	**	**	**	**	**	**
Genotype (G)						
Giza 159	17.99fg	12.18cd	2.36efg	26.63 kl	26.99g-k	0.56ij
Giza 175	16.15j-m	12.07cd	2.17ij	28.81 I	27.24g-k	0.57hij
Giza 176	16.03j-m	15.63a	2.11j	30.86 fgh	22.94n	0.61dfg
Giza 177	15.72lm	11.75def	2.43c-f	30.95fg	36.80a	0.61def
Giza 178	21.05ab	9.32l	2.28ghi	36.62a	30.68cd	0.74a
Sakha 101	16.79h-k	11.94de	2.46c-f	33.04c	26.78i-l	0.65bc
Sakha 102	16.69i-l	11.27efg	2.37efg	30.85fgh	30.35de	0.61def
Sakha 103	15.44m	13.24b	2.21hij	32.08cde	28.76efg	0.64cd
Sakha 104	19.33de	11.50def	2.54c	32.59cd	29.25def	0.65bc
GZ 1368-S-5-4	21.37a	8.53mn	2.42c-f	35.81ab	27.85f-j	0.74a
GZ 5121-5-2	19.82cd	9.12lm	2.50cd	36.45a	28.65e-h	0.74a
Giza 182	20.28bc	11.23fg	2.38d-g	27.93ij	24.45mn	0.55j
Agmi	16.63i-l	9.19l	2.36efg	25.66i	24.61m	0.52k
Goari	19.30de	11.79def	2.55c	32.26cd	32.44b	0.67b
Nabatat Asmar	17.46ghi	12.13cd	2.44c-f	31.06efg	26.68jkl	0.61def
IRAT 170	16.05j-m	10.75gh	2.49cde	26.4kl	28.51f-i	0.55jk
IRAT 112	15.91klm	11.77def	2.34fgh	28.36i	30.87bcd	0.59fgh
Milyang 93	15.91klm	10.21hij	2.25ghi	28.23i	32.09bc	0.58ghi
IET 1444	18.73ef	9.50kl	2.43c-f	31.85def	25.15lm	0.65bc
Suweon 360	18.13fg	10.29hi	2.19ij	30.27gh	26.01klm	0.62de
Yun Len 4	16.95hij	9.62jkl	2.70b	27.14jk	26.96h-k	0.57hij
WAB 878	19.57cde	8.24n	2.80b	32.64cd	29.15def	0.68b
Morobrekan	18.11fg	8.99lm	3.17a	35.22b	27.31g-k	0.73a
Suweon 349	18.18fg	9.97ijk	2.33fgh	29.8h	26.92h-k	0.61def
E. Yasmine	17.64gh	12.69bc	2.53c	28.25i	29.34def	0.56hij
F test	**	**	**	**	**	**
Interaction						
G*Y	**	**	**	**	*	**
G*E*Y	ns	**	*	ns	ns	ns

*, ** and ns indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means within the same column of each factor followed by a common letter are not significantly different at the 5% level, according to DMRT.

The lowest sterility percentages were found in the WAB 878, GZ 1368-S-5-4 and Morobrekan, (8.24, 8.53 and 8.99) while it was higher in the Giza 176 and Sakha 103 (15.63 and 13.24). Similarly, Morobrekan, WAB 878 and Yun Len 4 had the maximum 100 grain weight (13.7, 2.80 and 2.70).

On the other hand, the Giza 177, IRAT 112, Milyang 93 and Gaori were given the highest mean values for harvest index percentage comparing with other genotypes (36.80, 30.87, 32.09 and 32.44) in Table 1.

The highest grain yield plant⁻¹ was found in the Morobrekan, GZ 1368-S-5-4, GZ 5121-5-2 and Giza 178 with highest values ranged from 32.0 to 36.0 g while, the lowest grain yield plant⁻¹ were seen with the Agmi, IRAT170, Giza 159 and Yun Len 4 with the values ranged from 25.66 to 27.14 g in Table 1.

Concerning WUE, the genotypes Giza 178, Morobrekan, GZ 1368-S-5-4 and GZ 5121-5-2 were found the most efficient in water use with values ranged from 0.7 to 0.74 kg/m³. While, the varieties Agmi and E. Yasmin was given the lowest mean values, ranged from 0.52 to 0.56 kg/m³.

Variation and interactions

The interaction between genotype and environment was highly statistically significant for all the studied traits (Table 1). The tested genotypes varied from environment to the other and ranked differently from normal to stress conditions. This interaction genotype x year were significant for all of the investigated traits, while genotype x environment x year interactions were not found statistically significant except for 100-grain weight (g) and sterility percentage (%) were significant, indicating that the performance of the genotypes in each environment will not be changed from year to year.

Table 2 shows that interaction between genotypes and environments had significant effect on number of panicles plant⁻¹, sterility (%) and 100-grain weight (g).

Significant reduction in number of panicles plant⁻¹ was observed under drought conditions compared with the non-stress conditions in the Giza 178, IET 1444 and GZ 1368-S-5-4 had the highest mean values under both normal and drought conditions except in the IET 1444 under the drought conditions while IRAT 170 under normal condition and Sakha 103 under drought conditions gave the lowest mean. These results were in agreement with those reported by Abd Allah (2010), Singh *et al.* (2010) and Krishnan *et al.* (2011).

TABLE 2. Number of panicles plant⁻¹, sterility (%) and 100-grain weight (g) as affected by the interaction between genotypes and environments over two years.

Genotype	number of panicles plant ⁻¹		Sterility (%)		100-grain weight (g)	
	NS	DS	NS	DS	NS	DS
Giza 159	22.05cde	13.93t-w	7.29opq	17.07bc	2.51f-j	2.22no
Giza175	18.77j-m	13.53uvw	6.92p-s	17.23b	2.32j-o	2.01p
Giza 176	18.95i-m	13.10vw	10.60kl	20.67a	2.52e-j	1.71q
Giza 177	19.67g-k	11.78xy	7.26opq	16.23cd	2.60c-h	2.26l-o
Giza 178	23.53ab	18.58klm	7.10opq	11.53ij	2.32j-o	2.25mno
Sakha 101	20.52fgh	13.07vw	7.66opq	16.22cd	2.53e-i	2.40i-n
Sakha 102	18.53k-n	14.85tu	7.12opq	15.43d	2.56d-i	2.18op
Sakha 103	19.61g-k	11.27y	9.02n	17.46b	2.42h-m	2.01p
Sakha 104	21.13def	17.53m-r	7.72opq	15.28de	2.66c-g	2.43h-m
GZ1368-S-5-4	23.73a	19.02i-l	5.77t	11.28jk	2.52e-j	2.32j-o
GZ 5121-5-2	21.19def	18.46k-n	6.03st	12.22g-j	2.49g-k	2.51f-j
Giza 182	22.85abc	17.71l-p	7.96o	14.50e	2.51f-j	2.25mno
Agmi	20.45fgh	12.80wx	6.13rst	12.24g-j	2.42h-m	2.30k-o
Goari	20.36f-i	18.24k-o	7.87opq	15.71d	2.70c-f	2.40h-n
Nabatat Asmar	18.27k-o	16.64pqr	11.75hij	12.52fgh	2.48g-k	2.40h-n
IRAT 170	16.93o-r	15.18st	9.01n	12.49f-i	2.55e-i	2.43h-m
IRAT 112	17.16n-r	14.67tu	11.35jk	12.19g-j	2.53e-i	2.15op
Milyang 93	17.66l-q	14.16t-w	7.02o-r	13.41f	2.67c-g	1.83q
IET 1444	18.25k-o	19.20h-k	7.36opq	11.63hij	2.46h-l	2.40i-n
Suweon 360	20.08f-j	16.17rs	7.64opq	12.94fg	2.24mno	2.14op
Yun Len 4	18.73j-m	15.16st	7.90op	11.33jk	2.74bcd	2.65c-g
WAB 878	22.40bcd	16.75pqr	7.38opq	9.09n	2.89b	2.71cde
Morobrekan	19.25h-k	16.96o-r	7.78opq	10.21lm	3.57a	2.76bc
Suweon 349	20.09f-j	16.27qrs	6.87qrs	13.08fg	2.43h-m	2.24mno
E. yasmine	20.97efg	14.32tuv	9.49mn	15.90d	2.56d-i	2.50g-k

Means followed by a common letter are not significantly different at the 5% level by DMRT.

NS= continues flooding and DS= irrigation every 12 days

Highest sterility percentage (%) was observed under drought conditions compared with the non-stress conditions in all of the studied rice genotypes and the lowest sterility percentages was recorded by the Morobrekan, WAB 878 and GZ 1368-S-5-4. in Table 2. Changes in carbohydrate levels and enzyme activities, associated with inhibition of starch accumulation in pollen, are potential causes of spikelet sterility (Sheoran & Saini, 1996) spikelet sterility also found affected by a slower rate of panicle exertion due to water stress (O'Toole & Namuco, 1983).

With regard to 100-grain weight (g) in Table 2, the cultivars Morobrekan, WAB 878 and Yun Len 4 gave the highest mean values under the normal and drought conditions compared while the Suweon 360 under normal condition and Giza 176 under drought conditions were given the lowest mean values. In general, there was a significant reduction in 100-grain weight (g) under drought stress comparing with normal condition in most of the studied rice varieties, Water stress imposed during the grain filling period enhanced remobilization of pre-stored carbon reserves to grains and accelerated grain filling and this led to reduction in 100-grain weight (g) under drought conditions (Yang *et al.*, 2001).

Table 3 shows significantly difference on number of panicles plant⁻¹, sterility (%) and 100-grain weight (g) as affected by the interaction between genotypes and environments over two years.

The genotypes GZ 5121-5-2, Sakha 101 and Giza 178 had the highest grain yield plant⁻¹ (g) under normal conditions (43.1, 44.50 and 45.66) while the genotypes GZ 1368-S-5-4, Morobrekan, GZ 5121-5-2, WAB 878 and Goari had the highest grain yield plant⁻¹ (g) under drought conditions (31.38, 30.98, 29.73, 28.99 and 29.25) in Table 3. The outstanding performance of in GZ 1368-S-5-4 for grain yield plant⁻¹ (g) under drought conditions seems due to its superiority for number of panicles plant⁻¹, heavier grain weight and low sterility percentage (%).

Table 3 shows that the highest water use efficiency WUE was recorded in the Giza 178, Sakha 101 and GZ 5121-5-2 cultivars under the normal conditions and in the GZ 1368-S-5-4, Morobrekan and GZ 5121-5-2 cultivars under the drought conditions. These results are in accordance with those obtained by Yu *et al.* (2003) and Cha-um *et al.* (2010).

Harvest index, another important physiological parameter, were calculated as highest in the Gaori and IRAT 112 (29.8 and 27.8 %) cultivars under the drought conditions, respectively in Table 3. Contrarily, the lowest harvest index values were detected in the Giza 177 and Sakha 104 (45.9 and 42.7) under non-stress conditions, respectively. In general, the highest harvest index values were observed under non-stress condition compared with that under drought condition in all of the studied rice genotypes. This finding could be attributed to the adversely effect of water stress on the grain yield and straw weight of plant and these could be reduced by the harvest index. This result is consistent with the findings of Keshava *et al.* (2011) and Abdel – Hafez *et al.* (2013).

TABLE 3. Grain yield plant⁻¹ (g), water use efficiency and harvest index (%) as affected by the interaction between genotypes and environments over two years.

Genotype	Grain yield plant ⁻¹ (g)		Water use efficiency (WUE)		Harvest index (%)	
	NS	DS	NS	DS	NS	DS
Giza 159	28.39no	24.87bq	0.49qrs	0.62i-l	28.43opq	25.56r
Giza175	38.40fg	19.22u	0.66ghi	0.48rs	32.20j-n	22.27st
Giza 176	42.22c	19.50tu	0.73c-f	0.49qrs	30.15l-p	15.73yz
Giza 177	41.90cd	20.00stu	0.72def	0.50o-s	45.94a	27.66qr
Giza 178	45.66a	27.58o	0.79a	0.69fg	38.05de	23.31s
Sakha 101	44.50ab	21.58r	0.77abc	0.54no	40.63bc	12.92z
Sakha 102	40.53de	21.16rs	0.70efg	0.53n-q	37.36ef	23.34s
Sakha 103	42.41c	21.74r	0.73c-f	0.54n	39.86cd	17.67xy
Sakha 104	42.80c	22.38r	0.74b-e	0.56mn	42.70b	15.80yz
GZ 1368-S-5-4	40.24e	31.38k	0.69fg	0.79a	36.50ef	19.19u-x
GZ 5121-5-2	43.18bc	29.73lmn	0.75bcd	0.74bcd	36.19efg	21.12s-v
Giza 182	37.29gh	18.57u	0.64hij	0.46s	33.74h-k	15.16z
Agmi	30.32klm	21.00rst	0.52n-r	0.53n-q	31.24k-n	17.97wxy
Goari	35.28ij	29.25mn	0.61jkl	0.73c-f	35.08f-i	29.80n-q
Nabatat Asmar	42.19c	19.93stu	0.73c-f	0.50o-s	33.47ijk	19.88t-x
IRAT 170	28.94mno	23.86q	0.50o-s	0.60klm	31.29k-n	25.74r
IRAT 112	31.24kl	25.47p	0.54nop	0.64ijk	33.91g-j	27.83pqr
Milyang 93	31.66k	24.80pq	0.55n	0.62i-l	36.51ef	27.67qr
IET 1444	38.37fg	25.33pq	0.66ghi	0.63ijk	30.11m-p	20.20t-w
Suweon 360	35.35ij	25.19pq	0.61jkl	0.63i-l	31.46j-n	20.56tuv
Yun Len 4	28.61no	25.67p	0.49qrs	0.64hij	32.69i-l	21.23s-v
WAB 878	36.28hi	28.99mno	0.63i-l	0.73c-f	30.69l-o	27.61qr
Morobrekan	39.46ef	30.98kl	0.68gh	0.78ab	35.92e-h	18.71vwx
Suweon 349	34.14j	25.46p	0.59lm	0.64ijk	32.43j-m	21.40stu
E. yasmine	36.62hi	19.88stu	0.63ijk	0.50p-s	37.63de	21.05s-v

Means followed by a common letter are not significantly different at the 5% level by DMRT. NS=continues flooding and DS= irrigation every 12 days

Genetic parameters

Estimates of genetic variance (GV), phenotypic variance (PV), genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV) and heritability (HB) for all the studied characters are given in Table 4. Results showed that the grain yield plant⁻¹ (g) and harvest index had the highest genotypic and phenotypic variances, while WUE (unit) recorded the lowest genotypic and phenotypic variances under both normal and drought conditions.

TABLE 4. Estimates of phenotypic variance (PV), genetic variance (GV), genetic coefficient of variance (GCV), phenotypic coefficient of variance (PCV) and heritability in broad sense (H) for all the studied traits.

Characters	GV		PV		GCV (%)		PCV (%)		HB (%)	
	NS	DS	NS	DS	NS	DS	NS	DS	NS	DS
number of panicles plant ⁻¹	3.42	5.16	4.24	5.70	9.25	14.59	10.30	15.33	90.58	80.65
Sterility percentage (%)	2.25	7.25	2.46	7.70	18.93	19.34	19.82	19.94	94.07	91.24
100-grain weight (g)	0.06	0.06	0.07	0.07	9.48	10.41	10.25	11.61	85.58	80.37
Grain yield plant ⁻¹ (g)	27.52	14.91	28.55	15.84	14.01	15.99	14.27	16.49	96.40	94.09
Water use efficiency	0.008	0.01	0.009	0.01	13.87	15.99	14.71	16.83	90.32	88.89
Harvest index (%)	13.47	19.73	25.92	21.73	10.40	20.59	14.42	21.60	90.81	51.7

GV=genotypic variance, PV= phenotypic variance, GCV= genetic coefficient of variation, PCV= phenotypic coefficient of variation and HB= heritability in broad sense

Relatively, high phenotypic coefficient of variability (PCV) was found for the harvest index (21.60) and sterility percentage (19.94) under drought stress while, it was lower for 100-grain weight (g) (10.25 g) under normal condition.

The genotypic coefficient of variability (GCV) showed the same trend as for PCV for these traits, indicating that these two traits might be more genotypically predominant, and it would be possible to achieve further improvement in both traits. The genetic coefficient of variability refers to the additive and non-additive genetic variance played an important role in inheritance of these traits. These results are in agreement with those obtained by Abd Allah *et al.* (2005), El-Malky *et al.* (2008), and Hammoud *et al.* (2012).

High estimates of heritability (%) were found in all characters under both normal and drought conditions, which ascertains the presence of both additive and non-additive genetic variance in the inheritance of most traits except harvest index under drought stress (51.7%). Therefore, it could be concluded that its selection procedures are successful in improving these traits we investigated. Similar results were obtained by Abd Allah *et al.* (2005), Hammoud *et al.* (2012) and Abdel- Hafez *et al.* (2013) and these researchers are verified the our findings.

Correlation coefficients among the studied traits under normal and drought conditions over the two years are seen in Table 5. Under normal environment grain yield was significantly and positively correlated with WUE and harvest index. Also positive and significant correlation was observed between WUE and harvest index. Similar positive correlation was reported by Hadifa (2012).

Positive correlation between grain yield and WUE cleared that high WUE cultivars can lead to genotypes with high yield potential (Eivazi & Habibi,

2013). Under the drought stressed environs, grain yield was significantly and positively correlated with harvest index, number of panicles plant⁻¹ and 100-grain weight (g), this show that increasing the number of panicles plant⁻¹ and 100- grain weight (g) will consequently increase the grain yield plant⁻¹ (g). Significant positive correlation between grain yield with the number of panicles plant⁻¹ and 100- grain weight (g) under stress was also observed by Gomez *et al.* (2006) and Site Noorzuraini *et al.* (2012).

TABLE 5. Correlation coefficients among the studied traits under normal and drought stress over the two years.

Character	Env.	W.U.E.	Harvest index (%)	Number of panicles plant ⁻¹	Sterility (%)	100 grain weight (g)
Grain yield plant ⁻¹ (g)	Normal	0.99**	0.585**	0.302	-0.003	0.196
	Drought	0.99**	0.331	0.613**	-0.645**	0.451*
W.U.E.	Normal		0.585**	0.301	-0.003	0.196
	Drought		0.330	0.613**	-0.645**	0.452*
Harvest index (%)	Normal			0.137	-0.105	0.212
	Drought			0.014	-0.208	0.019
number of panicles plant ⁻¹	Normal				-0.473*	0.394
	Drought				-0.581**	0.444*
Sterility (%)	Normal					-0.088
	Drought					-0.634**

Env. =environments and WUE= water use efficiency

Positive and significant correlation was obtained between WUE and number of panicles plant⁻¹ and 100-grain weight (g). Also, it was significantly correlated with number of panicle plant⁻¹. These traits appeared to be promising traits for selection to improve the yield under stress and consequently develop high yielding drought tolerant rice varieties. All traits studied except harvest index had significant and negative correlation with sterility percentage (%), indicating that the increasing of sterility percentage led to decrease grain yield. Hadifa (2012) reported negative correlation between sterility percentage and grain yield under water stress condition.

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تأثير نقص ماء التربة على المحصول ومكوناته في مراحل النمو المختلفة في الأرز

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تم تقييم خمسة و عشرون تركيب وراثي من الأرز تحت الظروف العادية (الغمر المستمر) و الجفاف (الري كل ١٢ يوم) بالمزرعة البحثية بمركز البحوث و التدريب بسخا – كفر الشيخ - مصر، في موسمي ٢٠١١ و ٢٠١٢ لدراسة الاختلاف الوراثي و الارتباط البيئي بالإضافة الى تحديد التراكيب الوراثية المرغوب فيه و التي يمكن استخدامها كمصدر لصفة تحمل الجفاف في برنامج تربية الأرز.

تم إجراء تحليل التباين المشترك للبيانات المتصل عليها لمحصول الحبوب للنبات بالجرام ، عدد الداليات للنبات ، وزن ١٠٠ حبة بالجرام ، نسبة العقم (%) و دليل الحصاد و كفاءة استخدام الماء.وجدت اختلافات عالية المعنوية بين جميع التراكيب الوراثية لجميع الصفات المدروسة. وجدت فروق عالية المعنوية بين متوسطات مربعات التفاعل بين التراكيب الوراثية و البيئه لكل الصفات المدروسة.

سجلت التراكيب الوراثية GZ Morobrekan, GZ 1368-S-5-4 كأفضل التراكيب الوراثية تحت ظروف الجفاف في متوسط محصول الحبوب للنبات بالجرام (٣١,٣٨ ، ٣٠,٩٨ ، ٢٩,٧٣ ، ٢٨,٩٩ و ٢٩,٢٥ جرام) على الترتيب و يمكن استخدامها كمصدر لتحسين صفة محصول الحبوب تحت ظروف تحمل الجفاف .

أعطى محصول الحبوب للنبات بالجرام و معامل الحصاد اعلى تباين وراثي وبيئي . أعطت كفاء استخدام الماء أقل تباين وراثي وبيئي تحت كلا الظروف. كان معامل الاختلاف البيئي اعلى من معامل الاختلاف الوراثي تحت كل من الظروف العادية و الجفاف لكل الصفات. وجدت اختلافات وراثيه واسعه بين التراكيب الوراثية المستخدمه و التي يمكن ان تستخدم في التهجين فيما بينها لتحسين مقاومه للجفاف.

كانت قيم تقدير درجة التوريث عاليه لكل الصفات المختبره تحت كلا من الظروف العادية و الجفاف ما عدا صفة معامل الحصاد. لوحظ ان هناك ارتباط معنوي و موجب بين محصول الحبوب للنبات بالجرام و معظم مكونات المحصول تحت الظروف العادية و الجفاف.