SCREENING RICE GENOTYPES FOR DROUGHT TOLERANCE IN EGYPT

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ABSTRACT

A series of experiments were conducted under normal and drought conditions to examine the magnitude of grain yield response of diverse genotypes to drought stress and to identify traits that might confer drought tolerance. Thirty- three local and exotic rice entries including eighteen Egyptian genotypes (selected from Fn generation of the breeding for drought tolerance program, Rice Research and Training Center, Egypt), six Italian and nine Chinese rice varieties were grown at Rice Research and Training Center Experimental Farm for evaluation under normal, as well as drought conditions, during 2007 and 2008 rice growing seasons. Two experiments were conducted under drought stress with the same set of genotypes, following direct drilling and transplanting methods. Experiments were laid out in a randomized complete block design, with three replications, in all experiments. This study was funded by EU Project (CEDROME Project). Analysis of variance indicated highly significant differences among the genotypes for all traits studied. In field screening test, many promising lines were found to be tolerant against drought stress at different growth stages i.e. seedling stage, early and late vegetative, panicle initiation and heading stages. These lines possessed useful traits associated with drought tolerance, such as early maturity (drought escape mechanism), medium tillering ability, medium plant height, root depth, root thickness, root volume, dry root: shoot ratio, plasticity in leaf rolling and unrolling (drought avoidance mechanism), in addition to crop water use efficiency and water application efficiency. The results showed that the genotypes; viz., Giza 178, Giza 182, GZ5121, GZ 6296-12-1-2-1-1, GZ 8310-7-3-2-1, GZ 8367-11-8-3-2, GZ 8372-5-3-2-1, GZ 8375-2-1-2-1, GZ 8450-19-6-5-3, GZ 8452-7-6-5-2, GZ 1368-S-4, Augusto and SIS R215 were the best selected entries under drought conditions, where, they possessed many desirable traits, which were useful for drought tolerance such as shoot, root and grain yield and its components, were less affected, comparing with the other entries, as well as some chemical characters at the two seasons of study . So, these genotypes proved to be drought tolerant lines. Among the traits studied; viz. , number of tillers per plant, number of panicles per plant,

100- grain weight and panicle weight, except for plant height and sterility %, revealed significant genotypic correlation with grain yield. Also, number of filled grains per panicle depicted the highest direct contribution of 0.630 and it, also, showed the highest indirect contribution of 0.867 followed by 100 -grain weight (0.850) towards grain yield. Path coefficient analysis demonstrated that number of panicles per plant, 100 grain weight; number of filled grains per panicle and panicle weight should be improved in order to increase grain yield under both normal and drought conditions.

Key words: Rice, drought stress, yield, screening, path analysis

INTRODUCTION

The world's irrigated area per capita has decreased from a peak of 48 ha/1000 people, in late 1970, to about 42 ha/1000 people in 2002(Gleick, 1993). Drought stress is a major constraint to rice production and yield stability and is, generally, avoided in irrigated rice production systems, but it is a consistent feature across much of the 63.5 million hectares of rainfed rice annually sown, most of which is in tropical Asia, Africa, and Latin America (Narciso and Hossain, 2002).

In some cases, superior response to vegetative stage stress is associated with better performance under reproductive stage stress, but, in many cases, the strategies that appear to be successful at the reproductive stage may be counterproductive, when stress occurs at flowering (Pantuwan et al., 2002). Direct selection for improved yield, under drought, has been hampered by the unpredictability of drought events, which means that selection pressure is, generally, inconsistent, and possibly contradictory, across years. Progress has been made, however, through the inclusion of tolerant parents in crossing (*Chang et al. 1982; Pinheiro 2003*). More recently, the use of managed environments and targeted multilocation testing has been implemented to facilitate progress in breeding drought tolerant rice (*Fischer et al. 2003*). The success of these initiatives will be known within the next few years. As the demand for water for domestic, municipal, industrial, and environmental purposes rises in the future, less water will be available for agriculture. But, the potential for new water resource development projects and expanding irrigated area are limited. Rice is the stable food for nearly one half of the world population, most of them live in developing countries and the crop occupies one- third of the world total area planted to cereals and provides 35-60% of the calories consumed by 2.7 billion people. Rice is known to be more susceptible to shortage of irrigation water than most of other crops, because rice is a semi -aquatic plant species and is commonly grown in lowland paddies where there is standing water during all stages of growth (Inthapan and Fukai, 1988). In Egypt, rice is one of the major water consuming crops and continuous flooding is the only methods for irrigation. Rice occupies about 22% of the total cultivated area in Egypt during summer season and it consumed about 20% of the total water resources. Because of the water resources in Egypt are limited, in addition to increasing population, the total water requirements for the rice crop is considered a problem. Some rice cultivated areas especially that located at the end of the canals terminal in the northern part of the Nile Delta, 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. To overcome this problem, ways must be found to increase the productivity of water, which used for irrigation, and find ways for saving more irrigation water. One of the important ways for that is the use of short -duration varieties. It is very important to find ways for saving more water without significant reduction in grain yield. It was started to overcome this problem in Egypt by developing short duration varieties, such as Giza 177(released in 1995); Giza 178 (released in 1997); Shakha 101 (released in 1997); Sakha 102 (released in 1997); Sakha 103 (released in 1999); Giza 182 (released in 2000) and Sakha 104 (released in 2000).The second direction for saving irrigation water is developing drought- tolerant lines to be grown in the areas affected by the shortage of irrigation water to reduce the total water requirements. This study was conducted to identify the most important traits associated with drought tolerance in some elite rice genotypes in Egypt.

MATERIALS AND METHODS

Thirty- three rice entries, including eighteen Egyptian genotypes (nine varieties and promising lines, selected from Fn generation of the breeding for drought tolerance program-2005, Rice Research Program) ; six Italian and nine Chinese rice varieties, were evaluated under normal and drought conditions during 2007 and 2008 rice growing seasons. Each genotype was planted in seven rows of five meters length each. Adopting spacing of 20x20 cm spaced plants; and two to three seedlings / hill. These materials were replicated three times in a randomized complete block design (RCBD) in two experiments (under normal and drought conditions). Two experiments were conducted under drought stress with the same set of genotypes under drill as well as transplanting methods. On May10th , the drill experiment was directly sown and at the same day, two sets of the same genotypes were grown in the nursery for thirty days, after which they were transplanted under the stress, as well as normal growing conditions. Drought stress was imposed by using flush irrigation (flush irrigation is one of the surface irrigation without standing water after irrigation) every twelve days to reach the soil moisture content to the filed capacity, two weeks after transplanting to harvesting and recommended cultural practices were followed. Shoot characters, such as plant height in cm (length of the main culm in centimeters was measured from the soil surface to the tip of the main panicle at maturity); panicle length in cm (the main panicle of each plant was measured from the base to the tip of the panicle, excluding awns at complete maturity); tiller number per hill (the total number of tillers per plant); leaf angle (measuring the angle between the line and vertical axis with a protractor); leaf rolling (estimated by visual estimation based on methods proposed by *De Data et al., 1988*); flag leaf area in c m^2 (flag leaf area of twenty leaves were measured by using leaf area meter (model L1 -3000A); flag leaf dry weight in g (the same leaves were transferred to the oven and dried at 70 c for 72h or to a constant weight ,then , the dry weight of each leaf was estimated); chlorophyll content (measured by using chlorophyll meter (SPAD-502) Minnolta camera Co.Ltd., Japan)); and nitrogen (%) was studied (N content in rice leaves were estimated according to Hafez and Mikkelsen,1981). Root characters, such as root length in cm (length of the root from the base of the plant to the tip of its longest root), root number per hill (number of all developed roots per plant), root volume in ml (volume (ml) of the root per plant was determined in cubic centimeter), root: shoot ratio (ratio of the root dry weight to the shoot dry weight) and root xylem vessel numbers (the average xylem vessel number of four roots of the same plant were recorded under light microscope), were recorded at panicle initiation stage. Grain yield (t/ha) and its components, such as number of panicles per plant (counting the number of panicles per plant when all plants were at the ripening stage), number of filled grains per panicle (filled grains of the main panicle were separated and counted), sterility (%) (the unfilled grains of the main panicle were separated and counted and sterility percentage was calculated), 100-grain weight (in g) (recorded as the weight of 100 random rice grains per plant) and panicle weight (in g) was recorded (by using the main panicle weight of each plant) at harvesting. The drought stress was fully monitored, and the total amount of water consumed was estimated using water counters.

The statistical analysis of variance and covariance for the data collected for the studied traits and co- variability were carried out by using the procedures of *Steel and Torrie (1980)*. The pairwise comparison of genotypic means was accomplished by using *Duncan New Multiple Range Test (1955)*. The method of *Burton and Devane (1953)* was used for estimating heritability as an index of transmissibility associated with various plant performance traits. Genotypic and phenotypic correlations were calculated by using the technique, given by *Kwon and Torrie (1964)* in order to determine the extent of characters association at genotypic and phenotypic levels. The combined analysis was calculated over the two years to test the interaction of the different genetic components with the two years. The homogeneity of error variance was tested as described by *Bartlett (1937)*.

The weather data, physical and chemical analysis of soil properties of the experimental field, are given in Tables 1 and 2.

Table (1): Weather data of Sakha Agricultural Research Station.

Month	Air temperature	Relative humidity (%)	Wind speed (m/s)	Evaporation (Pan mm)	Rain fall (mm)	Solar radiation ($Mjm^{2)}$
April	25.70	62.60	1.50	4.90	00	26.10
May	27.20	64.20	1.50	5.20	00	26.30
June	29.20	71.60	1.30	5.40	00	28.40
July	28.60	75.30	1.30	5.20	00	27.70
August	27.30	70.50	1.10	4.00	00	23.00

Evaporation pan (in mm) is primarily concerned with solar radiation and air temperature which amount its peak in June month. Relative humidity ranged from 62.6% in April to 75.3% in July. Wind speed recorded the lower value in August being 1.10 m/s, while, it recorded the highest value in April and May to be 1.5 m/s. It means that the evapotranspiration attributes of rice plants are primarily concerned with values of air temperature, solar radiation and evaporation pan.

Table (2): Some physical and chemical properties of the soil in the experimental site.

Characters	Value
pH	8.3
EC (dS m-1)	2
Soluble Cations meq. L-1	
Ca^{++}	5.1
Mg^{++}	2.1
K^{+}	0.4
Soluble anions meq. L-1	
Na^{+}	12
HCO_3	3.5
Cl^{-}	14.8
Mechanical analysis	
SO_4	1.3
Clay (%)	56.1
Silt (%)	31.3
Sand (%)	12.6
Texture	(Clayey)

The soil was clayey in texture, whereas, particle size distribution was 56.1% clay, 31.30% silt and 12.6% sand. Soil pH (1:2.5) was 8.3 and electrical conductivity of soil and irrigation water was 2.00.

RESULTA AND DISCUSSION

The combined analysis of variance for shoot characters ; viz. , plant height, number of tillers per plant, flag leaf area, flag leaf dry weight and root characters (viz., root length, root numbers/plant, root volume, root/ shoot ratio and root xylem vessel number); and for grain yield and its component; i.e., number of panicles/plant, sterility (%), and 100- grain weight of the two years of study are presented in Table (3).Years mean squares were significant and highly significant for all studied traits except for 100 - grain weight, panicle weight, root to shoot ratio and root xylem vessel number which would indicate overall wide differences among these genotypes. The genotypes and years interaction were not significant for all characters studied. It could be considered that some varieties surpassed the others, if the interaction of genotypes was highly significant than the interaction of genotypes with years, and , therefore, the most superior genotypes could be recommended.

The data, presented in Tables 4,5,6,7 and 8, showed that the genotypes, Giza 178, Giza 182, GZ5121, GZ 6296-12-1-2-1-1, GZ

8310-7-3-2-1, GZ 8367-11-8-3-2, GZ 8372-5-3-2-1, GZ 8375-2-1-2-1, GZ 8450-19-6-5-3, GZ 8452-7-6-5-2, GZ 1368-S-4, Augusto, SIS R215 were the best selected under drought conditions, where it possessed many desirable traits for drought tolerance, such as shoot, root and grain yield and its components, as well as desirable grain quality characters at the two rice growing seasons and their combined data . So, these genotypes proved to be drought tolerant lines.

The data on mean performance of genotypes, mentioned in Table 4, indicated that the mean values for number of days to heading, plant height, number of tillers/plant, leaf angle, leaf rolling score, flag leaf area and flag leaf dry weight ranged from 92 to 114 days, 78.60 to 119.20 cm, 12.60 to 28.40 tillers, narrow to wide, 1 to 7 score, 10.00 to 25.60 cm and from 1.53 to 2.00 g. For heading date, the genotypes, GZ 5310-20-3-3, GZ 6296-12-1-2-1-1, GZ8375-2-1-2-1, Augusto, Eurosis, SIS R215 and Luxor, were the earlier plants. While, the genotypes Giza 14, GZ8372-5-3-2-1, Handao 297, IAPAR-9, Nong Xuan 2, Qinai, Zheng Zhou and L696, gave the highest mean values in the two years and their combined data . Early maturity has been shown to be an important trait under stress conditions, because early flowering rice can escape from the late season drought stress (*Rajatasereekul et al., 1997; Cooper and Somrith, 1997 ;)*. Maximum plant height was recorded in genotypes GZ 8372-5-3-2-1, GZ 8375-2-1-2-1 and TP 219, (the values ranged from 116-119 cm), while, the least plant height was noted in GZ 8452-7-6-5-2, SIS R215 and Eurosis genotypes , their values ranged from 78.60 to 81 cm. The maximum number of tillers /plant was reported in GZ 8310-7-3-2-1, GZ 8375-2-1-2-1 and GZ 8452-7-6-5-2 genotypes (from 27.16-28.40), while, the lowest number of tillers/plant was counted for the genotypes Handao 4, Nong Xuan 2 and Qinai (12-13 tiller). The genotypes, nos.10, 11,15,18,20,21,22,23,24,25,27,28,29,32 and 33 had wide leaf angles compared with the others. The genotypes, GZ 1108-16-1, GZ 8310-7-3-2-1, GZ 8372-5-3-2-1, GZ 8399-1-1-1-1, Nong Xuan 2, TP 21and Zheng Zhou Zaojing had good drought scores compared to the others. The desirable flag leaf area and flag leaf dry weight values were found in case of the genotypes, Ciza 175, GZ 8372-5-3-2-1, GZ 8375-2-1-2-1, GZ 8452-7-6-5-2, IAPAR-9, Qinai and TP 21. Water deficit stress mostly reduced leaf growth and in turn the leaf areas in many species of plant (*Wullschleger et al., 2005 and Zhang et al., 2004*). It could be concluded that these genotypes were superior for shoot characters studied (Table 4). In spite of water stress at tillering prolonged vegetative period, reduce plant height, tiller number, leaf length and induce leaf rolling, the data showed that these genotypes were earlier in heading, remained tall in height, having more tillers/plant and they were able to recover after the water stress condition was terminated , having smaller leaf canopy to minimize transpiration rate, had good drought scores from 1 to 3 and desirable flag leaf area , which was contributed by the higher proportion of carbohydrate to grain filling after heading. So, shoot characters, comprising plant height, tiller number, number of leaves, leaf angle; plasticity in leaf rolling and unrolling, and root to shoot ratio could be used as selection criteria in selecting drought tolerant cultivars in many crops.

With respect to grain yield and its components (Table 5), it is clear that the maximum number of productive tillers/plant was recorded in GZ 8310-7-3-2-1, GZ 8399-1-1-1-1 and GZ 8452-7-6-5-2 genotypes (the values ranged from 23 to 25 panicles), while, the lowest mean values of some traits were detected in Handao 4, Nong Xuan 2 and Qinai genotypes. Ciza 178, GZ 6296-12-1-2-1-1, GZ 8372-5-3-2-1, GZ 8450-19-6-5-3 and GZ 1368-S-4 genotypes had the maximum number of filled grains/panicle, whereas it was minimized in genotypes Eurosis, Handao 29, Handao 29. The lowest sterility (%) was found in GZ 5310-20-3-3, GZ 1108-16-1 and GZ 8450-19-6-5-3 genotypes, while, it was higher in genotypes Handao 11, Qinai, Zheng Zhou (Zaojing), and L 469 PB08. GZ 5310-20-3-3, GZ 8310-7-3-2-1 and Augusto genotypes had the maximum 100- grain weight comparison with the others. The highest yield was recorded in the genotypes GZ 8450-19-6-5-3, GZ 8452-7-6-5-2, GZ 1368-S-4 (the values ranged from 8 to 10 t/ha), while, the lowest grain yields were found with the genotypes, Augusto, Handao 11 and TP 21.The outstanding performance of GZ 8452-7-6-5-2 for grain yield could be due to its superiority for total number of tillers/plant, number of panicles/plant, heavy grain weight and low sterility (%). Drought stress, at the reproductive stage can have a large effect on grain yield and its components. *Yambo (1988), Wopereies et al., (1996) and Boonjung (1996)* reported that, if drought stress developed soon after panicle initiation, the number of spikelet developed was decreased , and this might result in reduction in grain number per panicle , coupled with reduced grain weight and, hence, a reduction in grain yield. It could be concluded that, in spite of drought stress at reproductive stage, it was the most damaging to rice crop by the reduction of dry matter production and therefore, reduction of productive tillers, these genotypes having more panicles / plant indicating that most of their tillers bear panicles under drought conditions. This might be due to the increase in nitrogen content in their shoots. Also, drought stress at booting and flowering stages reduced number of filled grains/panicle and induced sterility (%), whereas, these genotypes had a high number of filled grains/ panicle and low sterility (%). This may be due to higher sugar in their stems.

Concerning root characters (Table 6), the maximum root length was found in genotypes GZ 5121-5-2(34cm), GZ 6296-12-1-2-1-1(35 cm), GZ 8452-7-6-5-2 (34 cm), and SIS R215 (35 cm), while it was the lowest in Ciza 175 (19cm), Nong Xuan 2(16 cm), and Qinai genotypes (16 cm). Root size, morphology and root depth and length are important in maintaining high leaf water potential against evapotranspirational demand under water stress (*Kamoshita and Yamauchi 2000*). The highest mean values of root volume was found in Ciza 178 (35), Ciza 182 (40), GZ 5121-5-2 (35) and GZ 8450-19-6-5-3(45) genotypes, while, the genotypes, Handao 4 (12), Handao 29(10), and Nong Xuan 2(13) gave the lowest mean values of root volume. High root volume was indicative of the ability to permeate a large volume of soil and / or to have thick roots. Generally a drought tolerant variety possesses high root volume. The maximum root numbers was observed in Ciza 182(285), Sakha 104(310), SIS R215 (360), and L 469 PB08 (270) genotypes, whereas it was minimum in genotypes Handao 11(118), and Handao 29(110). Root to shoot ratio was higher in Ciza 175(2.10), GZ 6296-12-1-2-1-1(2.00), GZ 8450-19-6-5-3(2.20), and SIS R215 (2.00), while Augusto (0.70), Handao 11(0.67), and Qinai (0.77) had low values. The varieties with high deep root: shoot ratio was more drought tolerant (*Kamoshita et al., 2002*). A moderate stress tolerance in terms of shoot dry weight was noticed in rice (Lafitte et al., 2007). Root xylem vessel numbers were higher in genotypes GZ 8372-5-3-2-1(9), GZ 8450-19-6-5-3(9.50), and GZ 8452-7-6-5-2(9.50), while the genotypes Handao 4(4), and Luxor (4.40) have lower root xylem vessel numbers. Bigum (1985) observed that upland varieties had larger size and higher number of root xylem vessels than those of lowland varieties.

From the forgoing discussion, it could be concluded that these genotypes have deep rooted plants, high root number, high root volume and high root: shoot ratio. So, it were effectively use of more water stored at the deeper soil layers and, therefore they keep the water potential high by absorbing the water and conduct it to the shoot very efficiently and quickly (Table 7). Similar results were reported by *Abd Allah (2004)* by using different genotypes. The data in Table 6 showed that the best selected lines were superior in chlorophyll content and nitrogen (%) in their shoot at early tillering, their values ranged from 31.68 to 44.90% and from 2.20 to 2.80 %, respectively.

According to the data presented in Table 8 , the promising genotypes could be divided into two groups, based on their grain yield response to stress conditions; namely the first group included GZ 8367-11-8-3-2, GZ 8372-5-3-2-1, GZ 8450-19-6-5-3, GZ 8452-7-6-5-2 and GZ 1368-S-4 that produced high grain yield under both normal and stress conditions, and the second group included GZ 6296-12-1-2-1-1, GZ 8375-2-1-2-1, Augusto, SIS R215, Douradao and TP 21 have narrow gab between normal and stress conditions. Roots and shoots are naturally interdependent measurements and roots alone cannot be fully interpreted without considering the shoots.

Analysis of variance and heritability:

Heritability and phenotypic and genotypic variances for most of the characters studied are presented in Table (9). The results reveal that genotypic differences among the genotypes studied were found. These genotypes were highly diversified for the performance and selection could be performed for various morph-genetic traits. Maximum variability was recorded in number of roots/plant, root volume, and plant height, respectively. It is observed that phenotypic variability was higher than genotypic variability for all traits. Moderate to high heritability estimates were found for all studied traits. These results were in agreement with those reported by Abd Allah (2004).

Correlation:

The association of grain yield with other characters was estimated by genotypic and phenotypic correlation coefficients (Table 10). Root xylem vessel number/ plant had significant correlations at genotypic level with all other traits except for grain yield. At phenotypic level, root xylem vessel number/ plant had a non-significant association with all other traits, while it had a negative association with nitrogen (%) and sterility (%). This result indicates that a decrease in root xylem vessel number/ plant may bring an increase in nitrogen (%) and sterility (%). Hence the results from the present study did not coincide with the findings of *Khan et al., (1991*), who reported negative correlation between root xylem vessel number/ plant and root to shoot ratio. *Sharma and Reedy(,1991*) observed positive correlation between root xylem vessel number/ plant and grain yield /plant, while *Kupkanchanakul et al., (1991)* reported negative correlation between root xylem vessel number/ plant and grain yield/plant. In this study, non -significant results might be due to differences in genetic constitution in breeding materials and different years of experimentation. Nitrogen (%) had significant genetic and phenotypic correlation with all studied traits. *Rangel et al., (1980)* reported negative correlation between nitrogen (%) and grain yield/plant. Root to shoot ratio had highly significant genotypic correlation with flag leave area, leaf angle, flag leaf dry weight and grain yield character. *Deshmukh and Chau (1992)* reported positive and significant genetic association between root to shoot ratio and grain yield per plant. Flag leaf area had significant and positive genotypic and phenotypic correlation with leaf angle, flag leaf dry weight and grain yield/plant. Leaf angle was highly and positively genotypically and phenotypically correlated with flag leaf dry weight and grain yield /plant, while it had negative genotypic and phenotypic correlation with sterility(%).Genotypic correlation was negative for sterility(%) with flag leaf dry weight and grain yield. While phenotypic correlation was found between sterility (%) and flag leave dry weight. Genotypic and phenotypic correlations were found between flag leaf dry weight and grain yield.

Path coefficient analysis:

Path coefficient analysis is an effect to assess the magnitude of contribution of most important traits related to grain yield in the form of cause and effect. Table 11 reveals the results of direct and indirect effects of various traits to grain yield. The direct effect of plant height was negative and low (-0.044). Indirect effects through number of panicles/plant, 100- grain weight, panicle weight, sterility (%), and number of filled grain were positive, but through no. of tillers/plant were negative. Maximum positive indirect effect (0.008) was observed through total number of tillers/plant. Highly significant genotypic correlation was present between grain yield with number of panicles/plant, 100 grain weight, panicle weight and number of filled grains/panicle, but the direct effect of the number of tillers/plant was negative(-0.187). Positive indirect effect of no. of tillers/plant, number of panicle/plant, 100 grain weight, panicle weight, sterility %, number of filled grains/panicle was observed. Number of panicles/plant showed positive direct effect (0.398). Significant positive genotypic correlation (0.398) between number of panicles/plant and grain yield is present. *Soares et al., (1990)* reported that productive tillers/plant had direct effect on grain yield. Negative direct effect was reported by *Buu and Trouong (1988)*. The differences in results might be attributed to the differences in genetic material and environmental conditions of the experiment.

The direct effect of 100- grain weight was positive and also a genotypic correlation between 100 -grain weight and grain yield was positive (0.850). Panicle weight and number of filled grains/panicle were directly affecting positively grain yield. Its maximum positive indirect effect was through panicle weight (0.736).

Table (3): Combined analysis of variance of the characters studied of rice genotypes.

S.O.V.	df	Mean squares								
		Number of days to heading	Plant height	Flag leaf area	Tillers number	F.l. d.w.	N (%)	No. of panicle	Sterility (%)	100 - Grain weight
Years	**1**	6..948	2.494	2.596	1.144	2.406	1.645	6.641	4.279	0.000
Reps/years	**4**	6.854	7.072	6.427	5.344	7.214	0.009	7.064	6.262	0.002
Genotype/years	**24**	49.10**	340.7**	33.30**	45.12**	37.71**	0.465	42.33**	30.53**	0.021
Genotypes	**12**	97.9**	681.0**	65.8**	88.5**	74.3**	0.929	84.0**	60.1**	0.040
Geno.x years	**12**	0.239	0.487	0.719	1.677	1.114	0.000	0.596	0.876	0.002
Error/years	**48**	0.207	0.281	0.209	0.310	0.149	0.000	0.173	0.316	0.001

Table (3) : Continued

S. O. V.	df	RWC	WUE	Grain yield	Root length	No. of roots	Root volume	Root/ Shoot ratio	Root thick.
		9.646	0.006	0.023	8.908	7.733	9.597	0.007	3.205
Years	**1**	7.405	0.041	8.324	7.179	7.455	8.048	0.589	0.006
Reps/years	**4**	429.4**	0.090	126.1**	34.58**	6778.3*	351.9**	0.808	0.033
Genotype/years	**24**	858.7**	0.180	252.1**	69.103	135.5**	703.9**	1.612	0.067
Genotypes	**12**	0.114	0.000	0.138	0.069	0.084	0.051	0.004	4.316
Geno.x years	**12**	0.118	0.000	0.063	0.094	0.058	0.057	0.004	4.017
Error/years	**48**								

Nots:

F.l.d.w. = Flag leaf dry weight
RWC= Relative water content
Root thick. = Root thickness
N (%) = Nitrogen content
WUE= Water use efficiency

Table (4): Mean values of shoot characters of the studied rice genotypes under drought stress conditions.

No	Entries	Origin	Days to heading (days)	Plant h eight (cm)	Tiller no./pl.	Leaf angle	Leaf Rolling score	Flag Leaf area	Flag Leaf dry weight
1	Ciza 14	Egypt	110.00	106.00	21.00	Narrow	5	19.7	1.73
2	Ciza 175	Egypt	106.00	90.00	22.00	Narrow	5	21.1	2.00
3	Ciza 178	Egypt	102.00	97.00	25.00	Narrow	3	17.3	1.82
4	Ciza 182	Egypt	102.00	85.20	24.33	Narrow	3	18.0	1.81
5	Sakha 104	Egypt	105.00	102.00	20.50	Narrow	3	14.0	1.69
6	GZ 5121-5-2	Egypt	106.00	93.80	19.66	Narrow	3	12.0	1.58
7	GZ 5310-20-3-3	Egypt	98.00	101.40	20.66	Narrow	5	16.0	1.81
8	GZ 1108-16-1	Egypt	106.00	92.60	20.33	Narrow	1	20.0	1.65
9	GZ 6296-12-1-2-1-1	Egypt	97.00	86.00	17.66	Narrow	3	19.0	1.76
10	GZ 8310-7-3-2-1	Egypt	101.00	109.80	27.16	Wide	1	19.5	1.64
11	GZ 8367-3-2-1-1	Egypt	102.00	88.40	16.80	Wide	3	19.6	1.80
12	GZ 8367-11-8-3-2	Egypt	103.00	95.00	20.20	Narro	2	11.0	1.76
13	GZ 8372-5-3-2-1	Egypt	107.00	119.20	21.50	Narrow	1	21.0	2.00
14	GZ 8375-2-1-2-1	Egypt	98.00	116.60	28.40	Narrow	3	14.0	2.00
15	GZ 8399-1-1-1-1	Egypt	107.00	98.20	24.60	Wide	1	15.0	1.64
16	GZ 8450-19-6-5-3	Egypt	107.00	94.40	23.60	Narrow	3	13.0	1.99
17	GZ 8452-7-6-5-2	Egypt	102.00	78.60	27.40	Narrow	3	17.0	2.00
18	GZ 1368-S-4	Egypt	107.00	93.40	23.80	Wide	7	10.0	1.89
19	Augusto	Italy	92.00	82.00	17.80	Narrow	3	18.0	1.50
20	Eurosis	Italy	92.00	81.00	14.80	Wide	5	19.0	1.65
21	SIS R215	Italy	95.00	80.80	19.60	Wide	3	10.0	1.80
22	Douradao	China	102.00	110.00	14.60	Wide	5	20.0	1.63
23	Handao 11	China	100.00	81.40	15.00	Wide	7	14.0	1.78
24	Handao 4	China	93.00	89.20	13.00	Wide	3	19.7	1.85
25	Handao 29	China	110.00	102.60	14.20	Wide	3	19.9	1.76
26	IAPAR-9	China	111.00	115.20	14.20	Narrow	3	21.7	2.00
27	Nong Xuan 2	China	114.00	100.00	13.00	Wide	1	25.6	1.85
28	Qinai	China	110.00	94.80	12.60	Wide	3	20.0	2.00
29	TP 21	China	108.00	117.00	16.80	Wide	1	15.0	2.00
30	Zheng Zhou (Zaojing)	China	113.00	91.60	18.00	Narrow	1	21.0	1.66
31	Luxor	Italy	98.00	83.40	18.80	Narrow	3	11.0	1.75
32	L 469 PB08	Italy	106.00	98.60	15.20	Wide	5	18.0	1.53
33	L 469 L469 PB08	Italy	112.00	84.20	16.33	Wide	3	13.0	1.63
	LSD at 0.05	-	2.50	3.40	1.80	-	1.00	0 80	0.22

Table (5): Mean grain yield and its components of the studied rice genotypes under drought conditions.

No.	Entries	Origin	Panicle length (cm)	No. of panicles/plant	No of filled grains/pan.	Sterility (%)	100 – grain Weight (g)	Panicle weight (g)	Grain yield (t/ha)
1	Ciza 14	Egypt	21.85	20.83	121.00	12.00	1.50	1.80	5.52
2	Ciza 175	Egypt	24.45	19.33	100.00	11.00	1.80	2.30	4.80
3	Ciza 178	Egypt	23.25	22.33	135.00	10.00	2.30	2.50	7.20
4	Ciza 182	Egypt	22.70	18.66	131.00	13.29	2.30	3.50	7.00
5	Sakha 104	Egypt	21.60	18.33	110.00	9.72	2.30	3.40	6.70
6	GZ 5121-5-2	Egypt	19.40	18.16	118.00	15.00	2.30	2.70	7.70
7	GZ 5310-20-3-3	Egypt	20.00	17.33	111.00	8.00	2.80	2.90	7.20
8	GZ 1108-16-1	Egypt	23.05	16.33	120.00	7.00	2.40	1.80	6.00
9	GZ 6296-12-1-2-1-1	Egypt	18.75	16.5	135.00	13.00	2.40	2.40	6.50
10	GZ 8310-7-3-2-1	Egypt	19.15	24.33	131.00	9.00	2.80	2.10	7.20
11	GZ 8367-3-2-1-1	Egypt	22.30	13.4	128.00	16.00	2.50	3.20	6.75
12	GZ 8367-11-8-3-2	Egypt	19.80	17.4	117.00	19.00	2.50	2.80	7.50
13	GZ 8372-5-3-2-1	Egypt	21.95	18.25	139.00	11.00	2.60	2.70	7.50
14	GZ 8375-2-1-2-1	Egypt	22.30	2 1.00	127.00	19.00	2.20	2.80	7.10
15	GZ 8399-1-1-1-1	Egypt	20.10	23.00	103.00	17.00	2.60	2.90	7.00
16	GZ 8450-19-6-5-3	Egypt	20.25	21.00	141.00	8.50	2.50	2.80	9.60
17	GZ 8452-7-6-5-2	Egypt	22.55	25.00	133.00	12.00	2.40	3.50	10.0
18	GZ 1368-S-4	Egypt	22.45	21.8	136.00	18.00	2.60	2.40	8.00
19	Augusto	Italy	23.75	16.00	81.00	28.00	2.70	3.60	3.00
20	Eurosis	Italy	20.25	13.00	78.00	29.00	2.00	4.30	4.10
21	SIS R215	Italy	19.00	14.80	115.00	16.00	2.40	3.00	6.50
22	Douradao	China	22.20	13.00	107.00	26.00	2.30	3.20	3.60
23	Handao 11	China	18.15	14.00	75.00	45.00	2.50	2.90	3.12
24	Handao 4	China	20.10	11.00	91.00	32.00	2.50	2.90	3.80
25	Handao 29	China	21.05	12.80	77.00	35.00	2.30	2.70	3.80
26	IAPAR-9	China	23.65	12.80	110.00	31.00	1.90	2.20	3.30
27	Nong Xuan 2	China	22,00	11.00	95.00	42.00	2.60	3.20	4 80
28	Qinai	China	21.00	10.00	82.00	45.00	2.00	2.60	4.30
29	TP 21	China	24.60	15.00	99.00	33.00	2.20	3.40	4.20
30	Zheng Zhou (Zaojing)	China	18.35	16.00	107.00	40.00	2.50	2.10	4.30
31	Luxor	Italy	17.00	17.00	95.00	33.00	2.60	3.00	4.80
32	L 469 PB08	Italy	19.00	13.40	80.00	50.00	2.30	3.50	4.60
33	L 469 L469 PB08	Italy	14.70	12.50	88.00	38.00	2.00	2.40	4.80
	LSD at 0.05		1.62	2.80	5.50	4.82	0.23	0.18	0.50

Table (6): Mean root characters of the studied rice genotypes under drought stress conditions.

No.	Entries	Origin	Root length (cm)	No. of roots/ plant	Root volume (mL)	Root/ shoot ratio	Root xylem vessel no.
1	Ciza 14	Egypt	23.00	165.00	22.00	0.93	4.50
2	Ciza 175	Egypt	19.00	125.00	24.00	2.10	5.00
3	Ciza 178	Egypt	30.00	250.00	35.00	1.80	8.33
4	Ciza 182	Egypt	33.00	285.00	40.00	2.85	8.50
5	Sakha 104	Egypt	25.00	318.00	28.00	1.12	5.00
6	GZ 5121-5-2	Egypt	34.00	240.00	35.00	1.23	8.00
7	GZ 5310-20-3-3	Egypt	30.00	165.00	27.00	1.10	4.70
8	GZ 1108-16-1	Egypt	22.00	170.00	20.00	1.75	7.50
9	GZ 6296-12-1-2-1-1	Egypt	35.00	168.00	31.00	2.00	8.50
10	GZ 8310-7-3-2-1	Egypt	25.00	220.00	32.00	1.58	8.40
11	GZ 8367-3-2-1-1	Egypt	24.00	138.00	22.00	1.20	4.30
12	GZ 8367-11-8-3-2	Egypt	20.00	210.00	27.00	0.95	4.50
13	GZ 8372-5-3-2-1	Egypt	26.00	200.00	30.00	0.87	9.00
14	GZ 8375-2-1-2-1	Egypt	31.00	170.00	16.00	0.93	5.00
15	GZ 8399-1-1-1-1	Egypt	28.00	228.00	25.00	1.43	5.00
16	GZ 8450-19-6-5-3	Egypt	30.00	181.00	45.00	2.20	9.50
17	GZ 8452-7-6-5-2	Egypt	34.00	243.00	32.00	1.85	9.50
18	GZ 1368-S-4	Egypt	30.00	189.00	25.00	1.13	5.50
19	Augusto	Italy	28.00	200.00	25.00	0.70	4.40
20	Eurosis	Italy	22.00	180.00	19.00	0.90	4.50
21	SIS R215	Italy	35.00	360.00	30.00	2.00	5.30
22	Douradao	China	31.00	270.00	20.00	0.75	5.00
23	Handao 11	China	25.00	118.00	19.00	0.67	4.70
24	Handao 4	China	22.00	123.00	12.00	1.10	4.00
25	Handao 29	China	25.00	110.00	10.00	1.20	4.50
26	IAPAR-9	China	20.00	180.00	25.00	1.35	4.30
27	Nong Xuan 2	China	18.00	120.00	13.00	0.88	5.00
28	Qinai	China	16.00	197.00	25.00	0.77	4.80
29	TP 21	China	26.00	138.00	16.00	1.12	5.50
30	Zheng Zhou (Zaojing)	China	21.00	155.00	15.00	0.77	4.60
31	Luxor	Italy	31.00	140.00	15.00	0.92	4.40
32	L 469 PB08	Italy	33.00	270.00	30.00	0.90	5.00
33	L 469 L469 PB08	Italy	25.00	220.00	28.00	0.91	5.00
	LSD at 0.05		3.70	8.50	3.22	0.25	0.60

Table (7): Chemical parameters mean performance of the tested materials under drought stress conditions.

No.	Entries	Origin	Chlorophyll content	Nitrogen (%)
1	Ciza 14	Egypt	37.32	2.30
2	Ciza 175	Egypt	40.08	2.70
3	Ciza 178	Egypt	40.10	2.50
4	Ciza 182	Egypt	38.50	2.40
5	Sakha 104	Egypt	36.24	1.70
6	GZ 5121-5-2	Egypt	35.88	1.60
7	GZ 5310-20-3-3	Egypt	35.10	1.34
8	GZ 1108-16-1	Egypt	35.76	1.30
9	GZ 6296-12-1-2-1-1	Egypt	39.78	2.14
10	GZ 8310-7-3-2-1	Egypt	40.82	2.20
11	GZ 8367-3-2-1-1	Egypt	36.64	2.29
12	GZ 8367-11-8-3-2	Egypt	35.52	0.91
13	GZ 8372-5-3-2-1	Egypt	36.42	2.24
14	GZ 8375-2-1-2-1	Egypt	43.24	2.35
15	GZ 8399-1-1-1-1	Egypt	40.26	2.45
16	GZ 8450-19-6-5-3	Egypt	44.08	2.70
17	GZ 8452-7-6-5-2	Egypt	41.44	2.82
18	GZ 1368-S-4	Egypt	37.00	1.40
19	Augusto	Italy	33.48	1.18
20	Eurosis	Italy	37.72	1.22
21	SIS R215	Italy	34.84	1.55
22	Douradao	China	31.68	2.08
23	Handao 11	China	33.28	1.95
24	Handao 4	China	42.40	1.22
25	Handao 29	China	44.90	1.73
26	IAPAR-9	China	36.42	1.76
27	Nong Xuan 2	China	36.08	2.03
28	Qinai	China	42.74	1.98
29	TP 21	China	35.32	0.91
30	Zheng Zhou (Zaojing)	China	42.70	1.02
31	Luxor	Italy	43.45	1.66
32	L 469 PB08	Italy	40.44	1.52
33	L 469 L469 PB08	Italy	43.40	1.27
	LSD at 0.05		2.90	0.40

Table (8): Grain yield mean values comparison between the tested materials transplanted and drilled under normal and drought conditions.

No.	Entries	Origin	Grain yield t/ha (normal)	Grain yield t/ha (Drought) (Transplanted)	Grain yield t/ha (Drought) (Drilled)
1	Ciza 14	Egypt	10.80	5.52	3.50
2	Ciza 175	Egypt	12.50	4.80	4.30
3	Ciza 178	Egypt	10.50	7.20	4.20
4	Ciza 182	Egypt	9.50	7.00	4.25
5	Sakha 104	Egypt	12.10	6.70	5.10
6	GZ 5121-5-2	Egypt	10.60	7.70	6.50
7	GZ 5310-20-3-3	Egypt	10.00	7.20	4.60
8	GZ 1108-16-1	Egypt	10.40	6.00	4.85
9	GZ 6296-12-1-2-1-1	Egypt	7.50	6.50	5.75
10	GZ 8310-7-3-2-1	Egypt	11.00	7.20	3.60
11	GZ 8367-3-2-1-1	Egypt	10.80	6.75	5.00
12	GZ 8367-11-8-3-2	Egypt	10.00	7.50	3.80
13	GZ 8372-5-3-2-1	Egypt	10.60	7.50	3.50
14	GZ 8375-2-1-2-1	Egypt	7.90	7.10	6.75
15	GZ 8399-1-1-1-1	Egypt	12.50	7.00	3.10
16	GZ 8450-19-6-5-3	Egypt	11.80	9.60	6.60
17	GZ 8452-7-6-5-2	Egypt	11.00	10.0	5.00
18	GZ 1368-S-4	Egypt	13.00	8.00	3.40
19	Augusto	Italy	5.00	3.00	2.80
20	Eurosis	Italy	7.70	4.10	2.10
21	SIS R215	Italy	7.50	6.50	5.30
22	Douradao	China	4.00	3.60	2.00
23	Handao 11	China	4.60	3.12	1.00
24	Handao 4	China	6.60	3.80	1.50
25	Handao 29	China	5.82	3.80	1.60
26	IAPAR-9	China	5.04	3.30	1.10
27	Nong Xuan 2	China	9.30	4.80	3.75
28	Qinai	China	5.00	4.30	2.00
29	TP 21	China	4.33	4.20	3.10
30	Zheng Zhou (Zaojing)	China	6.24	4.30	3.70
31	Luxor	Italy	8.50	4.80	4.50
32	L 469 PB08	Italy	9.00	4.60	3.10
33	L 469 L469 PB08	Italy	9.50	4.80	3.50
	LSD at 0.05		0.70	0.40	0.38

Table (9): Heritability in broad- sense and coefficient of variability estimates for the characters studied.

Traits	Variance components		Heritability
	Phenotypic	Genotypic	Hb
Days to heading(day)	22.00	13.00	0.60
Plant height(cm)	120.00	113.00	0.94
Tiller no./plant	17.00	14.00	0.85
Flag leaf area(cm)	15.00	11.00	0.73
Flag leaf dry weight(g)	18.00	13.00	0.72
No. of panicles/plant	22.00	14.00	0.63
Sterility %	15.00	10.00	0.75
100 grain weight(g)	0.007	0.001	0.87
Grain yield(t/ha)	45.00	41.00	0.91
Root length (cm)	15.00	10.00	0.75
No. of roots/ plant	2280.0	2256.00	0.98
Root volume(ml)	120.0	116.00	0.88
Root/ shoot ratio	0.45	0.26	0.57

Table (10): Phenotypic and genotypic correlation coefficients among grain yield and some traits related to drought tolerance in the studied genotypes.

Traits	Correlation	Root xylem vessel no.	Nitrogen (%)	Root/shoot ratio	Flag leaf area	Leaf ngle	Sterility (%)	Flag leaf dry weight
Nitrogen (%)	Genotypic	0.480**						
	Phenotypic	-0.256						
Root/shoot ratio	Genotypic	0.385	0.660**					
	Phenotypic	0.343	0.850**					
Flag leaf area	Genotypic	0.420*	0.450*	0.580**				
	Phenotypic	0.220	0.330	0.514**				
Leaf angle	Genotypic	0.110	0.780**	0.315	0.825**			
	Phenotypic	0.100	0.960**	0.130	0.630**			
Sterility (%)	Genotypic	-0.088	0.130	0.118	0.112	-0.475**		
	Phenotypic	0.069	0.111	0.230	0.110	-0.425*		
Flag leaf dry we.	Genotypic	0.450**	0.002	0.640**	0.550**	0.653**	-0.380	
	Phenotypic	0.188	0.031	0.520**	0.420*	0.560**	0.310	
Grain yield	Genotypic	0.069	0.670**	0.830**	0.618**	0.940**	-0.550**	0.810**
	Phenotypic	0.150	0.540**	0.590**	0.535**	0.630**	-0.460*	0.620**

Table (11): Direct and indirect effect of most important traits to grain yield in some rice genotypes under drought conditions.

Traits	Genotypic correlation with yield	Plant height (cm)	No. of tillers/pl.	No. of panicles/pl	100 grain weight (g)	Panicle weight (g)	Sterility (%)	No. of filled grain
Plant height(cm)	0.0056	**(-0.044)**	0.005	0.004	0.002	0.003	0.005	0.0045
No. of tillers/plant	0.092	-0.035	**(-0.187)**	0.023	0.122	0.032	0.003	0.006
No. of panicles/plant	0.734	0.006	0.009	**(0.398)**	0.054	0.094	0.085	0.008
100- grain weight(g)	0.850	0.008	0.007	0.009	**(0.615)**	0.650	0.118	0.550
Panicle weight(g)	0.611	0.004	-0.005	0.005	0.006	**(0.478)**	0.091	0.731
Sterility (%)	-0.450	0.001	0.004	-0.007	0.002	-0.740	**(-0.220)**	-0.005
No. of filled grain	0.867	0.002	0.006	0.003	0.005	0.736	0.164	**(0.630)**

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الملخص العربي

تقييم تراكيب وراثية من الأرز لتحمل الجفاف فى مصر

عبدالله عبدالنبى عبدالله ، مجاهد حلمى عمار وعبدالعظيم الطنطاوى بدوى
مركز البحوث و التدريب فى الأرز –معهد بحوث المحاصيل الحقلية

أجريت سلسلة من التجارب تحت ظروف الجفاف وكذلك الظروف العادية لدراسة الاستجابة المحصولية لمجموعة من التراكيب الوراثية المختلفة من الأرز لتحمل الجفاف ، وكذلك لتحديد الصفات الهامة لتحمل الجفاف.

تم إستخدام ٣٣تركيب وراثى تشتمل على ١٨ سلالة مصرية (تم إنتخابها من برنامج التربية لتحمل الجفاف فى الارز –مركز بحوث الارز- سخا) ، ستة أصناف من ايطاليا و تسعة أصناف من الصين . حيث تم تقييم تلك التراكيب الوراثية المختلفة تحت ظروف الجفاف والظروف العادية (الرى الغمر) خلال المواسم الزراعية ٢٠٠٧، ٢٠٠٨ حيث تم التمويل من الاتحاد الاوربى (مشروع تابع لـ C E D R O ME project) .

أستخدم تصميم القطاعات الكاملة العشوائية مع ثلاث مكررات فى كل من التجارب المستخدمة . وتم استخدام طريقتين من طرق الزراعة وهى طريقة الشتل المنتظم و طريقة الزراعة المباشرة

أوضحت النتائج المتحصل عليها من الموسمين وجود إختلافات عالية المعنوية بين التراكيب الوراثية المختلفة فى كل الصفات المدروسة .

كما أوضحت النتائج بأن الصنف جيزة ١٧٨ و السلالات جى زد ٥١٢١ ،جى زد١ -١-٢-١-٢-١-١٢-٦٢٩٦، جى زد ١-٢-٣-٧-٨٣١٠ ،جى زد ٢-٣-٨-١١-٨٣٦٧ ، جى زد ١-٢-٣-٥-٨٣٧٢ ، جى زد ١-٢-١-٢-٨٣٧٥ ، جى زد ٣-٥-٦-١٩-٨٤٥٠ ،جى زد ٢-٥-٦-٧-٨٤٥٢ ، جى زد ٤-٥-٨-١٣٦٨ ، والأصناف أوجيستو ، إس اى إس ار ٢١٥ كانت من أفضل التراكيب التى تم إنتخابها لتحمل الجفاف حيث تمتلك كثير من الصفات المرغوبة والتى لها علاقة بصفة تحمل الجفاف مثل بعض الصفات الخضرية و صفات الجذور وبعض الصفات الفسيولوجية و الكيماوية و الصفات المحصولية بالمقارنة بالتراكيب الأخرى المستخدمة فى الدراسة . وبالتالى فإن تلك السلالات تمتلك ميكانيكية تجنب الجفاف ، ومكانيكية الهروب من الجفاف و ميكانيكية الأستشفاء من الجفاف .

أوضحت النتائج أيضا وجود إرتباط وراثى معنوى بين صفة المحصول و كل من صفة عدد الفروع / نبات ، عدد السنابل / نبات ، وزن ١٠٠ حبة ، وزن السنبلة و أن صفة عدد الحبوب الممتلئة / سنبلة لها تأثير مباشر (0.٦٣٠) وتاثير أيضا غير مباشر (0.٨٦٧) و كذلك صفة وزن ١٠٠ حبة (٠,٨٥٠) على صفة محصول الحبوب / نبات . كما أوضحت نتائج تحليل معامل المرور أن تحسين صفات عدد السنابل / نبات ، وزن ١٠٠ حبة ، عدد الحبوب الممتلئة / سنبلة ، ووزن السنبلة تؤدى الى تحسين صفة محصول الحبوب تحت ظروف الجفاف وكذلك الظروف العادية .