GENETIC STUDIES ON SOME TRAITS RELATED TO DROUGHT TOLERANCE IN RICE

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Rice (*Oryza sativa* L.) is one of the most important food crops in the world and major food crop of about one half of the world's population. It is the staple diet for most people living in South and South East Asia, which is grown in 154 million hectares world-wide in a wide range of environments (IRRI, 2004). In Egypt, rice is considered as one of the most important field crops, since it contributes about 20% of the total cereal consumption. Annually, more than one and half million feddans (1 feddan = 4200 m^2) are cultivated with rice, producing about 6.5 million tons of rice, with an average of 4.2 ton/ fed (10 ton/ ha) (Proceeding of 2006, Activities at RRTC) this average ranked the first among the rice producing countries in the world.

Drought is a major a biotic stress limiting rice production in the world, which about 30% of the world's rice producing areas suffer from moisture stress and water deficit, in both rainfed and irrigated areas about 18 million tons of rice valued at 650 million US$ is lost annually to drought (Pandey *et al*., 2005). For this reason, breeding for drought tolerance is becoming of high priority in rice breeding program, especially under Egyptian conditions, the total water requirements for rice crop is a serious problem because of the limited irrigation water available from the River Nile.

Drought tolerance traits are greatly affected by environmental factors, and take a long time to recover. Thus, to overcome this problem, the traditional breeding methods and up to date breeding methodology such as tissue culture and genetic engineering are recommended.

Breeding for drought tolerance through conventional means is slow. Alternatively, secondary traits contributing to drought resistance could be selected through breeding for drought tolerance. However, phenotypic selection for several secondary traits is difficult. Therefore, this investigation aimed to estimate the genetic parameters and heterosis for some important traits and determine the relationships between some morphological characters and yield under normal and water limited conditions

MATERIALS AND METHODS

Six rice (*Oryza sativa*, L.) varieties were used. These varieties were; Giza 177, IET1444, Sakha 105, IRAT170, IR

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64 and Azucena. Two of these varieties are Egyptian and Japonica type (Giza 177 and Sakha 105). The rest varieties were Indica type and introduced by International Network for Genetic Evaluation of Rice (INGER). During summer of 2008, seeds of these varieties were cultivated at four periodical sowing dates, which were applied with 15 days intervals to synchronize the flowering time between these divergent parents at the farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt. After 30 days from sowing, seedlings were transplanted in the experimental field in three rows/entry with 5 m long. At the flowering period, bulk emasculation method was applied according to Jodon (1938) by using hot water (42-44C°) for 10 min.). Direct cross was carried out between paired parents at flowering to produce three crosses (Giza 177 x IET1444), (Sakha 105 x IRAT170) and (IR 64 x AZUCENA). At maturity, the hybrid seeds were obtained.

In summer season of 2009, a part of the obtained hybrid seeds of the three crosses, was sown and the rest being saved to the next season to repeat the same procedure in summer season of 2011 (1^{st} may). Some of F_1 plants were self-pollinated and some others were back-crossed to both parents to obtained F_2 and backcross seeds of each cross. In summer season of 2010 (1^{st} may) the six populations, P_1, P_2, F_1, F_2, BC_1 and BC_2 for each cross were evaluated under three levels of irrigation in a randomized complete block design, with three replications in two years. Each replicate comprised 10 rows of F_2 and three rows of each of BC_1, BC_2, F_1 and the parents. The rows were five meters long with 20 x 20 distance between rows and hills during 2010 and 2011 growing seasons. All recommended culture practices were applied at proper time. Estimation data were recorded on individual plant represented by 45 plants for each parent and F_1, 100 plants for each backcrosses and 300 plants for each F_2 crosses.

The procedure of irrigation system (regime) to represent drought stress was applied as follow:

A: Irrigation every 4 days, Control treatment consumed 325 m^3 water = 6066 m^3/feddan,

B: Irrigation every 8 days, Stress 1 treatment consumed 230 m^3 water = 4293 m^3/feddan,

C: Irrigation every 12 days, Stress 2 treatment consumed 185 m^3 water = 3453 m^3/feddan

Submerged flow orifice with fixed dimension was used to convey and measure the irrigation water applied, as the following equation (Michael, 1978):

$$Q = CA\sqrt{2GH}$$

Where Q = Discharge through orifice, ($cm^3\ sec^{-1}$).

C = Coefficient of discharges (0. 61).

A = Cross sectional area of orifice, cm^2.

G = Acceleration due to gravity, cm/sec^2 (980 cm/sec).

H = Pressure head, over the orifice center, cm.

The traits related to drought tolerance were measured as follows:

Leaf rolling: It was recorded by a visual estimation based on methods proposed by De Datta *et al.* (1988). Flag leaf area (cm^2), was estimated at maximum tillering stage following the formula given by Yoshida (1976). Fertility percentage: the filled grains of the main panicle were separated and counted and fertility percentage was calculated as follows:

$$\text{Fertility percentag} = \frac{No.\ of\ filled\ grains/\ panicle}{No.\ of\ filled\ grains + No.\ of\ unfilled\ grains/\ panicle} x100$$

Grain yield/plant (g): it was recorded as the weight of the individual plant grain yield and adjusted to 14% moisture content. Root length (cm) was determined as the length of the root from the base of the plant to the tip of the main axis of primary root, Root thickness (mm) was measured by microscope with micrometer slid, Metaxylum vessels number (MXN) /root: was measured by microscope with micrometer slid, Metaxylum vessels area (MXA)/root: was measured by microscope with micrometer slid.The following data for the root characters were taken at 60 days after sowing (at maximum tillering stage). Drought susceptibility index (DSI): was calculated for each genotype According to the formula given by Ali Dib *et al*. (1990).

DSI = (YN – YS)/YN, Where**:**

YN: is yield under normal condition.

YS: is yield under Stress condition.

The statistical analyses were performed according to Steel and Torrie (1980). The genetically analyses were performed according to Gamble (1962).

RESULTES AND DISCUSSION

The data obtained from the three irrigation levels and years for parental genotypes and their six populations were set up in a combined analysis of variances and the obtained results are presented in Tables (1, 2, 3 and 4). The results showed highly significant mean squares for all studied traits, indicating the presence of real differences among genotypes. Furthermore, the variation due to irrigation levels and genotype x levels interaction were also highly significant for all traits except for flag leaf area. The results indicated the presence of significant differences among crosses for all studied traits in the three levels of irrigation. However, the results revealed that the presence of highly significant difference among populations within crosses as well as among populations within each cross with respect to all studied traits in three irrigation levels. Furthermore, years, crosses by years and populations within crosses by years in addition to population within each cross by years mean squares were significant in most of genotypes tested. This indicates that these genotypes gave different performances at different environmental conditions. These results are in agreement with the results obtained by Hammoud (2004) and Abd El-Maksoud *et al.* (2007).

Since, these genotypes which included parents and their populations gave different performance with different irrigation levels for the studied traits. So, the combined data over the two years could be more precise to present information concerning the performance of these genotypes. Therefore, the means of six populations of each cross obtained from the combined data over two years and the obtained results are shown in Tables (5, 6 and 7). In spite of, significant differences were observed among most of parental varieties for studied traits, greatest mean values were observed in the second cross (Sakha 105 x IRAT 170) for flag leaf area (FLA), fertility% (Fert.%), grain yield/plant (GY/P), maximum root length (MRL), and metaxylm root vessels number (MXN) with means of 63.65, 95.85, 47.75, 35.68 and 7.16, respectively and recorded the lowest values for leaf rolling score special in sever stress of drought with mean (1.53). In addition, lowest values of drought susceptibility index (DSI) were 0.266. These results are in agreement with the results obtained by Abd Allah (2009), Abdulmajed (2011) and Soliman (2012).

Heterosis relative to mid-parents (M.P) and better parents (B.P), inbreeding depression (ID) and potence ratio (Pr) for all studied traits were estimated from the combined data over the two years (2010 and 2011) and the obtained results are presented in Table (8). Concerning the results from combined data over both years, positive and highly significant heterosis over mid-parents were observed in the first cross (Giza 177 x IET 1444) for all studied traits at the three levels of irrigations except for fertility percentage and metaxylme root number. These values ranged from (9.27-24.16%) for leaf rolling, (24.73-39.96%) for flag leaf area, (13.79-37.19%) for grain yield/plant, (15.45-17.06%) for maximum root length, (11.05-15.13%) for root thickness and (20.17-34.08%) for metaxylme root area.

The second cross (Sakha 105 x IRAT 170) exhibited positive and high significant heterotic value over mid-parents for all studied traits at the three levels of irrigations except for fertility percentage. These values ranged from (18.31-32.88%) for LR, (24.66-37.78%) for FLA, (19.32-33.33%) for GY/P, (13.79-19.63%) for MRL, (27.82-35.46%) for RV, (6.69-7.66%) for RTh, (2.79-9.40%) for MRN and (34.01-39.96%) for MRA. Regarding to the third cross (IR64 x Azucena) positive and high significant heterotic values were exhibited for most studied traits. These values ranged from (23.98-28.71%) for leaf rolling, (20.61-30.14%) for flag leaf area, (12.99-28.37%) for GY/P, (16.57-19.53%) for MRL, (9.30-17.79%) for RTh, (5.54-12.67%) for MRN and (35.36-35.80%) for metaxylm root vessels area.

In addition, positive heterotic values relative to the high parent were observed in the first cross (Giza 177 x IET 1444) at most levels of irrigation in all studied traits except for metaxylme root vessels number. However the second cross exhibited positive and high significant heterotic values in most irrigation levels for some traits and the values ranged from

8.09% to 17.18% for flag leaf area and from 16.44% to 23.68% for grain yield/plant. In addition, positive heterotic values relative to high parent were observed in the third cross (IR64 x Azucena) for some studied traits. These values ranged between 7.32% and 20.56% for G.Y./P., and from 6.88% to 7.56% for MRL. These high significant values of heterosis may be due to the deferential between the couples of parents in each cross which we selected one parent Indica and other temperate Japonica and the major role to dominance effect for these studied traits. Similar results were previously obtained by El-Abd and Abd Allah (2002), Abdulmajed (2011) and El-Refaee and Abdulmajid (2011). Regarding inbreeding depression, positive values were associated with highly significant and positive heterosis relative to mid-and/or better parent with respect to most of studied traits at the three levels of irrigation in the three crosses. This is logic, since the expression of heterosis in F_1 hybrids will be followed by considerable reduction in the F_2 generation performances. The high level of heterosis and reduction due to inbreeding depression present in these cases were taken as evidence of the relative importance of dominance gene action in the genetic expression of the studied traits.

Significant heterosis and negative inbreeding depression were detected for leaf rolling in the first and third crosses. This observed discrepancy, where the presence of heterosis and absence of inbreeding depression may be due to the role of additive and additive by additive gene action and/or may be due to the presence of linkage between genes controlling these traits, with respect to these crosses. In this respect, Tarumoto (1974) reported that inbreeding depression in F_2 generation appeared largely in forage yield. Also, the results showed that potence ratio was positive or negative and more than unity at all studied crosses in all cases of levels of irrigation for some traits as flag leaf area, grain yield/plant and maximum root length, insuring again the role of over dominance in the genetic expression of these cases. While, other cases exhibited positive or negative values of potence ratio less than unity such as metaxylum root vessels number and leaf rolling at the first and second cross also fertility percentage for the first and second cross, root thickness and maximum root vessels area in the second and third cross. These results indicated partial dominance. Similar results were previously obtained by El-Abd and Abd Allah (2002) and Hammoud (2004).

Genetic analysis of generation means to give estimate of additive (a), dominance (d) and the three epistatic effects (aa), (ad) and (dd) were obtained according to relationships illustrated by Gamble (1962). The gene effects using the population means of the three crosses for studied traits through the three levels of irrigation in the data combined over two years 2010 and 2011, are presented in Tables (9 and 10). The values of F_2 mean (m) were highly significant in all the studied traits at the three levels of irrigation in all studied crosses. The studied crosses affected by several types of gene action for all studied traits. Additive gene action (a) was highly significant for leaf rolling and fertility percentage at most of irrigation levels in the first cross (G177 x IET1444). Also, similar results for third cross (IR64 x Azucena) which additive values were highly significant for leaf rolling and fertility percentage at most of levels. In addition, other types of gene effects were highly significant for some cases but less than additive gene effect for all the three studied crosses.

Dominance gene action (d) was highly significant for flag leaf area (levels A and B) and grain yield/plant under the three irrigation levels in first cross (G177 x IET1444). However, high significant values were observed in the second cross (Sakha 105 x IRAT170) for flag leaf area (levels A and B) and grain yield/plant and all levels for fertility percentage. Also, dominance gene action was highly significant for flag leaf area (levels A and C) and grain yield/plant at all levels and B and C levels for fertility percentage. Types of epistatic gene action played important role in the inheritance for these traits such as additive x dominance (ad) and dominance x dominance (dd).

The results of type of gene action for studied root traits at the three irrigation levels and their combined data for the three studied crosses are shown in Table (10). The values of F_2 mean (m) were highly significant for all studied root traits at the three irrigation levels in all studied crosses. Regarding the cross number one (Giza 177 x IET1444), the results of additive gene action for studied root traits were high and highly significant additive gene effect for all studied root traits except for root thickness (C level), for metaxylem root vessels number (B and C) levels. In this cross other types of gene action were high and highly significant for all studied root traits except in some cases.

The second cross (Sakha 105 x IRAT 170) exhibited similar results for studied root traits and the values of (a) were significant and highly significant for all studied traits. Dominance gene action was highly significant for all studied traits in some cases in addition to (aa) and (dd) epistatic effect for root traits in this cross. Also, similar results of types of gene action were found in the third cross (IR62 x Azucena) which significant and highly significant additive values for all studied root traits except additive effect for maximum root length (levels C) and for metaxylum root number (level A). Other types of gene action, i.e. (d), (aa), (ad), and (dd) were significant and highly significant for some cases but the major effects were additive gene action.

In general, several types of gene action were significant in all crosses for all studied traits but the additive gene action played the major role of the genetic for leaf rolling, fertility%, maximum root length, root thickness, metaxylum root vessels number and metaxylum root vessels area. While, dominant gene action played the major role in the inheritance of flag leaf area and grain yield/plant.

The estimates of heritability in broad (H_b) and narrow sense (H_n), as well as dominance degree ratio for all studied traits were also obtained from the combined data over the two seasons in the three irrigation levels and the results are presented in Table (11). However, the estimated amount of (H_b) was higher than the corresponding values of heritability in narrow sense with respect to the three crosses for all studied traits. This finding was evidence about the importance of dominance genetic effect in the inheritance of these traits. Regarding the first cross (Giza 177 x IET 1444) the estimated values of heritability in broad sense for studied traits ranged from 67.20% for root thickness in A level to 98.13% for fertility% in A level also and ranged from 61.84% for leaf rolling at level A to 96.19% for flag leaf area level B in the second cross (Sakha 105 x IRAT 170) and from 62.80% for leaf rolling in level A to 95.26% for grain yield/plant at level A in the third cross (IR62 x Azucena). Low estimates of heritability in narrow sense were detected for all studied traits except for, fertility percentage, root thickness and metaxylum root vessels number and the dominance degree ratio $(\sigma^2D/\sigma^2A)^{½}$ was more than unity for all studied traits except for the some studied traits which recorded high values for H_n.

Finally, we can concluded that these results of the three studied crosses had similar behavior for genetic expression for the studied traits in the data combined over two years at the three levels of irrigation. The results also showed the important role of additive and dominance gene action in the genetic expression of the studied traits with different levels of contributions. This finding could be emphasized by dominance degree ratio for all studied traits.

The genotypic and phenotypic correlations between each pair of studied traits were made for three crosses. Subsequently, the genotypic and phenotypic correlations among all studied traits were estimated and the obtained results are shown in Table (12). The estimates of genotypic and phenotypic correlation were calculated between all studied pairs of traits combined over the two years under the third level of irrigation (C). The results revealed highly significant positive genotypic and phenotypic correlations between flag leaf area and each of grain yield/plant, and all studied root traits and between grain yield/plant and each of maximum root length and metaxylum root vessels area. Concerning to genotypic and phenotypic correlation among root traits, negative high correlation observed between leaf rolling and each of flag leaf area, metaxylem root vessels number and metaxylem root vessels area. In general, the coefficients of genotypic correlation were larger in magnitudes than the corresponding values of phenotypic correlations indicating that these pairs of traits are strongly genetically associated to each other. Therefore, the selection for one of these traits will be associated with the improvement of the other traits during the selection program. From the above mentioned results, it could be concluded that yield ability under drought stress could be achieved through selection for i.e. FLA, MRL and M x A.

SUMMARY

This investigation aimed to evaluate some genotypes of rice (*Oryza sativa* L.) under different irrigation conditions in order to study their genetic behavior to assess their drought tolerance. The genetic materials used in this investigation were six parental varieties and their six populations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for three crosses were obtained from crossing among them. These populations were evaluated during 2010 and 2011 seasons at the Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt. The parental varieties were Giza 177, IRAT1444, Sakha 105, IRAT 170, IR 64 and Azucena. The irrigation applied were two levels of flash irrigation, the first level was irrigation every 8 days and the second was irrigation every 12 days as well as control (irrigation every 4 days). The obtained results revealed that genotypic mean squares were highly significant for all studied traits, indicating the presence of real differences among genotypes. Furthermore, the variation due to irrigation levels and genotype x levels interaction were also highly significant for all traits except for flag leaf area. The results indicated the presence of significant differences among crosses for all studied traits under the three levels of irrigation. However, the results also revealed the presence of a highly significant difference among populations within crosses as well as among populations within each cross for all studied traits under the three irrigation levels, indicating that these genotypes gave different performances under different irrigation conditions. The second cross (Sakha 105 x IRAT 170) was the best combination, which recorded the highest values for most of the studied traits except for leaf rolling score and drought susceptibility index (DSI). The second and third crosses exhibited highly significant (MP) heterotic values for most of the studied traits except for fertility percentage. Positive inbreeding depression values were associated with high significant positive heterosis, indicating the role of dominance genes in the genetic expression of these traits. This fact is emphasized by high values of heritability in broad sense with low values of heritability in narrow sense for most of the studied traits. Positive and highly significant genotypic and phenotypic correlations were found between yield and flag leaf area and all studied root traits under drought conditions. Therefore, the hybrid rice breeding programs should be taken these traits in consideration for improving yield and its components under drought stress.

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Table (1): Combined analysis of variance and the mean squares of genotypes, irrigation levels, years and their interactions for all studied traits.

SOV	DF	LR	FLA	Fert. %	GY/P	MRL	RT	MRN	MRA
Years	1	8.387**	201.89	749.36	49.656**	23.95**	0.008**	0.138	2.145
Reps / Years	4	0.030	181.15	307.83	0.083	0.101	0.004**	0.007	1.505
Levels	2	206.78**	1545**	7382**	6009**	1257**	0.005**	0.361**	125.14**
Years x Levels	2	0.284**	992.73**	252.53	87.189**	97.22**	0.037**	0.125**	10.973**
Genotypes	17	5.210**	1382**	2321**	310.20**	160.65**	0.701**	12.459**	3651**
Genotypes x Years	17	0.784**	227.51	338.67	20.070**	31.792**	0.052**	0.442**	9.213**
Genotypes x Levels	34	1.376**	233.01	459.54*	36.772**	19.241**	0.012**	0.374**	14.368**
Genotypes x Levels x Years	34	0.638**	250.84	328.89	8.747**	12.256**	0.014**	0.336**	10.393**
Error	212	0.026	178.97	302.35	0.149	2.037	0.001	0.007	0.050

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage;; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.

Table (2): The combined analysis of variance and the mean squares for studied traits of crosses, and their populations at the first level of irrigation.

SOV	DF	LR	FLA	Fert. %	GY/P	MRL	RT	MRN	MRA
Years	1	1.116**	14.19**	62.91**	33.13**	111.2**	0.009*	0.092**	17068**
R.Y	4	0.060*	0.107	0.101	0.060	0.032	0.003	0.016	74.40
Crosses	2	0.579**	236.1**	1501**	150.0**	70.78**	0.234**	1.630**	766836**
Cr.Y	2	0.292**	13.75**	248.2**	29.23**	1.388**	0.009**	0.505**	38206**
Rep.W.Cr*Y(Ea)	8	0.011	0.063	1.248	0.059	0.089	0.002	0.007	305.5
Pop.W.Cr.	15	0.222**	41.90**	1593**	28.46**	21.47**	0.092**	0.660**	109392**
Pop.W.Cr.1	5	0.412**	418.7**	856.4**	255.4**	42.98**	0.066**	1.662**	506340**
Pop.W.Cr.2	5	0.962**	798.1**	42.02**	123.0**	86.80**	0.408**	4.515**	151452**
Pop.W.Cr.3	5	0.268**	615.3**	162.6**	77.94**	132.6**	0.324**	4.791**	145223**
Pop.W.Cr.*Y	15	0.126**	24.64**	25.97**	3.767**	2.479**	0.011**	0.315**	9077.5**
Pop.W.Cr.1*Y	5	0.125**	28.22**	43.80**	5.557**	3.674**	0.005**	0.871**	8502.1**
Pop.W.Cr.2*Y	5	0.349**	210.2**	6.303**	1.787**	1.862**	0.027**	0.144**	11702**
Pop.W.Cr.3*Y	5	0.224**	31.82**	57.30**	3.572**	1.991*	0.021**	0.309**	12271**
Rep.W.P*Cr(Eb)	60	0.028	0.078	0.110	0.059	0.060	0.001	0.007	213.05
Rep.W.P*Cr.1(Ea)	20	0.017	0.039	0.067	0.090	0.020	0.001	0.017	143.80
Rep.W.P*Cr.2(Ea)	20	0.029	0.000	0.000	0.000	0.016	0.002	0.000	693.44
Rep.W.P*Cr.3(Ea)	20	0.039	0.194	0.263	0.088	0.145	0.000	0.003	488.42

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage;; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
Cr.1 : Giza 177 x IET1444, Cr.2 : Sakha 105 x IRAT 170, Cr.3 : IR 64 x Azucena.

Table (3): The combined analysis of variance and the mean squares for studied traits of crosses, and their populations at the second level of irrigation.

SOV	DF	LR	FLA	Fert. %	GY/P	MRL	RT	MRN	MRA
Years	1	3.929**	1107**	15.05**	26.33**	68.57**	0.049**	0.031	5819**
R.Y	4	0.046	0.190	0.273	0.24	0.186	0.002	0.008	277
Crosses	2	0.788**	787.8**	1458**	184.3**	42.84**	0.359**	6.220**	61559**
Cr.Y	2	2.101**	813.7**	28.23**	69.16**	43.97**	0.075**	0.028**	3981**
Rep.W.Cr*Y(Ea)	8	0.037	0.411	0.156	0.056	0.341	0.075	0.013	131
Pop.W.Cr.	10	0.874**	80.10**	274.2**	29.92**	7.863	0.055**	2.039**	14621**
Pop.W.Cr.1	5	2.191**	502.7**	833.7**	264.7**	27.18**	0.056**	1.979**	451238**
Pop.W.Cr.2	5	2.351**	698.9**	46.87**	45.95**	50.70**	0.351**	6.168**	773315**
Pop.W.Cr.3	5	1.685**	151.8**	796.7**	71.92**	31.83**	0.222**	7.058**	147416**
Pop.W.Cr.*Y	10	0.352**	116.5**	33.69**	9.087**	8.748	0.021**	0.551**	3394**
Pop.W.Cr.1*Y	5	0.650**	43.20**	47.24**	5.446**	16.69**	0.014**	0.761**	6209**
Pop.W.Cr.2*Y	5	00439*	24.66**	3.675**	26.28**	45.26**	0.012**	0.155**	50477**
Pop.W.Cr.3*Y	5	0.807**	237.7**	33.43**	9.204**	33.21**	0.019**	0.332**	1484**
Rep.W.P*Cr(Eb)	60	0.040	0.290	0.177	0.089	7.025	0.001	0.009	159.8
Rep.W.P*Cr.1(Ea)	20	0.005	0.427	0.132	0.189	3.947	0.001	0.002	163.0
Rep.W.P*Cr.2(Ea)	20	0.111	0.216	0.000	0.000	10.15	0.001	0.000	0.000
Rep.W.P*Cr.3(Ea))	20	0.005	0.227	0.399	0.077	6.969	0.001	0.025	316.4

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage;; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
Cr.1 : Giza 177 x IET1444, Cr.2 : Sakha 105 x IRAT 170, Cr.3 : IR 64 x Azucena.

Table (4): The combined analysis of variance and the mean squares for studied traits of crosses, and their populations at the third level of irrigation.

SOV	DF	LR	FLA	Fert. %	GY/P	MRL	RT	MRN	MRA
Years	1	3.910**	342.1**	29.01**	164.5**	38.60**	0.025**	0.265**	4263**
R.Y	4	0.002	0.130	0.996	0.227	0.053	0.000	0.006	318
Crosses	2	3.263**	179.9**	1550**	68.06**	23.17**	0.409**	4.580**	790991**
Cr.Y	2	0.826**	39.46**	4.432	41.00**	103.1**	0.039**	0.089**	7762**
Rep.W.Cr*Y(Ea)	8	0.015	0.273	1.175	0.309	0.044	0.001	0.005	115
Pop.W.Cr.	15	0.780**	15.15**	272.4**	12.46**	12.10**	0.068**	1.614**	170863**
Pop.W.Cr.1	5	7.945**	328.8**	1048**	70.19**	40.88**	0.045**	3.135**	491491**
Pop.W.Cr.2	5	4.359**	429.7**	95.17**	148.6**	94.49**	0.268**	5.269**	1878858**
Pop.W.Cr.3	5	5.043**	346.9**	805.5**	115.8**	114.7**	0.321**	5.360**	1922671**
Pop.W.Cr.*Y	15	0.798**	29.12**	34.64**	7.139**	5.776**	0.026**	0.185**	4523**
Pop.W.Cr.1*Y	5	1.528**	49.01**	101.9**	3.589**	5.905**	0.003**	0.174**	2304**
Pop.W.Cr.2*Y	5	0.667**	9.155**	27.63**	9.519**	11.38**	0.052**	0.433**	12114**
Pop.W.Cr.3*Y	5	1.448**	16.99**	18.25**	6.997**	13.65**	0.071**	0.357**	5402**
Rep.W.P*Cr(Eb)	60	0.011	0.220	0.379	0.296	0.038	0.001	0.006	181
Rep.W.P*Cr.1(Ea)	20	0.004	0.287	0.276	0.840	0.033	0.001	0.014	275
Rep.W.P*Cr.2(Ea)	20	0.028	0.003	0.075	0.000	0.000	0.000	0.000	0.000
Rep.W.P*Cr.3(Ea)	20	0.001	0.368	0.785	0.048	0.082	0.001	0.003	267

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage;; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
Cr.1 : Giza 177 x IET1444, Cr.2 : Sakha 105 x IRAT 170, Cr.3 : IR 64 x Azucena.

Table (5): The mean performance of entries for three levels of irrigation from the data combined over two years of 2010 and 2011 for some yield traits.

Traits	Crosses	Levels	P_1	P_2	F_1	F_2	BC_1	BC_2
Leaf rolling	Giza177 x IET1444	A	1.55±0.08	1.105±0.05	1.8±0.11	1.51±0.05	1.05±0.08	1.73±0.06
		B	2.47±0.16	1.165±0.07	1.65±0.08	2.05±0.12	1.20±0.16	1.33±0.20
		C	5.75±0.30	1.415±0.21	3.53±0.13	4.98±0.29	1.93±0.19	4.37±0.36
	Sakha105 x IRAT170	A	1.46±0.15	1.95±0.05	1.57±0.06	1.43±0.10	4.85±0.15	1.11±0.14
		B	1.93±0.21	1.1±0.07	2.63±0.19	1.86±0.25	1.86±0.32	2.22±0.33
		C	5.2±0.35	1.6±0.20	3.45±0.32	4.16±0.42	1.53±0.35	2.61±0.36
	IR 64 * Azucena	A	1.53±0.05	2.2±0.04	1.49±0.17	1.98±0.18	3.4±0.16	1.58±0.14
		B	2.13±0.21	1.4±0.08	2.45±0.17	2.4±0.33	1.34±0.50	2.04±0.21
		C	5.56±0.30	1.36±0.31	4.69±0.22	4.48±0.51	1.88±0.60	3.88±0.45
Flag leaf area(cm^2)	Giza177 x IET1444	A	36.25±0.51	55.00±1.1	59.05±0.4	48.65±2.5	44.7±1.5	51.35±2.3
		B	21.95±0.51	52.72±1.3	49.15±0.7	38.6±2.2	43.35±2.2	43.3±1.7
		C	14.49±0.80	37.35±1.6	34.75±0.6	29.95±2.0	30.87±1.9	37.5±1.2
	Sakha105 x IRAT170	A	37.4±1.2	58.15±1.3	63.65±1.1	49.74±2.3	21.05±1.4	61.1±1.7
		B	21.27±1.1	58.45±1.2	51.11±0.5	38.5±1.8	42.86±1.2	42.2±1.4
		C	16.85±0.5	42.35±1.1	39.45±1.1	34.57±1.7	27.85±1.1	26.1±1.3
	IR 64 x Azucena	A	34.12±0.3	35.31±0.28	62.35±0.13	47.04±1.4	25.56±0.9	51.85±1.0
		B	20.75±0.1	53.25±0.18	42.87±0.14	38.25±1.0	39.45±0.5	39.4±0.8
		C	17.25±0.1	47.32±0.11	35.55±0.19	32.25±0.9	26.85±0.4	28.2±0.6
Fertility %	Giza177 x IET1444	A	95.0±1.3	92.45±0.41	73.45±2.8	64.45±2.4	73.43±2.4	77.96±2.9
		B	85.15±3.1	78.85±4.1	61.25±2.4	57.05±4.1	57.26±4.2	65.68±2.4
		C	73.05±2.3	78.88±3.7	49.15±3.00	55.18±4.1	58.38±3.9	51.89±2.4
	Sakha105 x IRAT170	A	95.85±1.6	90.52±1.3	88.65±1.4	86.34±2.5	87.05±1.1	86.13±1.3
		B	78.75±2.9	82.75±2.0	81.54±3.3	76.035±4.1	75.88±2.8	80.72±1.7
		C	74.95±2.6	78.95±4.5	74.55±1.8	68.75±3.9	73.65±1.7	72.87±2.7
	IR 64 x Azucena	A	89.24±1.2	90.92±1.2	79.35±1.6	79.66±1.3	79.75±1.4	83.22±1.4
		B	78.22±1.1	83.75±1.3	55.65±2.6	55.45±1.5	65.95±2.1	72.40±1.3
		C	75.66±1.2	81.68±1.9	60.68±0.74	47.87±1.2	68.45±2.1	70.44±0.9
Grain yield / plant (gm)	Giza177 x IET1444	A	40.46±0.51	36.63±0.60	44.85±0.81	37.16±0.43	40.66±0.53	38.85±0.50
		B	26.58±0.41	27.72±0.35	43.25±0.36	25.63±0.26	27.75±0.35	33.53±0.33
		C	20.58±0.32	24.35±0.45	30.65±0.33	22.67±0.31	24.81±0.41	27.86±0.26
	Sakha105 x IRAT170	A	39.93±0.48	36.64±0.47	47.75±0.46	36.16±0.38	35.2±0.37	38.76±0.42
		B	25.99±0.34	27.38±0.56	33.08±0.28	25.15±0.33	28.05±0.22	27.94±0.26
		C	19.45±0.35	26.04±0.51	34.12±0.20	25.36±0.41	25.87±0.26	29.68±0.31
	IR 64 x Azucena	A	40.13±0.38	35.21±0.48	43.3±0.22	34.56±0.60	33.75±0.34	37.41±0.36
		B	22.99±0.31	25.94±0.37	32.66±0.38	23.35±0.33	25.80±0.27	27.08±0.29
		C	18.02±0.35	25.77±0.50	30.55±0.29	22.88±0.34	20.05±0.23	25.67±0.30

A : irrigation every 4 days(control) B : irrigation every 8 days(stress 1) C : irrigation every 12days(stress 2).

Table (6): The mean performance of entries for three levels of irrigation from the data combined over two years of 2010 and 2011 for some root traits.

Traits	Crosses	Levels	P_1	P_2	F_1	F_2	BC_1	BC_2
Maximum root length(cm)	Giza177 x IET1444	A	24.44±0.25	27.98±0.31	31.60±0.28	29.87±0.33	26.71±0.24	31.00±0.32
		B	20.73±0.22	26.48±0.24	28.38±0.25	22.9±0.26	21.68±0.22	24.42±0.27
		C	19.70±0.21	25.29±0.25	26.61±0.24	23.85±0.24	20.73±0.21	22.38±0.21
	Sakha105 x IRAT170	A	25.90±0.26	35.61±0.45	35.68±0.33	29.37±0.36	29.00±0.45	31.19±0.46
		B	20.39±0.22	32.00±0.26	29.59±0.28	27.58±0.33	21.52±0.36	26.98±0.55
		C	20.77±0.31	27.79±0.32	30.21±0.31	26.33±0.28	20.72±0.31	25.49±0.42
	IR 64 x Azucena	A	24.99±0.39	33.73±0.19	36.49±0.22	29.29±0.51	26.98±0.41	35.15±0.39
		B	19.07±0.35	28.32±0.29	28.40±0.27	24.73±0.61	20.88±0.36	25.58±0.35
		C	19.76±0.36	25.70±0.27	27.60±0.31	28.22±0.75	18.14±0.42	21.55±0.28
Root thickness (mm)	Giza177 x IET1444	A	1.16±0.02	1.15±0.02	1.47±0.02	1.36±0.03	1.29±0.02	1.43±0.02
		B	1.13±0.01	1.33±0.02	1.42±0.02	1.33±0.03	1.21±0.02	1.38±0.01
		C	1.14±0.01	1.34±0.02	1.38±0.01	1.33±0.03	1.21±0.02	1.4±0.01
	Sakha105 x IRAT170	A	1.19±0.02	1.31±0.03	1.56±0.01	1.44±0.04	1.30±0.04	1.53±0.03
		B	1.14±0.02	1.70±0.02	1.61±0.00	1.51±0.04	1.31±0.04	1.56±0.03
		C	1.18±0.03	1.85±0.02	1.53±0.01	1.43±0.04	1.27±0.03	1.48±0.02
	IR 64 x Azucena	A	1.06±0.00	1.67±0.01	1.70±0.01	1.42±0.03	1.39±0.02	1.56±0.02
		B	1.20±0.01	1.73±0.02	1.66±0.01	1.54±0.02	1.39±0.02	1.77±0.02
		C	1.18±0.01	1.82±0.03	1.75±0.01	1.60±0.03	1.47±0.03	1.57±0.03
Metaxylum root number	Giza177 x IET1444	A	4.41±0.06	5.87±0.04	5.00±0.02	5.22±0.05	5.05±0.05	5.83±0.05
		B	4.66±0.05	5.66±0.03	5.00±0.03	4.82±0.04	4.99±0.03	4.61±0.06
		C	4.33±0.04	5.58±0.05	5.00±0.03	5.55±0.06	5.44±0.05	4.78±0.05
	Sakha105 x IRAT170	A	4.33±0.04	5.49±0.05	6.16±0.04	5.59±0.05	5.56±0.03	6.40±0.06
		B	4.17±0.03	6.83±0.06	6.00±0.04	5.94±0.04	5.59±0.04	6.55±0.06
		C	4.66±0.04	7.16±0.06	6.17±0.03	5.60±0.06	5.80±0.05	6.79±0.07
	IR 64 x Azucena	A	4.33±0.06	7.13±0.07	6.00±0.04	5.82±0.09	5.27±0.07	6.09±0.06
		B	4.33±0.05	7.00±0.06	6.16±0.05	5.78±0.06	4.59±0.05	6.59±0.05
		C	4.50±0.06	7.00±0.05	6.33±0.06	6.00±0.09	4.67±0.04	6.12±0.05
Metaxylum root area (μ m^2)	Giza177 x IET1444	A	4548±38	10987±125	11784±110	6819±93	6258±69	9758±92
		B	4870±38	10987±118	11778±155	6819±68	7098±39	10246±71
		C	7061±39	11062±134	11781±115	8018±95	6547±52	10714±126
	Sakha105 x IRAT170	A	3414±71	11748±147	15621±221	10408±175	7120±38	12939±175
		B	3495±55	16343±271	15043±388	10954±139	6645±79	13673±143
		C	3456±38	16357±166	16185±336	11582±173	6804±97	13334±181
	IR 64 x Azucena	A	3388±41	15976±235	15827±315	11786±151	7011±53	12915±165
		B	3142±39	16949±265	15415±258	11458±145	6642±53	13335±147
		C	3395±40	16650±213	16328±341	11878±138	6722±33	13667±178

A: irrigation every 4 days (control) B: irrigation every 8 days (stress 1) C: irrigation every 12days (stress 2).

Table (7): The mean performance for the three crosses populations at 2010, 2011 years and the data combined over both years for drought susceptibility index (DSI).

Crosses	P_1	P_2	F_1	F_2	BC_1	BC_2	Means
Giza177 x IET1444	0.488	0.334	0.314	0.389	0.389	0.293	0.367
Sakha105 x IRAT170	0.513	0.288	0.286	0.300	0.274	0.224	0.266
IR 64 x Azucena	0.549	0.268	0.293	0.334	0.406	0.297	0.357

Table (8): Heterosis over mid-parents (M.P) and better parents (B.P), inbreeding depression (I.D) and potence ratio (P) for all studied traits from the combined data over two years of 2010 and 2011 through three levels of irrigation.

Crosses	Traits	Levels	LR	FLA	F%	GY/P	MRL	RTH	MRN	MRA
Giza 177 x IET 1444	M.P	A	24.16**	24.73**	-27.6	13.97**	17.06**	15.13**	0.80	34.08**
		B	-16.6	39.96**	-34.2	37.19**	16.82**	13.33**	1.45	32.36**
		C	9.27*	38.63**	-54.6	26.67**	15.45**	11.05**	1.75	20.17**
	B.P	A	13.05**	10.80**	-29.4	9.706**	11.45**	10.74**	-13.3	6.763**
		B	-48.3	24.41**	-39.6	35.87**	6.694**	5.964**	-11.7	6.079**
		C	-63.3	19.00**	-60.6	20.52**	4.960**	5.072**	-9.90	0.284
	I.D	A	-20.55	19.23	8.23	15.34	16.58	14.28	0.81	33.61
		B	-18.56	35.36	6.47	26.37	15.84	13.04	1.14	30.47
		C	-16.44	31.28	-11.3	22.65	15.47	10.49	1.28	18.95
	P.	A	0.13	-1.48	0.35	6.38	4.26	2.45	-0.26	-3.15
		B	-0.32	-2.14	0.21	14.44	0.95	1.88	-0.37	-2.77
		C	-0.56	-1.86	0.48	9.15	3.24	1.24	-0.44	-0.51
Sakha 105 x IRAT 170	M.P	A	18.31**	24.66**	-3.43	19.89**	13.79**	7.66**	9.407**	36.76**
		B	32.88**	37.78**	1.21	19.32**	11.45	6.98**	5.541**	34.01**
		C	-7.71	34.76**	-3.22	33.33**	19.63**	6.69**	2.795**	39.96**
	B.P	A	6.68	8.091**	-4.76	16.44**	0.182	-8.62	-10.8	-4.62
		B	16.61	17.18**	-1.01	17.21**	-8.16	-14.9	-19.4	-8.73
		C	-51.3	11.60**	-5.95	23.68**	8.02**	-9.15	-18.8	1.291
	I.D	A	26.15	17.34	4.35	15.45	12.33	7.65	3.15	32.11
		B	34.85	28.11	3.68	15.14	3.72	5.27	-2.18	30.47
		C	-9.38	25.37	6.12	28.21	16.44	6.47	-3.48	36.88
	P.	A	0.93	-1.48	0.76	5.31	2.18	-0.41	-0.24	-0.81
		B	0.42	-2.24	0.34	4.75	-0.41	-0.37	-0.28	-0.48
		C	0.34	-1.51	0.24	-3.11	2.89	-0.69	0.19	-0.35
IR 64 x Azucena	M.P	A	1.677	30.14**	-13.5	12.99**	19.53**	17.79**	5.541**	35.75**
		B	28.71**	20.61**	-45.5	25.07**	16.57**	9.309**	8.069**	35.80**
		C	23.98**	24.31**	-29.6	28.37**	17.64**	12.57**	12.67**	35.36**
	B.P	A	-2.68	14.84**	-14.5	7.321**	7.562**	-2.05	-16.6	-7.09
		B	13.03**	-10.38	-50.5	20.56**	0.281	-9.30	-13.5	-8.01
		C	8.65	-2.77	-34.6	15.69**	6.882**	-7.14	-3.47	-8.47
	I.D	A	-6.47	25.36	2.15	14.38	19.88	12.38	3.28	31.44
		B	-23.18	11.35	-40.1	27.42	14.28	5.76	6.21	33.47
		C	-21.36	14.38	-22.3	28.11	16.68	10.10	-8.34	31.18
	P.	A	1.29	-2.45	1.36	2.47	-2.77	-0.64	-0.23	-0.85
		B	-2.31	-0.68	6.25	4.77	-0.37	-0.34	-0.41	-0.68
		C	2.14	-0.81	11.34	5.49	-2.11	-0.51	-0.69	-0.61

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
A: irrigation every 4 days (control) B: irrigation every 8 days (stress 1) C: irrigation every 12days (stress 2).

Table (9): Type of gene action for vegetative studied traits for the three crosses from the data combined over both years of 2010 and 2011 for the three levels of irrigation.

Crosses	Traits	Levels	m	a	d	aa	ad	dd
Giza 177 x IET 1444	LR	A	1.015**	0.47**	-0.16	-0.19	0.03	-0.54*
		B	2.050**	0.60**	-1.61**	-1.66**	-0.25	1.69**
		C	4.865**	1.23**	-1.27**	-1.92**	-0.15	-1.18
	FLA	A	48.63**	-11.95**	17.53**	2.915	3.14	6.80
		B	38.60**	-10.88	10.68**	-9.06	-3.25	21.89**
		C	29.90**	-11.0	0.05	-13.3	-4.20	19.22**
	Fer. %	A	64.80**	-4.41*	21.15*	42.03**	-5.73	-10.1*
		B	57.80**	-8.40**	-6.31**	14.66**	-11.6**	26.46**
		C	55.18**	6.49**	-20.5	-0.18	11.91**	34.80**
	GY/P	A	31.22**	-1.30	18.79**	10.27**	-1.47	2.53
		B	25.63**	-5.75**	36.15**	20.05**	-5.18**	-1.89
		C	22.67**	-2.55	22.35**	15.68**	0.830	-12.8**
Sakha 105 x IRAT 170	LR	A	1.11**	0.30*	0.005	-0.11	-0.34	-0.19
		B	2.22**	0.33**	-1.73	-2.09**	-0.33	1.09**
		C	4.11**	1.26**	-2.57**	-2.30**	0.265	0.44
	FLA	A	49.74**	-11.87**	11.95**	-3.75	-1.32*	31.75**
		B	38.50**	-15.99**	8.625**	-10.69**	-5.47**	33.19**
		C	34.57**	-9.73	-2.69	-16.58**	-0.47	26.90**
	Fert. %	A	86.34**	0.925	-2.05*	0.99	-0.25	13.35**
		B	75.85**	-4.83**	10.05**	9.06**	-3.01**	1.915
		C	68.75**	0.830	15.77**	18.14**	2.825**	-8.31**
	GY/P	A	36.16**	-3.56**	12.03**	3.27*	-4.46**	22.46**
		B	25.15**	0.105	17.75**	11.35**	0.805	-3.80
		C	25.36**	-5.13**	18.02**	6.65**	-2.03*	-1.02
IR 64 x Azucena	LR	A	0.96**	0.30*	-0.99	1.425**	0.33**	2.48**
		B	2.40**	0.60**	-2.42*	-0.035	0.27	2.24**
		C	4.455**	1.13**	-2.22*	0.135	3.07**	3.15**
	FLA	A	47.13**	-9.18	12.91**	-5.56	56.46**	12.26**
		B	37.77**	-15.6**	1.18	-12.29**	27.00**	46.11**
		C	31.50**	-9.94	6.09**	-8.020	19.72**	30.84**
	Fert. %	A	79.98**	-3.43*	-0.365	6.075	-2.00**	18.24*
		B	55.24**	7.60**	18.55**	55.74**	-3.09**	-75.8**
		C	50.57**	21.16**	52.59**	75.48**	-0.82	-64.7**
	GY/P	A	36.16**	-3.56**	12.03**	3.270*	-4.46**	22.46**
		B	25.15**	0.105	17.75**	11.35**	0.805	-3.80*
		C	25.36**	-5.315**	18.02**	6.655**	-2.03*	-1.02

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.

Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.

A: irrigation every 4 days (control) B : irrigation every 8 days (stress 1) C : irrigation every 12days (stress 2).

Table (10): Type of gene action for studied root traits for the three crosses from the data combined over both years of 2010 and 2011 for the three levels of irrigation.

Crosses	Traits	Levels	m	a	d	aa	ad	dd
Giza 177 x IET 1444	RL	A	29.87**	-3.83**	4.365**	-0.99	-0.63	2.19**
		B	22.90**	-2.54*	-7.95**	-11.6**	-0.06	23.5**
		C	23.85**	-3.01*	-1.85	-10.4**	-1.11	16.61**
	RT	A	1.36**	-0.32*	2.27**	2.06**	0.28	-0.99*
		B	1.33**	0.425**	-1.38**	-0.17	1.68**	4.145**
		C	1.34**	0.185	-1.32**	-0.43	1.40**	2.315**
	MRN	A	5.22**	-0.77*	-1.17*	3.59**	1.28*	-3.47**
		B	4.82**	0.380	-1.27*	-0.44	2.53	6.365**
		C	5.55**	0.665	0.85*	0.42	2.27	7.155**
	MRA	A	6819**	-3500*	1118**2	5305**	-597*	2377**
		B	6820**	-3147*	12602**	7079**	-107	266
		C	8018**	-4166*	7661*	1330	-421	5036**
Sakha 105 x IRAT 170	RL	A	29.37**	-2.88**	-1.24	0.44	0.265	9.675**
		B	27.58**	-5.01**	-2.92	-5.85**	-1.86	13.66**
		C	26.33**	-5.71**	-4.85**	-6.70**	-2.64*	16.99**
	RT	A	1.44**	-0.70**	0.50**	1.02**	-0.73**	-0.99**
		B	1.51**	-0.64**	0.37**	0.37*	2.080**	0.785**
		C	1.43**	-0.48**	0.06	0.11	0.135	2.095**
	MRN	A	5.59**	-0.84**	-2.01**	2.88*	3.935**	7.595**
		B	6.03**	-0.96**	-0.47	1.81	2.835*	5.575**
		C	5.60**	-0.99**	-0.57	2.55*	3.910**	3.980**
	MRA	A	10407**	-5818**	4260**	-1192	1332	13320**
		B	10954**	-7027**	3462**	-2063**	11.00	10222**
		C	11582**	-6529**	31.00	-1924**	1559*	21726**
IR 64 x Azucena	RL	A	29.29**	-7.06**	2.23	1.345	-2.96**	0.730
		B	24.73**	-3.52**	-6.79**	-5.22**	-0.12	9.270**
		C	24.35**	-2.33	-10.7**	-13.5**	-1.15	25.67**
	RT	A	1.425**	-1.04**	1.29**	2.31**	0.140	-4.49**
		B	1.390**	0.190*	-0.08	-1.11	1.525**	4.815**
		C	1.350**	-0.39**	0.40**	-2.21**	0.605	3.475**
	MRN	A	5.825**	-0.82	2.25**	4.24**	3.98*	1.320
		B	5.785**	-2.00**	-4.57**	2.91**	4.55**	-3.58**
		C	6.000**	-1.45*	-4.78**	3.91**	4.41**	6.015***
	MRA	A	10786**	-6163**	5014**	-6052**	525.0	11242**
		B	11158**	-6692**	3803*	-4791**	-1012	14453**
		C	11877**	-6944**	-280	-7270**	523.2	19399**

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
A: irrigation every 4 days (control) B : irrigation every 8 days (stress 1) C : irrigation every 12days (stress 2).

Table (11): Heritability in broad (Hb) and narrow (Hn) sense as well as dominance degree (D.d) ratio for studied traits at the three irrigation levels from the combined data over two years of 2010 and 2011.

Crosses		Levels	LR	FLA.	F%	GY/P	MRL	RTH	MRN	MRA
Giza 177 x IET 1444	Hb%	A	75.94	90.90	98.13	92.30	84.45	67.20	90.60	96.04
		B	77.14	91.54	91.81	92.38	87.28	72.04	93.43	96.30
		C	81.95	94.01	89.24	93.16	89.33	79.58	83.18	95.91
	Hn%	A	25.66	18.52	71.66	21.23	43.16	38.84	58.00	25.29
		B	30.52	23.05	70.86	23.30	39.45	32.08	60.97	42.22
		C	25.12	22.41	71.14	22.37	34.35	40.28	67.22	32.13
	D.d	A	1.399	1.979	0.607	1.846	0.980	0.854	0.751	1.672
		B	1.235	1.723	0.559	1.740	1.100	1.116	0.729	1.143
		C	1.504	1.787	0.504	1.793	1.265	0.993	0.482	1.493
Sakha 105 x IRAT 170	Hb%	A	61.84	89.78	90.69	92.13	77.89	80.26	92.57	89.23
		B	68.42	96.19	92.60	89.59	90.62	87.03	89.96	87.88
		C	63.97	91.36	92.90	93.38	84.02	73.65	92.38	95.10
	Hn%	A	29.30	23.43	60.63	22.76	39.58	40.05	65.76	35.99
		B	48.53	24.10	63.79	25.00	41.56	43.13	62.88	40.94
		C	35.39	23.65	60.64	21.11	35.70	41.05	50.81	38.54
	D.d	A	1.053	1.682	0.350	1.756	1.053	1.007	0.638	1.215
		B	0.640	1.729	0.672	1.606	1.204	1.020	0.656	1.071
		C	0.898	1.692	0.727	1.845	1.163	0.891	0.904	1.211
IR 64 x Azucena	Hb%	A	62.80	88.78	91.33	95.26	88.21	80.75	91.34	89.33
		B	71.01	85.54	88.57	88.95	79.93	78.88	91.88	86.60
		C	75.00	89.73	91.57	89.48	68.88	80.67	82.75	94.52
	Hn%	A	44.40	31.93	62.22	26.55	36.87	41.77	60.11	51.55
		B	32.04	28.66	58.58	24.71	39.78	40.67	52.85	56.62
		C	32.99	25.89	63.63	21.33	35.02	36.39	54.92	49.29
	D.d	A	0.643	1.334	0.404	1.611	1.179	0.976	0.718	0.856
		B	1.102	1.434	0.556	1.615	1.000	0.981	0.869	0.727
		C	1.128	1.537	0.671	1.806	0.977	1.111	0.711	0.957

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.
A: irrigation every 4 days (control) B: irrigation every 8 days (stress 1) C: irrigation every 12days (stress 2).

Table (12): Genotypic (above diagonal) and phenotypic (below diagonal) correlations for each pair of all studied traits combined over two years of 2010 and 2011 under the third irrigation level (irrigation/12 days).

	LR	FLA	Fert. %	GY/P	MRL	RT	MRN	MRA
LR		-.864**	-.452	-.529	-.554	-.838**	-.820**	-.760**
FLA	-.841**		-.242	.836**	.895**	.956**	.985**	-.960**
Fert. %	-.258	-.107		-.525	-.563	-.340	-.410	-.710*
GY/P	-.378	.708**	-.362		.870**	.640*	.840**	.810**
MRL	-.539	.842**	-.396	.837**		.870**	.870**	.900**
RT	-.574	.838**	-.126	.563	.740**		.990**	.920**
MRN	-.778**	.862**	-.024	.553	.789**	.890**		.890**
MRA	-.753**	.921**	-.066	.775**	.857**	.895**	.862**	

Note: * and ** significant at 0.05 and 0.01 levels of probability, respectively.
Abbreviations: LR, Leaf rolling; FLA, Flag leaf area; Fert.%, Fertility percentage; GY/P, Grain yield/Plant; MRL, Maximum root length; RT, Root thickness; MRN, Metaxylum root number; MRA, Metaxylum root area.