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GENETICAL STUDIES ON ROOT SYSTEM AND YIELD AND ITS COMPONENTS TRAITS UNDER WATER LIMIT CONDITION IN RICE (*Oryza sativa L.*)

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ABSTRACT

Water limit is one of the major a biotic stress limiting plant production in worldwide. The research work of the present study was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during the three successive rice seasons 2010, 2011 and 2012, to study the genetic effects on some of root system related to water limit and yield and its component traits under water limit condition. Six rice genotypes i.e. Giza 177, Sakha 101, GZ 7456-13-6-5-3, Sakha 105 (sensitive to drought stress), IRAT 112 and IRAT 170 (tolerant to drought stress), were chosen for this study. The results of this investigation revealed that both general and specific combining ability variances were found to be highly significant for all studied traits except root thickness, root dry weight and 1000-grain weight, indicating the importance of both additive and non-additive genetic variance in determining the inheritance of these studied traits i.e. root length, root volume, plant height, No. of days to heading, , No. of panicles/plant, No. of filled grains/panicle and grain yield/plant. With the exception of No. of panicles/plant and grain yield/plant, the GCA/SCA variances were found to be greater than unity for all the studied traits except for No. of panicles/plant and grain yield/plant, suggesting greater importance of additive genetic variance in the inheritance of these traits. Therefore, it could be concluded that selection procedures based on the accumulation of additive effect would be successful in improving of these traits. The results showed that IRAT 112 and IRAT 170 were highly significant and positive general combining ability effects for maximum root length, root thickness, root volume, root dry weight and yield and its component traits under water limit condition indicating that these genotypes could be considered as good combiners for the improvement of these traits i.e. Sakha 105 x IRAT 112 for maximum root length, Sakha 101 x IRAT 112 for root thickness, Giza 177 x IRAT 112 for root volume, IRAT 112x IRAT 170 for root dry weight and Sakha 101 x IRAT 170,Sakha 101 x IRAT 112 for grain yield/plant under water limit condition. Frequency distribution of phenotypes for each trait in F_2 and their parents, all studied traits approximately fit normal distribution, F_2 plants having phenotypic values greater than the higher parent and less than the lower parent (Transgressive Segregates) were observed for all studied traits.

INTRODUCTION

Large areas of rice are grown under lowland and upland rainfed conditions. These areas respectively occupy 31 and 11% of the global rice growing area. Drought is one of the major a biotic stress limiting plant production in rainfed ecosystem. (Evenson *et al.*, 1996) estimated global rice grain yield lost to drought to be 18 million tones annually or 4% of total rice production, which was valued conservatively at US$ 3.6 billion at that time. The worldwide water shortage and improvement of drought tolerance especially important (Luo and Zhang, 2001). Fulfillment of this goal would be enhanced by an understanding of the genetic and molecular basis of drought resistance. The main constraint of rice cultivation in Egypt is the limited source of irrigation water from Nile River and shortage of available water, especially in terminal canals in North Delta, therefore the development of the Egyptian rice varieties tolerance to drought stress is of great importance. In rice genotypes, depth of rooting, root thickness and root to shoot dry weight ratio were verified to be related to drought tolerance **(**Fukai and Cooper, 1995). Root thickness, root dry weight and root length were found highly heritable **(**Ekanayake *et al*., 1985). Direct selection for yield under stress has been considered ineffective because drought is sporadic and the broad-sense heritability of yield under stress is assumed to be lower than in non-stress environments (Fukai and Cooper, 1995). Plant is most sensitive to water stress at the reproductive stage. Dramatic reduction of grain yield occurs when stress coincides with the irreversible reproductive processes making the genetic analysis of drought tolerance at reproductive stage crucially important (Price and Courtois, 1999, Boonjung and Fukai, 2000 and Pantuwan *et al.,* 2002).The root traits play an important role in drought tolerance **(**Thanh *et al.*, 1999) and **(**Sharma *et al*., 2003). Recent development of molecular markers linked to such these traits offer new opportunity for drought tolerance breeding programs. The objective of this study was to study the inheritance of some root system related to drought tolerant and yield and its components under water limit condition.

MATERIALS AND METHODS

The research work of the present study was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during the three successive rice seasons 2010, 2011 and 2012, to study the inheritance of some root system related to drought tolerant and yield and its component traits under drought stress. Six rice genotypes i.e. Giza177, Sakha101, GZ 7456-13-6-5-3, Sakha105 sensitive to drought stress, IRAT112 and IRAT170 tolerant to drought were chosen for this study. These genotypes have a wide range of variation due to their different genetic background. The pedigree, group type and main traits of these genotypes are illustrated in Table 1. The six rice genotypes utilized in this study were grown in three successive sowing dates in 2010 season with 15 days intervals to overcome the difference of heading date among them. Thirty days after sowing, seedlings of each genotype were individually transplanted in the permanent field in three rows (5 meters long) and 20x20 cm apart between plants and rows. A half diallel cross were carried out among the six rice parents in 2010 growing season (without reciprocals). Emasculation method was practiced by using hot water technique according to Jodon (1938) and modified by Butany (1961).

A total of 15 crosses were made and the hybrid seeds were grown in 2011 rice season as F_1 plants in the third week of May and plants were transplanted individually after 30 days adopted a spacing of 20 x 20 cm. The experimental plots were grown in a Randomized Complete Block Design (RCBD), with three replications; each replicate consisted of one row for each parent, and three rows for each F_1 hybrid. Each row was 5 meters long and contained 25 individual plants. Only one F_2 population derived from the cross between Giza 177 (Egyptian rice variety lowland rice sensitive to drought) and IRAT 170 (developed in Cote dIvoire upland rice tolerant to drought) were selected to study the inheritance of drought tolerance. The genetic materials were evaluated at 2012 rice growing season in a Randomized Complete Block Design experiment with three replications. Each replicate comprised 15 rows of F_2 crosses. All recommended agricultural practices were applied as usual for the ordinary rice field. Weeds were chemically controlled.

At maximum tillering stage irrigation was withhold in order to impose drought (irrigation every 12 days). To avoid lateral irrigation water movement and more water control, each main plot was separated by two meter wide ditches. Water pump, provided with a calibrated water meter was used for water measurements according to (EL-Refaee, 2012).The physiological traits related to drought Viz, maximum root length, root volume, root dry weight and root thickness were recorded in the parental genotypes and their F_1 and F_2 individual plants. Also, No. of days to heading, plant height were measured. The yield and its component traits Viz, No. of panicles/plant, No. of filled grains/panicle, 1000-grain weight and grain yield/plant were measured at harvest. The data were recorded on an individual plant basis for the six parental genotypes and their F_1 hybrids and F_2 generations plants.

Table 1: Parental lines and their basic traits feature.

Genotype	Pedigree	Group type	Drought tolerance	Origen
Giza 177	Giza171/Yomji No.1//PiNo.4	Japonica	Sensitive	Egypt
Sakha 101	Giza176/ Milyang 79	Japonica	Sensitive	Egypt
GZ 7456-13-6-5-3	Sakha 101/SR1392-5-1-3	Japonica	Sensitive	Egypt
Sakha 105	GZ5581-46-7-1-1/GZ4316-7-1-1	Japonica	Sensitive	Egypt
IRAT 112		Indica	Tolerant	Cote dIvoire
IRAT 170	IRAT 13/Palawan	Indica	Tolerant	Cote dIvoire

RESULTS AND DISCUSSION

Mean performance of the parents and their F_1 of the half diallel cross for the ten studied traits i.e. maximum root length, root thickness, root volume, root dry weight, plant height, No. days to heading, No. of panicles/plant, No. of filled grains/panicle, 1000-grain weight and grain yield/plant are presented in the Tables 2 and 3). The mean performance of the vegetative traits varied from combination to another. The results of maximum root length suggested that dominant effect was variable and depends on the cross itself. Some crosses were tended to be toward the high parents, while the others were found to be closed to the low parents. However, the means of the other crosses were intermediate between the two parents involved, indicating presence of partial or no dominance effect. The desirable mean values towards the high were obtained from the two parents IRAT112 and IRAT 170 (32 and 31.6 cm) and the crosses IRAT112 x IRAT 170 (35 cm) and Sakha105 x IRAT112 (33.5cm). For root thickness, the obtained results showed that the parental genotypes IRAT112 and IRAT 170 and the rice crosses IRAT112 x IRAT 170, Sakha101 x IRAT170 and GZ 7456-13-6-5-3 x IRAT 170 exhibited the highest values of root thickness under water deficit. With respect to root volume, the highest mean values were obtained from the parents, IRAT 170, IRAT1222 and the crosses IRAT112 x IRAT 170 and Sakha 105 x IRAT 170 (Table 2). Root dry weight of the highest mean values were recorded by the varieties IRAT 170 and the cross IRAT112 x IRAT 170 which gave 8.50 and 8.7 gram/plant. While, the lowest values were recorded by the parents Giza 177 and Sakha 101 and the cross Giza 177x GZ 7456-13-6-5-3 gave 3.80 and 4.00 gram/plant. Regarding the plant height, the cross IRAT112 x IRAT 170 and IRAT 170 gave the highest values 107.33 and 104.33 cm. The high values of the most crosses could be due to the vigorous growth of the F_1 plants as a result of the crosses between the Indica and Japonica varieties. The results of No. of days to heading suggested that dominant effect was variable and depends on the cross itself. Some crosses were tended to be toword the early parents, while the others were found to be closed to the late parents. However, the mean values of the other crosses were intermediate between the two parents involved, indicating the presence of partial or no dominance effect.

Table 2: Mean performance of parents and their F_1 hybrid for root traits and plant height.

Genotypes	Root length (cm)	Root thickness (mm)	Root volume (cm^3)	Root dry weight (g)	Plant height (cm)
Giza 177	17.3	0.4	16.0	3.8	81.0
Sakha 101	20.0	0.5	22.0	4.0	70.3
GZ 7456-13-6-5-3	17.5	0.3	15.0	3.4	73.0
Sakha 105	20.0	0.8	20.3	4.7	87.0
IRAT 112	32.0	1.0	35.3	7.5	99.0
IRAT 170	31.6	1.4	40.0	8.5	104.3
Giza177xSakha 101	21.0	0.5	23.0	4.4	73.0
Giza 177x GZ7456	18.5	0.4	17.8	4.0	74.0
Giza177xSakha 105	21.2	0.8	23.3	5.3	94.6
Giza 177x IRAT112	31.5	0.8	37.0	4.8	92.0
Giza177 x IRAT170	28.8	1.0	37.0	5.7	94.0
Sakha 101xGZ7456	21.0	0.5	19.2	4.5	74.0
Sakha101x akha105	22.0	0.8	24.6	4.8	92.0
Sakha101x RAT112	32.6	1.1	22.0	5.2	97.0
Sakha101xIRAT170	32.0	1.2	30.0	5.4	97.6
GZ 7456x Sakha 105	22.1	0.7	23.6	5.0	90.0
GZ 7456x IRAT112	29.0	0.7	20.3	4.6	99.3
GZ 7456x IRAT170	31.0	1.2	24.0	6.1	88.0
Sakha105x RAT112	33.5	1.0	37.3	6.5	100.0
Sakha105x IRAT170	32.5	1.1	41.0	6.9	102.3
IRAT112x RAT170	35.0	1.3	45.3	8.7	107.3
LSD at 0.05	1.46	0.14	1.77	0.441	1.787
0.01	1.95	0.19	2.36	0.59	2.391

The desirable mean values towards the earliness were obtained from parents GZ 7456-13-6-5-3 and Giza 177 and the cross Sakha101 x GZ 7456-13-6-5-3 gave 92.66, 95.33 and 92 days, respectively (Table 2). For number of panicles/plant, the parents IRAT 170 and IRAT 112 and the crosses IRAT 112 x IRAT 170 and Sakha 101 x IRAT 112 gave the highest mean values for this trait. On the other, hand the parent GZ 7456-13-6-5-3 gave the lowest mean values. The parents IRAT 170 and the cross IRAT 112 x IRAT 170 showed the highest mean values regarding to No. of filled grains/panicle. Concerning 1000-grain weight, the parents IRAT 170 and IRAT 112 and the crosses IRAT 112 x IRAT 170,Giza 177 x IRAT 112, Giza 177 x IRAT 170, GZ 7456-13-6-5-3 x IRAT 112 and Sakha 101 x IRAT 112 showed the highest mean values. For grain yield/plant, the highest mean values were obtained from the parental varieties IRAT 112 and IRAT 170 with mean values of 42.33 and 37.00 gram/plant, respectively. The crosses IRAT 112 x IRAT 170, Sakha 101 x IRAT 170 and Sakha 101 x IRAT 112 gave the mean values of 54.33, 53.66 and 53.00 grams/plant, respectively. On the other hand the parent Giza 177 showed the lowest mean values (21.66 grams/plant) for the same trait.

Table 3: Mean performance of parents and their F_1 hybrids for days to heading and yield and its components.

Genotypes	Days to heading (day)	No. of panicles/plant	No. of filled grains/ panicle	1000-grain weight (g)	Grain yield/ plant (g)
Giza 177	95.3	10.0	84.6	24.6	21.6
Sakha 101	105.0	10.0	99.0	25.6	25.0
GZ 7456-13-6-5-3	92.6	8.0	72.6	24.3	24.0
Sakha 105	100.3	11.0	94.0	24.6	26.0
IRAT 112	104.0	13.3	112.0	28.0	42.3
IRAT 170	111.6	14.3	147.6	27.0	37.0
Giza177xSakha 101	93.6	11.0	90.0	26.6	42.3
Giza 177x GZ7456	87.6	10.0	83.3	25.3	38.3
Giza177xSakha 105	102.6	11.6	96.0	25.0	28.3
Giza 177x IRAT112	97.6	15.0	108.3	28.6	51.0
Giza177 x IRAT170	105.0	15.6	111.6	27.6	49.0
Sakha 101xGZ7456	92.0	12.0	93.3	25.3	37.0
Sakha101x akha105	109.0	12.3	100.0	25.3	28.0
Sakha101x RAT112	107.3	17.0	120.6	27.0	53.0
Sakha101xIRAT170	108.0	15.0	126.0	25.6	53.6
GZ 7456x Sakha 105	102.0	11.0	97.0	25.3	28.3
GZ 7456x IRAT112	99.0	13.0	117.3	27.3	45.0
GZ 7456x IRAT170	98.0	12.0	120.3	25.6	41.0
Sakha105x IRAT112	106.0	13.0	105.0	26.3	39.0
Sakha105x IRAT170	112.0	13.0	110.0	25.3	38.3
IRAT112x IRAT170	114.6	17.0	139.3	29.0	54.3
LSD at 0.05	2.345	1.792	3.820	1.183	2.050
0.01	3.138	2.398	5.111	1.583	2.743

Analysis of Combining Ability: Estimates of both general (GCA) and specific combining ability (SCA) variances for root traits, plant height, days to heading and yield and its component traits are presented in Tables 4 and 5.

Both general and specific combining ability variances were found to be highly significant for all studied traits except root thickness, root dry weight and 1000-grain weight, indicating the importance of both additive and non-additive genetic variance in determining the inheritance of these traits i.e. root length, root volume, plant height, No. of days to heading, No. of panicles/plant, No. of filled grains/panicle and grain yield/plant. The relative importance of each variance was determined using GCA/SCA, with the exception of plant height, No. of panicles/plant and grain yield/plant, the GCA/SCA variances were found to be greater than unity for all the studied traits, suggesting greater importance of additive genetic variance in the inheritance of these traits. Therefore, it could be concluded that selection procedures based on the accumulation of additive effect would be successful in improving these traits. The results obtained are in agreement with that reported by Meenakshi and Amirthadevarathinam (1999), EL-Refaee (2002), EL-Abd *et al.,* (2003), EL-Mowafi and Abou Shousha (2003), Fahmi *et al.,* (2004), Aidy *et al*., (2006) and Hammoud *et al*., (2008).

General Combining Ability Effects: Estimates of the general combining ability effects of the individual parental lines for all studied traits are given in Tables 6 and 7. Highly significant and positive (GCA) were observed for the root length, root thickness, root volume, root dry weight, No. of panicles/plant, No. of filled grains/panicle, 1000-grain weight and grain yield/plant, while, highly significant and negative values were recorded for No. of days to heading and plant height which are desirable for improvement of these traits in breeding programs since the low mean values are the target of breeder. With respect to root traits, i.e., maximum root length, root thickness, root volume and root dry weight the parental genotypes IRAT 112 and IRAT 170 showed highly significant and positive general combining ability effects under drought condition indicating that these entries could be considered as good combiners for the improvement of these traits. Regarding plant height, three entries viz, GZ 7456-13-6-5-3, Sakha 101 and Giza 177 showed highly significant and negative general combining ability effects with values of –7.333, -6.958 and –5.041, respectively. The negative values of (GCA) effects for this trait are required from breeding point of view since it refers to the short stature plant type. Concerning No. of days to heading, the varieties GZ 7456-13-6-5-3 and Giza 177 showed highly significant and negative general combining ability effects with values of -6.319 and -4.652, respectively, indicating that these entries could be used as a good combiner for this trait. For yield and its component traits, the estimated of (GCA) for the entries IRAT 112 and IRAT 170 were highly significant and positive values under drought condition. Therefore, the entries IRAT 112 and IRAT 170 could be used in the rice crossing programs as good combiners for yield and its component traits under drought stress. From the above mentioned results, it could be concluded that IRAT 112 and IRAT 170 considered as good combiners for improving the root traits, yield and its component traits under water deficit.

Table 4: Mean square estimates of the ordinary and combining ability analysis for root traits and plant height.

Source of variability	d. f	Root length (cm)	Root thickness (mm)	Root volume (cm^3)	Root dry weight (g)	Plant height (cm)
Replications	2	6.258**	0.0044	2.829	0.0211	1.857
Genotypes	20	117.162**	0.3182	253.09**	6.538**	397.566**
Parents	5	142.09**	0.576	325.60**	13.87**	567.15**
Crosses	14	99.029**	0.235	233.41**	4.36**	333.30**
Pvs.F1	1	246.39**	0.190	166.11**	0.33ns	449.24**
Error	40	0.7869	0.0076	1.151	0.0714	1.1738
GCA	5	129.683**	0.3821	262.39**	7.688**	434.34**
SCA	15	8.884**	0.0140	25.02**	0.343	31.914**
Error	40	0.262	0.0025	0.383	0.0238	0.3912
GCA/SCA		1.88	4.12	1.32	2.99	1.72

*** and ** Significant at 5% and 1% levels of probability, respectively.**

Table 5: Mean square estimates of the ordinary and combining ability analysis for days to heading and yield and its component traits.

Source of variability	d. f	Days to heading (Day)	No. of panicles/plant	No. of filled grains/panicle	1000-grain weight (g)	Grain yield/plant (g)
Replications	2	1.920	0.0634	0.444	0.0476	2.111
Genotypes	20	158.796**	17.163**	1018.94**	5.452**	328.144**
Parents	5	143.566**	16.488**	2051.20**	6.59**	206.932**
Crosses	14	174.97**	14.451**	687.50**	5.04**	252.65**
Pvs.F_1	1	8.46**	58.51**	497.78**	5.52**	1991.12**
Error	40	2.02	1.18	5.361	0.5142	1.544
GCA	5	169.304**	15.164**	1190.72**	5.450**	234.23**
SCA	15	14.141**	2.573**	55.95**	0.606	67.76**
Error	40	0.6735	0.393	1.787	0.171	0.514
GCA/SCA		1.56	0.84	2.74	1.51	0.434

*** and ** significant at 5% and 1% levels of probability, respectively.**

Table 6: Estimates of general combining ability (GCA) effects of each parent for root traits and plant height.

Parents	Root length (cm)	Root thickness (mm)	Root volume (cm3)	Root dry weight (g)	Plant height (cm)
Giza 177	-3.479**	-0.193**	-2.652**	-0.768**	-5.041**
Sakha 101	-1.845**	-0.105**	-3.577**	-0.701**	-6.958**
GZ 7456	-3.354**	-0.218**	-7.056**	-0.880**	-7.333**
Sakha 105	-1.512**	0.031*	-0.0986	0.0069	2.875**
IRAT 112	5.279**	0.131**	5.151**	0.852**	7.958**
IRAT 170	4.912**	0.352**	8.234**	1.490**	8.500**
LSD 0.05	0.1652	0.0162	0.1999	0.0497	0.02018
0.01	0.3305	0.0324	0.3998	0.0995	0.04036

*** and ** significant at 5% and 1% levels of probability, respectively**

Table 7: Estimates of general combining ability (GCA) effects of each parent for days to heading and yield and its component traits.

Genotype	Days to heading (day)	No. of panicles/plant	No. of filled grains/panicle	1000-grain weight (g)	Grain yield/plant (g)
Giza 177	-4.652**	-0.638**	-10.513**	-0.0833**	-1.902**
Sakha 101	0.680**	-0.138	-1.847**	-0.250*	-0.444*
GZ 7456	-6.319**	-1.805**	-10.763**	-0.708**	-3.736**
Sakha 105	2.222**	-0.680**	-5.847**	-0.833**	-6.694**
IRAT 112	2.263**	1.652**	8.986**	1.375**	7.430**
IRAT 170	5.805**	1.611**	19.986**	0.50**	5.347**
L.SD 0.05	0.2648	0.2024	0.4314	0.1336	0.2315
0.01	0.5297	0.4048	0.8628	0.2672	0.4631

*** and ** Significant at 5% and 1% levels of probability, respectively**

Specific Combining Ability Eeffects: Estimates of specific combining ability effects are shown in Tables 8 and 9. Regarding to maximum root length, nine hybrid combinations exhibited significant and highly significant positive values of SCA effects. The best hybrid combinations were Sakha 105 x IRAT 112, Giza 177 x IRAT 112, GZ 7456-13-6-5-3 x IRAT 170 and Sakha 101 x IRAT 112 gave 3.528, 3.495, 3.236 and 3.028, respectively. For root thickness, Sakha 101 x IRAT 112 and GZ 7456-13-6-5-3 x IRAT 170 gave the highest values of SCA effects with values of 0.2244 and 0.2160.

Table 8: Estimates of specific combining ability (SCA) effects for root traits and plant height.

Crosses	Root length (cm)	Root thickness (mm)	Root volume (cm^3)	Root dry weight (g)	Plant height (cm)
Giza177xSakha 101	0.120	-0.0506*	1.879**	0.477**	-5.00**
Giza 177x GZ7456	-0.871*	-0.0047	0.192	0.223**	-3.625**
Giza177xSakha 105	-0.046	0.1785**	-1.266**	0.635**	6.833**
Giza 177x IRAT112	3.495**	0.0119	7.150**	-0.710**	-0.916*
Giza177 x IRAT170	1.195**	-0.0089	4.067**	-0.447**	0.541
Sakha 101xGZ7456	-0.004	-0.0256	2.450**	0.623**	-1.708**
Sakha101x akha105	-0.846*	0.0244	0.992*	0.135	6.083**
Sakha101x RAT112	3.028**	0.2244	-6.924**	-0.376**	6.00**
Sakha101xIRAT170	2.728**	0.1035**	-2.007**	-0.814**	6.125**
GZ 7456x Sakha 105	0.761*	0.0369	3.471**	0.448**	4.458**
GZ 7456x IRAT112	0.870*	-0.0631*	-5.111**	-0.797**	8.708**
GZ 7456xIRAT170	3.236**	0.2160**	-4.528**	0.0982	-3.166**
Sakha105x IRAT112	3.528**	0.0202	4.929**	0.214*	-0.833*
Sakha105x IRAT170	2.961**	-0.1006**	5.513**	0.044	0.958*
IRAT112x RAT170	-1.396**	-0.0339	4.596**	0.931**	0.875*
L.S.D 0.05	0.4539	0.0445	0.549	0.1367	0.5544
L.S.D. 0.01	0.9079	0.0891	1.098	0.2734	1.108

*** and ** Significant at 5% and 1% levels of probability, respectively.**

Concerning root volume, nine rice crosses gave high and highly significant positive values of SCA effects. The crosses, Giza 177 x IRAT 112, Sakha 105 x IRAT 170, Sakha 105 x IRAT 112 and IRAT 112 x IRAT 170 were the best crosses gave 7.150, 5.513, 4.929 and 4.596, respectively. In case of root dry weight, the hybrid combinations, IRAT 112 x IRAT 170, Giza 177 x Sakha 105 and Sakha 101 x GZ 7456-13-6-5-3 exhibited the desirable values of SCA effects with values 0.931, 0.635 and 0.623, respectively. For plant height, six combinations showed highly significant and negative values of (SCA) effects. The best crosses of them were Giza 177 x Sakha 101, Giza 177 x GZ 7456-13-6-5-3 and GZ 7456-13-6-5-3 x IRAT 170 gave –5.00,-3.625 and –3.166, respectively. This indicating that these crosses may be useful in exploitation of heterosis due to their desirable stature. No. of days to heading showed that (SCA) of five crosses were highly significant and negative ranging from –2.023 for Giza 177 x IRAT 112 to – 4.440 for Giza 177 x Sakha 101 and Sakha 101 x GZ 7456-13-6-5-3. The crosses which gave negative significant could be utilized in rice breeding programs to improve this trait. In case of No. of panicles**/**plant, seven rice crosses showed positive high and highly significant values of SCA effects. The crosses Sakha 101 x IRAT 112 and Giza 177 x IRAT 170 exhibited the highest values compared with other crosses with values 2.851 and 2.059.The crosses which gave highly significant and positive estimates could be used as a donor for increase this trait. Regarding to No. of filled grains**/**panicle, nine crosses gave positive significant and highly significant estimates of SCA effects. The best crosses were GZ 7456-13-6-5-3 x IRAT 112,GZ 7456 x Sakha 105 and Sakha 101x IRAT 112, indicating that these crosses may be useful in exploitation of heterosis due to their desirable trait.

Table 9: Estimates of specific combining ability (SCA) effects for days to heading and yield and its component traits.

Crosses	Days to heading (day)	No. of panicles/plant	No. of filled grains/panicle	1000-grain weight (g)	Grain yield/plant (g)
Giza177xSakha 101	-4.440**	-0.857*	-3.750**	0.809**	6.458**
Giza 177x GZ7456	-3.440**	-0.190	-1.50*	-0.065	5.750**
Giza177xSakha 105	3.017**	0.351	6.250**	-0.273	-1.291**
Giza 177x IRAT112	-2.023**	1.351**	3.750**	1.184**	7.250**
Giza177 x IRAT170	1.767**	2.059**	-3.916**	1.059**	7.333**
Sakha 101xGZ7456	-4.440**	1.309**	-0.166	0.1011	2.958**
Sakha101x akha105	4.017**	0.517	1.583*	0.2261	-3.083**
Sakha101x RAT112	2.309**	2.851**	7.416**	-0.315	7.791**
Sakha101xIRAT170	-0.565	0.892*	1.750*	-0.773**	10.541**
GZ 7456x Sakha 105	4.017**	0.851*	7.500**	0.684*	0.541
GZ 7456x IRAT112	0.976*	0.517	13.00**	0.476*	3.083**
GZ 7456xIRAT170	-3.565**	-0.440	5.00**	-0.315	1.166*
Sakha105x IRAT112	-0.565	-0.607*	-4.250**	-0.398*	0.041
Sakha105x IRAT170	1.892**	-0.565*	-10.250**	-0.523*	1.458**
IRAT112x IRAT170	4.517**	1.101*	4.250**	0.934**	3.333**
L.S.D . 0.05	0.7274	0.5558	1.184	0.3669	0.6359
L.S.D. 0.01	1.454	1.111	2.369	0.7339	1.271

*** and ** Significant at 5% and 1% levels of probability, respectively.**

Concerning the 1000-grain weight, the results revealed that six crosses showed high and highly significant and positive estimates of SCA effects. The crosses, Giza 177 x IRAT 112 and Giza 177 x IRAT 170 recorded the highest values. The combinations with high positive estimates could be utilized for improving 1000-grain weight. Data in Table 8 revealed that 11 hybrid combinations showed high and highly significant positive values of SCA effects for grain yield**/**plant. The best crosses were Sakha 101 x IRAT 170,Sakha 101 x IRAT 112, Giza 177 x IRAT 170 and Giza 177 x IRAT 112gave 10.541, 7.791, 7.333 and 7.250, respectively.

Frequency Distribution of Phenotypes Frequency: Distribution of phenotypes for each trait in F_2 population (Giza177/ IRAT 170) and their parents are presented in Fig 1 to 5. Figure 1 shows the frequency distribution of F_2 plants, and the ranges and means of the F_1 and parents for root length and root volume traits. The distribution of F_2 plants was continuous for root length and discontinues with break point between 15 and 25 for root volume with two pick fitting 3:1 ratio. In the same time transgressive segregation over Giza177 and F_1 was observed for root length, while transgressive segregation over F_1 and both parents at root volume. Frequency distribution of F_2 plant for root thickness and root weight are showed at Fig. 2. Biomedical distribution of F_2 plants for root weight and discontinues for root thick, transgressive segregation over Giza177 and F_1 was observed for root length, while transgressive segregation over F_1 and both parents at root volume. Figure 3, shows the frequency distribution of F_2 plants, means of the F_1 and parents for No. of panicle/ plant and 1000- grain weight traits. Bimodal distribution of F_2 plants for both traits with 2˜3 break point. Transgressive segregation over Giza177 and F_1 was observed at No. of panicles/plant fitting 9:9:6:3 ratio, while transgressive segregation over F_1 and both parents at 1000-grain weight fitting 9:3:3:1 ratio. Biomedical distribution of F_2 plant for plant height and days to heading was observed in Fig 4. Transgressive segregation over IRAT 170 and F_1 was observed for days to heading, while transgressive segregation over F_1 and both parents at plant height. The results, indicates that these traits are polygenic determined. Figure 5, shows the frequency distribution of F_2 plants, and the ranges and means of the F_1 and parents for filled grains/panicle and grain yield /plant traits. Bimodal distribution of F_2 plants was continuous was observed for both traits.. In the same time transgressive segregation over F_1 and both parents, this results indicates that these traits are polygenic determined. These transgressive segregation of most of the studied traits and bimodal distribution indicated that most of these traits controlled by more genes (quantative traits). These results agree with Luo *et al.*, (2002) who reported that, the action of polygenic and complementary genes for root system and agronomic traits.

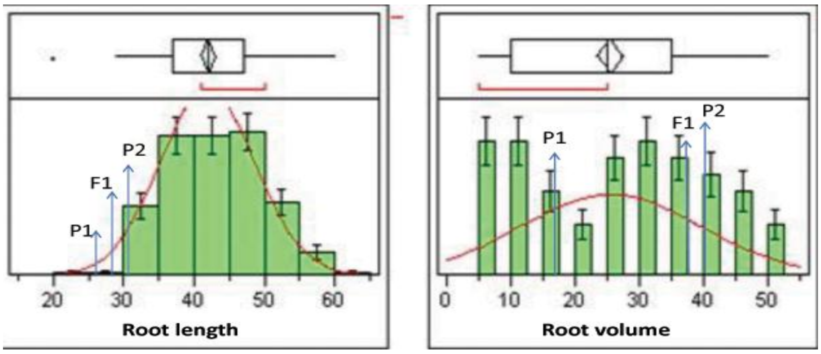

Fig. 1: Frequency distribution of root length and root volume for F_2 population derived from IRAT 170 and Giza177.

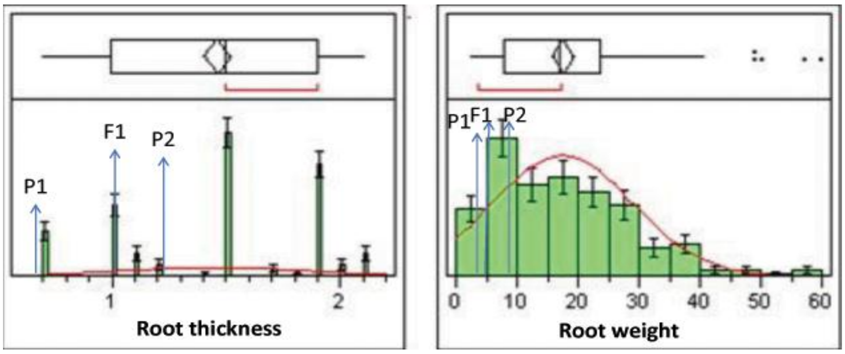

Fig 2: Frequency distribution of root thickness and root weight for F_2 population derived from IRAT 170 and Giza177.

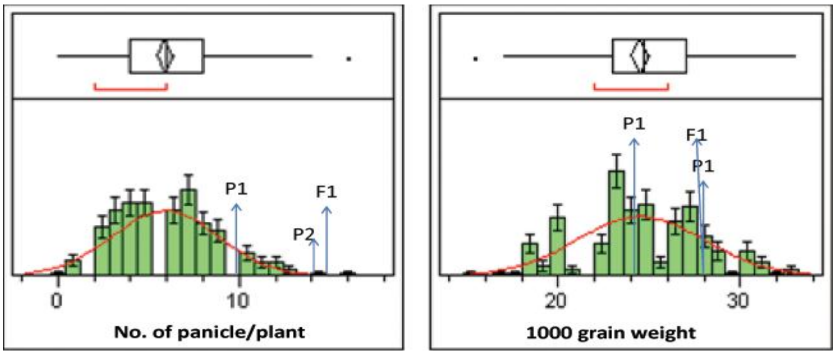

Fig 3: Frequency distribution of No. of panicles/plant and 1000 grain weight for F_2 population derived IRAT 170 and Giza177.

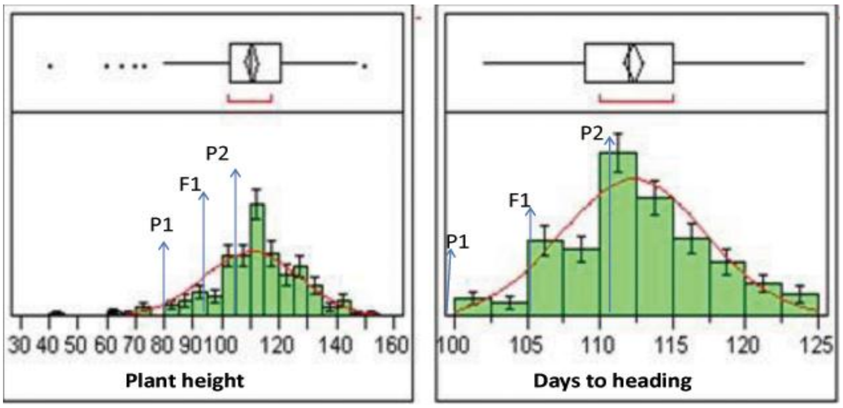

Fig 4: Frequency distribution of plant height and days to heading for F_2 population derived from IRAT 170 and Giza177.

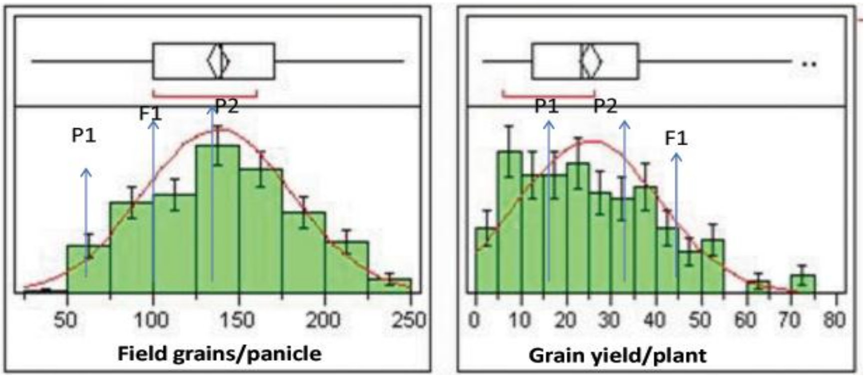

Fig 5: Frequency distribution of filled grains/panicle and grain yield /plant for F_2 population derived from IRAT 170 and Giza177.

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تعتبر محدودة المياه واحدة من الأجهادات الغير حيوية والمحددة للأنتاجية الأرز فى العالم. أجرى هذا البحث بالمزرعة البحثية لمركز البحوث والتدريب فى الأرز بسخا- كفرالشيخ –مصر أثناء مواسم ٢٠١٠، ٢٠١١ و ٢٠١٢ لدراسة بعض صفات الجذر وعلاقته بتحمل الأجهاد المائى والمحصول ومكوناته تحت ظروف محدودية المياه. أستخدمت فى هذه الدراسة ٦ تراكيب وراثية وهى جيزة ١٧٧، سخا ١٠١، سخا ١٠٥ و جى زد ٧٤٥٦ (أصناف حساسة لنقص الماء) وأرت ١١٢ و أرت ١٧٠ (أصناف متحملة لنقص الماء). أظهرت النتائج أن القدرة العامة والخاصة على الأئتلاف كانت عالية المعنوية لكل الصفات المدروسة ما عدا سمك الجذر، الوزن الجاف للجذر ووزن الألف حبة مما يدل على أهمية كلا من العامل الوراثى المضيف والغير مضيف فى وراثة أقصى طول للجذر،حجم الجذر، طول النبات، عدد الأيام للتزهير، عدد السنابل/نبات، عدد الحبوب الممتلئة/ السنبلة ومحصول الحبوب /النبات . كان تباين القدرة العامة على الأئتلاف الى القدرة الخاصة على الأئتلاف أكبر من الوحدة لكل الصفات المدروسة ما عدا عدد السنابل/نبات ومحصول النبات الفردى مما يدل على أهمية العامل الوراثى المضيف فى وراثة هذه الصفات مما يؤكد أهمية برنامج الأنتخاب فى تحسين هذه الصفات.

أظهر كلا من أرت ١١٢ و أرت ١٧٠ قدرة عامة على الأئتلاف عالية المعنوية للأقصى طول للجذر، سمك الجذر، حجم الجذر، الوزن الجاف للجذر والمحصول ومكوناته تحت ظروف الأجهاد المائى مما يدل على امكانية أستخدام هذان الصنفان فى برنامج التربية لتحسين هذه الصفات السابقة.

كانت أفضل لبعض الصفات المدروسة الهجن هى سخا ١٠٥ x أرت ١١٢لصفة طول الجذر، سخا ١٠١ x أرت ١١٢ لصفة سمك الجذر، جيزة ١٧٧x أرت ١١٢ لصفة حجم الجذر، أرت ١١٢ x أرت ١٧٠ للوزن الجاف للجذر وسخا ١٠١ x أرت ١٧٠ و سخا ١٠١ x أرت ١١٢ لصفة محصول النبات الفردى تحت ظروف الأجهاد المائى. أظهر التوزيع التكرارى فى الجيل الثانى توريعا طبيعا لمعظم الصفات محل الدراسة ووجود نباتات لها قيم أكبر من ألأب الأعلى فى الصفة وقيم أقل من الأب الأقل فى نفس الصفة مما يدل على الأنعزال الفائق الحدود لهذه الصفات