COMBINING ABILITY FOR SOME ROOT, PHYSIOLOGICAL AND GRAIN QUALITY TRAITS IN RICE (*ORYZA SATIVA* L.) UNDER WATER DEFICIT CONDITIONS

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ABSTRACT

An experiment involving 8 x 8 half diallel crossing was conducted in rice at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt during 2009 and 2010 rice growing seasons, to investigate the nature of gene action governing the various traits studied and to explore the combining ability behavior of various genotypes used in the studies. Eight root, agro-physiological and grain quality traits were included in the study in F_1 generation. It was conspicuous from the results that GCA variance was greater than the SCA variance for all the studied traits, indicating the preponderance of additive gene action for these traits. The GCA/SCA ratio was greater than unity for root length (1.07) and grain length (1.13) exhibited that additive gene action was played a remarkable role in the inheritance of these two traits and could easily manipulated for genetic improvement. On the contrary, the non-additive effects were more pronounced for root volume, root/shoot ratio, milling %, amylose content, and chlorophyll content indicating that their genetic improvement under water deficit conditions was a tedious exercise. The estimates of GCA effects indicated that parents, Balado and Wab 878 were good combiners for grain length and amylose content. The parent Wab 450 was a good general combiner for root length, root volume, chlorophyll content and grain length. In addition, Gaori and GZ 1368 were the best general combiners for root/shoot ratio and milling %. Sakha 104 was a good combiner for only milling %. Moreover, the cross combinations, Sakha 102 X GZ 1368, Wab 450 X Gaori and IET1444 X Gaori appeared to be the best ones for root length and root volume since they exhibited a significantly positive SCA effect and some of them involved parents with high GCA. Moreover, the cross combinations, Sakha 102 X Gaori, Sakha 104 X IET 1444, IET 1444 X Wab 878 and IET 1444 X GZ 1368 exhibited high sca and included at least one parent having good gca for milling %. Results further indicated that 19. 7, 8 and 8 crosses had significant positive better parent heterosis for root volume, root/shoot ratio, chlorophyll content and grain length. Moreover, highly significant estimates of heterosis were recorded in Sakha 102 X Sakha 104, Sakha 102 X IET 1444, Sakha 102 X GZ 1368, Balado X Wab 450, Balado X IET 1444, Balado X Wab 878 and IET 1444 X Wab 878 rice genotypes for grain length. On the other hand, IET 1444 X Gaori rice hybrid exhibited either highly significant positive estimates of heterosis for root volume, root/shoot ratio or negative for amylose content %. Among the studied crosses, Balado X IET 1444 and IET 1444 X GZ 1368 obtained highly significant heterosis when they measured as a deviation from better parent for root length and milling %, respectively. The phenotypic correlation coefficient was found to be highly significant positive between root length and each of root volume, root/shoot ratio and chlorophyll content %. Root volume was phenotypically associated with root/shoot ratio and chlorophyll content %. Moreover, chlorophyll content was correlated with root/shoot ratio. Regarding grain quality traits, grain length was significantly and positively correlated with milling % and amylose content%

Key words: rice – root traits – chlorophyll content – grain quality – combining ability, heterosis.

INTRODUCTION

Drought, like many other environmental stresses, has adverse effects on crop yield. Low water availability is one of the major causes for crop yield reduction affecting the majority of the farmed regions around the world. Drought tolerance is a complex trait, expression of which depends on action and interaction of different morphological, physiological and biochemical traits. Rice breeders have the common goal of identifying traits that confer an advantage under drought. They also have worked to identify lines with superior performance in the target environments, in order to gradually accumulate favorable alleles in improved cultivars and used the current knowledge about how plants grow to hypothesize which traits might be advantageous, and have then looked for genetic variation in those traits that can be correlated with yield in the target environments. Hence, breeders tend to work from yield to alleles to traits (ideotype)

Combining ability is defined as the ability of a parent line in hybrid combinations **(Kambal and Webster, 1965).** It plays an important role in selecting superior parents for hybrid combinations and in studying the nature of genetic variation **(Duvick, 1999).** It is a powerful method to measure the nature of gene action involved in quantitative traits **(Baker, 1978).** The authors defined GCA as the average performance of a line in hybrid combinations, while SCA as those instances in which certain hybrid combinations are either better or poorer than would be expected of the average performance of the parent inbred lines included. For random individuals, GCA is associated with additive effects of the genes, while SCA is related to dominance and epistatic effects (non-additive effects) of the genes **(Sprague and Tatum, 1942).** GCA effects represent the fixable component of genetic variance, and are important to develop superior genotypes. SCA represents a non-fixable component of genetic variation, it is important to provide information for hybrid performance **(Sprague, 1966).** The GCA/SCA ratio is studied as parameter of the genetic variability in a diallel analysis. It estimates the type of gene action, which controls a particular characteristic **(Quick, 1978; Sayed, 1978).** When the ratio is high, it means the effect of the additive genes is prevalent. If the ratio is lower than one, it means the effect of nonadditive genes is prevalent in determining a particular character. If GCA variance is higher than SCA variance, the greater is the magnitude of additive genetic effects. Otherwise, the non-additive or dominant genetic variances are prevalent **(Baker, 1978).** The closer this ratio is to unity the greater the magnitude of additive genetic effects.

Shull (1914) first, gave the concept of "heterosis". As a commercial concept, heterosis is described as the degree of hybrid performance over the best available parent line **(Virmani and Edwards, 1983). Flintham *et al.* (1997)** explained that the heterozygosity is an essential component of heterosis and it can arise when the over dominance at a single locus is the major cause of heterosis. Heterosis is an important parameter of plant improvement, and efforts will be continued in many plant species. It has been utilized successfully even though its genetic basis has not been determined for the large part **(Hallauer, 1999).** The present study was conducted to investigate the nature of gene action governing the various traits studied and to explore the combining ability behavior of various genotypes used in the studies. eight root, agro-physiological and grain quality traits were included in the study in F_1 generation.

MATERIALS AND METHODS

A half diallel set was made in 2009 summer season using eight local and exotic rice genotypes viz., Sakha 102, Sakha 104, Balado, Wab 450, IET 1444, Wab 878, Gaori, and GZ 1368 excluding reciprocals at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt. The parents and F_1s were evaluated in randomized complete block design with three replications during summer 2010 season. Each genotype was planted in four rows per replicate. Row was five meters length with the spacing of 20 x 20 cm among rows and plants, three to four 30 days old seedlings from each genotype were transplanted per hill. However, the outer two rows were used as borders, while, the inner two rows were used for root, physiological and grain quality traits evaluation. Flush irrigation was used every 8 days for the water stress conditions. Recommended cultural practices were followed.

For root measurements, 20 rice plants from each genotype were grown in plastic bag, one plant per bag. The bag was 20 cm in diameter and 0.5 m in length with holes on the top and down two sides. Bags were placed with water deficit treated basin. The studied root traits, root length, root volume and root/soot ratio were scored at the maximum tillering stage. To measure these traits, the plastic bag containing the soil and roots was pulled out from the basins. The lowest visible root in the soil after removing the plastic bag was scored as the maximum root length (in centimeters). The body of soil and roots was cut from the basal node of the plant and the soil was washed away carefully to collect roots, then the above mentioned root traits were measured.

Chlorophyll was extracted from the fully expanded third leaf at panicle initiation stage by 80% acetone at 17°C. Spectrophotometric measurements were made by Super Scan 3 Spectrophotometer. Chlorophyll content was determined using the specific absorption coefficient of **Mckinney (1941).**

In laboratory, grain qualities of thirty-six rice genotypes were investigated. Cleaned paddy samples from each genotype were dried to 13 % moisture contents and milled. Husking machines which used were Satake Rubber Roll Husker. The resulting brown rice was milled for 75 second in a Satake grain-testing mill TM05. Milled rice out-turn was expressed as percent of milled rice. Milled grain length was measured with the help of Dial Caliper on fifteen randomly selected full healthy rice grains. Rice samples were floured after strong for four months. The amylase content (A.C) determined cooking behavior and eating quality of cooked rice was estimated. Based on amylose content, milled rice was classified as waxy (1-2% amylose), very low (>2-9% amylose), low (>9-20% amylose), intermediate (>20-25% amylose) and high (25-33% amylose), Juliano (1971). The data thus obtained for each trait were statistically combined over the two seasons according to **Le clerg *et al.* (1962).**

Combining ability was analyzed according to **Griffing, (1956).** Tests of significance for general and specific combining ability were

M.S. (g)/ M.S. (s) and M.S. (s)l M.S. (e), respectively, referred to by **Griffing, (1956)** as his method 2, model I. The heterosis were estimated as the deviation of the F_1 mean value from the mid- and better-parent mean values as suggested by **Matzinger *et al.* (1962)** and **Fonsecca and Patterson (1968),** respectively. The following formulae were used for the estimation of mid-parent (MP) and better-parent (BP) heterosis for all the traits:

$$\text{Heterosis over the mid-parent} = [(F_1 - MP) / MP \times 100],$$

$$S.E.\ (F_1 - MP) = (3Me / 2r)^{1/2},$$

$$\text{Heterosis over the better-parent} = [(F_1 - BP) / BP \times 100], \text{ and}$$

$$S.E.\ (F_1 - BP) = (2Me / r)^{1/2}.$$

Where, Me = error mean squares for parents and F_1s from an individual environment; MP = mean mid-parent value = $(P_1 + P_2) / 2$; P_1 = mean performance of parent one; P_2 = mean performance of parent two; BP = mean of better-parent value; R = number of replications. The phenotypic correlation coefficient was calculated as per the method of **Dewey and Lu (1959).**

RESULTS AND DISCUSSION

Analysis of variance

The ANOVA for combining ability for 7 traits in 8 x 8 half diallel set revealed that variances due to the general (GCA) and the specific (SCA) combining abilities were significant for all the traits studied indicating the important of both additive and dominance gene action in the inheritance of all traits. Moreover, the GCA variance was greater than the sca variance for all the studied traits, indicating the preponderance of additive gene action for these traits. The gca/sca ratio was greater than unity for root length (1.07) and grain length (1.13) exhibited that additive gene action was played a remarkable role in the inheritance of the two mentioned traits. On the contrary, the gca/sca ratio was lower than unity for root volume, root/shoot ratio, milling %, amylose content % and chlorophyll content %; this in terms, revealed that predominance of dominance gene action in the inheritance of these traits (Table 1). Similar results were obtained previously by **El-Hissewy and Bastawisi (1998), Xu *et al.* (1998), Wang** *et al.* **(2003) and El-Abd and Abd Allah (2004)**

Table (1): Analysis of variance for combining ability

S.O.V	d.f	Root traits			Grain quality traits			Physiological traits
		Root length (cm)	Root volume	Root: Shoot ratio	Grain length (ml)	Milling (%)	Amylose content (%)	Chlorophyll Content
Replications	2	9.34	32.25	0.03	0.03	17.7	2.37	27.94
Genotypes	35	31.64**	3416.92**	0.14**	0.87**	125.17**	15.81**	33.23**
g.c.a	7	109.02**	5146.42**	0.23**	3.19*	207.16*	20.51*	42.38**
s.c.a	28	12.30**	2984.54**	0.12**	0.29**	104.67**	14.63**	30.94**
Error	70	2.41	10.27	0.01	0.01	6.74	0.99	7.07
g.c.a/s.c.a		1.07	0.17	0.20	1.13	0.20	0.14	0.14

*and ** significant at 0.05 and 0.01 probability levels, respectively.

Estimates of general (GCA) and specific combining ability (SCA) effects

The estimates of GCA effects indicated that the parent IET 1444 was a good combiner for root length, root volume and grain length. The parent Sakha 102 may be focused for root/shoot ratio. Moreover, parents, Balado and Wab 878 were good combiners for grain length and amylose content. The parent Wab 450 was a good general combiner for root length, root volume, chlorophyll content and grain length. In addition, Gaori and GZ 1368 were the best general combiners for root/shoot ratio and milling %. Sakha 104 was a good combiner for only milling %. (Table 2).

Some of the parents with high mean values exhibited low GCA effects and vice versa. Hence both per se and GCA effects should be taken into account for parental selection. The parent IET 1444 was selected as the best one since it had high mean values coupled with high GCA for root length, root volume and grain length, it was also a good general combiner for these traits. Similarly, each of Balado and Wab 450 are also judged as being very good parents for at least three traits. It is obvious that none of the parents were found to be good for all the traits. Hence, it would be desirable to have multiple crosses involving the parents' viz., IET 1444, Balado and Wab 450, and make a selection in the segregating generations to isolate superior genotypes (Table 3).

Table (2): Estimates of general combining ability (GCA) effects for the studied traits.

Parents	Root length (cm)	Root volume	Root : Shoot ratio	Chlorophyll content	Grain length (mm)	Milling (%)	Amylose content (%)
Sakha 102	-2.22**	-10.62**	0.17**	0.02	-0.28**	-0.09	0.13**
Sakha 104	-1.49**	-11.22**	-0.03**	-1.01**	-0.11**	2.77**	0.53**
Balado	-0.19*	-1.35**	-0.06**	1.59**	0.39**	-1.02**	-1.26**
Wab 450	2.24**	7.17**	-0.05**	1.97**	0.37**	-1.36**	0.43**
IET 1444	3.37**	29.07**	-0.02**	-0.31	0.13**	-5.34**	1.01**
Wab 878	0.14	-5.29**	-0.08**	-0.77**	0.22**	1.38**	-1.25**
Gaori	-1.12**	-5.49**	0.01**	-0.20	-0.45**	1.36**	0.13**
GZ 1368	-0.72**	-2.25**	0.08**	-1.29**	-0.27**	2.31**	0.27**
S.E (gi): 0.05	0.15	0.64	0.0008	0.44	0.0008	0.42	0.06
0.01	0.20	0.87	0.001	0.60	0.001	0.57	0.08
S.E (gi-gj):0.05	0.34	1.46	0.001	1.00	0.002	0.96	0.14
0.01	0.46	1.99	0.002	1.37	0.002	1.30	0.19

*and ** significant at 0.05 and 0.01 probability levels, respectively.

Table (3): Selection of parents based on mean and GCA effects

trait	Mean	*gca* effect	Mean and *gca* effect
Root length (cm)	P_4, P_5, P_6	P_4, P_5	P_4, P_5
Root volume	P_1, P_2, P_4, P_5	P_4, P_5	P_4, P_5
Root/shoot ratio	P_1, P_2, P_7, P_8	P_1, P_7, P_8	P_1, P_7, P_8
Chlorophyll content	P_1, P_3, P_4, P_6	P_2, P_3	P_3
Grain length (cm)	P_3, P_4, P_5, P_6	P_2, P_3, P_4, P_5	P_3, P_4, P_5
Milling %	P_2, P_3	P_2, P_6, P_7, P_8	P_2
Amylose content %	P_1, P_3, P_4, P_6	P_3, P_6	P_3, P_6

P_1: Sakha 102; P_2:Sakha 104; P_3 : Balado; P_4:Wab 450; P_5: IET 1444; P_6:Wab 878; P_7:Gaori; P_8:GZ 1368

The specific combining ability (SCA) is considered to be the best criterion for the selection of superior hybrids. Among the studied crosses, the crosses Sakha 102 X Sakha 104, Balado X Wab 450, Wab 450 X Gaori, Wab 450 X GZ 1368 and IET 1444 X Gaori recorded favorable SCA effects for four traits. Moreover, the hybrids Sakha 102 X GZ 1368, Sakha 104 X Wab 878, Balado X IET 1444, Balado X Wab 878, IET 1444 X Wab 878 and IET 1444 X GZ 1368 showed desirable sca effects for three traits. While, the crosses Sakha 102 X Balado, Sakha 102 X Gaori, Sakha 104 X GZ 1368, Wab 450 X IET 1444, Wab 450 X Wab 878 and Gaori X GZ 1368 were good specific combiners for two traits. On the other hand, the crosses Sakha 102 X Wab 450, Sakha 102 X IET 1444, Sakha 102 X Wab 878, Sakha 104 X IET 1444, Sakha 104 X Balado, Wab 878 X Gaori and Wab 878 X GZ 1368 exhibited superior sca effects for only one trait. None of the hybrids exhibited superior sca effects for all the traits. (Table 4).

The cross combinations, Sakha 102 X GZ 1368, Wab 450 X Gaori and IET1444 X Gaori appeared to be the best ones for root length and root volume since it exhibited a significantly positive SCA effect and some of them involved parents with high GCA. Moreover, the cross combinations, Sakha 102 X Gaori, Sakha 104 X IET 1444, IET 1444 X Wab 878 and IET 1444 X GZ 1368 exhibited high SCA and included at least one parent having good GCA for milling %. Therefore, the influence of additive and/or additive x additive gene action was observed in this cross combinations for milling %. Similarly, Sakha 104 X GZ 1368, Balado X GZ 1368 and Wab 450 X GZ 1368 were designated as being good cross combinations for chlorophyll content, all of them included GZ 1368 as a male parent which appeared to be a poor general combiner for this trait. In addition, Sakha 102 X Sakha 104 and IET 1444 X Gaori were found to be the best cross combinations for root/shoot ratio and amylose content. (Table 4). Same results were recorded earlier by **Sarathe *et al.* (1986), Geetha *et al.* (1994), Paramasivam *et al.* (1995) and Raju *et al.* (2002).**

Table (4): Estimates of specific combining ability (SCA) effects for the studied traits.

Genotypes		Root length (cm)	Root volume	Root : Shoot ratio	Chlorophyll content	Grain length (mm)	Milling (%)	Amylose content (%)
Sakha 102	x Sakha 104	1.05	7.34**	0.27**	0.48	0.37**	0.15	-0.85**
	x Balado	1.09*	-2.85	0.28**	-0.95	-0.25**	-13.76**	1.77**
	x Wab 450	-0.67	-6.05**	0.24**	-3.21*	-0.10**	-6.56**	0.63**
	x IET 1444	-4.47**	-13.62**	-0.35**	0.01	0.25**	-2.80	0.69**
	x Wab 878	-1.57**	-3.92	-0.11**	1.74	-0.42**	1.19	-1.03**
	x Gaori	-2.64**	-9.05**	-0.15**	0.51	0.13**	5.61**	1.47**
	x GZ 1368	2.95**	16.70**	-0.21**	-2.33	0.29**	2.42	0.70**
Sakha 104	x Balado	0.35	4.74*	-0.02**	-2.85	-0.03**	0.66	0.50*
	x Wab 450	-4.07**	-15.79**	-0.22**	-1.73	-0.30**	0.23	1.70**
	x IET 1444	0.45	-15.02**	-0.01**	2.52	-0.25**	5.20**	0.66**
	x Wab 878	0.69	6.34**	-0.04**	-0.65	0.41**	-0.34	-1.10**
	x Gaori	1.29*	-2.79	-0.11**	1.88	0.04**	0.88	1.27**
	x GZ 1368	1.55*	-0.69	-0.09**	4.90**	-0.32**	-4.86**	2.33**
Balado	x Wab 450 x IET 1444	1.62**	-20.32**	-0.16**	0.59	0.26**	5.34**	-1.22**
	x Wab 878	2.49**	-22.22**	-0.08**	2.44	0.47**	-1.07	-1.10**
	x Gaori	-1.27*	51.47**	0.07**	0.17	0.19**	-8.22**	0.59**
	x GZ 1368	-1.00	34.34**	0.01**	1.41	-0.65**	1.67	0.20
Wab 450	x IET 1444	-1.40**	3.77	0.009**	6.16**	-0.10**	2.32	-0.16
	x Wab 878	-2.94**	97.24**	0.11**	-0.97	-0.23**	-13.84**	2.22**

	x Gaori	-0.70	23.94**	-0.05**	-3.81*	-0.11**	3.45*	4.02**
	x GZ 1368	1.89**	6.14**	0.003	-1.97	0.11**	-5.63**	-2.62**
IET 1444	x Wab 878	-0.84	0.57	0.30**	6.91**	0.17**	4.72**	3.20**
	x Gaori	1.49**	-33.95**	-0.19**	2.01	0.67**	7.70**	0.31
	x GZ 1368	2.42**	36.24**	0.44**	0.91	-0.20**	-5.47**	-3.97**
Wab 878	x Gaori	0.02	52.00**	0.29**	-1.63	-0.19**	5.50**	1.75**
	x GZ 1368	-0.34	-3.72	0.46	2.67	-0.15**	0.21	-0.70**
Gaori	x GZ 1368	0.25	-16.95**	-0.26	1.92	-0.24**	-3.54*	-1.10**
		-1.47**	-23.42**	-0.36**	-4.97**	0.21**	00.99	-3.46**
S.E (Sij)	:0.05	1.07	4.56	0.005	3.14	0.006	2.99	0.44
	:0.01	1.31	5.57	0.006	3.83	0.008	3.65	0.53
S.E (Sij-Ski)	:0.05	2.08	8.88	0.011	6.11	0.01	5.82	0.85
	:0.01	2.55	10.85	0.013	7.47	0.01	7.12	1.04

*and ** significant at 0.05 and 0.01 probability levels, respectively

Estimates of mid and better parent heterosis

Among the crosses showing heterosis, the traits with the highest number of heterobeltiotic crosses were root volume, followed by chlorophyll content and grain length (Table 5). Results further indicated that 19. 7, 8 and 8 crosses had significant positive better parent heterosis for root volume, root/shoot ratio, chlorophyll content and grain length. Mid parent Heterosis expression in root length and milling % did not show consistency over the studied condition, indicating character x environment interaction.

It is clear from (Table 5) that most of the studied hybrids were superior cross combinations for root volume; their estimated values of heterosis were highly significant with positive direction for this trait, out of them, Balado X Gaori, Wab 450 X Gaori, IET 1444 X Gaori, and Wab 878 X Gaori, which included Gaori as a male parent. Moreover,

highly significant estimates of heterosis were recorded in Sakha 102 X Sakha 104, Sakha 102 X IET 1444, Sakha 102 X GZ

1368, Balado X Wab 450, Balado X IET 1444, Balado X Wab 878 and IET 1444 X Wab 878 rice genotypes for grain length. On the other hand, IET 1444 X Gaori rice hybrid exhibited either highly significant positive estimates of heterosis for root volume, root/shoot ratio or negative for amylose content %. Among the studied crosses, Balado X IET 1444 and IET 1444 X GZ 1368 obtained highly significant heterosis when it measured as a deviation from better parent for root length and milling %, respectively. In addition, Sakha 104 X IET 1444 and Sakha 104 X GZ 1368 recorded significant and positive heterosis for chlorophyll content %. The results also revealed that very few crosses appeared to be having desirable heterosis for root length, milling % and amylose content % under the present investigation. These results were in harmony with that observed by **Sarathe *et al.* (1986), Qi *et al.* (1990), Reddy *et al.* (1991), Reddy and Nerkar (1995), Veni *et al.* (2005) and Verma and Srivastava (2005).**

Table (5): Estimates of heterosis as a deviation from mid and better parent of the twenty eight rice crosses for some root, physiological and grain quality traits

Genotype	Root length (cm)		Root volume		Root : Shoot ratio		Chlorophyll content%	
	MP	BP	MP	BP	MP	BP	MP	BP
Sakha 102 x Sakha 104	-1.54	1.54	0.00	1.67	6.59	26.79**	-5.83	1.77
x Balado	0.00	2.22	2.28	27.68**	3.29	46.87**	-3.02	-0.35
x Wab 450	-25.26**	-11.81**	20.45*	54.75**	1.09	49.59**	-15.87**	-11.89**
x IET 1444	-33.67**	-21.24**	-5.69	21.13**	-62.63**	-48.48**	-5.28	1.02
x Wab 878	-18.43**	-12.69**	-14.76	-3.82	-41.75**	-23.18*	-2.23	4.67
x Gaori	-16.68**	-16.68**	-32.96**	-11.30	-35.16**	-24.84**	-3.84	-0.79
x GZ 1368	8.95	9.76	65.90**	81.36**	-34.06*	-25.00**	-13.27*	-1.44
Sakha 104 x Balado	0.00	5.35	21.99*	54.19**	-30.64**	-13.13	-4.99	0.08
x Wab 450	-33.67**	-19.72**	-17.57*	7.15	-61.29	-48.93**	-14.93**	-4.07
x IET 1444	-14.90**	2.55	-9.49	14.85**	-22.58**	-6.79	12.26*	13.86*
x Wab 878	-6.59	2.89	14.27	30.81**	-37.09**	-28.44*	3.15	4.20
x Gaori	4.54	7.82	-16.48	11.75	-36.36*	-34.37**	3.32	8.41
x GZ 1368	5.95	10.07	1.08	12.18	-26.08	-22.13*	19.47**	26.18**
Balado x Wab 450	-11.56**	2.45	71.74**	78.46**	-27.02	-21.73	-4.14	3.01
x IET 1444	-4.24	10.43*	-4.42	43.14**	-9.75	-5.12	10.22	14.53**
x Wab 878	-9.19	-4.82	295.67**	344.74**	0.00	11.90	3.29	7.76
x Gaori	-4.34	-2.22	309.56**	342.92**	-22.72	-0.97	7.86	8.31
x GZ 1368	-4.34	-2.93	84.95**	114.33**	-15.94	9.43	17.16**	29.97**
Wab 450 x IET 1444	-14.71**	-14.27**	238.64**	416.97**	43.90*	61.64**	-11.72*	-1.70
x Wab 878	-17.87**	-8.75*	211.82**	262.45**	-23.40	-8.86	-18.93**	-9.39*
x Gaori	-13.67**	1.86	222.47**	236.16**	-22.72	4.08	-13.68**	-6.87
x GZ 1368	-21.03**	-7.39	106.86**	147.56**	27.53**	74.25**	3.34	22.20**
IET 1444 x Wab 878	-6.38	3.52	-34.18**	-7.96	-46.80**	-43.18**	11.51	11.98*
x Gaori	-7.43	8.75*	98.74**	209.37**	48.48**	83.17**	2.63	6.22
x GZ 1368	-13.82**	0.63	134.82**	221.23**	31.88**	65.45**	0.10	7.16
Wab 878 x Gaori	-9.19	-2.81	33.84**	61.07**	-28.98	-13.27	5.95	10.09*
x GZ 1368	-5.25	0.71	-16.44	-13.47	0.00	18.96	9.51	16.77**
Gaori x GZ 1368	-5.95	-5.25	-43.85**	-30.53**	-59.42**	-58.51**	-14.93**	-5.99
L.S.D 0.05	2.53	2.19	5.23	4.48	0.16	0.14	4.34	3.76
0.01	3.37	2.91	6.95	5.96	0.21	0.18	5.77	5.00

TABLE (5): CONT. ESTIMATES OF HETEROSIS AS A DEVIATION FROM MID AND BETTER PARENT OF THE TWENTY EIGHT RICE CROSSES FOR SOME GRAIN QUALITY TRAITS.

Genotype	Grain length (cm)		Milling %		Amylose content%	
	MP	BP	MP	BP	MP	BP
Sakha 102 x Sakha 104	9.13**	5.93**	-4.32	-2.33	6.54	5.87
x Balado	7.52**	-2.67**	-25.28**	-24.49**	19.76**	15.16**
x Wab 450	9.13**	-1.21	-19.88**	-19.45**	24.85**	19.13**
x IET 1444	10.88**	5.70**	-17.88**	-10.50**	17.24**	8.20*
x Wab 878	2.95**	-3.40**	0.40	0.79	4.77	0.27
x Gaori	1.34	1.00	4.76	5.20	16.71**	1.70
x GZ 1368	5.91**	4.16**	2.39	4.04	13.39**	12.38**
Sakha 104 x Balado	6.33**	-0.65	-3.05	-2.06	6.32	9.68*
x Wab 450	2.66**	-4.08**	-5.99*	-4.53	33.29**	26.35**
x IET 1444	0.12	-1.61	-4.14	6.45*	17.70**	9.36**
x Wab 878	9.88**	6.31**	-2.01	-0.35	6.66	1.42
x Gaori	1.73	-0.91	-10.12**	-8.63**	16.30**	2.05
x GZ 1368	-3.51**	-4.74**	-7.04*	-3.61	22.55**	22.23**
Balado x Wab 450	2.00*	2.00**	-2.17	-1.65	5.95	5.16
x IET 1444	11.99**	6.58**	-16.55**	-8.17**	8.37	-4.10
x Wab 878	6.41**	2.87**	-17.14**	-16.58**	6.09	5.60
x Gaori	-0.80	-9.88**	-4.00	-3.38	10.82*	-7.59
x GZ 1368	6.11**	-2.21**	-1.22	1.40	9.51*	4.34
Wab 450 x IET 1444	3.05**	-1.92*	-34.59**	-28.36**	39.07**	22.03**
x Wab 878	2.37	-1.03	-0.37	-0.23	36.41**	36.02**
x Gaori	9.21**	-0.78	-13.05**	-12.95**	5.95	-12.42**
x GZ 1368	9.36**	0.77	2.80	4.99	40.46**	32.78**
IET 1444 x Wab 878	12.36**	10.66**	0.28	9.69**	17.58**	3.51
x Gaori	1.86	-2.55**	-18.86**	-11.23**	-20.65**	-24.78**
x GZ 1368	1.56	-1.51	2.47	10.05**	21.39**	13.10**
Wab 878 x Gaori	3.60**	-2.45**	-0.91	-0.87	6.66	-11.53**
x GZ 1368	2.08*	-2.54**	-3.92	-2.00	5.17	-0.27
Gaori x GZ 1368	1.86	0.52	1.57	3.63	-10.20*	-20.97**
L.S.D 0.05	0.16	0.14	4.22	3.66	1.62	1.4
0.01	0.21	0.18	5.61	4.86	2.15	1.86

*and ** significant at 0.05 and 0.01 probability levels, respectively.

Estimates of phenotypic correlation coefficients

Obviously, as shown in (Table 7), the phenotypic correlation coefficients were found to be highly significant positive between root length and each of root volume, root/shoot ratio and chlorophyll content %. Root volume was phenotypically associated with root/shoot ratio and chlorophyll content %. Moreover, chlorophyll content was correlated with root/shoot ratio. Regarding grain quality traits, grain length was significantly and positively correlated with milling % and amylose content %. (Table 8). Similar results were recorded by **Deosarkar and Nerkar (1994), Yolauda and Das (1995), Zhou *et al.* (2002) and Wang *et al.* (2003).**

Table (6): Range of mid (MP) and better (BP) parent heterosis and number of desirable crosses for the seven studied traits.

Trait	Range of heterosis (%)		No. of crosses showing heterosis	
	MP	BP	MP	BP
Root length (cm)	-33.67 – - 11.56	-19.72 – 10.43	-	2
Root volume	-43.85 – 309.56	-30.53 – 416.97	14	19
Root/shoot ratio	-62.63 – 48.48	-58.51 – 83.17	4	7
Chlorophyll content	-18.93 – 19.47	-11.89 – 29.97	3	8
Grain length (cm)	-3.51 – 12.36	-9.88 – 10.66	19	8
Milling %	-34.59 - - 13.05	-28.36 – 10.05	-	3
Amylose content %	40.46 - - 20.65	36.02 - - 24.78	2	4

Table (7): Estimates of phenotypic correlation coefficients all possible pairs of root and chlorophyll content traits

Trait	Root length (cm)	Root volume	Root/Shoot ratio
Root length (cm)	-		
Root volume	0.493**	-	
Root/Shoot ratio	0.419**	0.552**	-
Chlorophyll content	0.409**	0.295**	0.294*

*and ** significant at 0.05 and 0.01 probability levels, respectively.

Table (8): Estimates of phenotypic correlation coefficients all possible pairs of grain quality traits

Trait	Grain length	Milling %
Grain length (cm)	-	
Milling %	0.288*	-
Amylose content %	0.295*	-0.152

*and ** significant at 0.05 and 0.01 probability levels, respectively.

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الملخص العربى

القدرة على التآلف لبعض صفات الجذر والصفات الفسيولوجية وصفات جودة الحبوب فى الارز تحت ظروف الاجهاد المائى

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** قســـــم الـــــوراثة – كلـــــية الـــــزراعة – جـــــامعة كـــــفر الشـــــيخ – مـــــصر

تم التهجين بين ثمانية تراكيب وراثية بنظام التهجين التبادلى (دايلل) فى اتجاه واحد وذلك فى تجربة اقيمت فى المزرعة البحثية لمركز البحوث والتدريب فى الارز – سخا – كفرالشيخ – مصر وذلك خلال مواسم زراعة الارز ٢٠٠٩ – ٢٠١٠، وذلك بهدف دراسة طبيعة الفعل الجينى المتحكم فى وراثة الصفات المدروسة

ولاكتشاف سلوك القدرة على التآلف للتراكيب الوراثية المستخدمة فى الدراسة. وتمت الدراسة على بعض صفات الجذر والصفات الفسيولوجية وصفات جودة الحبوب فى الجيل الاول.

اوضحت النتائج تفوق تباين القدرة العامة على تباين القدرة الخاصة على التآلف فى جميع الصفات المدروسة مشيرة الى اهمية التاثير المضيف للجين فى وراثة هذه الصفات، كانت النسبة بين القدرة العامة الى القدرة الخاصة على التآلف اكبر من الواحد الصحيح لصفتى طول الجذر (١,٠٧) وطول الحبة (١,١٣) موضحة ان الفعل المضيف للجين قد لعب دورا كبيرا فى وراثة هاتين الصفتين، وبناءا عليه فانه يمكن اجراء التحسين الوراثى لهما بسهولة، وعلى النقيض من ذلك، كانت تاثيرات الفعل السيادى للجين بارزة فى وراثة صفات حجم الجذر، النسبة المئوية للمجموع الجذرى الى المجموع الخضرى، النسبة المئوية لمحتوى الحبوب من الاميلوز والنسبة المئوية لمحتوى الورقة من الكلوروفيل موضحة ان التحسين الوراثى لهذة الصفات تحت ظروف الاجهاد المائى يكون غاية فى الصعوبة. كما اوضحت تاثيرات القدرة العامة على التآلف ان الابوين بالادو وواب ٨٧٨ كانت افضل الاباء قدرة عامة على التآلف لصفتى طول الحبة و النسبة المئوية لمحتوى الحبوب من الاميلوز. وكان الاب واب ٤٥٠ افضل الاباء قدرة عامة على التالف لصفات طول الجذر، حجم الجذر، النسبة المئوية لمحتوى الورقة من الكلوروفيل وطول الحبة. اضافة الى ذلك فقد كان الابوين جاورى، جى زد ١٣٦٨ افضل الاباء قدرة عامة على التآلف لصفتى النسبة المئوية للمجموع الجذرى الى المجموع الخضرى والنسبة المئوية لتصافى التبييض. وكان الصنف سخا ١٠٤ افضل الاباء قدرة عامة على التالف لصفة النسبة المئوية لتصافى التبييض.

اضافة الى نلك فقد اظهرت التراكيب الوراثية سخا ١٠٢ X جى زد ١٣٦٨، واب ٤٥٠ X جاورى، اى اى تى ١٤٤٤ X جاورى افضل قدرة خاصة على التآلف عالية المعنوية وموجبة لصفتى طول الجذر وحجم الجذر وفى نفس الوقت فقد اشتمل بعضها على اباء ذات قدرة عامة على التآلف عالية المعنوية وموجبة. كما كانت التراكيب الوراثية سخا ١٠٢ X جاورى، سخا ١٠٤ X اى اى تى ١٤٤٤، اى اى تى ١٤٤٤X واب ٨٧٨، اى اى تى ١٤٤٤ X جى زد ١٣٦٨ افضل الهجن قدرة خاصة على التالف واشتملت على أحد افضل الاباء فى القدرة العامة على التآلف لصفة النسبة المئوية لتصافى التبييض.

كما اوضحت النتائج ان قوة الهجين كانت عالية المعنوية وموجبة فى ١٩، ٧، ٨، ٨ هجينا وذلك عند قياسها كانحراف عن قيم الاب الافضل لصفات حجم الجذر، النسبة المئوية للمجموع الجذرى الى المجموع الخضرى، النسبة المئوية لمحتوى الورقة من الكلوروفيل وطول الحبة. كما اكدت النتائج على ان قوة الهجين كانت عالية المعنوية وموجبة للتراكيب الوراثية سخا ١٠٢ X سخا ١٠٤، سخا ١٠٢ X اى اى تى ١٤٤٤، سخا ١٠٢ X جى زد ١٣٦٨، بالادو X واب ٤٥٠، بالادو X اى اى تى ١٤٤٤، بالادو X واب ٨٧٨ ، اى اى تى ١٤٤٤ X واب ٨٧٨ وذلك لصفة طول الحبة. كما اظهر الهجين اى اى تى ١٤٤٤ X جاورى قوة هجين عالية المعنوية وموجبة لصفتى حجم الجذر والنسبة المئوية للمجموع الجذرى الى المجموع الخضرى، كما اظهر قوة هجين عالية المعنوية وسالبة لصفة النسبة المئوية لمحتوى الحبوب من الاميلوز. من بين الهجن المدروسة، اظهر الهجينين بالادو X اى اى تى ١٤٤٤ و اى اى تى ١٤٤٤ X جى زد ١٣٦٨ قوة هجين عالية المعنوية وموجبة وذلك عند قياسها كانحراف عن قيم الاب الأفضل لصفتى طول الجذر و النسبة المئوية لتصافى التبييض على الترتيب.

كما اظهرت النتائج ان طول الجذر قد تلازم تلازما معنويا موجبا مع كل من حجم الجذر، النسبة المئوية للمجموع الجذرى الى المجموع الخضرى و النسبة المئوية لمحتوى الورقة من الكلوروفيل. اضافة الى ذلك فقد كانت قيم معامل الارتباط الظاهرى عالية المعنوية وموجبة بين حجم الجذر وكل من النسبة المئوية للمجموع الجذرى الى المجموع الخضرى و النسبة المئوية لمحتوى الورقة من الكلوروفيل. كما كانت قيم معامل الارتباط الظاهرى عالية المعنوية وموجبة بين النسبة المئوية لمحتوى الورقة من الكلوروفيل و النسبة المئوية للمجموع الجذرى الى المجموع الخضرى. ايضا فقد ارتبطت صفة طول الحبة ارتباطا ظاهريا عالى المعنوية وموجبا مع كل من النسبة المئوية لتصافى التبييض و النسبة المئوية لمحتوى الحبوب من الاميلوز.