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INHERITANCE OF SOME QUANTITATIVE CHARACTERS UNDER DROUGHT CONDITIONS IN RICE (*Oryza sativa* L.)

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ABSTRACT

Six rice genotypes with deferent drought tolerance were crossed. Six populations (P_1, P, F_1, F_2, BC_1 and BC_2) of three rice crosses namely Cica 4 x sakha 101 (Cross I); IET 1444 X Sakha 102 (Cross II) and Mizuhe X Sakha 103 (cross III) were raised in a randomized complete block design during the three successive seasons from 2009 to 20011 at the farm of Rice Research and Training Center Sakha, Kafer El-Sheikh, Egypt. Flashing water irrigation were added after 12 days intervals, Gene action, heritability, genetic advance and phenotypic correlation response to selection and prediction by the new lines for heading date, plant height, panicle length, no. of panicles/plant, no. of grains/panicle, sterility %,100-grain weight and grain yield/plant, were estimated. The results obtained from the mean of parents, F_1 and F_2 generations showed there are wide ring in mean values between the parents and the presence of partial and over-dominance were found for all characters studied. Scaling test provide evidence of non- allelic interaction in controlling all the characters studied in all crosses, the additive gene effect (d) was more important in the genetic system controlling heading date, plant height, and 100 grain weight in most of studied crosses, dominance gene effects (h) was played an important role in the inheritance of plant height, panicle length, no. of panicles/plant, no. of grains / panicles and grain yield / plant. The additive x additive (i) were significant and involved in the inheritance of heading date, no. of grains / panicles, 100 grain weight, and grain yield. However, the dominance x dominance (l) were involved in the genetic control of heading date, plant height, panicle length, no. of panicles /plant, no. of grains / panicle, and 100 grain weight. Heritability estimates in broad sense were moderate to high in most cases indicating the effect of the environmental condition on these characters. Meanwhile, heritability estimates in narrow sense were mostly low. The maximum genetic advance of the mean values was found to be high for plant height and hading date in cross 1. Highly significant and positive correlation was found for grain yield with heading date, plant height, number of panicles/plant, number of grains/panicles and 100 grain weight in the all studied crosses. Also there are highly significant and positive for grain yield / plant with plant height and panicle length in the first two crosses. The data showed that the highest crop water use efficiency 0.60 and 0.58 (kg / m^3) were recorded from one m^3 water irrigation in cross I (Cica 4 x Sakha 101) and cross II (IET1444 X Sakha 102). From the foregoing results, cross I (Cica 4 x Sakha 101) and cross II (IET1444 X Sakha 102) could be recommended for growing under drought conditions to obtain the highest rice grain yield and the highest value of saving water at the same time.

Keywords: Water Stress, Six Parameters, Genetic Variability, Quantitative Characters, Rice

INTRODUCTION

Rice is one of the most important crops in Egypt after wheat and each export crop after cotton. Covered about 22% of the cultivated area in Egypt. But it highly increased during the last five years to better net return of rice comparing to other summer crops. Water shortage is a major problem for rice grown under lowland conditions. The water of Nile River is not sufficient for irrigation of both old and new reclaiming new lands. Progress in irrigated areas, where supplied are scarce or unreliable. A major reason for the slow progress in breeding for drought tolerance in rice is the complexity of the drought environment, which often results in the lack of clear identification of the target environments **[1]**. Developing rice varieties for drought tolerance are needed to overcome the shortage of irrigation water. **[2]** reported that, increasing irrigation intervals decreased plant height, panicle length, number of panicles / m^2, number of field grains / panicle, 1000- grain weight and grain yield. But, the opposite was true for sterility % and WUE. Also, rice quality was not significantly affected by irrigation intervals. Upland rice crop are grown in non-puddle aerobic soil without standing water **[3]**. Less water requirement is a set of characteristics that should be incorporated into future rice cultivars to meet the needs of various environmental and water regimes. They observed that yong leaf rolling decline of cumulative transpiration in the upland rice. Soil moisture deficit significantly reduces rice yield **[4]**.

Breeding for drought tolerance varieties is become of high priority in the Egyptian rice breeding program in order to reduce the water requirements in one hand, and also to tolerate the drought conditions which occurred in some rice growing areas due to the shortage of irrigate water, in the other hand.

The success of developing and releasing new rice varieties suitable for drought conditions will increase the rice production in Egypt and also increase the farmer's welfare. Yield and its component characters considered very important to increase yield under water stress. The present study aimed to determine the heterosis, degree of dominance, genetic variance, heritability and genetic advance as percent of means among yield and its component studied characters under drought conditions.

MATERIALS AND METHODS

The present investigation was carried out at the farm of the Rice Research and Training Center (RRTC), Sakha, Kafer El-Sheikh, Egypt, during the three successive rice growing seasons; i.e. 2009, 2010 and 20011 to study the inheritance behavior of some characters related to drought tolerance in rice. According to the flowing data the six genotypes were crossed to produce F_1 hybrid seeds of three crosses namely

I. Cica 4 (tolerant) X Sakha 10 (sensitive)

II. IET1444 (tolerant) X Sakha 102 (moderate)

III. Mizuhe (moderate) X Sakha 103 (sensitive)

Six populations P_1, P_2 , F_1 , F_2 , BC_1 and BC_2 for each cross were utilized in this study.

A. Experimental Field Procedures

In the summer 2009, six rice genotypes were grown at the farm of Rice Research and Training Center in three dates of planting with ten days intervals in order to overcome the differences in flowing time between parents. Thirty days old seedling of each parent was individually transplanted in the permanent field in ten rows. Each row was 5 m long and contained 25 hills. At flowering time, hybridization among parents was carried out viz. Cica 4 x sakha 101 (Cross I); IET 1444 X Sakha 102 (Cross II) and Mizuhe X Sakha 103 (cross III) following the technique proposed by **[5]** and modified by **[6].**

In 2010, parents and F_1 hybrid seeds of three crosses were planted for F_2 seed production and simultaneously crossing between F_1 and the recurrent parent to produce BC_1 and BC_2 hybrid seeds were done.

In 2011, season seeds of the parents and F_1, F_2, BC_1 and BC_2 were sown in dry seedbed. Thirty old seedling were transplanted in the field plot. Eighteen entries belongs to different generations (6 parents, 3 F_1, 3 BC_1 3 BC_2 and 3 F_2) were transplanted in a randomized complete block design with three replications. Each replicate containing 10 rows of each P_1, P_2 and rows of F_1, BC_1 and BC_2 and 20 rows of F_2. Row was 5 m long and 20 x 20 cm apart was maintained between rows and seedlings. All agriculture practices were applied as recommended. Flush irrigation was used every 12 days. Hand weeding was done when it was needed.

Sixty plants from each P_1, P_2 and F_1, 90 plants from each BC_1 and BC_2 and 200 plants from F_2 populations were taken at random. These plants were individually harvested and threshed separately to determine the grain yield and its components characters.

The studied characters; i.e heading date, plant height, panicle length, no. of panicles/plant, no. of grains/panicle, no, of filled grains/panicle, 100-grain weight, sterility % and grain yield/plant were estimated. Heterosis, degree of dominance, inbreeding depression, phenotypic coefficient of variation, genetic variance and phenotypic correlation coefficient were estimated according to **[7-8]**.

B. Water Relations

Monitoring Soil Moisture

Soil samples were collected before two days after each irrigation from three successive layers (20 cm each) to determine soil moisture content **(Table 2)**.

Table 1: Mean Values for Six Rice Characters Under Flushing Water Irrigation Every Seven Days

Characters / Genotypes	Days to 50% heading	Plant height (cm)	Panicle length (cm)	Number of panicles / plant	100 grain weight (gm)	Grain yield / plant (gm)
Cica 4	85	94	16	14	2.5	26
Sakha 101	99	90	12	10	2.1	22
IET1444	100	95	18	15	2.6	28
Sakha 102	94	86	14	12	2.4	24
Mizuhe	89	90	13	13	2.3	23
Sakha 103	92	79	11	12	2.2	21

Table 2: Soil Moisture Contents of the Experimental Site

Soil depth, (cm)	Field capacity (F.C) %	Permanent wilting point (PWP) %	Available water (AW) (cm)	Bulk density, (g/cm^3)
0-20	46.03	26.60	21.43	1.09
20-40	44.20	22.41	22.80	1.30
40-60	36.10	19.90	17.90	1.21

Water Consumptive Use

Soil moisture content was determined before and after each irrigation to calculate water consumptive use, according to:

$$Cu = \sum_{i=I}^{n=1} \frac{\theta_2 - \theta_1}{100} \times Bd \times D \times 4200\ m^2$$

Where:

Cu = Water consumptive use in each irrigation (cm^3), θ_2 = Soil moisture percent after irrigation (%, d.b), θ_1 = Soil moisture percent before irrigation (%, d.b), **Bd =** Soil bulk density in (g/cm^3), n = Number of irrigation, $_I$ = Number of soil layer**, D =** Depth of soil layer of the soil (cm) and 4200 m^2 = Area of fed.

Crop water use efficiency (CWUE)

It was calculated, according to the following equation:

$$CWUE\ (kg/m^3) = \frac{\text{Yield (kg/fed)}}{\text{Water consumptive use } (m^3/fed)}$$

Field water use efficiency (FWUE)

It was calculated according to the following equation:

$$FWUE\ (kg/m^3) = \frac{\text{Yield (kg/fed)}}{\text{Water applied } (m^3/fed)}$$

RESULTS AND DISCUSSION

1. Mean Performance

Table 3 shows mean values of the studied characters for three studied crosses. The results indicated that the parents differed significantly in all characters studied. The F_1 mean values were higher than the highest parent for plant height, panicle length, number of panicles and 100 grain weight in all studded crosses, number of panicles / plant, sterility % and grain yield / plant for crosses I and II. While the F1 main values were intermediated between the tow parents in heading date in the three crosses, and number of grains / panicle and grain yield / plant in cross III. While it was lower thane the lowest parent for number of grains / panicle in cross II and for 100 grain weight in cross III. these results indicating that over- dominance was important in the inheritance of these traits verified by the computed of which were the value of potence ratio. While partial dominance was recorded for heading date in all studied crosses and for no. of grains / panicle and grain yield / plant in cross III.

This advantage of F_1 population over the top parent was greater in crosses I and II. Moreover, the F_2 mean values approximately nearer to the mid- parent with few exceptions. On the other hand the transgressive segregation was recorded for plant height, no. of panicles / plant and 100 grain weight in cross II and for sterility % in crosses I and II. The performance of backcross populations tended towards the means of recurrent parent varied somewhat among yield and its major components. These results were agreement with those reported by **[9-11]**

In continuation the crosses I and II could offset the hazard effect of drought stress and exerted the value of yield reduction as compared with others under normal and drought conditions. Thereby crosses I and II could be recommended for growing under drought stress as drought tolerance.

2. Genetic Parameters

The percentage of heterosis as a deviation from mid- and better- parent and degree of dominance were showed in **Table 4**. Highly significant and significant and positive were recorded in must of all studied crosses for grain yield and its components in the present investigation. On the contrary the not significant heteroses as a deviation from mid- and better- parent were recorded in all studied crosses for heading date, cross III for panicle length and no of panicles / plant, crosses II and III for no. of grains / panicle and 100 grain weight, cross II for sterility% and cross III for grain yield /plant. It is noteworthy that heterotic effect for grain yield and its component was larger in magnitude than that for any its major components which is logically expected. Also the results indicated that thepanicle length and no. of panicles/plant were the main contributing factor for increasing heterosis in grain yield.

Concerning to Degree of dominance greater than unity in all studied crosses for must of all studied characters indicating over dominance for these characters. While the partial dominance was recorded for heading date, in all studied crosses and grain yield / plant in cross III. While negative over-dominance was involved in the sterility% in all the studied crosses and no. of grains / panicle and grain yield in cross III. These results were agreed with **[12, 13]**.

From the previous results that crosses I and II was the best crosses showed highest estimates of heterosis for most studied traits. However, the degree of dominance were more than unity for most studied traits, therefore, crosses I and II could be recommended for growing under drought stress as a drought tolerance cross and the parent IET 1444 was too.

Table 5 Illustrates the scaling test parameters (A B and C) estimated for yield and its component characters bin three studied crosses. Most of the computed permeates of scaling test were statistically significant. Thus in turn revealed the presence of non-allelic interaction. These results appear that the genotype X environment type of gene interaction were important in the inheritance of yield and its component characters.

As shown in **Table 6** most of all characters more affected by dominance gene effect for all studied crosses except heading date in cross II, 100 grain weight in crosses I and II, and grain yield / plant in cross I more affected by additive gene effect. The major contribution of the additive gene effects was indicated by the magnitude and the significance of parameter (d) in the three crosses for all studied characters with few exceptions. The majority of significance estimates of additive gene effects were positive. This suggests that additive gene effects made a significant contribution to the inheritance of the characters in these crosses.

Thus, the contribution of any effects depend on the cross itself and the character. The additive gene effect appeared to be the most important gene effects in the inheritance of yield and its major components in cross II. Nevertheless, a sufficient amount of additive appears to be present for selections to be successful in any of these characters under drought stress.

Dominance gene effects appeared to be the most important gene effects in the inheritance of yield and its related characters except for 100-grain weight in cross I. All estimates of dominance gene effects were positive except for 100-grain weight in crosses II and III and in sterility % in the three crosses which exhibited negative values.

The magnitude of dominance gene effects relative to magnitude of the additive gene effects were large for yield and its components, showing that dominance effects were relative more important in the inheritance of quantitative traits, thus, increasing yield performance in rice under drought conditions could be achieved through a breeding procedure which emphasizes the dominance gene effects for such crosses.

With regard to the individual types of digenic epistatic gene effects, the significant additive x dominance gene effects were exhibited more frequency than two types of digenic epistatic, but estimates of the dominance x dominance gene effects have relatively greater magnitude for all studied characters.

Two of these epistatic gene effects apparently counteract each other. The additive x additive gene effects which were mostly significant and positive indicating enhancing effect in inheritance. The additive x dominance gene effects exhibited less frequently than the other two types. In contract, most of the dominance x dominance gene effects was negative significantly suggesting a diminishing effect due to this type of gene effects and undesirable epistasis.

Evidently, epistatic gene effects had a significant contribution in the inheritance of studied characters. At least one epistasis gene effects was significant for all studied traits in the three crosses. The additive x additive gene interactions appears to contribute more to epistasis gene effects than any other source of epistasis. Also, these findings suggest that genetic effects could be an important major contributor to gene actions in the present genetic materials and character under present investigation.

Table 7 shows that the importance of both additive and dominance gene action in the expression of yield and its related characters, However, dominance genetic variance was more important than additive genetic variance in most studied traits. The relative magnitude of additive variance to dominance variance may be depend upon the cross itself, because they were a wide range differences between studied crosses in the present investigation.

Additive genetic variance was more than dominance genetic variance in all studied crosses for hiding date and no. of grains / panicle, cross I for plant height and no. of panicles / plant, cross II for panicle length, crosses I and II for 100 grain weight and cross III for gain yield / plant. However dominance genetic variance appeared to be the most important than the additive genetic variance in crosses II and III for plant height and no. of panicles / plant, crosses I and III for panicle length, all studied crosses for sterility %, cross III for 100 grain weight, and crosses I and II for grain yield / plant. The results were agreed with **[14, 15, 16].**

Evidently, the additive type of gene action play a significant role in the genetic control of yield and its related traits in cross III.

This finding is in line with that previously found by means of gene action estimates and genetic effects of genes **Table 7**. These results indicate that breeder can easily raise the level of yield and related traits by simple breeding methods. Similar results were obtained by **[11, 14, 16]**.

The previous results of genetic variance and heritability estimates for grain yield and its component revealed that the dominance genetic variance played more important role in the inheritance of most of these characters than the additive genetic one, and this finding differs from characters to another and also between crosses. Heritability estimates in broad sense were moderate to high in most cases indicating the effect of the environmental condition on these characters. Meanwhile, heritability estimates in narrow sense were mostly low. This was expected due to the high estimates of dominance genetic variance results for most characters. This in turn suggested that these characters behaved in quantitative manner on improving of grain yield and its component and effective selection could be achieved in late generation. This conclusion may be useful to rice breeder in planning a selection program for improvement the yield in such crosses, also, the use of hybridization of their improvement under drought condition. These results agreed with the one reported by **[9, 11]**.

Table 8 shows that, phenotypic correlation coefficient between grain yield and its related characters in three studied crosses. Highly significant and positive correlation was found for grain yield with heading date, number of panicles/plant, number of grains/panicles and 100 grain weight in the all studied crosses. Also there are highly significant and positive for grain yield / plant with plant height and panicle length in the first two crosses. While highly significant and negative correlated was recorded between grain yield and sterility % in the three studied crosses. These results were agreement with these reported by **[9, 11, 17, 18]**.

Water Relations

Crop and field water use efficiency

Data in **Table 9** illustrates that crop water use efficiency was significantly affected by irrigation methods. The maximum CWUE % values were recorded for the first parent (P_1) followed by F_1 generation, BC1 generation and F2 generation, bing 0.64, 0.63, 0.58 and 0.54 (kg / m^3) respectively. While, the minimum value was obtained for BC2 generation and the second parent (P_2), and were 0.50 and 0.44 (kg / m^3) respectively. On the other hand, crosses I and II gave the highest value 0.60 and 0.58 (kg / m^3) of crop water use efficiency, followed by the cross III, bing 0.50 (kg / m^3) respectively. The data showed that the highest crop water use efficiency 0.60 and 0.58 (kg / m^3) were recorded from one m^3 water irrigation in cross I (Cica 4 x Sakha 101) and cross II (IET1444 X Sakha 102). Also data indicated the significant effect of irrigation method on FWUE %. The maximum FWUE % value was recorded for the first parent (P_1) followed by F_1 generation, BC1 generation and F2 generation,. Whereas, the minimum value was recorded for BC2 generation and the second parent (P_2). On the other hand the highest value of FWUE % was found in cross I, followed by crosses II and III. These results were in harmony with those obtained by **[10, 19, 20]**.

From the foregoing results, cross I (Cica 4 x Sakha 101) and cross II (IET1444 X Sakha 102) could be recommended for growing under drought conditions to obtain the highest rice grain yield and the highest value of saving water at the same time.

Table 3: Mean Performances and Standard Error of the Six Populations for Yield and its Components Characters in the Three Studied Crosses

Characters	Crosses	Mean Performance and standard error					
		P_1	P_2	F_1	BC_1	BC_2	F_2
Heading date	I	99.81+0.62	107.52+0.48	103.42+0.53	100.95+0.87	104.22+0.96	100.97+0.82
	II	95.71+0.56	103.11+0.84	100.11+0.53	99.24+0.98	101.14+0.82	96.63+0.86
	III	100.16+0.76	105.84+0.67	103.8+0.73	98.66+1.99	100.86+1.59	94.11+1.44
Plant height	I	85.62+0.61	86.43+0.41	105.71+0.81	88.61+1.84	98.96+1.64	102.35+1.71
	II	89.61+0.56	75.35+0.69	102.81+0.64	95.18+0.78	92.66+0.82	103.18+0.76
	III	72.66+0.54	78.51+0.88	88.01+0.65	75.43+1.05	79.11+1.42	89.97+0.83
Panicle length	I	13.64+0.87	10.11+0.68	14.45+0.62	11.05+0.55	10.51+0.56	11.91+0.72
	II	12.54+0.77	10.16+0.98	13..57+0.67	10.95+0.94	11.86+0.58	10.74+0.61
	III	11.16+0.78	9.91+0.45	11..55+0.55	10.76+0.49	10.05+0.51	9.09+0.81
No. of panicle/plant	I	11..82+0.63	8.75+0.63	12.11+0.65	10.25+1.14	9.23+1.17	10.65+0.55
	II	11..52+0.73	10.06+0.78	12.06+0.46	11.22+0.59	10.53+0.65	10.67+0.47
	III	9.46+0.48	8.71+0.52	9.91+0.45	9.01+0.67	8.26+0.86	9.15+0.44
No. of grains/panicle	I	110.68+0.56	89.44+0.61	111.48+0.67	110.97+1.42	90.56+1.22	110.72+0.82
	II	106.85+0.66	100.78+0.8	102.21+0.86	104.65+1.28	103.48+1.62	106.93+1.07
	III	99.88+0.84	87.36+0.97	98.52+0.74	96.63+1.55	90.24+1.68	91.54+1.63
Sterility (%)	I	18.59+0.65	22.51+0.67	15.34+0.49	16.86+1.65	19.32+1.23	19.89+1.75
	II	15.49+0.44	25.09+0.82	15.04+0.65	16.06+0.84	20.79+0.87	17.62+0.69
	III	16.52+0.62	19.61+0.84	19.93+0.81	18.11+0.72	19.19+0.95	17.82+0.92
100grain weight (g)	I	2.41+0.06	2.22 + 0.06	2.47 + 0.03	2.31 + 0.06	2.29 + 0.04	2.32 + 0.07
	II	2.36 +0.04	2.17 + 0.03	2.38 + 0.05	2.32 + 0.12	1.85 + 0.21	2.21 + 0.17
	III	2.21+0.05	1.95 + 0.04	1.74 + 0.03	2.15 + 0.23	1.92 + 0.33	1.86 + 0.11
Grain yield/plant	I	25.95+1.62	16.97+1.65	26.87+1.11	24.93+1.67	20.68+1.66	22.49+1.37
	II	24.89+1.92	18.58+1.38	24.93+1.21	23.75+1.81	19.71+1.28	20.35+1.45
	III	22.84+1.38	15.81+1.37	20.16+1.44	20.21+1.72	17.46+0.92	18.46+1.62

Table 4: Estimates of Heterosis as a Deviation from Mid-Parent (MP) and Better-Parent (BP) and Degree of Dominance for Yield and its Components Characters, in the Studied Crosses

Characters	Crosses	Heterosis %		Degree of dominance
		MP	BP	
Heading date	I	-0.22	4.46	0.06
	II	1.12	5.26	0.27
	III	0.98	3.01	0.72
Plant height	I	20.68**	17.97**	9.32
	II	22.89**	14.61**	2.71
	III	17.33**	12.82**	4.33
Panicle length	I	27.23**	7.61	2.11
	II	18.18**	8.33	2.01
	III	10.12**	-1.43	1.12
No. of panicle/plant	I	33.41**	9.09	1.66
	II	20.32**	18.18**	4.32
	III	16.67**	4.65	2.87
No. of grains/panicle	I	12.12**	0.91	1.24
	II	-0.97	-3.77	-1.35
	III	5.37	-1.01	0.83
Sterility (%)	I	25.31**	16.66**	-2.52
	II	25.71**	-2.90	-1.31
	III	13.17**	20.48**	-1.62
100grain weight (g)	I	7.39	2.48	1.33
	II	8.18	0.84	1.27
	III	-24.34**	-20.91**	-3.73
Grain yield/plant	I	13.02**	3.47	1.34
	II	14.22**	0.43	1.23
	III	1..51	-11.89**	0.08

Where: * significant at 0.05 % and ** significant at 0.01 %

Table 5: Scaling Test for Adequacy of Additive and Dominance Model of Rice Yield and its Components for the Three Studied Crosses

Characters	Crosses	A	B	C
Heading date	I	-2.46+2.38*	6.28+1.44	-12.68+3.42**
	II	3.91+1.98	-1.45+1.83*	-14.61+3.81*
	III	-7.42+3.46**	-8.91+3.25**	-35.12+4.19**
Plant height	I	-14.35+2.99**	2.92+3.26	24.93+3.28**
	II	-1.46+2.23**	7.09+2.48	44.36+3.07**
	III	-10.41+2..28**	7.95+2..36**	30.86+3.55
Panicle length	I	-5.67+1.25	-4.66+1.19**	-7.46+2.56*
	II	-5.89+1.07**	-1.74+1.23	-8.18+2.44**
	III	-2.35+1.25	0.92+1.37	-6.74+3.41**

No. of panicle/plant	I II III	-3.92+2.19** -1.49+1.33** -0. 61+1.86	-2.37+2.46 -2.68+1.86 -1.29+1.72**	-3.82+4.13 -5.62+1.72** 1.32+2.13**
No. of grains/panicle	I II III	-1.82+2.65** -0.63+2.84** -5.47+5.46*	-20.12+2.85 2.43+3.66 -5.26+5.14	19.31+3.97** 12.86+4.35** -18.46+6.14**
Sterility (%)	I II III	-1.28+2.29** 2.83+1.56 1.71+1.63	1.27+2.23** 0.28+1.73** 0.11+1.57	6.38+3.23 -2.72+2..39 -5.82+2..19**
100grain weight (g)	I II III	-0.23+0.19 -0.09+0.33* 0.37+0.24	0.06+0.17** -0.73+0.84 0.28+0.52	0.35+0.81 0.65+0.62** 0.15+0.24
Grain yield/plant	I II III	-3.53+1.71** -2.69+1.24 -2.12+1.68	-7.05+1.59 -4.18+1.65** -2.74+1.68	-10.49+2.15** -10.82+1.82** -6.57+2.63

Table 6: Genetic Components of Generation Mean for Rice Yield and its Components Characters for the Three Studied Crosses

Characters	Crosses	Genetic components of generation mean					
		M	d	H	I	j	L
Heading date	I II III	100.97** 96.63** 94.11**	4.12** -2.14 2.65	9.43** 1.71 13.91**	8.48** 16.12** 20.36**	1.23 2.46 1.71	-10.72** -18.43** -5.42**
Plant height	I II III	102.35** 103.18** 89.97**	-10.33** 3.78* -4.61	-44.27** -17.83** -33.79**	-36.73** -40.81** -21.49**	-8.19** -3.34* -4.43**	48.84** 32..19** 66.34**
Panicle length	I II III	11.91** 10.74** 9.09**	1.45 -1.38 0.53	3.19 4.28** 5.64**	-2.34 2.14 4.35**	0.55 -2.63 -0.91	11.44** 4.65** -2.57
No. of panicle/plant	I II III	10.65** 10.67** 9.65**	1.39 1.23 1.03	2.53 3.68** -1.15	-2.25 2.68 -2.13	0.32 0.16 0.65	7.34** 1.03 3.25
No. of grains/panicle	I II III	110.72** 106.93** 91.54**	20.46** 1.87 6.54	-28.12** -12.42** 12.58**	-40.25** -10.36** 8.19**	10.41** -1.33 4.76**	61.59** 13.68** 2.18
Sterility (%)	I II III	19.89** 17.62** 17.82**	-3.25** -4.63** -1.62	-15.68** -6.51** -12.44**	-6.18** 4.14** 6.37**	-1.64 1.18 0.52	6.79** -6.84** -7.82**
100grain weight (g)	I II III	2.32** 2.21** 1.86**	0.12 1.48 1.15	-017 -0.11 0.39	0.22 -1.81* 1.16	0.16 0.07 0.15	-0.63 -0.25 -1.59
Grain yield/plant	I II III	22.49** 20.35** 18.46**	4.36** 4.25** 3.44*	3.47 7.64 9.28**	0.85 4.67** 2.57	0.54 1.32 0.64	10.41** 2.02 2.16

Table 7: Estimates of additive genetic variance (1/2D), dominance genetic variance (1/4 H), broad and narrow-sense heritability and genetic advance (G.S %) for yield and its components characters, in all studied crosses

Characters	Crosses	Genetic variance		Heritability		G. S	G. S %
		1/2D	1/4H	Broad-sense	Narrow-sense		
Heading date	I II III	25.26 14.82 11.86	19.75 10.22 9.63	44.62 25.93 22.84	25.26 14.45 11.70	70.32 32.56 29.86	0.69 0.33 0.31
Plant height	I II III	34.64 23.23 11.57	28.25 27.18 16.29	60.74 48.5 30.32	33.33 22.34 12.35	93.31 62.51 31.69	0.91 0.60 0.35
Panicle length	I II III	3.62 5.29 3.61	7.75 4.57 4.84	90.75 91.23 77.78	25.41 50.41 33.31	27.24 44.27 24.72	3.20 4.24 2.08
No. of Grains/panicle	I II III	5.19 3.92 2.73	3.33 6.96 6.74	82.41 90.75 88.8	49.62 33.54 22.51	41.47 27.93 17.30	3.91 2.63 1.89
No. of filled Grains/panicle	I II III	52.41 59.32 50.73	39.68 19.25 27.54	82.71 73.58 84.61	47.27 55.66 54.94	13.81 14.72 12.39	1.41 1.38 1.07
Sterility %	I II III	3.84 2.64 5.43	8.15 10.48 6.43	57.83 70.58 64.70	15.78 11.76 29.41	16.99 11.79 25.72	0.89 0.69 1.51
100-grain weight (g)	I II III	0.25 0.24 0.13	0.22 0.10 0.18	20.43 15.45 17.22	10.86 10.91 7.22	3.94 6.23 2.51	1.71 2.83 1.39
Grain yield/plant (g)	I II III	6.63 5.16 8.41	13.41 5.26 8.96	84.82 65.17 66.63	27.27 25.41 44.54	33.22 39.28 29.07	2.51 2.46 1.72

Table 8: Phenotypic Correlation Coefficient (rph) Among all Possible Pairs of Yield and its Component Characters and Grain Yield in the F_2 Generation in the Studied Crosses

Characters	Crosses	Heading date	Plant height	Panicle length	No. of panicle /plant	No. of grains /panicle	Sterility(%)	100grain weight (g)
Plant height	I II III	0.25 0.33 0.14	---					
Panicle length	I II III	0.42** 0.21 0.58**	0.29 0.43** 0.15	----				
No. of panicle/plant	I II III	0.46** 0.29 0.39*	0.65** 0.52** 0.62**	-0.55** -0.61** 0.22	----			
No. of grains/panicle	I II III	-0.22 -0.61** -0.17	-0.32 -0.45** 0.19	0.25 -0.26 0.27	-0.55** -0..46** 0.34	----		

Sterility (%)	**I II III**	**-0.55** -0.80** -0.58****	**0.38 0.31 0.21**	**0.26 0.46** 0.39**	**0.62** 0.21 0.26**	**-0.62** -0.53** -0.33**	**----**	
100grain weight (g)	**I II III**	**0.18 0.27 0.31**	**0.32 0.26 0.29**	**0.38 0.39 0.22**	**0.21 0.83* 0.12**	**-0.44** -0.48** -0.29**	**0.45** 0.53** 0.41****	**----**
Grain yield/plant	**I II III**	**0.63** 0.81** 0.43***	**0.54** 0.65** 0.21**	**0.45** 0.41** 0.35**	**0.61** 0.52** 0.37***	**0.69** 0.57** 0.41****	**-0.46** -0.48** -0.41****	**0.63** 0.49** 0.46****

Table 9: Crop and Field Water use Efficiency Under Drought Condition in 2008 Season

Character	Cross	P1	P2	F1	BC1	BC2	F2	Average
Grain yield Kg/fed.	I II III	2652 2520 2310	1680 1890 1575	2730 2536 2100	2520 2415 2106	2109 1995 1785	2310 2100 1890	2333.5 2242.6 1614.5
Average		2494	1715	1778.35	1634.85	1567.65	2100	2063.5
CWUE %	I II III	0.68 0.65 0.60	0.43 0.49 0.40	0.70 0.65 0.54	0.65 0.62 0.54	0.54 0.51 0.46	0.60 0.54 0.49	0.60 0.58 0.50
Average		0.64	0.44	0.63	0.58	0.50	0.54	0.56
FWUE %	I II III	0.54 0.51 0.47	0.34 038 0.32	0.55 0.51 0.42	0.51 0.49 0.43	0.43 0.40 0.36	0.47 0.42 0.38	0.47 0.45 0.39
Average		0.50	0.34	0.50	0.46	0.40	0.42	0.44

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