COMBINING ABILITY AND HETEROSIS FOR YIELD AND SOME PHYSIOLOGICAL CHARACTERISTICS IN RICE (*ORYZA SATIVA* L.).

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Abstract

Information on combining ability and heterosis was derived from data on grain yield/plant and 6 physiological characteristics of 8 rice genotypes and their 28 F_1 hybrids grown at the farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt during 2001 and 2002 seasons. The results indicated that both general and specific combining ability (GCA and SCA) variances were highly significant for all the studied traits. Therefor, it seemed that both additive and non-additive genetic effects were operative for all traits. The magnitude of GCA variance was relatively higher than SCA variance suggesting predominance of additive gene action for leaf area index, chlorophyll content, number of stomata/mm^2 at upper leaf surface, number of stomata/mm^2 at lower leaf surface, and grain yield/plant, while the SCA variance was higher than the GCA variance for stomata area at upper and lower leaf surface indicating prevalence of non-additive gene action in the expression of these two traits. On the basis of GCA effects, the parents Sakha 104, Giza 175, Milyang 79 and Sakha 102 were good general combiners for grain yield/plant and some studied traits. Almost all the crosses involved the above parents were more promising and therefore these parents could be exploited in the hybridization program. Based on the promising effects of SCA and heterosis of the characters included, viz. chlorophyll content, leaf area index, and grain yield /plant, the best specific combiners could be descendingly ordered as follows: Sakha 104 x BG 33-5,Sakha102x BG 33-5 and Milyang 79 x BG 33-5, respectively. Hence, these combiners were identified for further use in breeding program for improving such traits.

High estimates of broad sense heritability were recorded for leaf area index (87%), chlorophyll content (96%), number of stomata/mm^2 at upper leaf surface (81%), grain yield/plant (78%) and number of stomata /mm^2 at lower leaf surface (77%), while, moderately high estimates were detected for stomata area at upper leaf surface (59%) and stomata area at lower leaf surface (61%).The previous estimates are expected to be upward biased presence of due to g X E interaction.

In addition, highly significant and positive estimates of phenotypic correlation coefficients were exhibited between grain yield /plant and each of chlorophyll content and leaf area index, while it was highly significantly and negatively correlated between grain yield and the other remaining characters.

Key words: *Rice – Leaf area – Chlorophyll – Stomata - Heritability – Correlation.*

INTRODUCTION

The green leaves of rice plants are photosyntheticaly active organs which are able to store absorbed solar energy in reduced organic compounds. These assimilates represent the pool for both energy and compounds which have to meet the plant requirements for growth and development. The study of yield and physiological traits viz. leaf area index, chlorophyll content, number and area of stomata on both upper and lower leaf surface has traditionally concentrated on their response to environmental factors. However, recently there has been an increasing interest in studying the genetic control of the physiological traits and their potential use in breeding programs.

The combining ability studies provide useful information for the promising selection of parents for effective breeding besides elucidating the nature and magnitude of gene action involved. Such information is required to design efficient breeding programs for crop improvement. The phenomenon of heterosis in rice was first reported by Jones (1926) who observed marked increase in culm number and grain yield in some F_1 hybrids in comparison to their parents. Parental combinations giving high heterosis can produce better progenies and the exploitation of hybrid vigour appears to be an alternative for making further breakthrough in rice yield. So it is interesting to know whether it is possible to step up the yield still further by genetical manipulation in yield and its related traits. Therefore, the present study was conducted to obtain information on the nature of gene action for grain yield and some physiological traits, and to assess the extent of exploitable heterosis in 8x8 half-diallel cross in rice.

MATERIALS AND METHODS

Eight elite rice cultivars, Giza 175, Sakha 101, Sakha 102, Sakha 104, Suweon 349, TKY 1014, Milyang 79 and BG 33-5 were selected based on their variability for morphological and physiological characteristics. These cultivars were crossed in all possible combinations (excluding reciprocals) in 2001 season. The parents and their 28 F_1s were grown in randomized complete block design with three replications at the research farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt in 2002 season.

Twenty-five days old seedlings of each parent and their F_1 hybrids were transplanted to paddy field in five rows/plot. Each row was 2.5 m long and a single plant was left per hill with 20 x 20 cm spaces. Recommended cultural practices were followed.

Data were recorded on 15 randomly plants excluding any plant surrounded by a missing hill from each plot, and plot means were used in the statistical analysis. The observations were recorded for grain yield / plant and six physiological traits as follows:

Leaf area index (LAI) was measured as a leaf area per unit land area directly after harvesting using material kept moist to prevent shrinkage or rolling by leaf area meter (LI–COR LI-3100).

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 contents were determined by using the specific absorption coefficient of McKinney (1941).

A hand-cut cross section of the leaf blade was taken at panicle initiation stage for investigation of number and area of stomata per square millimeter of both upper and lower leaf surfaces. For counting the number of stomata per unit leaf area, a good incident light microscope was used. The stomata on artificial replicas made with varnish were prepared and the stomatal impressions on these replicas were counted with the help of calibrated grid in the eyepiece of the microscope. Stomatal areas were determined according to the method of Hall et al. (1993).

The combining ability analysis was preformed following method Π, model I of Griffing (1956). Heterosis was measured as a deviation of F_1 hybrid from its better parent value. Significance of the estimates of heterosis was tested by "t" test at error degrees of freedom. In addition, heritability in broad sense and phenotypic correlation coefficients for genotype means were estimated following formulae suggested by Singh and Chaudhary (1979) and Hays *et al.* (1955), respectively.

RESULTS AND DISCUSSION

1- Analysis of variances for combining ability effects:

As shown in Table (1), combining ability analysis revealed that mean squares for general (GCA) and specific (SCA) combining abilities were highly significant, indicating the importance of both additive and non-additive genetic effects in the inheritance of the studied traits. Ratio of GCA : SCA variance was less than unity for stomata area/mm^2 at upper leaf surface (0.418) and stomata area/mm^2 at lower leaf surface (0.546) revealing preponderance of non-additive gene action in the inheritance of these two traits, however, these traits have been reported to be highly influenced by the environmental conditions (Hall *et al.*, 1993). On the other hand, the ratio of GCA : SCA variance was greater than unity for leaf area index (LAI), chlorophyll content, number of stomata/mm^2 at upper leaf surface, number of stomata/mm^2 at lower leaf surface and grain yield/plant, suggesting the importance of additive gene action in the expression of these traits. Similar results were observed previously by Murthy and Shivashankar (1992) confirming that additive gene action was important for leaf area index at 45 days and grain yield /plant. On the contrary, Nguyen and Bui (1993) reported that both additive and non-additive gene action played a remarkable role in the inheritance of leaf area index.

2- Performance of parents and F1 hybrids:

Mean values of parents and F_1 hybrids for grain yield /plant and physiological characteristics are presented in Table (2). Previous results showed that genotype with low leaf area index, high chlorophyll content, low number of stomata/mm^2 at upper and lower leaf surface and narrow stomata area/mm^2 at upper and lower leaf surface was the best parent because leaf area index is the major factor determining the amount of light intercepted by the plant canopy, its value for a closed canopy is related to the ability of the lower leaves to intercept sufficient light to maintain a positive carbon balance. Rice genotypes react to stress in the environment by producing canopies with lower leaf area index (Hall *et al.,* 1993). Consequently, the parental mean values revealed that the superiority of leaf area index was recorded for BG 33-5, Sakha 102, Milyang 79 and TKY 1014, respectively. On the other side, TKY 1014, Sakha 104 and Giza 175 genotypes have a lower number of stomata/mm^2 at both upper and lower leaf surface, while narrow stomata area/mm^2 at both upper and lower leaf surface were observed for BG 33-5, Milyang 79 and Suweon 349 cvs. In addition, Sakha 101 followed by Sakha 104 and Giza 175 were the highest yielding rice varieties attributable to their high mean values of chlorophyll content. Among the hybrids, Sakha 101 X Sakha 104, Sakha 102 X Milyang 79, Sakha 104 X TKY 1014 and Milyang 79 X BG 33-5 performed the best by remaining superior parents for grain yield/plant, leaf area index, number of stomata/mm^2 at both upper and lower leaf surface and stomata areas/mm^2 at both upper and lower leaf surface, respectively. Most of hybrids that recorded high chlorophyll content also produced high grain yield/plant. Out of 28 rice hybrids, the mean values of F1 crosses 9, 7, 22, 19, 15, 22, and 3 crosses were intermediate between their parental means for leaf area index, chlorophyll content, number of stomata/mm^2 at upper leaf surface, number of stomata/mm^2 at lower leaf surface, stomata area/mm^2 at upper leaf surface, stomata area/mm^2 at lower leaf surface, and grain yield/plant respectively, and most of them tended toward the better parent. These findings revealed that partial dominance played a remarkable role in the inheritance of these traits in these crosses. On the other hand, the F_1 mean values of the other remaining rice crosses were either lower or higher than the mean of the lowest or highest parent, respectively indicating the importance of over-dominance in the inheritance of these traits.

3- Estimates of general and specific combining ability effects:

The estimates of general combining ability effects of the parents are given in Table (3). The ranking of the highest positive parents on the basis of GCA effects indicated that Sakha 104, Giza 175, Milyang 79 and Sakha 102, had good general combiners for grain yield/plant. Their GCA effects were also high for number of stomata/mm2 at both upper and lower leaf surface and chlorophyll content. Hence, these cultivars can be used as parents in hybridization programs to provide desirable segregants for selection. However, BG 33-5, Suweon 349 and TKY 1014 were poor general combiners for grain yield/plant. In addition, highly significant and desirable negative estimates of general combining ability effects of TKY 1014, Sakha 102, Milyang 79 and BG 33-5 rice cultivates were observed for leaf area index character.

Results of specific combining ability effects of the crosses (Table 4) indicated that the cross Milyang 79 X BG 33-5 was the best specific cross combination for grain yield / plant followed by Sakha 101 X Sakha 104, TKY 1014 X BG 33-5 and Giza 175 X Sakha 101. Moreover, the crosses Sakha 104 X TKY 1014, Suweon 349 X TKY 1014, Giza175 X TKY 1014 and Giza 175 X Sakha 104 were the best specific cross combinations for number of stomata/mm^2 at both upper and lower leaf surface. Examining relationships of SCA effects of crosses and GCA effects of parents indicated that the SCA combinations for grain yield / plant, viz. Sakha 101 X Sakha 104 and Giza 175 X Sakha 101 involved good X good general combiners. The superiority of such crosses might be due to the concentration and interaction between favorable genes contributed by the parents. Since parents of these crosses had also high mean performance of several desirable characters, they could be exploited for isolating promising lines through pedigree breeding method. On the other hand, the high specific combinations for grain yield/plant, viz. Milyang 79 X BG 33-5, Sakha 104 X Suweon 349, Sakha 104 X BG 33-5, TKY 1014 X BG 33-5 and Suweon 349 X BG 33-5 included either good X poor or poor X poor general combiners. The antecedent crosses also indicated high mean performance which could be attributed to interaction between positive alleles from the good combiner and negative alleles from the poor combiner. The high yield of such a cross would be non-fixable in the subsequent generation and should be exploited for hybrid rice breeding. Furthermore, Sakha 101 X TKY 1014, Sakha 101 X Milyang79, Giza 175 X Sakha 101, Giza175 X Sakha102, and Sakha 104 X BG 33-5 were found to be the best cross combinations for stomata area/mm^2 at both upper and lower leaf surface and chlorophyll content traits. Moreover, Sakha 101 X Suweon 349, Sakha 102 X BG 33-5 and Sakha 102 X Milyang 79 were the best cross combinations for leaf area index.

4- Estimates of heterosis:

The percentage of heterosis over better parent for grain yield/plant and the studied physiological traits are presented in Table (5). The expression of heterosis varied with the crosses and also characters. Highly significant and positive estimates of heterosis for grain yield/plant were exhibited in crosses TKY 1014 X BG 33-5 followed by Milyang 79 X BG 33-5, Giza 175X Sakha 101, and Suweon 349 X BG 33-5. These crosses also showed desirable highly significant either negative or positive estimates of heterosis for leaf area index and chlorophyll content respectively. The above results indicate that high heterosis for yield/plant was due to heterotic effects for leaf area index and chlorophyll content.

Furthermore, significant and negative estimates of heterosis were detected for number of stomata/mm^2 at both upper and lower leaf surface in Giza 175 X Sakha 104 and Sakha 101 X BG 33-5, and for stomata area/mm^2 at both upper and lower leaf surface in Sakha 101 X Suweon 349 rice crosses. Heterosis estimates for grain yield/plant ranged between -20.30 and 40.28, indicating good potential of hybrids to improve current rice yield levels.

Incidentally, it could be observed that there was a close relationship between SCA effects and crosses showing heterosis over better parent for all the studied traits. So it could be concluded that there is an ample scope for obtaining high yielding hybrids, if the selection is based on the studied physiological traits. Almost all hybrids involving Giza 175 and Sakha 102 as one of the parent possessed significant better parent heterosis for yield because of their superiority with respect to GCA. So, there is a need to give attention by the breeder for their exploitation.

5- Broad sense heritability and phenotypic correlation coefficient estimates:

High broad-sense heritability values were obtained for leaf area index, chlorophyll content, number of stomata/mm^2 at both upper and lower leaf surface, and grain yield/plant, while, moderately high values were obtained for stomata area/mm^2 at both upper and lower leaf surface 59 and 61 %, respectively, (Table 6). A related misconception about heritability is to imagine that a high heritability implies that a trait is relatively insensitive to environmental changes. This idea is wholly false. However, the broad–sense heritability dose convey how much of the total phenotypic variation in a trait is due to genetic variation, combining together the additive, dominance, interaction and assortative mating effects. It measures the relative importance of heredity versus environment on the variance of such traits.

Results in Table (6) showed that grain yield/plant was positively correlated with leaf area index and chlorophyll content. On the contrary, it was negatively and significantly correlated with each of number of stomata/mm^2 at both upper and lower leaf surface and stomata area at both upper and lower leaf surface. In addition, the phenotypic correlation coefficient estimates were significant and positive between leaf area index and each of chlorophyll content, number of stomata/mm^2 at upper leaf surface, and stomata area/mm^2 at both upper and lower leaf surface.

Furthermore, chlorophyll content was negatively and significantly associated with number of stomata/mm^2 at both upper and lower leaf surface, and stomata area/mm^2 at upper leaf surface. Number of stomata/mm^2 at upper leaf surface was negatively and significantly correlated with stomata area/mm^2 at upper leaf surface. Moreover, stomata area at lower leaf surface exhibited significant negative and positive correlation with number of stomata/mm^2 at lower leaf surface and stomata area/mm^2 at upper leaf surface, respectively. These findings indicated that the selection for desirable leaf area index and high chlorophyll content might enhance grain yield/plant. Similar results were reported by Anupam *et al.* (1999) and Chandra and Das (2000).

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Table 1. Mean squares of analysis of variance for general (G.C.A.) and specific (S.C.A.) combining ability in a half-diallel cross in rice.

Source of variance	d.f.	Leaf area index	Chlorophyll content	No. of Stomata/mm^2 at U.L.S.	No. of stomata/ mm^2 at L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	Grain yield/ Plant
Replications	2	0.568	0.456	1.584	6.872	7.456	12.834	1.497
Genotypes	35	58.215**	89.546**	148.324**	208.649**	467.258**	643.597**	553.698**
Parents	7	195.25**	213.25**	412.74**	651.25**	158.76**	145.87**	356.98**
Crosses	27	83.56**	97.81**	168.46**	312.64**	380.76**	298.25**	304.54**
Parents vs Crosses	1	42.85**	64.32**	79.54**	88.61**	73.42**	54.21**	97.65**
G.C.A.	7	653.987**	758.453**	1014.252**	2453.168**	456.827**	543.627**	598.244**
S.C.A.	20	298.125**	435.716**	457.942**	843.587**	1093.658**	995.321**	298.468**
Pooled error	70	1.640	5.460	123.520	238.650	24.560	62.980	4.560
G.C.A. / S.C.A.		2.194	1.741	2.215	2.908	0.418	0.546	2.004

** : Significance at 0.01 levels of probability;
U.L.S. : Upper leaf surface
L.L.S. : Lower leaf surface

Table 2. Mean values of the studied rice genotypes and F1 hybrids for grain yield and some physiological traits

Genotype	Traits						
	Leaf area index	Chlorophyll content	No. of stomata/ mm^2 at U.L.S.	No. of Stomata/mm^2 at L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	Grain yield/ Plant (g)
Giza 175	4.99	44.73	57	68	291	185	42.15
Sakha 101	4.50	48.25	74	87	325	178	44.52
Sakha 102	3.45	42.32	62	77	360	169	39.90
Sakha 104	4.02	46.45	51	56	310	195	43.99
Suweon 349	4.23	45.01	64	79	267	177	38.45
TKY 1014	3.90	44.65	34	45	284	201	37.56
Milyang 79	3.56	43.43	76	89	259	153	40.85
BG 33-5	3.15	43.99	68	81	230	162	37.15
Giza 175 x Sakha 101	5.21	45.34	61	77	345	167	59.99
Giza 175 x Sakha 102	5.64	46.59	61	78	320	174	54.26
Giza 175 x Sakha 104	5.22	47.41	48	46	315	188	58.54
Giza 175 x Suweon 349	3.86	48.08	58	70	296	179	53.25
Giza 175 x TKY 1014	5.02	47.90	47	41	320	195	51.23
Giza 175 x Milyang 79	5.01	47.52	62	75	287	164	54.12
Giza 175 x BG 33-5	3.56	48.55	62	72	267	172	54.00
Sakha 101 x Sakha 102	4.87	48.21	65	81	368	173	49.56
Sakha 101 x Sakha 104	5.65	46.90	70	73	340	184	60.20
Sakha 101 x Suweon 349	3.94	46.10	66	80	250	164	48.23
Sakha 101 x TKY 1014	4.61	42.56	58	68	261	198	40.23
Sakha 101 x Milyang 79	4.76	43.89	78	90	217	166	39.23
Sakha 101 x BG 33-5	3.46	51.62	66	71	210	172	35.48
Sakha 102 x Sakha 104	5.22	49.05	56	66	324	188	40.23
Sakha 102x Suweon 349	3.22	35.46	67	75	278	164	35.68
Sakha 102x TKY 1014	3.57	43.85	58	59	298	183	37.26
Sakha 102 x Milyang 79	2.69	45.16	65	82	264	158	45.26
Sakha 102 x BG 33-5	2.15	42.55	64	68	270	160	43.51
Sakha 104x Suweon 349	4.68	41.23	55	65	296	184	53.00
Sakha 104x TKY 1014	4.55	49.65	32	50	301	205	36.00
Sakha 104 x Milyang 79	3.86	39.21	64	71	267	175	47.21
Sakha 104 x BG 33-5	3.54	53.45	61	68	249	173	52.00
Suweon 349x TKY 1014	4.11	44.01	51	62	298	184	43.25
Suweon 349 x Milyang 79	3.97	54.25	73	81	284	168	46.25
Suweon 349 x BG 33-5	2.99	56.32	71	71	254	171	51.23
TKY 1014 x Milyang 79	3.70	47.25	61	63	275	176	50.20
TKY 1014x BG 33-5	3.64	45.56	55	61	260	188	53.69
Milyang 79x BG 33-5	3.09	46.25	70	79	225	151	55.76
Average	3.76	46.19	60.86	70.13	277.47	221.41	46.48
L.S.D. 0.05	0.96	3.15	5.43	6.32	8.55	7.51	4.49

U.L.S. : Upper leaf surface

L.L.S. : Lower leaf surface

Table 3. Estimates of general combining ability effects of parents for grain yield and some physiological traits from a half-diallel cross in rice.

Parents	G.C.A. effects						
	Leaf area index	Chlorophyll content	No. of stomata/mm^2 at U.L.S.	No. of Stomata/mm^2 at L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	Grain yield/ Plant
Giza 175	1.56**	0.69**	-8.25**	-23.48**	21.25**	59.52**	3.56**
Sakha 101	1.55**	0.75**	-22.89**	-49.21**	31.64**	-33.42**	0.54
Sakha 102	-0.95**	-0.42*	36.45**	41.20**	-27.55**	-13.80**	2.99**
Sakha 104	0.39*	0.28*	-83.25**	-61.84**	2.58*	5.69**	4.59**
Suweon 349	0.82**	-1.08**	14.83**	30.42**	-34.63**	11.12**	-3.60**
TKY 1014	-1.86**	-1.62**	52.44**	22.24**	-3.50**	-1.05	-1.58*
Milyang 79	-0.94**	0.38*	-33.58**	-12.58**	23.81**	32.58**	3.15**
BG 33-5	-0.57**	-0.96**	44.25**	53.25**	-13.60**	-60.61**	-9.65**
S.E. at 0.05 level	0.24	0.25	4.56	2.65	1.86	1.58	1.06

*, ** : Significance at 0.05 level of probability,
U.L.S. : Upper leaf surface
L.L.S. : Lower leaf surface

Table 4. Estimates of specific combining ability effects for grain yield and some physiological traits from a half-diallel cross in rice.

Crosses	S. C. A. effects						
	Leaf area index	Chlorophyll content	No. of stomata/mm^2 at U.L.S.	No. of stomata/ mm^2 at L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	Grain yield/ Plant
Giza 175 x Sakha 101	0.96**	1.52**	-350.09**	132.25**	-54.12**	-98.25**	3.54**
Giza 175 x Sakha 102	1.98**	0.36*	83.95**	64.24**	-56.21**	-45.23**	2.54**
Giza 175 x Sakha 104	1.53**	1.78**	-309.15**	-213.25**	99.25**	-43.58**	2.94**
Giza 175 x Suweon 349	-1.71**	1.45**	-279.32**	-245.23**	62.45**	-34.29**	1.95**
Giza 175 x TKY 1014	1.84**	0.89**	-325.56**	-351.25**	215.26**	21.00**	0.98**
Giza 175 x Milyang 79	0.46**	1.97**	181.54**	110.02**	98.26**	11.25**	1.09**
Giza 175 x BG 33-5	-0.45**	0.37*	47.42**	54.65**	45.18**	28.54**	0.99**
Sakha 101 x Sakha 102	2.71**	2.82**	75.34**	63.21**	25.64**	-35.21**	0.84**
Sakha 101 x Sakha 104	0.81**	0.61**	183.84**	89.21**	67.25**	23.56**	3.88**
Sakha 101 x Suweon 349	-1.96**	-0.27*	133.79**	64.84**	-79.21**	-45.36**	0.86**
Sakha 101 x TKY 1014	1.36**	1.71**	97.61**	76.43**	-165.45**	-23.58**	0.54*
Sakha 101 x Milyang 79	0.73**	0.87**	284.62**	185.64**	-215.36**	-22.58**	-0.53*
Sakha 101 x BG 33-5	-1.88**	-2.41**	-126.54**	-99.46**	-25.31**	-13.78**	-0.49*
Sakha 102 x Sakha 104	1.15**	4.21**	-87.42**	46.35**	28.15**	-46.73**	0.75**
Sakha 102x Suweon 349	-0.57**	-4.71**	130.71**	-76.21**	-95.24**	-25.64**	-0.64*
Sakha 102x TKY 1014	0.32*	0.88**	188.84**	43.65**	13.25**	39.87**	-0.35*
Sakha 102 x Milyang 79	-1.81**	1.44**	169.54**	151.25**	45.65**	45.71**	1.43**
Sakha 102 x BG 33-5	-1.94**	-2.73**	175.64**	-101.24**	-15.58**	10.25**	0.71**
Sakha 104x Suweon 349	1.16**	2.62**	-231.85**	111.87**	-12.58**	-12.85**	1.04**
Sakha 104x TKY 1014	0.91**	2.88**	-432.21**	-215.96**	22.58**	87.26**	-0.13
Sakha 104 x Milyang 79	-0.42**	-4.66**	112.19**	86.21**	16.54**	62.01**	0.64*
Sakha 104 x BG 33-5	-0.24*	2.95**	-263.14**	-136.22**	-45.32**	-12.54**	1.99**
Suweon 349x TKY 1014	1.33**	0.88**	-365.82**	-199.65**	78.32**	-9.25**	1.09**
Suweon 349 x Milyang 79	0.19	1.42**	292.65**	145.67**	99.54**	-8.45**	2.01**
Suweon 349 x BG 33-5	-0.66**	1.15**	212.31**	-79.65**	-13.58**	23.78**	2.45**
TKY 1014 x Milyang 79	0.98**	2.94**	31.25**	21.54**	-31.58**	-13.20**	2.64**
TKY 1014x BG 33-5	0.13	0.87**	220.43**	97.65**	-11.58**	-4.56*	3.87**
Milyang 79x BG 33-5	-0.46**	1.26**	320.01**	-46.58**	-10.25**	-16.58**	4.05**
S.E. at 0.05 level	0.21	0.25	2.01	1.08	1.21	2.85	0.32

*, ** : Significance at 0.05 level of probability.
U.L.S. : Upper leaf surface
L.L.S. : Lower leaf surface

Table 5. Estimates of heterosis as a deviation from better parent for grain yield and some physiological traits in a half-diallel cross in rice.

Crosses	*Heterosis percentage as a deviation from better parent*						
	Leaf area index	Chlorophyll content	No. of stomata/mm^2 at U.L.S.	No. of stomata/ mm^2 at L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	Grain yield/ Plant
Giza 175 x Sakha 101	15.78**	-6.03**	7.02**	13.24**	-6.18**	18.56**	34.75**
Giza 175 x Sakha 102	63.48**	4.16**	7.02**	14.71**	2.95*	9. 96**	28.73**
Giza 175 x Sakha 104	29.85**	2.07	-5.88**	-17.90**	1.62	8. 24**	33.08**
Giza 175 x Suweon 349	-8.74**	6.82**	1.75	2.94*	1.12*	10.86**	26.33**
Giza 175 x TKY 1014	28.72**	7.09**	40.88**	-8.88**	5.40**	12.68**	21.54**
Giza 175 x Milyang 79	40.73**	6.24**	8.77**	10.29**	7.19**	9.65**	28.40**
Giza 175 x BG 33-5	13.02**	8.54**	8.77**	5.88**	6.17**	16.09**	28.11**
Sakha 101 x Sakha 102	41.16**	-0.08	4.83**	5.19**	2.36	13.23**	11.32**
Sakha 101 x Sakha 104	40.55**	-2.80*	37.25**	30.36**	3.37*	9.67**	35.22**
Sakha 101 x Suweon 349	-6.85**	-4.46**	3.12*	1.62	-7.34**	-6.36**	8.33**
Sakha 101 x TKY 1014	18.21**	-11.80**	70.59**	51.11**	11.24**	-8.09**	-9.63**
Sakha 101 x Milyang 79	33.71**	-9.04**	5.40**	3.44**	8.49**	-16. 30**	-11.90**
Sakha 101 x BG 33-5	9.84**	6.98**	-2.94*	-12.40**	6.17**	-8.69**	-20.30**
Sakha 102 x Sakha 104	15.30**	5.60**	9.80**	17.86**	11.24**	4. 51**	-8.54**
Sakha 102x Suweon 349	-6.66**	-21.20**	8.60**	-2.59*	-7.34**	4.12**	-10.60**
Sakha 102x TKY 1014	3.47*	-1.79	70.59**	31.11**	8.28**	4. 93**	-6.61*
Sakha 102 x Milyang 79	-22.03**	3.98*	4.83**	6.49**	3.26*	1. 93*	10.80**
Sakha 102 x BG 33-5	-31.75**	-3.27*	3.22*	-11.70**	-1.23	17.39**	9.05**
Sakha 104x Suweon 349	16.42**	-11.20**	7.84**	16.07**	3.95*	10.86**	20.48**
Sakha 104x TKY 1014	16.67**	6.89**	-5.88**	11.11**	5.12**	5. 98**	-18.20**
Sakha 104 x Milyang 79	8.42**	-15.60**	25.49**	26.79**	14.38**	3.08**	7.32**
Sakha 104 x BG 33-5	12.38**	15.07**	19.61**	21.43**	6.79**	8. 26**	18.21**
Suweon 349x TKY 1014	5.38**	-2.22	50.00**	37.78**	3. 95 *	11.61**	12.48**
Suweon 349 x Milyang 79	11.52**	20.53**	14.60**	2.53*	9.80**	9.65**	4.05
Suweon 349 x BG 33-5	-5.07**	25.13**	10.94**	-10.20**	5. 55**	10.40**	33.24**
TKY 1014 x Milyang 79	3.93*	5.82**	79.41**	40.00**	15.03**	6.17**	22.89**
TKY 1014x BG 33-5	15.56**	2.04	61.76**	35.56**	16.05**	13.10**	40.28**
Milyang 79x BG 33-5	-1.90	5.14**	2.94*	-2.46*	-1.30	-2.17*	36.5**
L. S. D 5%	2.18	2.36	2.15	1.95	2.73	1.84	4.47

*, ** : Significance at 0.05 level of probability.
U.L.S. : Upper leaf surface
L.L.S. : Lower leaf surface

Table 6. Estimates of phenotypic correlation coefficients and broad sense heritability (h^2b) for the studied traits in rice

Characters	LAI	Chlorophyll content	No. of stomata/mm^2 at U.L.S.	No. of Stomata/mm^2 At L.L.S.	Stomata area/mm^2 at U.L.S.	Stomata area/mm^2 at L.L.S.	H^2b
Leaf area index (LAI)							87
Chlorophyll content	0.532**						96
No. of stomata/mm at U.L.S.	0.325*	-0.532**					81
No. of stomata/mm at L.L.S.	0.295	-0.381*	0.208				77
Stomata area at U.L.S.	0.624**	-0.657**	-0.563**	0.198			59
Stomata area at L.L.S.	0.423*	-0.159	0.059	-0.861**	0.310*		61
Grain yield / plant	0.554**	0.753**	-0.465**	-0.391*	-0.598**	-0.526**	78

*, ** : Significance at 0.05 and 0.01 levels of probability, respectively

U.L.S. : Upper leaf surface

L.L.S. : Lower leaf surface

دراسات علي القدرة علي التآلف وقوة الهجين للمحصول وبعض الصفات الفسيولوجية في الأرز

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أجريت هذه الدراسة بمزرعة مركز البحوث والتدريب في الأرز – سخا – كفر الشيخ – مصر. بهدف دراسة القدرة العامة والخاصة علي التآلف وقوة الهجين لصفة المحصول وست صفات فسيولوجية في الأرز وذلك باستخدام ثمانية تراكيب وراثية من الأرز وثمانية وعشرين هجينا ناتجة من التهجين بينها بطريقة التهجين الدائرى مع استبعاد الهُجن العكسية .

أوضحت النتائج أن جميع تباينات القدرة العامة والخاصة علي التالف كانت عالية المعنوية لجميع الصفات المدروسة مما يبين أهمية كل من الفعل المضيف والفعل السيادي للجينات في وراثة هذه الصفات .كما كانت قيم تباين القدرة العامة علي التآلف أعلي من قيم تباين القدرة الخاصة علي التآلف لصفات دليل مساحة الورقة ، محتوي الكلوروفيل ، عدد الثغور/مم^{2} علي كل من السطح العلوي والسطح السفلي للورقة ومحصول النبات الفردي مما يوضح أهمية الفعل المضيف للجينات في وراثة هذه الصفات. بينما كان تباين القدرة الخاصة علي التالف أعلي من تباين القدرة العامة علي التالف لصفتي مساحة الثغر علي كل من سطحى الورقة مبينة أهمية الفعل السيادي للجين في السلوك الوراثي لهاتين الصفتين. أوضحت تأثيرات القدرة العامة علي التآلف أن الأصناف سخا ١٠٤ ، جيزة ١٧٥، ميليانج ٧٩ وسخا ١٠٢ كانت افضل الآباء في قدرتها العامة علي التالف لصفة محصول النبات الفردي وبعض الصفات الفسيولوجية المدروسة .كما أشارت النتائج الي أن التهجينات التي احتوت علي هذه الأباء المذكورة أو أى منها كانت مبشرة للغاية وعليه فانه يمكن الاستفادة من هذه الآباء في برنامج التربية. و استنادا إلى تأثيرات القدرة الخاصة علي التآلف أوضحت النتائج أن أفضل الهجن التي أظهرت قدرة خاصة علي التآلف لصفات محتوي الكلوروفيل ، دليل مساحة الورقة و محصول النبات الفردي وكذلك قوة هجين عالية عند قياسها كانحراف عن قيمة الأب الأفضل كانت تى كى واى ١٠١٤ X بي جي ٣٣-٥ ، مليانج ٧٩ X بي جي ٣٣-٥ ، جيزة ١٧٥ × سخا ١٠١ و سيون ٣٤٩ × بى جى ٣٣-٥ علي الترتيب . وعليه فانه يمكن استخدامها في برامج التربية لتحسين هذه الصفات .

كانت قيم تقديرات درجة التوريث بمعناها الواسع عالية لصفات دليل مساحة الورقة (٨٧ %) ، محتوي الكلوروفيل (٩٦ %) ، عدد الثغور/ مم^{2} علي السطح العلوي للورقة (٨١ %) ، عدد الثغور/مم^{2} علي السطح السفلي للورقة (٧٧ %) ومحصول النبات الفردي (٧٨ %) ،. بينما كانت متوسطة الارتفاع لصفات مساحة الثغر علي السطح العلوي للورقة (٥٩ %) ومساحة الثغر علي السطح السفلي للورقة (٦١ %) . إضافة إلي ذلك أوضحت النتائج أن قيم معامل الارتباط الظاهري كانت عالية المعنوية وموجبة بين محصول النبات الفردي وكل من محتوي الكلوروفيل ودليل مساحة الورقة ، بينما ارتبط محصول النبات الفردي ارتباطا عالى المعنوية وسالبا مع باقي الصفات المدروسة .