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GENOTYPE X ENVIRONMENT INTERACTION FOR GRAIN QUALITY CHARACTERS IN RICE (Oryza sativa L.)

A. A. EL-HISSEWY, A. A. EL-KADY and R. LÁSZTITY*

Rice Research Section, Filed Crops Research Institute,
Agricultural Research Centre, Sakha, Kafr El-Sheikh,
Egypt

*Department of Biochemistry and Food Technology,
Technical University, H-1521 Budapest, Hungary

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Abstract

Fourteen rice (Oryza sativa L.) varieties and lines were grown at three locations over 2 years. The effect of genotype X environment (G x E) interactions on some grain quality characters was evaluated. The characters investigated were the following ones: grain length, grain width, grain shape (L/W ratio), hulling %, milling %, head rice %, elongation, gelatinization temperature (G.T.) and amylose content. It was found that the first order interaction variety x location was significant for hulling %,milling %, head rice % and G.T. only. On the other hand, the variety × year interaction was insignificant for all the studied traits except G.T. The second order interaction variety x location × year, however, was highly significant for all the studied traits.

The best grain shape was recorded for the new promising line Gz 2175-5-6, while the variety Giza 171 had the highest milling outturn among the short grain varieties and Giza 181 among the long grain ones.The lowest amylose content values were determined for Giza 172 (18.04%) and Giza 171 (18.9%), however, the rice variety IR 28 showed the highest amylose content (27.21%).

Keywords: Oryza sativa L., genotype × environment interaction, rice grain quality, amylose content of rice grain.

Introduction

Genotype × environment (GE) interaction is important for rice breeders of the confounding effects it introduces in comparisons among genotype tested different locations and different years. Environment as defined by plant breeder includes the integrated influence of all non-genetic variables affecting phenotypic expression of various genotypes. So GE interactions are a concern to breeders as they may reduce the correlation between phenotype and genotype (COMSTOCK and MOLL, 1963) and may contribute to the instability of genotypes were grown in various environments. consequently, a knowledge of the magnitude and the nature of GE interactions is of value in determining the number of years and locations, or year location combinations to be evaluated in order to attain the level of precision necessary to measure differences among genotypes (ALLARD and BRADSHAW, 1964).

In a study evaluating the importance of interactions NEI (1960), in Japan, compared the performance of 32 rice varieties at one location for 2 years. For culm length, ear length, and ear Weight per plan, significant variety × year interaction was observed. RAM et al. (1978) reported that twelve forms, including japonica and indica types and representing early and medium maturity groups, were evaluated in twelve environments consisting of combinations of fertilizes treatments and sowing and transplanting dates in two years. They found that differences among forms and the linear component of GE interactions were significant. Moreover, CHUTIMA et al. (1980), observed a marked GE interactions for protein content in trails at a total eleven sites using 1787 varieties during 1969–1975.

More information about GE interaction for grain quality characters of rice is needed. The purposes of this study were to determine the relative magnitudes of genotypes, environments and GE interaction effects for some grain quality traits under the Egyptian conditions.

Materials and Methods

Data used in this study were obtained from 14 rice varieties and promising lines during 1987 and 1988 growing seasons at 3 research stations namely, Sakha, Zarzoura and Gemmaiza. These varieties were Giza 171, IR 28, Giza 172, Giza 181, Giza 175, GZ 2175–5–6, GZ 2069–1–2–2, GZ 2122–S–8–1, GZ 2447–S–17, IR 25898–91–3–3, IR 19743–46–2–3, IR 25571–31–1,IR 25882–32–1–3 and IR 29725–22–3–3.

Standard cultural practices were employed at all locations. After harvesting, duplicate samples from each replicate for every variety were used in the grain quality tests. Nine grain quality traits were determined according to KUSH et al. (1979) and LITTLE et al (1968). These traits were, grain length, grain width, grain shape (length/width ratio), hulling percentage, milling percentage, head rice percentage, grain elongation, gelatinization temperature (GT) and amylose content.

The data were analyzed as a three-way factorial as discussed by KEMPTHORNE (1952) and COMSTOCK and MOLL (1963).

Genotypes (G), years (Y), and locations (L) were treated as random effects. The G × L × Y interaction was tested by the error mean square, while the G × L and G × Y interactions were tested by mean square of the G × L × Y interaction. The main effect of genotype was tested as suggested by COCHRAN (1951) with effective degrees of according to SATTERTHWAITE (1946).

Table 1
Mean square values of the studied traits of 14 varieties grown over 2 years and three locations

S. O. V.	d. f.	M. S.								
		Gr.length	Gr.width	L/W	Hull %	Mill %	Head %	Elongstation	G.T.	Amylose
Genotype	17	10.315**	5.637**	11.811**	130.129**	141.539**	81.137**	1.037**	0.938**	11.751**
Genotype × location	34	0.363	0.187	0.355	19.736**	20.360**	36.458**	0.036	0.517**	4.641
Genotype × years	17	0.128	0.635	0.132	1.861	4.003	1.935	0.169	0.234*	0.659
Genotype × location × years	34	3.065**	1.932*	4.755**	12.774**	11.792*	21.584**	0.823**	0.446**	3.077**
Error	208	1.433	1.815	2.143	5.289	6.934	9.119	0.374	0.205	1.107

*, ** significant and highly significant at 0.05 and 0.01 level, respectively. d.f. - degree of freedom

Table 2
Means ranked over years (1977 and 1988) for the fourteen rice varieties of grain appearance characters

No.	Varieties	Grain lenght				Grain width				L/W ratio			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
1	Giza 171	7.83	7.60	7.43	(6)7.62	3.20	3.07	2.81	(4)3.02	2.40	2.47	2.37	(3)2.41
2	Giza172	7.31	7.51	7.41	(2)7.41	3.30	3.17	3.20	(3)3.20	4.17	2.38	2.31	(7)2.95
3	Giza175	7.57	7.42	7.17	(1)7.38	2.80	2.72	2.40	(8)2.60	2.68	2.72	2.94	(6)2.78
4	Gz 2175-5-6	7.66	7.56	7.34	(4)7.52	3.50	3.48	3.10	(1)3.36	2.15	2.17	2.36	(1)2.22
5	Gz 2069-1-2-2	7.87	7.48	7.51	(6)7.62	3.40	3.24	3.13	(2)3.26	2.30	2.30	2.41	(2)2.33
6	Gz 2122-S-8-1	7.82	7.20	7.60	(5)7.54	3.20	3.09	2.66	(6)2.98	2.42	2.33	2.90	(5)2.55
7	Gz 2447-S-17	7.73	7.43	7.15	(3)7.43	3.30	3.07	2.49	(5)3.01	2.35	2.41	2.88	(4)2.54
8	IR28	8.52	8.33	8.52	(7)8.45	2.60	2.55	2.46	(9)2.53	3.28	3.27	3.46	(9)3.33

Table 2
Means ranked over years (1977 and 1988) for the fourteen rice varieties of grain appearance characters

No.	Varieties	Grain lenght				Grain width				L/W ratio			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
9	Giza181	9.59	9.21	9.18(11)	9.32	2.80	2.60	2.47 (7)	2.62	3.32	3.50	3.71(10)	3.51
10	IR 25898-91-3-3	8.71	8.51	9.18 (8)	8.80	2.80	2.64	2.38 (8)	2.60	3.08	3.23	3.35(8)	3.22
11	IR 19743-46-2-3	9.39	9.19	9.01(10)	9.19	2.50	2.57	2.35(12)	2.47	3.17	3.57	3.83(11)	3.52
12	IR 25571-31-11	9.27	9.40	9.29(11)	9.32	2.60	2.58	2.39(10)	2.52	3.08	3.65	3.88(12)	3.53
13	IR 25882-32-1-3	9.27	8.91	8.99 (9)	9.05	2.50	2.51	2.31(13)	2.44	3.67	3.54	3.90(14)	3.70
14	IR 29725-22-3-3	9.21	8.86	9.09 (9)	9.05	2.60	2.46	2.38(11)	2.48	3.57	3.60	3.81(13)	3.66

Table 3

Means ranked over years (1987 and 1988) for the fourteen rice varieties of milling characters

No.	Varieties	Hulling				Milling %				Head rice %			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
1	Giza 171	82.05	79.70	79.60	(1) 80.45	72.25	70.50	71.75	(1) 71.50	68.80	66.70	67.30	(1) 67.60
2	Giza 172	80.80	81.30	80.30	(2) 80.80	68.80	73.10	70.70	(2) 70.80	64.40	70.60	66.60	(5) 62.20
3	Giza 175	77.70	79.05	78.40	(7) 78.30	64.80	69.70	69.50	(6) 68.00	58.10	63.30	61.90	(7) 61.10
4	Gz 2175-5-6	81.25	80.00	79.80	(3) 80.30	68.00	70.50	70.90	(5) 69.80	65.50	66.05	68.10	(2) 66.80
5	Gz 2069-1-2-2	79.10	79.25	78.05	(5) 78.90	69.35	70.60	69.80	(4) 69.91	65.05	64.00	63.90	(3) 64.30
6	Gz 2122-S-8-1	79.10	77.05	76.75	(8) 77.70	64.80	65.909	68.90	(7) 66.53	59.05	58.90	62.20	(8) 60.05
7	Gz 2447-S-17	79.00	78.20	78.00	(6) 78.40	67.90	66.75	59.40	(10) 64.68	63.50	59.50	65.15	(9) 62.71

Table 3
Means ranked over years (1987 and 1988) for the fourteen rice varieties of milling characters

No.	Varieties	Hulling				Milling %				Head rice %			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
8	IR 28	77.90	77.40	74.60	(11) 76.60	61.60	65.40	64.50	(13) 63.83	50.90	53.40	55.40	(11) 53.23
9	Giza 181	80.05	79.05	78.50	(4) 79.20	68.50	70.65	71.65	(3) 70.20	62.40	64.95	61.60	(6) 62.90
10	IR 25898-91-3-3	77.40	76.75	75.60	(12) 76.50	66.30	66.80	62.40	(9) 65.10	55.15	51.70	51.90	(6) 62.90
11	IR 19743-46-2-3	79.10	78.10	75.90	(8) 77.70	62.95	69.20	64.00	(8) 65.30	48.40	52.75	56.55	(12) 52.50
12	IR 25571-31-11	78.85	76.35	77.05	(9) 77.40	66.35	65.15	64.65	(9) 65.10	53.30	52.15	51.30	(13) 52.25
13	IR 25882-32-1-3	78.80	76.15	76.60	(10) 77.10	63.35	68.70	63.80	(11) 64.60	55.60	57.20	55.70	(8) 56.16
14	IR 29725-22-3-3	78.05	76.90	74.10	(13) 76.30	63.65	68.50	61.40	(12) 64.50	55.10	58.10	52.00	(10) 55.06

Table 4

Means ranked over years (1987 and 1988) for the fourteen rice varieties of some chemical characters

No.	Varieties	Elongation				G. T.				Amylose			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
1	Giza 171	0.91	0.92	0.74	(4) 0.85	5.50	5.00	4.50	(5) 5.00	19.35	18.20	19.15	(2) 18.90
2	Giza 172	0.79	0.58	0.85	(7) 0.74	5.00	7.00	5.00	(4) 5.60	18.54	17.22	18.36	(1) 18.04
3	Giza 175	0.39	0.28	0.29	(11) 0.32	6.50	7.00	6.50	(8) 6.60	26.63	25.99	26.07	(8) 25.89
4	Gz 2175-5-6	1.00	0.90	0.70	(3) 0.86	3.50	4.50	4.50	(6) 4.80	19.06	19.93	20.11	(4) 19.70
5	Gz 2069-1-2-2	0.99	0.89	1.18	(1) 1.003	3.00	4.00	4.50	(8) 3.80	19.31	18.97	18.87	(3) 19.05
6	Gz 2122-S-8-1	0.97	0.67	0.69	(6) 0.77	4.00	3.50	5.00	(7) 4.10	20.22	19.73	19.36	(5) 19.77
7	Gz 2447-S-17	0.69	0.49	0.67	(8) 0.61	3.00	3.00	4.50	(9) 3.50	20.80	19.55	20.88	(6) 20.41

Table 4

Means ranked over years (1987 and 1988) for the fourteen rice varieties of some chemical characters

No.	Varieties	Elongation				G. T.				Amylose			
		Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall	Sakha	Zar-zoura	Gem-miza	Overall
8	IR 28	0.21	0.24	0.29	(13) 0.24	1.00	3.50	1.00	(10) 1.80	27.90	27.07	26.98	(14) 27.31
9	Giza 181	0.91	0.70	0.98	(2) 0.86	4.00	4.50	6.50	(4) 5.00	21.11	22.15	22.07	(07) 10.77
10	IR 25898-91-3-3	0.55	1.01	0.87	(5) 0.81	1.00	1.00	1.00	(11) 1.00	26.51	25.93	26.66	(10) 26.36
11	IR 19743-46-2-3	0.27	0.22	0.60	(10) 0.36	6.50	7.00	7.00	(2) 6.80	26.42	25.65	26.75	(9) 26.27
12	IR 25571-31-11	0.24	0.35	0.49	(10) 0.36	7.00	7.00	7.00	(1) 7.00	27.11	26.98	27.54	(13) 27.21
13	IR 25882-32-1-3	0.20	0.23	0.44	(12) 0.29	1.00	1.00	1.00	(11) 1.00	26.38	27.55	26.87	(11) 26.93
14	IR 29725-22-3-3	0.35	0.28	0.57	(9) 0.40	1.00	1.00	1.00	(11) 1.00	27.15	26.93	27.33	(12) 27.13

Results and Discussion

Table 1 shows the mean square values of the 9 studied traits of the 14 rice varieties grown over 2 years of study and three locations. It is clear that the interaction of variety × location was significant at the 1% level for hulling percentage, milling percentage, head rice percentage and gelatinization temperature, while it was insignificant for the other studied traits. The significant variety × location interaction for the mentioned quality traits indicates that there are consistent location effects. This is somewhat expected as soil type, drainage, and fertility level vary from place to place in Nile Delta. Moreover, the non-significant variety × location interaction for the other traits might be because these characters were less affected by environmental factors.

The magnitude of the mean square for the interaction of variety × year was small and non–significant for all the characters except gelatinization temperature (*Table 1*). This indicates that the performance of the varieties was basically the same in each of the two years of testing. however, it should be recognized that the data based on the two-year period may not provide the true picture of variety × year interaction effects. LIANG et al. (1966) suggested that if the variety × year interaction actually is greater than the estimates obtained, it would be desirable to evaluate the varieties in more than one year. Otherwise, it would be possible to shorten the evaluation program of potential new narieties by testing them at an adquate number of location in one year.

The second order interaction variety × location × year however, was of considerable magnitude and highly significant for all the quality traits studied (*Table 1*). The significant second order interaction that occured indicates that the varieties involved responded differently when grown under different environments. Hence, the relatively larger second–order interaction as compared to the first-order interaction must be due to one or more aspects of environment for which the potter of variation among locations differs from year to year. MATZINGER (1963), in a review of G × E interaction of various crops, found that three-way interaction were usually of greater importance.

Breeders often make selection based on the ranking of genotypes at one or more environments. For practical reasons other statistical comparions among genotypes may be ignored (CRAMER and BEVERSDORF, 1984). Consequently, the impact of G × E interaction on the ranking of breeding lines at different environments is of interest.

Table 2 demonstrates means of the grain appearance characters i.e. grain length, grain width and grain shape (L/W ratio) in the three locations ranked over the two years of the study, 1987 and 1988 for the 14 rice varieties. The best grain shape (2.22) was recorded for the new promising line GZ 2175–5–6. This result indicated that this line can be recommended for different rice growing areas. Furthermore, the rice variety, Giza 171 had the highest milling outturn among the short grain varieties, while the new variety Giza 181 was the best among the long grain varieties (*Table 3*). The head rice percentages were 67.6% and 62.71% for the two rice varieties, respectively.

Regarding the chemical characters, it is obvious (*Table 4*) that the new promising line GZ 2069–1–2–2 had the higher ability for elongation after cooking followed by Giza 181, while the rice variety IR 28 showed the lowest elongation ability among all the tested varieties. On the other hand, the results revealed that the gelatinization temperature values were 7 and 6.8 for the two lines TR 2557–31–1 and IR 19743–46–2–3, respectively. This result indicated that these two lines need less cooking time than the other tested varieties. However, the reaction of three lines namely IR 25898–91–3–3, IR 25882–32–1–3 and IR 29725–22–3–3 to alkali test was 1 indicating that the cooking time needed for these lines is very long.

Evidently, data in *Table 4* emphasize that the two rice varieties Giza 172 and Giza 171 had the lowest amylose content among the short grain varieties. The rice variety Giza 181 had the lowest amylose content (21.77%) among the long grain varieties. High amylose content (27.21%) was determined for the introduced variety IR 28.

This research that G × E interaction must be considered when breeding for grain quality because they effect both the ranking of genotypes and the precision of detecting significant differences among genotypes. When differences in these important characters need to be detected, more than one year and/or location of testing are probably required.

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Addresses:

Ahmed Ali EL-HISSEWY, Adel Abdelmoaty EL-KADY
Rice Research Section, Filed Crops Research Institute,
Agricultural Research Centre, Sakha, Kafr El-Sheikh,
Egypt

Radomir LÁSZTITY
Dept. of Biochemistry and Food Techology
Technical University of Budapest
H–1521 Budapest, Hungary.