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Performance and Yield Stability of some Egyptian Rice (*Oryza sativa* L.) Cultivars under Different Environments

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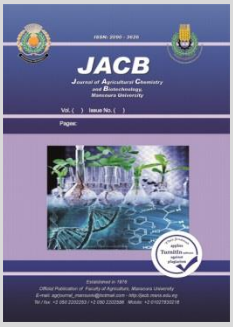
Sara A. El-Leithy[*] ; Tahany M. Mazal and Samah M. Aamer

Rice Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt



ABSTRACT

Stability analysis for some Egyptian rice cultivars was studied in this paper to identify high-yielding stable rice varieties and to determine their suitable areas as well as their adaptability to different climatic and topographic conditions. A field experiments for ten rice varieties were evaluated by designing randomized complete block with three replications in five successive rice growing season from 2016 to 2020at three Agricultural Research Stations (Sakha, Gemmeiza and Zarzoura) in Egypt. Result of ANOVA analysis showed high significance in the studied cultivars, environment and genotype-environment interaction indicated that there is genetic diversity among the cultivars yield. Based on the performance of the rice cultivars across the locations, highly promising for grain yield among cultivars studied, the cultivars Giza 178, Sakha 103, Sakha 104, Sakha 101 and Sakha 106 were considered stable and adapted under different environments. Furthermore, the results indicated that studied cultivars slightly differ in their response to the various environmental conditions, which suggested the importance of cultivars assessment under many environments due to identification the best genetic make up for a particular environment.

keywords: Rice, (*Oryza sativa* L.), Stability analysis, yield and its component traits.

INTRODUCTION

Rice (*Oryza sativa* L.) is an herbaceous plant species belonging to the family Poaceae and it is considered as the most staple food for more than half of the world's population as well as its ranking as the second food grain crop after Wheat and/or Maize (Manjappa and Hittalmani 2014). Rice is grown under different ecosystems *i.e*, irrigated, rainfed low land, upland and deep water. Previously, analyses of the environments of rice growth have been reported on declined rice production which was due to physical environmental limitations (Roy and Panwar 1994). Moreover, the rice genotypes should be more stable besides high yielding varieties. The rice breeder should use tools to efficiently and accurately measure the response of these lines in multiple test environments (Yan and Hunt 2002). Analyses of cultivars stability can be achieved by studying genotype/ environment interaction, which could be used for general cultivation. Moreover, Shrestha *et al.*,2012 indicated that selecting of superior cultivars based on yield at a particular location will not be enough due to yield complexity of quantitative character which it is mainly influenced by environmental fluctuations.

Thus, evaluating of cultivars for adaptability of performance under different environmental conditions for yield has become a key for rice breeding program. Recently, it has been reported that the largest proportion of total variation in grain yield of some rainfed lowland rice genotypes was attributed to different environmental conditions (Tariku *et al.*, 2013) indicating the effects of genotype/ environment interaction, therefore, no genotype had superior performance in all environments. Most of the cultivars showed ecological specificity, so it would be possible to group the test sites into homogeneous to be used for breeding for specific and/or for large-scale adaptation. Beside yielding, high stability has a key aspect in varietal recommendation to gain better economic benefits for farmers as reported by Anputhas *et al.* (2011). Many methods are available for evaluating the stability of the performance rice cultivars, these methods which are helpful for the rice breeders in identification of the adaptability of the rice cultivars over a wide range of environments and effective selection for yield stability and prediction of varietal response under changing environments (Kumar *et al.*, 2012).The method recommended by Eberhart and Russell (1966) more utilize for identify of cultivar response to environmental changes using a linear regression coefficient and the variance of the regression deviations. The cultivars are categorized according to the size of their regression coefficients, less than, equal to, or greater than one and according to the size of the variance of the regression deviations (equal to or different from zero). The cultivars with regression coefficients greater than one would be adapted to favorable growth conditions, which with regression coefficients less than one would be adapted to unfavorable environmental conditions, and cultivars with regression coefficients equal to one would have an average adaptation to all environments. Thus, cultivars with variances in regression deviations equal to zero would have highly predictable behavior, while with a regression deviation greater than zero, they would have low predictability. The main objectives of this work is to evaluate and identify the adaptation or stability of some Egyptian rice cultivars at three locations

[*] **Corresponding author.**
E-mail address: saraelleithy@gmail.com
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in five rice growing season as well as study the effect of different environments conditions on rice characteristics.

MATERIALS AND METHODS

Plant materials and experimental design

The parentage and types of the ten Egyptian rice cultivars i.e., Giza177, Giza178, Sakha101, Sakha102, Sakha 103, Sakha104, Sakha105, Sakha106, Giza182 and Egyptian Yasmin are presented in Table 1. These cultivars were evaluated for their stability parameters with respect to its grain yield and its components in multi-location trials at three sites (Sakha, Gemmeiza and Zarzourz) during five successive rice growing seasons from 2016 to 2020. The pre-germinated seeds of the rice cultivars were broadcasted in the nursery on 5th of May during the summer season; seedlings were transplanted after 25 days sowing, using a single plant per hill and plant spacing 20x20 cm between hills and rows. The experimental design was randomized using Complete Block design method with three replications.

The plot size was 1 x 5 m². Phosphorus application was performed during soil preparation at the rate of 36 kg P_2O_5 ha^{-1} whereas $ZnSO_4$ containing 22% zinc was applied at 24 kg per hectare. Nitrogen fertilizer was supplied in the form of Urea (46.5%) according to the recommendation (165 kg N ha^{-1}) in two split applications, i.e. two thirds as basal and incorporated into the soil immediately before flooding, followed by the one third after 30 days from the first dose. Once the seedlings were transplanted, water depth was maintained at 5 cm in the experimental plots. Pest control was performed through the rice season as recommended protocols to avoid any yield loss.

Table 1. Rice Cultivars, Parentage and Type.

No	Genotypes	Parentage	Type
1	Giza177	Giza171 / Yomjo No.1 / / PiNo.4	*Japonica*
2	Giza178	Giza175 / Milyang49	*Indica/japonica*
3	Sakha101	Giza176 / Milyang79	*Japonica*
4	Sakha102	GZ4098-7-1 / Giza177	*Japonica*
5	Sakha103	Giza177 / Suweon 349	*Japonica*
6	Sakha104	GZ4096-8-1 / GZ4100-9-1	*Japonica*
7	Sakha105	GZ5581-46-3 / GZ4316-7-1-1	*Japonica*
8	Sakha106	Giza177 / Hexi30	*Japonica*
9	Giza182	Giza181 / IR65844-29-1-3-1-2 // Giza181	*Indica*
10	EgyptianYasmin	IR262-43-8-11 x KDML 105	*Indica*

Plant characters

Total duration (days), plant height (cm), number of panicles per plant, panicle length (cm), number of filled grains per panicle, 1000-grain weight (g) and grain yield (t/ha) were recorded according to the Standard Evaluation System for rice (IRRI, 1996).

Statistical analysis

Data obtained from the different locations and years were subjected to homogeneity test known as Bartlett's test was done according to Gomez and Gomez (1984). The stability model were used for comparing the adaptability of rice cultivars suggested by Eberhart and Russell (1966), there are two parameters in this technique were obtained, b and s^2d (regression coefficient and mean squares of deviation from regression, respectively). The data of different locations were used for calculating the cultivars stability indices across all seasons.

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance for the studied traits revealed significant differences among the Egyptian rice cultivars and locations (Sakha, Gemmiza and Zarzoura) with respect to the five rice seasons as shown in Table 2. Data presented in Table 2 showed that highly significant mean squares due to the interaction between the rice cultivars and environments (locations) G x E indicating that the rice cultivars interacted considerably with environmental conditions. Both linear and non-linear components of G x E interaction were found to be significant for all studied traits as indicated by highly significant mean squares due to G x E (linear) interaction and pooled deviation.

Table 2. Variance analysis of the stability performance for grain yield and its component traits

Sources of variance	d.f.	Duration (days)	Plant height (cm)	No. panicles /plant	panicle length (cm)	No. of filled grains	1000-grain weight(g)	Grain yield (t/ha..)
Environment	14	13.80**	92.97**	35.13**	19.52**	2947.46**	1.82**	21.67**
Genotypes (G)	9	3130.65**	1251.89**	80.35**	97.11**	7059.91**	116.49**	14.06**
G× E	126	8.75**	24.12**	7.53**	4.09**	489.98**	1.39**	0.62**
(G× E)+ Environment	140	9.26**	31.01**	10.29**	5.63**	735.72**	1.44**	2.73**
Environment (Linear)	1	193.19**	1301.51**	491.76**	273.31**	41264.43**	25.545**	303.42**
G × E (Linear)	9	21.59**	8.10$^{n.s}$	9.85**	5.80**	223.58**	1.157**	0.70**
Pooled deviation	130	6.99**	22.82**	6.62**	3.56**	459.42**	1.27**	0.55**
Pooled error	298	1.57	5.43	1.70	0.79	68.86	0.28	0.08

The obtained results are in agreement with those obtained by (Kumar *et al.*, 2012) and (Zewdu *et al.*, 2020). The grain yield of rice cultivars differed considerably with the change in environmental conditions including locations and years.

Therefore, the variety which has rational yield stability is eligible for risk management to avoid yield loss in severe environmental conditions of unfavorable low land situation. High significant difference has been found in cultivars x environments (Linear) compared to non-linear (pooled deviation) interaction showing importance in

G x E interaction determination suggesting the predictability of the grain yield performance and its components on multi-site trajectories. (Eberhart and Russell, 1996). Hence, linear (bi) and non-linear (s^2 di) component of G x E interactions were considered in the phenotypic stability assessment. Furthermore, it has been reported that the high mean of linear regression co-efficient equal to non-linear is recommended for good variety. Also, it has been indicated that the non-linear regression could be used for stability measurement whereas the linear regression could be used to measure the varietal response to various environmental conditions (Ravindra *et al.*, 2012 and Girma 2018). Therefore, the mean and the deviation from regression of each cultivar should be considered for stability and linear regression for the varietal response evaluation (Girma, 2018; Zewdu *et al*., 2020).

Mean performance

Data presented in Table 3 & 4 showed the average of all traits for all rice cultivars in five years at multi-locations yield trials. Sakha 103 was the earliest in total duration which it recorded 122.31 days while, Egyptian Yasmin and Sakha101 were the latest rice cultivars with values of 144.93 and 143.4 days. Regarding to grain yield, the rice cultivars Sakha101 and Giza178 exhibited the highest grain yield as average during the investigation 10.16 and 10.02 t/ha. On the other hand, Egyptian Yasmin showed the lowest grain yield 8.43 t/ha under the same conditions. For plant height, Sakha101 recorded the shortest plants 93.64 cm. Meanwhile, Sakha102 and Egyptian Yasmin gave the tallest plants 109.44 and 108.38 cm. concerning to number of panicles /plants Sakha101 and Giza178 rice varieties gave the highest values of number of panicles /plant 23.6 and 22.72 as average of the trait during the present investigation. Meanwhile, Sakha103 and Giza177 gave the lowest values 19.36 and 19.80. Egyptian Yasmin gave the longest panicle 24.95 cm while; Sakha103 gave the shortest panicle 19.22 cm. Giza178, Sakha101 and Egyptian Yasmin showed the highest values of number of filled grains/panicle 153.58, 145.62 and 145.16, respectively. On the other hand, Sakha103 showed the lowest value 117.53. For 1000-grain weight, Sakha105, Giza177 and Sakha102 gave the heaviest grains 28.05, 28.04 and 28.00 gram, respectively. While, Giza178 gave the light grain 23.17 grams. According to these results, it could conclude that Sakha101 and Giza178 were the best cultivars regarding to grain yield and its components as average of these traits in five years and at different locations of the investigation. This obtained results in agreement with by (Sedeek *et al*., 2009).

Table 3. Analysis of variance of studied traits for Egyptian rice cultivars over 15 environments.

Cultivar	Duration (days)	Plant height (cm)	No. panicles/plant	Panicle length (cm)	No. of filled grains/panicle	1000-grain weight (g)	Grain yield (t/ha.)
Giza 177	1.33ns	11.07*	1.65ns	3.04**	445.37**	0.25ns	0.15*
Giza 178	7.14**	20.67**	7.79**	4.03**	376.49**	5.48**	0.42**
Sakha 101	8.85**	12.54**	5.72**	1.10ns	507.47**	0.37ns	0.42**
Sakha 102	2.83*	22.52**	5.37**	2.72**	246.08**	1.05**	0.69**
Sakha 103	9.84**	27.66**	6.36**	4.11**	742.14**	0.50*	0.86**
Sakha 104	8.63**	27.87**	2.81**	1.60*	307.42**	1.53**	0.13ns
Sakha 105	9.29**	12.36**	1.29ns	3.43**	268.42**	0.53*	0.72**
Sakha 106	4.5**	17.16**	9.38**	4.00**	353.84**	1.02**	0.89**
Giza 182	4.05**	22.32**	7.38**	9.01**	881.75**	0.99**	1.05**
Egyptian Yasmin	13.42**	54.04**	18.43**	2.58**	465.23**	0.99**	0.21**

Table 4. Mean performance of the studied traits for ten rice cultivars.

No.	Cultivar	Duration (day)	Plant height (cm)	No. panicles /plant	Panicle length (cm)	No. of filled grain /panicle	1000-grain weight(g)	Grain yield (t/ha.)
1	Giza 177	125.18	100.22	19.8	20.70	121.36	28.04	8.94
2	Giza 178	134.82	100.84	22.72	22.02	153.58	23.17	10.02
3	Sakha 101	143.4	93.64	23.6	22.62	145.62	27.95	10.16
4	Sakha 102	125.24	109.44	19.69	22.52	121.27	28	9.03
5	Sakha 103	122.31	98.38	19.36	19.22	117.53	26.24	8.67
6	Sakha 104	135.69	107.78	21.22	21.48	133.4	27.43	9.22
7	Sakha 105	124.38	98.96	20.6	21.55	122.36	28.05	8.84
8	Sakha 106	125.67	106.07	20.73	21.83	126.16	27.92	9.15
9	Giza 182	125.76	99.10	21.06	22.42	136.68	25.66	8.79
10	Egyptian Yasmin	144.93	108.38	21.44	24.95	145.16	25.81	8.43
Grand Mean		130.74	102.28	21.02	21.93	132.31	26.83	9.13
L.S.D. 0.05%		0.92	1.70	0.95	0.65	6.06	0.39	0.21

Stability parameters

Mainly, the genotype performance is depending on environmental interaction. It has been proved that estimation of phenotypic stability involving regression analysis is a suitable technique for the response assessment of different cultivars under environmental change. The evaluation of genotype- environmental interactions which is giving an idea of the buffering capacity of the population is still under study. The low magnitude of cultivars by environmental interaction consistent performance of a population over variable environments. Thus, stability analysis was done from the data of replicated trails conducted over three different locations for five years. However, the stability analysis depends on if the genotypes by environments interaction (G x E) found significant, the stability analysis can be carried out using one of the four known models. Thus, in our study, the Eberhart and Russell Model were performed (Eberhart and Russell, 1966). The ideal cultivars would be the one with high mean, regression coefficient equal to unity (b=1) and low deviation mean squares (Sd1=0). The statistics "b" measures the linear response of individual cultivar to an environmental index, whereas S^2di refers to deviations from this response. They further pointed out that the varieties exhibiting high regression coefficients (b>1) could be considered as below average stable varieties. Such varieties will perform well only in favorable environments while their performance will be poor in unfavorable environments. The varieties with low regression coefficients (bi<1) are above average stable and are adapted especially to poor environments. For duration, the rice cultivar Giza182 recorded the negative value and lower than 1 of bi it mean that this cultivars suitable for poor environments while, Giza178, Sakha103 and Sakha104 gave values of bi more than 1 it mean that these genotypes are suitable for cultivation in favorable environments. Regarding to S^2di only Giza177 gave value near of 0 (Table 5).

Concerning grain yield, the data in Table 5 revealed that the rice varieties Giza178, Sakha103, Sakha104, Sakha101 and Sakha106 are near of 1 regarding to bi indicating that these cultivars are adapted under different environments. While, Giza182 and Egyptain Yasmin gave values lower than 1 of bi indicating that these genotypes suitable for poor environments. Sakha105 ,Giza177 and Sakha102 exhibited bi higher than 1 it means that it's suitable for favorable environments while its performance will poor in unfavorable environments (Ravindra *et al.*, 2012; Girma, 2018 and Zewdu *et al*., 2020). Thus, these rice cultivars can be valuable for severe environments studies which the identified varieties are recommended for their appropriateness under poor environmental conditions as shown in Table 6.

Table 5. Stability parameters for studied traits of rice cultivars.

No.	Genotypes	Duration (days)		Plant height (cm)		No. panicles /plant		Panicle length (cm)		No. of filled grain/panicle		1000-grain weight(g)		Grain yield (t/ha.)	
		bi	*S^2di*	*bi*	*S^2di*	*bi*	*S^2di*	*bi*	*S^2di*	*bi*	*S^2di*	*Bi*	*S^2di*	*bi*	*S^2di*
1	Giza 177	0.42	-0.08	0.83	1.88	0.54	-0.02	0.98	0.75	0.97	125.50	0.31	0.01	1.20	0.02
2	Giza 178	1.98	1.86	0.95	5.08	0.44	2.02	0.72	1.08	1.00	102.54	0.01	1.73	1.02	0.11
3	Sakha 101	0.51	2.43	0.75	2.37	0.68	1.33	0.29	0.10	0.78	146.20	0.62	0.03	1.04	0.11
4	Sakha 102	0.54	0.42	0.82	5.69	1.05	1.22	0.92	0.64	1.28	59.07	1.37	0.25	1.18	0.20
5	Sakha 103	1.55	2.76	1.59	7.40	0.65	1.55	0.93	1.11	0.85	224.42	1.76	0.07	1.03	0.26
6	Sakha 104	1.29	2.36	0.94	7.48	0.94	0.36	1.84	0.27	0.64	79.52	1.17	0.41	1.08	0.02
7	Sakha 105	-0.30	2.58	1.13	2.31	1.37	0.14	1.17	0.88	0.78	66.52	1.30	0.80	1.22	0.21
8	Sakha 106	0.93	0.98	1.11	3.91	1.25	2.55	0.78	1.10	1.13	94.99	0.71	0.24	1.06	0.26
9	Giza 182	-0.13	0.83	0.78	5.62	1.15	1.89	1.66	2.74	1.34	270.96	2.15	0.24	0.75	0.32
10	Egyptian Yasmin	3.22	3.95	1.1	16.21	1.90	5.57	0.68	0.59	1.17	132.12	0.85	0.24	0.98	0.04

Table 6. Recommended cultivars for different environments.

No	Adaptive specificity	Cultivars suitable
1	favorable environment	Sakha105, Giza177 and Sakha102
2	Poor environment	Egyptain Yasmin and Giza182
3	Over all environment	Giza178, Sakha103, Sakha104, Sakha101 and Sakha106

CONCLUSION

The present investigation was carried out to evaluate the genotypic and environmental performance of 10 Egyptian rice cultivars under over a range of environments. The results revealed that a significant difference among the rice cultivars and environments for all studied traits indicating the presence of wide variability among these cultivars. The components of genotypes x environment interaction were significant, suggesting that the main portion of interaction was linear naturally as well as the prediction for environments was possible. For yield trait, data showed that significant pooled deviations, indicating that there are considerable differences in genotype. Based on the stability parameters, Giza178, Sakha103, Sakha104, Sakha101 and Sakha106 were suitable for all environments. Sakha105, Giza177 and Sakha102 were suitable for favorable environments. Egyptain Yasmin and Giza182 were identified for poor environments. Genetic studies to detect the genetic stability among the studied cultivar will be needed as a further work.

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أداء بعض أصناف الأرز المصريه وثباتها المحصولى فى مواقع زراعيه مختلفه

ساره عابدين الليثى ، تهانى محمد مظال و سماح محمد عامر

قسم بحوث الأرز- معهد بحوث المحاصيل الحقليه – مركز البحوث الزراعيه- الجيزه - مصر

أجريت هذه الدراسه بهدف تحدبد أصناف الأرز عاليه المحصول وثباتها وكذلك المناطق المناسبه لزراعتها تم دراسه تحليل الثبات لبعض أصناف الأرز المصريه المنزرعه وتأقلمها للتغيرات المناخيه وظروف التربه.لذا تم إجراء تجارب حقليه لعشره أصناف من الأرز بزراعتها فى قطاعات كامله العشوائيه فى ثلاث مكررات فى خمس سنوات تحت ثلاث مواقع مختلفه وهى (سخا وجميزه وزرزوره). وأظهرت النتائج المجمعه لتحليل التباين للأصناف والبيئات والتفاعل بينهما على وجود إختلافات عاليه المعنويه. وهذه الاختلافات المعنويه تدل على أن هناك تباعد وراثى بين التراكيب الوراثيه المدروسه من ناحيه المحصول. وبناءا على آداء تلك الأصناف تحت المواقع المختلفه كان هناك مجموعه من الأصناف عاليه المحصول والمبشره وهى جيزه ١٧٨ , سخا١٠٣ ,-سخا١٠٤ ,- سخا١٠١ وسخا١٠٦ وأكدت النتائج على أن تلك الأصناف أكثر ثباتا وتأقلما تحت البيئات المختلفه . الأصناف سخا ١٠٥ ,جيزه ١٧٧ , سخا ١٠٢كان أكثر ثباتافى الآراضى الجيده والآصناف, الياسمين المصرى و جيزه ١٨٢ تستجيب زراعتها فى الآراضى الفقيره. وبناءا على النتائج المتحصل عليها من دراسه تلك التراكيب الوراثيه وإستجابتها لظروف البيئات المختلفه فإن هذا يدل على أهميه تقييم الأصناف تحت بيئات مختلفه وكذلك تحديد أفضل تركيب وراثى فى أفضل أى من هذه المواقع المدروسه.