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Environmental Stability and Adaptation of Several Rice (*Oryza Sativa* L.) Cultivars with Different Climate Change

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Stable assortment is fundamental for long-haul grain yield security to the ranchers. Creating site-explicit assortment is a decent approach to keeping up with variety and getting possible yield. Stable boundaries were assessed given twelve rice assortments assessed under three different planting dates at research homestead of Sakha research station KafreElshiekh Egypt, during 2021 and 2022 seasons. The genotypes were affected by the shifting circumstances and G x E connection which was profoundly critical for a long time to development, seed set % and collect record, showing to responses of the rice assortments in various conditions. These characteristics are vital for adoption of assortments in rancher's field. It very well may be construed that, itis plausible of creating nearby unambiguous assortment which is steady and adaptable across these conditions. From the results showed that, the rice Sakha 106, Sakha107, Sakha 108 and Giza 178 are near 1 regarding bi indicating that, these cultivars are adapted under different environments. While, Values of less than one for bi indicated that the cultivars Giza 177, E. yasmin, and Sakha super 300 were appropriate for unfavorable conditions. Conversely, Sakha 101, Sakha 104, Sakha 105, and Giza 182 demonstrated bi values greater than 1, indicating their suitability for good conditions and their poor performance in unfavorable ones. Because of this, these rice cultivars can be useful for studying harsh environments. The discovered types are suggested because they are suitable for harsh situations.

Keywords: Rice varieties, Stability, environment, Grain yield.

Abbreviations: (ANOVA) Analysis of Variance, (G) genotypes, (E) environments, (Y) years, (D) dates of sowing, (LSD) lowest significant different, (RCB) randomized complete blocks, (PCV) phenotypic coefficient of variability, (GCV) genotypic coefficient of variability, (h_2b) broad scence heritability, (bi) regression coefficient, (S^2di) deviation from regression, (ASV) AMMI Stability Value, (Wi^2) Wricke's Ecovalence for stability, (ASI) AMMI Stability Index.

Introduction

Rice is the staple food crop for Egypt and a large portion of African nations, as well as, is a significant piece of the eating routine for some others. Since quite a while back, the interest in rice has increased quickly. In Egypt, the rice developed region is around 0.450 million hectares and the yearly creation of this area is more than 4.227 million tons of paddy rice (**RRTC 2023**). The rice creation needs to increment to 40% for all rice environments considerably under different pressure regions to accomplish food security by 2025 (**Pennisi,**

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2008). Abiotic stresses are viewed as one of the significant requirements for augmenting grain yield. in over 30% of paddy fields in Egypt, thusly the improvement of the Egyptian rice assortment resistance to dry season pressure is vital. Emotional decrease of grain yield happens when stress concurs with the irreversible regenerative cycles making the hereditary investigation of dry spell resistance (**Pantuwan, et al., 2002**). Before releasing a new variety for commercial purposes, plant breeders usually evaluate the set of genotypes across multi-environments. A stable genotype produces the expected yield in a particular environment (**Wricke 1962**). The stronger a genotype–environment interaction is, the more unpredictable it is to assess the performance of a genotype in multi-environments (**Piepho 1994**). Selection of a particular genotype becomes difficult due to genotype_ environment interaction (**Farshadfar et al 2012**). Hence, it is significant to assess the adaptation and stability of a group of genotypes before commercial release. Various statistical methods that have been developed for this purpose are divided into parametric and non-parametric stability statistics. Parametric stability statistics is further divided into univariate and multivariate methods. The univariate methods include Wricke's ecovalence (Wi2) (**Wricke 1962**), Shukla's stability variance (s2) (**Shukla 1972**), coefficient of variance (CV) (**Francis 1978**), Environmental variance (S^2) (**Roemer 1917**),

Mean-variance component (q) (**Plaisted, and Peterson 1959**), GE variance component (q') (**Plaisted 1960**), Regression coefficient (bi) [Finlay, and Wilkinson 1963], and many others. The multivariate methods imply the additive main effects and multiplicative interaction (AMMI) model (**Gauch 1988**). Multivariate methods can effectively predict the genotype _ environment interactions by using the approaches such as the 'which-won-where' pattern, identifying mega environments, ideal genotypes across different testing environments, and ranking environments [Gauch 2008]. Non-parametric methods include Nassa and Huhn's and Huhn's statistics (S) (**Nassar, and Hühn 1987**), and Genotype stability index (GSI) (**Farshadfar 2008**). The objectives of the study are to focus on the adequacy among some rice cultivars and to choose the best genotype is stable for different biological conditions.

Materials and Methods

Materials of the current study comprised of 12 rice cultivars were evaluated during 2021 and 2022 seasons under three sowing dates, April 20th, May 10thand May30that rice research farm Sakha Agricultural Station – Kafr elshiekh – Egypt (31°5′ 54″N, 30°57′0″E)., to evaluate the genetic stability among 12 rice varieties for some growth and yield attributes. The rice cultivars were Sakha 101, Sakha 104, Sakha105, Sakha 106, Sakha 107, Sakha 108, Giza177, Giza178, Giza179, Giza 182, Egyptian yasmine and Sakha super 300.

The analysis was spread-out split-plot design with three replications in randomized complete block design Sowing dates were allocated in the main plots and Rice varieties were applied in the sub- plots. Each replication included seven rows for each variety; the length of each row was 5m and the harvested 5 m^2. Plot size was 2 x 3 m. Nursery to raise the seedlings was laid out according to the proper season of individual site. Seedling of 25-30 days old was relocated at the dispersing of 20 x 15 cm. Two seedlings for each slope were continued in all destinations. The rate of NP 60:30 kg/h was applied as follows, 30 kg $P2O_5$ as single upper phosphate (15%P_2O_5) was applied in the long-lasting field and consolidated with soil during land groundwork for all replications. 60kg N//ha as urea (46.5%) was applied in two parts, the primary portion 2/3 added as basal application and consolidated with soil during land arrangement. While, the subsequent portion was top-dressed following 30 days of relocating. All suggested rural practices were applied as expected for the conventional rice field and weeds were synthetically controlled as suggested by (**RRTC 2019**

The studied characteristics are days to heading (days), plant height, number of panicles/plant, grain yield/ plant and harvest index % were measured according to (**IRRI, 2016**).

Statistical Analysis :

Every environmental data as different sowing dates with two seasons (six locations) was individually accustomed to Analysis of Variance (ANOVA) to examine variances among varieties for grain yield and pooled across locations to determine G x E interaction. For Eberhart and Russell's (1969) model, the significant G × E was used for stability analyses. A variety with unit regression coefficient (bi=1) and deviation not significantly different from zero (S2di=0) was taken to be a stable genotype with the unit response. The mean comparisons among varieties means were estimated by the least significant difference (LSD) test at 5% level of significance Gomez and Gomez (1984). The ANOVA was performed using RCBD to derive variance components using GenStat statistical package (12th edition) .

Results

The results in Table (1) showed the, the mean square values for days to heading, plant height, no of panicles/plant, grain yield/ plant and harvest index %, significant differences among the Egyptian rice varieties under different sowing dates. The differences among the environments and varieties were significant for all studied traits, the differences between years were highly significant, also, the differences among the different sowing dates were significant for all studied traits, years x different sowing dates for all studied traits except days to heading were highly significant. Also, the mean square for the differences among the rice varieties were highly significant for all studied traits, the interaction between rice varieties x years were found to be significant and highly significant for all the studied traits, except days to heading (Table 1), the interaction between rice varieties x years were found to be significant and highly significant for all the studied traits, the interaction between rice varieties x date of sowing were found to be significant and highly significant for all the studied traits, the interaction among years x rice varieties x date of sowing were found to be significant and highly significant for all the studied traits. These results indicated that, the studied varieties responded differently to the environmental conditions suggesting the importance of the assessment of rice cultivars under different environments in order to identify the best cultivars that more adapted for a particular environment. The mean squares due to environments were the most important source of the total mean squares for all characteristics. Also, the variances due to environments were higher than those of interactions between varieties and environments for all studied characters. Therefore, most of the differences in the performance of rice varieties in these experiments were due to environment and not to variety by environment interaction differences.

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.

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.

TABLE 1: Mean square for days to heading, plant height, No. of panicles/plant, grain yield and harvest index% of twelve genotypes in rice.

SOV	df	Days to heading	Plant height	Number of panicles/plant	Grain yield/plant	Harvest Index %
Years (Y)	1	41.51**	208.27**	55.89**	343.27**	243.82**
date (D)	2	371.15**	47.33**	197.47**	204.71**	221.50**
Y*D	2	1.84	65.25*	9.94**	21.80**	9.17**
Rep/D/Years = (Ea)	8	0.14	6.54	0.87	2.15	1.82
Geno (G)	11	808.26**	2070.76**	38.01**	18.92**	17.27**
G*Y	11	7.29**	59.93**	5.06**	3.84**	2.37*
G*D	22	3.24**	5.42**	3.12**	0.66	0.85*
G*Y*D	22	1.39**	8.28**	7.98**	1.36	0.79**
Error/D/years (Pooled Error) = (Eb)	134	0.71	2.97	0.39	0.49	0.49

Results of combined analysis of variance are given in Table 2. Combined analysis indicated that there were highly significant different between sites, between rice varieties and their interaction effects. This Table guided for selecting stable rice varieties across sites and most adopted variety in favorable environment. Option exists to select better varieties based on days to heading, plant height, no of panicles/plant, grain yield/ plant and harvest index %. These traits are considered most important by farmers. Responses of these varieties in each site and site mean are given in Table 2. The combined analysis of variances over the six environments (three sowing dates and two seasons).Indicates significant differences among environments for all the studied traits . The relative magnitude of genotypic variation (σ^2g) was more than error one (σ^2e) for days to heading, plant height, no of panicles/plant grain yield/plant and harvest index, this finding reflects the influence little of environmental effects on these traits, on the contrary, it was obvious the σ^2g was important in magnitude compared to σ^2eg for all traits, representing, the genetic effects had an important role in the expression of those traits.

Estimated phenotypic (PCV) and genotypic (GCV) coefficient of variability were observed with slight differences between them for all studied traits, exanimate at all six environments (Table 2), also, heritability in the broad sense were recorded the highest values for all the studied traits the values were more than 94%. It was interested to note that all rice cultivars behaved constantly as most environments including days to heading, plant height, No. of panicles/plant, grain yield/plant and harvest index.

TABLE 2. Combined analysis of variance for different traits of twelve rice varieties

Genetic parameters	Days to heading (day)	Plant height (cm)	Number of panicles/ plant	Grain yield/plant (g)	Harvest Index %
$\sum^2$g	808.26	2070.76	38.01	18.92	17.27
$\sum^2$eg	3.24	5.42	1.12	0.66	0.85
$\sum^2$e	0.71	2.95	0.39	0.51	0.49
$\sum^2$p	812.21	2079.13	39.52	20.09	18.61
PCV	17.20	25.79	20.26	14.15	5.49
GCV	17.00	25.72	19.95	13.84	5.26
h_2b %	99.51	99.60	96.18	94.17	92.80

Mean Performance: -

The days to heading of different rice cultivars was ranged from 88.7 for Giza 179 to 109 days to Sakha super 300, but for different environmental the range for days to heading was 93.8 for E6 to 99.2 for E1, indicated to the differences for rice varieties was more than the environments that referred to highly diversity for rice cultivars (Table 3).

The plant height of different rice cultivars was ranged from 88 cm for Giza 179 to 124 cm to Egyptian yasmine, but for the different environmental, the range for plant height was 99,5 for E6 to 103.6 for E2, indicated to the differences for rice varieties was more than the environments that referred to highly diversity for rice cultivars (Table 3).

TABLE 3: Average value for days to heading and plant height for of rice varieties over different environments.

Ge varieties	Days to heading							Plant height						
	E1	E2	E3	E4	E5	E6	Mean	E1	E2	E3	E4	E5	E6	Mean
Sakha 101	105.4	103.1	99.9	104.5	103.7	100.2	102.8	102.3	101.0	102.3	102.0	100.5	96.7	100.81
Sakha 104	100.4	99.5	96.7	100.0	99.0	97.0	98.8	114.0	117.0	114.3	113.0	111.9	110.4	113.44
Sakha105	92.7	92.3	88.3	92.0	90.9	88.5	90.8	95.0	97.3	96.3	94.3	93.5	93.1	94.93
Sakha 106	95.6	94.5	91.7	92.9	91.7	89.0	92.6	96.0	96.0	96.0	96.0	94.7	95.0	95.61
Sakha 107	91.0	92.3	88.1	90.5	89.2	87.4	89.7	96.7	96.0	96.0	96.7	95.7	94.1	95.85
Sakha 108	103.0	101.8	98.7	101.7	100.7	96.6	100.4	105.7	107.0	106.3	105.0	103.5	101.0	104.74
Giza177	95.3	93.8	90.9	91.2	90.1	88.2	91.6	107.7	111.0	111.7	105.0	103.1	101.0	106.58
Giza178	100.8	98.7	93.8	100.0	97.8	94.7	97.6	108.7	108.7	111.0	103.3	100.4	99.2	105.22
Giza179	91.4	87.9	87.3	90.0	88.5	87.2	88.7	91.0	87.3	86.0	92.0	89.7	87.3	88.89
Giza 182	96.3	90.5	88.8	92.7	90.4	88.7	91.2	85.3	85.3	85.3	87.0	86.3	86.3	85.94
Egyptian yasmine	107.1	104.9	102.1	107.8	105.1	102.3	104.9	125.3	125.0	126.3	125.7	123.0	119.0	124.06
Sakha super 300	111.1	108.5	106.1	113.1	108.8	106.4	109.0	104.3	112.0	103.3	114.2	110.1	110.3	109.04
Mean	99.18	97.32	94.37	98.03	96.33	93.85	96.51	102.6	103.6	102.9	102.8	101.0	99.45	102.09
LSD 0.05	1.0	2.5	1.0	1.03	1.17	1.24	0.55	3.4	3.5	4.4	1.56	1.58	1.87	1.12
LSD 0.01	1.4	3.4	1.4	1.41	1.59	1.69	0.72	4.7	4.8	6.0	2.12	2.15	2.54	1.48

The No. of panicles/plant of different rice cultivars was ranged from 16 for Sakha 107 to 119.4 panicles to Sakha 108, but for the different environmental, the range for no. of panicles/plant was 15.38 for E6 to 19.5 for E1, indicated to the differences for rice varieties was similar to the environments that referred to the interaction between rice cultivars with the different sowing dates (Table 4).

The harvest index of different rice cultivars ranged from 43.13 for Sakha 107 to 46.2 days to Sakha 101, but for the different environmental the range for harvest index was 42.3 for E6 to 47.5 for E1, indicated to the differences for environments was more than the rice varieties that referred to affected this trait by environments (Table 4).

Most probably this is due to variation in temperature and day length. Earliest variety, sakha 107 was heading in 88 days in late sowing date and most long duration variety was heading within 115 days in early sowing date. Plant height is important both in term of lodging susceptibility and use value to farmers. Systematic changes in plant height were observed among sites. It indicated that climatic variation is more influential to change height in these cultivars. Highest no of panicles/plant was observed in all genotypes except sakha 107 grown in late sowing date. Similarly varieties grown in late sowing date produced lowest grain yield. Response pattern of these varieties with respect to environment was similar to harvest index. Sakha 108 variety produced highest value for harvest index which grown in early sowing date . on the other hand, some rice cultivars fluctuated from one environment to another, i.e., the rice cultivars Sakha 108 superior for No. of panicles/plants and grain g/plant at E1, while Sakha super 300 for the same traits under E6.

TABLE 4: Average value for Number of panicles/plant and Harvest index of rice varieties tested in tested sites over environments.

Varieties	Number of panicles / plant							Harvest index						
	E1	E2	E3	E4	E5	E6	Mean	E1	E2	E3	E4	E5	E6	Mean
Sakha 101	20.7	19.9	18.0	20.6	18.0	16.0	18.9	48.3	47.8	46.0	47.5	44.4	43.2	46.20
Sakha 104	19.9	18.8	17.1	19.4	18.0	15.8	18.2	48.0	47.1	44.2	46.4	44.2	43.1	45.49
Sakha105	17.0	16.6	15.1	15.9	13.8	13.3	`15.3	47.0	46.8	43.8	45.4	43.4	42.5	44.82
Sakha 106	18.1	17.1	16.0	17.6	15.4	13.9	16.3	47.7	46.8	43.2	46.9	43.7	43.0	45.22
Sakha 107	17.8	16.9	15.8	17.2	14.7	13.6	16.0	44.9	44.0	43.5	44.0	41.8	40.9	43.19
Sakha 108	21.3	20.6	17.8	21.5	18.6	16.3	19.4	49.3	47.1	44.9	46.6	45.0	43.7	46.10
Giza177	19.6	18.8	17.2	19.7	17.2	15.1	17.9	47.0	46.0	43.7	44.2	41.5	41.6	43.97
Giza178	20.7	20.8	18.0	20.8	18.1	17.1	19.3	48.0	47.3	44.7	46.5	44.4	42.9	45.64
Giza179	21.1	17.9	16.6	21.5	18.6	17.6	18.9	48.2	47.0	44.1	47.6	45.0	42.5	45.72
Giza 182	19.3	17.9	17.1	19.1	17.4	15.5	17.7	47.2	46.6	44.0	44.6	42.3	40.3	44.16
Egyptian yasmine	21.2	20.0	16.5	21.4	18.0	17.0	19.0	47.0	45.8	42.6	44.4	42.2	40.5	43.74
Sakha super 300	17.1	16.1	16.5	17.3	16.1	13.4	16.1	47.2	45.0	43.5	45.5	44.0	43.0	44.68
Mean	19.48	18.45	16.81	19.33	16.99	15.38	17.75	47.48	46.44	44.00	45.80	43.49	42.26	44.91
LSD 0.05	1.2	0.9	0.9	1.13	1.18	1.06	0.41	0.8	1.1	0.9	1.36	1.57	1.32	0.46
LSD 0.01	1.6	1.3	1.2	1.53	1.61	1.43	0.53	1.1	1.4	1.2	1.84	2.13	1.80	0.60

The grain yield/plant of different rice cultivars ranged from 42 gm/plant for Sakha 107 to 45.6 gm/plant to Sakha 108, but for different environmental the range was 41 gm/plant for E6 to 46.45 gm/plant for E1, indicated to the differences for environments was more than rice varieties, the that referred to highly diversity for date of sowing.

Only the linear component of G × E interaction was recorded significant, which suggested significant difference among the varieties for linear response to environments. Hence, it would be least susceptible to environmental changes and the behavior of cultivars over environments can be predicted more accurately. Significant varieties mean sum of squares were observed due to the varied effect of environments on varieties, The cultivars Giza 179 and Giza 177 were regarded as stable with lower grain yield per plant and good for poor yielding environments exhibiting regression coefficients lesser than unity with non-significant deviation from regression coefficient.

Stability parameters

The stability regression coefficient (bi) and deviation from regression (S^2d) for the studied varieties are presented in Tables 5, 6and 7. A stable variety is one with a high mean performance, unit regression coefficient (bi = 1) and deviation from regression equal to zero.

The predictability of varieties for the grain yield ranged from 0.04 for Sakha 106, to 1.37 for Sakha super 300 (Table 7). Based on regression coefficient (bi) values,for grain yield, the data in Table 7 revealed that , the rice Sakha 106, Sakha107, Sakha 108 and Giza 178 are near of 1 regarding to bi indicating that these cultivars are adapted under different environments. While, Giza 177, E. yasmin and Sakha super 300 gave values lower than 1 of bi indicating that these varieties suitable for poor environments. Sakha 101, Sakha 104, Sakha 105 and Giza 182 exhibited bi higher than 1 it means that it's suitable for favorable environments while its performance will poor in unfavorable environments

Thus, these rice cultivars can be valuable for severe environments studies which the identified varieties are recommended for their appropriateness under poor environmental conditions. The simple parameters, ASV, Wi2 and ASI. were used to select stable and site-specific varieties that can be again included in the experiments (Table 7). Sakha 105, Sakha 108, Giza 178 and Giza 182 have lower AvD, SDD and SD, therefore, these are grouped as stable varieties with respect to harvest index % response. The genotype with highest AvD, SDD and SD is Sakha101 and this variety is highly adapted to favorable environments.

TABLE 5: Mean performance and phenotypic stability measurements for days to maturity and plant height of twelve varieties over three environments.

Varieties	Days to maturity						Plant height					
	Mean	**bi**	**S^2di**	**ASV**	**W^2i**	**ASI**	**Mean**	**bi**	**S^2di**	**ASV**	**W^2i**	**SI**
Sakha 101	102.79	1.05	0.470	18.46	1.94	4.27	100.81	1.21	1.432	18.46	6.28	3.00
Sakha 104	98.78	0.73	0.128	28.77	2.09	4.07	113.44	1.31	1.162	28.77	5.85	3.13
Sakha105	90.78	0.90	0.353	1.83	1.65	3.47	94.93	0.90	0.949	1.83	3.95	2.67
Sakha 106	92.57	1.00	1.457	21.71	5.84	5.07	95.61	0.34	0.118	21.71	5.79	2.47
Sakha 107	89.74	0.74	1.173	15.79	6.13	5.20	95.85	0.52	0.302	15.79	4.03	2.87
Sakha 108	100.42	1.10	0.495	8.58	2.20	3.87	104.74	1.39	0.218	8.58	2.74	1.87
Giza177	91.58	1.00	2.826*	17.20	11.31	6.20	106.58	2.39	5.758**	17.20	46.48	5.53
Giza178	97.62	1.33	0.451	19.41	4.16	4.27	105.22	2.62	9.259**	19.41	68.72	6.47
Giza179	88.72	0.71	0.675	27.73	4.49	4.73	88.89	0.17	6.888**	27.73	35.90	5.27
Giza 182	91.24	1.24	1.825	4.33	8.58	4.47	85.94	-0.20	0.503	4.33	19.46	4.93
Egyptian yasmine	104.88	1.06	0.857	17.05	3.51	3.47	124.06	1.64	1.163	17.05	9.58	3.33
Sakha super 300	108.99	1.13	2.110	15.91	8.83	3.73	109.04	-0.29	22.866**	15.91	111.45	6.07

bi: regression coefficient

S2di: deviation from regression

ASV: AMMI Stability Value

Wi2: Wricke'sEcovalence for stability;

ASI: AMMI Stability Index.

TABLE 6: Mean performance and phenotypic stability measurements of No of panicles/plant and harvest index (%) for twelve genotypes over three environments.

	No of panicles/plant						Harvest index %					
	Mean	**bi**	**S2di**	**ASV**	**W2i**	**SI**	**Mean**	**bi**	**S2di**	**ASV**	**W2i**	**SI**
Sakha 101	18.9	0.94	0.106	18.46	0.63	1.00	46.20	1.00	0.279	18.46	1.12	4.20
Sakha 104	18.2	0.80	0.343	28.77	3.22	2.73	45.49	0.98	0.045	28.77	0.19	2.27
Sakha105	`15.3	1.12	0.273	1.83	1.76	2.60	44.82	0.93	0.137	1.83	0.65	3.40
Sakha 106	16.3	0.13	1.908	21.71	44.18	5.93	45.22	1.03	0.528	21.71	2.13	4.67
Sakha 107	16.0	0.77	0.045	15.79	2.78	2.60	43.19	0.72	0.323	15.79	2.80	5.27
Sakha 108	19.4	1.04	1.085	8.58	4.41	4.00	46.10	0.98	0.254	8.58	1.03	4.13
Giza177	17.9	1.47	0.480	17.20	12.84	4.60	43.97	1.07	0.577	17.20	2.41	4.33
Giza178	19.3	2.06	1.439	19.41	59.72	5.67	45.64	0.99	0.032	19.41	0.14	2.27
Giza179	18.9	0.57	1.256	27.73	14.05	4.53	45.72	1.09	0.550	27.73	2.35	5.27
Giza 182	17.7	0.50	1.089	4.33	16.40	4.87	44.16	1.27	0.511	4.33	3.47	6.00
Egyptian yasmine	19.0	1.22	0.242	17.05	3.31	3.33	43.74	1.23	0.055	17.05	1.23	4.47
Sakha super 300	16.1	1.39	3.204*	15.91	20.01	4.27	44.68	0.71	0.394	15.91	3.20	5.33

bi: regression coefficient S2di: deviation from regression

ASV: AMMI Stability Value Wi2: Wricke'sEcovalence for stability;

ASI: AMMI Stability Index.

TABLE 7: Average value for grain yield/ plant of twelve rice cultivars over environments.

Genotypes	**Grain yield / plant (gm)**								
	E1	E2	E3	E4	E5	E6	Mean	**bi**	**S^2di**
Sakha 101	47	47	44.9	46.6	44.3	41.0	45.0	1.21	0.315
Sakha 104	47.1	47.1	44.2	46.8	43.1	40.9	44.9	1.20	0.276
Sakha105	46.8	46.8	43.8	45.2	43.2	40.8	44.4	1.11	0.027
Sakha 106	46.9	46.8	43.2	44.7	43.5	41.6	44.4	0.96	0.395
Sakha 107	44.0	44.0	43.5	42.7	41.1	38.4	42.3	0.98	0.788
Sakha 108	47.8	47.8	46.9	46.6	44.7	41.5	45.6	1.00	0.244
Giza177	46.0	46.0	43.7	43.8	42.3	41.2	43.8	0.88	0.270
Giza178	47.3	47.3	44.7	46.1	44.7	42.2	45.4	0.92	0.105
Giza179	47.0	47.0	44.1	46.9	45.0	43.3	45.5	0.72	0.514
Giza 182	46.6	46.6	44.0	43.7	40.2	39.3	43.4	1.40	1.166
Egyptian yasmine	45.8	45.8	42.6	44.6	42.6	42.1	43.9	0.75	0.484
Sakha super 300	45.0	45.0	43.5	44.5	42.8	40.2	43.5	0.86	0.176
Mean	46.45	46.44	44.02	44.18	43.13	41.04	44.37		
LSD 0.05	1.1	1.1	0.9	1.28	1.51	1.40	0.47	-	-
LSD 0.01	1.4	1.4	1.2	1.74	2.05	1.91	0.61		

bi: regression coefficient S2di: deviation from regression

ASV: AMMI Stability Value Wi2: Wricke'sEcovalence for stability;

ASI: AMMI Stability Index.

Discussion :

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., The grain yield of rice varieties differed considerably with the change in environmental conditions including sowing dates and years. (Eberhart and Russell, 1996). Hence, linear (bi) and non-linear (S2di) 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 (Zewduet al., 2020).The relative magnitude of genotypic variation (σ2g) was more than error one (σ2e) for desirable characters, this finding reflects the influence little of environmental effects on these traits, on the contrary, it was obvious the σ2g was important in magnitude compared to σ2e for all traits, representing, the genetic effects had an important role in the expression of those traits. This obtained results reported by (Sedeek et al., 2009).A stable genotype is one with a high mean performance, unit regression coefficient (bi = 1) and deviation from regression equal to zero (Awad, 1997). the rice Sakha 106, Sakha107, Sakha 108 and Giza 178 are near of 1 regarding to bi indicating that these cultivars are adapted under different environments. While, Giza 177, E. yasmin and Sakha super 300 gave values lower than 1 of bi indicating that these varieties suitable for poor environments. Sakha 101, Sakha 104, Sakha 105 and Giza 182 exhibited bi higher than 1 it means that it's suitable for favorable environments, while its performance will poor in unfavorable environments. Thus, these rice cultivars can be valuable for severe environments studies, which the identified varieties are recommended for their appropriateness under poor environmental conditions. Sakha108 was released in 2018 as a high yielding cultivar amended for enhancing rice production in Egypt. The application of 165 kg N/ha-1 and wider space (25x20 cm) significantly increased growth, yield attributes and grain yield of the new cultivar Sakha108, the new cultivar exhibited multiple resistance to other important biotic stresses Hammoud et al (2020). This will significantly help to improve /maintain varietal policy with new high yielding and biotic stress resistant varieties to replace old/susceptible varieties. This is also a model of continuous flow of new rice varieties to cope with highly variable biotic stress agent such as blast fungus. Sakha108 is now taking place on rice belt as a leading rice variety.On the same line Vishal Pandeyet al (2020) , mentioned, the genotypes, DRR Dhan 48 and HURZ-3 showed good mean values for all the traits and was also stable for grain zinc, yield per hectare, 1000 grain weight, had shorter plant height and can be suggested for use as high yielding cultivars with high grain Zinc and could be further used in breeding programmes successfully.

The highest values of number of panicles per hill, number of filled grains per panicle, grain yield, hulling, milling and broken rice grain were recorded in the early sowing date. While,the number of days from seeding to maturity and number of unfilled spikelet's per panicle were recorded in the decline trend, as sowing was delayed.Metwallyet al (2016). These differences might be related to the genetic diversity among evaluated genotypes under different sowing dates. Maiti and Sen (2003) indicated that the growth duration exhibited an increase trend of early planted crop and decrease trend of late planted crop.The highest values of number of filled grains per panicle were observed by Egyptian Hybrid Rice 1 followed by Giza179, Giza178 and Sakha101.Dawadi and Chaudhary (2013) and El-Malky and El-Zun (2014) found that number of filled grains per panicle increased in the early sowing and declined gradually in the successive later sowing dates.Sakha107 was released in 2016 as a high yielding cultivar, good grain quality and short stature with earliness under water shortage in Egypt It is an outstanding new cultivar to released and recommended for cultivation in the various rice-producing regions, mainly in areas that are exposed to declining water irrigation and resources in Egypt.Abdallahet al 2022

Conclusion

From the above results could be concluded that, the rice Sakha 106, Sakha107, Sakha 108 and Giza 178 are near of 1 regarding to bi indicating that, these cultivars are adapted under different environments. While, Giza 177, E. yasmin and Sakha super 300 gave values lower than 1 of bi indicating that, these varieties suitable for poor environments. On the other side, Sakha 101, Sakha 104, Sakha 105 and Giza 182 exhibited bi higher than 1 it means that it's suitable for favorable environments, while its performance will poor in unfavorable environments. Thus, these rice cultivars can be valuable for severe environments studies, which the identified varieties are recommended for their appropriateness under poor environmental conditions.

Conflicts of interest.

The authors declare that, the research was conducted in the absence of any commercial or relationships that could be construed as potential conflict of interest.

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References

Abdallah, A. A.; M. I. Aboyousef; S. A Hammoudet al (2022). Sakha 107 Egyptian Rice Variety with High Yielding and Good Grain Quality under Water Shortage. J. of Plant Production, Mansoura Univ., Vol. 13 (3):85-98. DOI: 10.21608/jpp.2022.127304.1100.

Al-juthery H. W. A and Sahar F. S . (2019). Fertilizer use efficiency of nano fertilizers of micronutrients foliar application on Jerusalem artichoke, Al-Qadisiyah Journal For Agriculture Sciences, 9(1) 156-164. DOI: 10.33794/qjas.Vol9.Iss1.74

Dawadi, K. P. and Chaudhary N.K. 2013. Effect of sowing dates and varieties on yield and yield attributes of direct seeded rice in Chitwan, Nepal. Int. J. of Agric. Sci. Res., 2(4): 095-102. DOI: 10.3126/aej.v14i0.19792

Eberhart, SA and WA Russel. 1966. Stability parameters for comparing analysis for yield and its components in promising rice hybrids. The Ecoscan. 9(1&2): 311-321.

El-Malky, M.M. and El-Zun H.M. 2014. Genetic behavior of yield, grain quality, stem borer and storage insect infestation traits for some rice genotypes at different sowing dates. J. Plant Production, Mansoura Univ., 5(6): 917-935. DOI: 10.21608/JPP.2014.55441

El-Ramady, H.R., El-Marsafawy, S.M. and Lewis, L.N. 2013. Sustainable agriculture and climate changes in Egypt. Sustainable Agriculture Review. E. Lichtfouse (ed.). Springer. 12: 41-95. DOI 10.1007/978-94-007-5961-9_2.

Farshadfar, E. (2008). Incorporation of AMMI stability value and grain yield in a single non-parametric index (GSI) in bread wheat. Pak. J. Biol. Sci. PJBS, 11, 1791–1796. DOI: 10.3923/pjbs.2008.1791.1796

Farshadfar, E.; Mohammadi, R.; Aghaee, M.; Vaisi, Z.(2012). GGE biplot analysis of genotype x environment interaction in wheat-barley disomic addition lines. Aust. J. Crop Sci., 6, 1074–1079.

Finlay, K.W.;Wilkinson, G.N. (1963).The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res., 14, 742–754.

Francis, T.R.; Kannenberg, L.W. (1978). Yield stability studies in short-season maize. i. a descriptive method for grouping genotypes. Can. J. Plant Sci., 58, 1029–1034. doi.org/10.4141/cjps78-157

Gauch, H.G., Jr. (1988). Model selection and validation for yield trials with interaction. Biometrics, 44, 705–715. doi.org/10.2307/2531585

Gauch, H.G., Jr.; Piepho, H.-P.; Annicchiarico, P. (2008). Statistical Analysis of Yield Trials by AMMI and GGE: Further Considerations. Crop Sci., 48, 866–889. doi.org/10.2135/cropsci2007.09.0513

Gomez K. and A. Gomez. 1984. Statistical Procedures of Agricultural Research. John Wiley and Sons. Inc., New York, U.S.A.

Hammoud S. A; M.I. Abo yousef et al (2020) .Sakha108 Egyptian Rice Variety Japonica Type High Yielding and Resistant to Blast. J. of Plant Production, Mansoura Univ. 11 (11):1153 - 1162. DOI: 10.21608/jpp.2020.131158

IRRI (2016). Standard Evaluation System for rice 3rd Edition, Int. Rice Testing Programm.

Joshi, BK. 2004. Rice gene pool for mid and high hills and its conservation in Nepal. In: Agricultural Research for Enhancing Livelihood of Nepalese People

Joshi, BK. 2006. Crossing frequency and ancestors used in developing Nepalese mid and high hill rice cultivars: Possible criteria for yield improvement and rice genes conservation. In: Proceedings of 4th National Conference on Science and Technology, 23-26 March 2004, Kathmandu, NAST. Vol I. Pp.502-513.

Joshi, BK; R Gardner; and DR Panthee. 2011. GGE biplot analysis of tomato F1 hybrids evaluated across years for marketable fruit yield. Journal of Crop Improvement 25:488-496. http://dx.doi.org/10.1080/15427528.2011.587138.

Joshi, BK; S Gyawali; and D Poudyal. 2002. Regression analyses and multiple comparison procedures: Uses and misuses. JIST. 12:69-81.

Metwally, T.F. , H. M. El-Zun and Nilly A.H. Abdelfattah (2016). Performance of Some Rice Genotypes Sown on Different Dates in Yield, Quality Traits and Infestation by Lesser Grain Borer. J. Plant Production, Mansoura Univ., Vol. 7 (9): 973 - 981.

Metwally, T.F. : H. M. El-Zun and Nilly A.H. Abdelfattah. (2016) .Performance of Some Rice Genotypes Sown on Different Dates in Yield, Quality Traits and Infestation by Lesser Grain Borer . J. Plant Production, Mansoura Univ., Vol. 7 (9): 973 – 981.

Metwally, T.F. ; E.E. Gewaily and M.M. El-Malky. 2015. Influence of top leaf clipping on growth and yield of rice under different sowing dates. The 5th Field Crops Conf., Field Crops Res. Inst. Egypt. J. Agric. Res., 93 (2A): 87-106.

Nassar, R.; Hühn, M. (1987). Studies on Estimation of Phenotypic Stability: Tests of Significance for Nonparametric Measures ofPhenotypic Stability. Biometrics, 43, 45–53. [CrossRef].

Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S., and O'Toole, J. C. (2002). Yield response of rice (Oryza sativa L.) genotypes to different types of drought under rainfed lowlands: Part 1. Grain yield and yield components. Field Crops Research, 73(2-3), 153-168.

Pennisi, E. (2008). The blue revolution, drop by drop, gene by gene. Science, 320(5873), 171-173.

Piepho, H.P. (1994). A Comparison of the Ecovalence and the Variance of Relative Yield as Measures of Stability. J. Agron. Crop Sci.,173, 1–4. [CrossRef]

Plaisted, R.L. (1960). A shorter method for evaluating the ability of selections to yield consistently over locations. Am. Potato J., 37, 166–172. [CrossRef]

Plaisted, R.L.; Peterson, L.C. A technique for evaluating the ability of selections to yield consistently in different locations or seasons. Am. Potato J. 1959, 36, 381–385. [CrossRef]

Roemer, J. (1917). Sinde die ertagdreichen Sorten ertagissicherer. Mitt DLG, 32, 87–89.

RRTC (2019). National Rice Research Program: Final results of 2020 growing season. Sakha, Egypt.

Saidaiah, P., Kumar, S.S. and Ramesha, M.S. (2011). Stability analysis of rice (Oryza sativa) hybrids and their parents. Indian Journal Office, PusaCampus, New Delhi-i 10012, India. 167-173..

Shukla, G. (1972).Some statistical aspects of partitioning genotype environmental components of variability. Heredity, 29, 237–245. [CrossRef].

Sorour, F.A.; A.Y. Ragab; T.F. Metwally and A.A. Shafik(2016). Effect of planting methods and nitrogen fertilizer rates on the productivity of rice (Oryza sativa L.). J. Agric., Res., Kafrelsheikh Univ., J.Plant Production 42(2):207-216.

Vishal Pandey, S.K. Singh, MounikaKorada, D.K. Singh, A.R. Khaire, SonaliHabde, Prasanta Kumar Majhi. (2020). Stability Analysis in Rice (Oryza sativa L.) Genotypes with High Grain Zinc. hIndian Journal of Agricultural Research, Volume Issueh A-5353 - [1-10].

Vishnuvardhan, R.B., Payasi, K.D. and Anwar, Y. (2015). Stability yield in rice. Oryza. 45(1): 115-119.

Wricke, G. (1962). Uber eine Methode zur Erfassung der okologischen Streubreite in Feldverzuchen. Z. Pflanzenzuchtg 1962, 47, 92–96.

Yakhin O.I., A.A. Lubyanov, I.A. Yakhin and P.H. Brown. (2017). Biostimulants in plant science: A global perspective. Frontiers in Plant Science.;7(2049):1-32.Zobel, RW; MJ Wright; and HG Gauch. 1988. Statistical analysis of a yield trial.Agron. J . 80:388–393.

Yan, W and NA Tinker. 2006.Biplot analysis of multi-environment trial data: Principles and applications. Can. J. Plant Sci. 86:623–645.

Yan, W.; Cornelius, P.L.; Crossa, J.; Hunt, L.A. (2001). Two Types of GGE Biplots for Analyzing Multi-Environment Trial Data. Crop Sci., 41, 656–663. [CrossRef]

Yan, W; MS Kang; B Ma; S Woods; and PL Cornelius. 2007. GGE biplot vs. AMMI analysis of genotype by environment data. Crop Sci. 47:643–655.