ASSOCIATION BETWEEN PARAMETRIC AND NONPARAMETRIC MEAURES OF PHENOTYPIC STABILITY IN RICE GENOTYPES (*Oryza sativa L.*)

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ABSTRACT

Evaluation of performance stability and high yield is essential for yield trials in different environments. The mostly used, classical parametric approaches for an analysis of genotype x environment interaction are based on several assumptions: normality of the distribution, homogeneity of variances, additively. If some of mentioned assumptions are not fulfilled, the validity of these methods may be questionable. By use of nonparametric methods, which are simple and easy for analysis, all of the mentioned assumptions are avoided.

In this paper we used five of parametric and 11 of nonparametric techniques for analysis of genotype x environment interaction for grain yield of 7 rice (*Oriza sativa* L.) genotypes through three locations in two years (2005, and 2006). The objectives of this study were to study the interrelationship among various parametric and nonparametric phenotypic stability statistics, and to evaluate the similarity between these methods, and to determine the most suitable methods for assessing the rice genotypes yield stability. Values of the stability measures shown that genotypes with the highest grain yield in the majority of cases were not the most stable. The results of Spearman's rank correlation indicates that the nonparametric measure $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, $S_i^{(6)}$, $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$, $NP^{(4)}$ and parametric measures b_i, $S^2{}_d$, $S^2{}_i$, and W_i were positively related with each others and negatively correlated with mean yield and only the rank-sum and modified rank-sum showed a positive correlation with mean yield. The Principle Component Analysis (PCA) showed four distinct groups: group1 consist of $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$,$S_i^{(6)}$, $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$,$NP^{(4)}$,b_i,,$S^2{}_d$,S^2i, and W_i ; group 2 consist of RS, RS1, and RS2; group 3 consist of mean yield (Y); and group 4 consist of CV.

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In conclusion, the modified rank-sum methods (R_s^1, R_s^2) which use the nonparametric measures $S_i^{(1)}$ and $S_i^{(2)}$ with the rank mean yield of genotypes, seems to be useful under conditions where the basic assumptions of parametric stability are not met, and for simultaneously selection for high yield and stability.

INTRODUCTION

The success of crop improvement activities largely depends on the identification of superior varieties for mass production. A genotype can be considered superior if it has potential for high yield under favorable environment, and at the same time has a great deal of phenotypic stability. The genotype by environment interaction (GEI) is a major problem in the study of quantitative traits because it complicates the interpretation of genetic experiments and makes predictions difficult. It is a particular problem in plant breeding where genotypes have to be selected in one environment and used in another (Kearsey and Pooni, 1996; Giaufert *et al,* 2000; Farshadfar and Sutka, 2003).

Genotype-by-environment interactions are important sources of variation in any crop, and the term stability is sometimes used to characterize a genotype, which shows a relatively constant yield, independent of changing environmental conditions. On the basis of this idea, genotypes with a minimal variance for yield across different environments are considered stable. This idea of stability may be considered as a biological or static concept of stability (Becker and Leon, 1988). This concept of stability is not acceptable to most breeders and agronomists, who prefer genotypes with high mean yields and the potential to respond to agronomic inputs or better environmental conditions (Becker, 1981). The high yield performance of released varieties is one of the most important targets of breeders; therefore, they prefer a dynamic concept of stability (Becker and Leon, 1988).

There are two major approaches to studying GEI and determine the adaptation of genotypes (Huehn, 1996; Truberg and Huehn, 2000). First, is the parametric approach which based on statistical assumptions about distribution of genotype, environment, and GEI effects. Second, is the nonparametric or analytical clustering, which makes no specific assumptions when relating to environment and phenotypic relative to biotic and abiotic environmental factors.

Parametric methods for estimating phenotypic stability are widely used in plant breeding and they were mostly related to the variance components and related statistics. Lin *et al*. (1986) identified three concepts of parametric stability. Type 1**,** A genotype is considered to be stable if its among-environment variance is small. Becker and Léon, (1988) called this stability a static, or a biological concept of stability. Parameters used to describe this type of stability are coefficient of variability (***CVi***) used by Francis and Kannenburg (1978) for each genotype and the genotypic variances across environments (Si^2),and the coefficient of determination (r^2). Type 2, a genotype is considered to be stable if its response to environments is parallel to the mean response of all genotypes in the trial. Becker and Léon, (1988) called this stability the dynamic or agronomic concept of stability. Parameters used to describe this type of stability are regression coefficient *bi*(Finlay and Wilkinon, 1963), Wricke's (Wricke, 1962) ecovalence (W_i) and Shukla's stability variance σ^2_i (Shukla, 1972). Type 3, A genotype is considered to be stable if the residual MS from the regression model on the environmental index is small. Type 3 is also part of the dynamic or agronomic stability concept according to Becker and Léon (1988). Parameters used to describe this type of stability are the methods of Eberhart and Russell (1966) and Perkins and Jinks (1968). These stability estimates have good properties under certain statistics assumptions, based on the normal distribution of error and GEI effects, but may not perform well if these assumptions are violated by factors such as the presence of outliers (Akura and Kaya, 2008).

Nonparametric stability measures based on ranks provide a viable alternative to present parametric measures based on absolute data (Nassar and Huehn, 1987). For many applications, including selection in breeding programs, the rank order of genotypes are the most essential data. There is ample justification for the use of nonparametric measures of crop varieties in the assessment of yield stability. According to Huehn (1990) nonparametric procedures have the following advantages over parametric stability methods: (i) they reduce the bias cause of outliers, (ii) No assumptions are needed about the distribution of observed values. (iii)They are easy to use and interpret. (iv) Addition or deletion of one or more genotypes does not cause much variation in results.

It is a known fact that the nonparametric are less powerful than their parametric counterpart. The studies conducting against this background by Raiger (1997) and Raiger and Prabhakaran (2000) have shown that when a number of genotypes is fairly large, the power efficiency of the nonparametric measures will be quite close to those of parametric measures. So in situation, which are commonly encountered, i.e. those involving good number of genotypes being performance tested in a set of environments whose number is neither too small nor too large, the risk of selecting inferior genotypes from use of nonparametric measures is minimal (Rao and Prabhakaran, 2000).

There are an increasing number of stability measures for genotypes grown in different environments. It is therefore, useful to study the statistical statistics to find relations between the parametric and nonparametric stability the best and appropriate parameters for testing genotypes in breeding programs. One approach is to calculate the rank correlation coefficient (Spearman's correlation) between different stability parameters on the basis of empirical data sets. Another approach is using the principle component analysis to study the relationship between stability statistics (Piepho and Lotito,1992).

The objectives of this study were to study the interrelationship among various parametric and nonparametric phenotypic stability statistics, and to evaluate the similarity between these methods, and to determine the most suitable methods for assessing the rice genotypes yield stability.

MATERIALS AND METHODS

Yield performance of six rice genotypes from various genetics background (Table 1) were evaluated at three locations (Diyala, Kut, and Najaf Governorate) in mid-region of Iraq during the 2005 and 2006 growing seasons. For both growing seasons the sowing dates were 15th of June for all locations.

Table 1. *Names and code names of 7 rice genotypes grown in 6 environments*.

Code	Genotype	Code	Genotype	Code	Genotype
G1	Anbar 33	G4	CNTLR	G7	Mishkhab-1
G2	Yasamin	G5	A nbar hybrid		
G3	Sumood	G6	Program-4		

Experimental layout was a randomized complete block design with four replicates in each location. The experimental unit was 5 x 5 m, and seeding rate was 120 kg ha^{-1}. Fertilizers applications was 100 kg ha^{-1}of triple super phosphate (46% P2O5)and 340 kg ha^{-1}Urea (46% N) added as followed; 100 kg/ha at seedling stage, 140 kg/ha at tillering stage, and 100 kg ha^{-1}at flowering stage (Jadoa, 1999). Harvesting was done to 2 x 2 m from each plot, and grain yield was obtained by converting plot yield (at 14% moisture content) to seed yield per hectare.

Statistical analysis

The statistical procedures adopted for the stability analysis of the genotypes were listed in Table (2).

Table 2. *The parametric and nonparametric statistical procedures that used in this study and their references.*

Parametric statistics	Symbol	Reference
Coffiecient of Variation	CV	Francis and kannenberg (1978)
Regression coefficient	b_i	Finlay and Wilkinson (1963)
Deviationfrom regression	S^2_d	Eberhart and Russel (1966)
Ecovaliance	W_i	Wricke (1962)
Genotypic variance	S^2_i	Shukla (1972)
Nonparametric statistics		
Rank-sum	R_s	Kang (1988)
Huehn and Nassar	$S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, $S_i^{(6)}$	Huehn (1979), Nassar and Huehn (1987)
Thennarasu NP	$NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$, $NP^{(4)}$	Thennarasu (1995)
Modified rank-sum	R_s^1, R_s^2	Yue *at el.*(1997)[¥]

[¥] The modified rank-sum method of which both yield (in rank) and first two Huehn (1979) nonparametric stability statistics (in rank) are combined.

The stability statistics were compared using spearman's rank correlation coefficient. Spearman's rank correlation coefficient, as calculated from the rank of parametric and nonparametric stability statistics results in measuring the linear relationship between these methods. Principle component analysis (PCA) method was used for stratifying phenotypic stability methods and genotypes. The combined experimental yield data were statistically analyzed using Genstat version 12 (2009), for plots and correlation matrix Minitab V.15 were used. MS-EXCEL (2003) used to calculate parametric and nonparametric stability measures with spreadsheet formula commands.

RESULTS AND DISCUSSION

The results of eleven different nonparametric stability statistics and genotypes mean yield and their ranks are presented in Table 3 and 4 respectively; and the results of the parametric statistics and their ranks are presented in Table 5 and 6 respectively. Evaluation of the genotypes based on the 11 different nonparametric measurements and genotype mean yield and the significant test statistics of $Si^{(1)}$ and $Si^{(2)}$ are discussed in details in the previous paper (Kadhem et al, 2010). Evaluation of the genotypes based on the different parametric measurements and genotype mean yield are discussed in Atabe (2008).

The results of the Spearman's rank correlations between mean yield and each pair of parametric and nonparametric stability methods are presented in Table 7. Correlation between mean yield and rank-sum and modified rank-sum were modernity positive, but it was negatively correlated with the other stability parameters. The non-significant and negative correlation between yield and stability parameters suggest that, stability parameters provide information that can not be gleaned from average yield alone (29). The nonparametric stability parameters $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, $S_i^{(6)}$ and $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$, $NP^{(4)}$ were highly positively correlated between others and with the parametric parameters b_i, S^2_d, S^2_i, and W_i , and negatively with CV and moderate non-significant positive correlation with the ranks-sum method. Scapim *et al* (30) and Kang and Pham (31), Mut *et al*, (32) also reported significant positive correlation between $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, $S_i^{(6)}$, $NP^{(2)}$, and $NP^{(4)}$. That would suggest the possibility of using only one of them to select stable genotypes in breeding programs.

Table 3. *Mean yield values (Y) and nonparametric stability parameters for grain yield of 7 rice genotypes evaluated in 6 environments.*

Genotyp‡	Y◊	$S_i^{(1)}$©	$S_i^{(2)}$©	$S_i^{(3)}$©	$S_i^{(6)}$©	$NP^{(1)}$¥	$NP^{(2)}$ ¥	$NP^{(3)}$ ¥	$NP^{(4)}$ ¥	R_S §	R_S^1 †	R_S^2†
G1	4.08	1.8	2.17	3.97	2.83	1.17	0.47	0.54	0.48	4	6	6
G2	4.55	3.33	7.9	11.2	11.2	2.17	2.17	1.92	0.82	7	7	7
G3	3.7	2.47	4.57	7.03	5.48	1.5	0.3	0.43	0.47	9	9	9
G4	3.83	1.33	1.87	3.2	2.15	0.67	0.17	0.30	0.30	6	5	6
G5	4.15	3.47	8.8	12.2	11	2.67	1.07	0.96	1.09	9	9	9
G6	3.63	1.4	1.5	2.9	1.67	0.83	0.14	0.20	0.29	9	8	7
G7	2.48	2.93	5.87	8.8	8	2	0.29	0.32	1.12	12	12	12

◊ Mean grain yield (t. ha^{-1}), © Huehn (1990) parameters, ¥ Thennarasu (1995) parameters

‡ Genotype codes (see Table 1).

§ RS is the rank-sum of Kang (1988). † R_S^1 *and* R_S^2 the modified rank-sum (Yue et al, 1997)

Table 4. *Ranks of mean yield and nonparametric stability parameters for grain yield of 7 rice genotypes evaluated in 6 environments.*

Genotype	Y	$S_i^{(1)}$	$S_i^{(2)}$	$S_i^{(3)}$	$S_i^{(6)}$	$NP^{(1)}$	$NP^{(2)}$	$NP^{(3)}$	$NP^{(4)}$	*RS*	R_S^1	R_S^2
G1	3	3	3	3	3	3	5	5	4	1	2	2
G2	1	6	6	6	7	6	7	7	5	3	3	4
G3	5	4	4	4	4	4	4	4	3	6	6	6
G4	4	1	2	2	2	1	2	2	2	2	1	2
G5	2	7	7	7	6	7	6	6	6	6	6	6
G6	6	2	1	1	1	2	1	1	1	6	4	4
G7	7	5	5	5	5	5	3	3	7	7	7	7

Table 5. *Mean yield values (Y) and parametric stability parameters for grain yield of 7 rice genotypes evaluated in 6 environments.*

Genotyp‡	Y◊	CV	b_i	S^2_d	W_i	S_i^2
G1	4.08	11.17	1.05	0.077	0.08	0.01
G2	4.55	14.93	1.56	0.215	0.49	0.24
G3	3.7	14.62	1.30	0.058	0.14	0.07
G4	3.83	12.93	1.17	0.036	0.06	0.03
G5	4.15	6.30	0.32	0.255	0.66	0.33
G6	3.63	13.42	1.13	0.071	0.09	0.04
G7	2.48	10.64	0.47	0.158	0.41	0.20

Table 6. *Ranks of mean yield and parametric stability parameters for grain yield of 7 rice genotypes evaluated in 6 environments.*

Genotyp‡	Y◊	CV	b_i	S^2_d	W_i	S_i^2
G1	3	3	1	4	1	1
G2	1	7	6	6	6	6
G3	5	6	4	2	4	4
G4	4	4	3	1	2	2
G5	2	1	7	7	7	7
G6	6	5	2	3	3	3
G7	7	2	5	5	5	5

To understand the relationships among the rank-based statistics, principal component analysis (PCA) was performed on the rank correlation matrix (Table 7). PCA is a multivariate statistical technique which can be used for simplification and dimensionality reduction in a data set by retaining those characteristics that contribute most to its variation (Rao, 1964). In this regard lower-order principal components are retained and higher order ones are ignored. The results indicate that the loadings of the first two PCAs which explained 86.6% (65.5% and 21.1% by PCA1 and PCA2 respectively) of the variation of original variables. PCA1 is primarily stability and PCA2 is mostly yield. The relationships among the different parametric and nonparametric stability statistics are graphically displayed in a biplot of PCA1 versus PCA2 in Fig. 1, where both axes were considered simultaneously. Four groups in Fig. 1 can be defined as;

Group 1: $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$,$S_i^{(6)}$, $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$,$NP^{(4)}$,b_i,,$S^2{}_d$,S^2i, and W_i

Group 2: RS, R_S^1 and R_S^2

Group 3 Mean yield: (Y)

Group 4 :, CV

Group 1 that included the nonparametric statistics $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$,$S_i^{(6)}$, $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$, and $NP^{(4)}$, in addition to the parametric statistics b_i, S^2_d, S^2i, and $W_{i.}$ These measures were positively linearly correlated with each other and with RS, R_S^1 and R_S^2 but a negative correlated with mean yield (Table 7). Group 1 statistics provide a measure of stability in the static sense. Static stability is analogous to the biological concept of homeostasis: a stable genotype tend to maintain a constant yield across environments (Becker and Leon, 1988; Lin et al, 1986). Since a genotype showing a constant performance in all environments does not necessarily respond to improved growing conditions with increased yield. Nassar and Huehn (1987) reported that their test statistics $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$,and $S_i^{(6)}$) associate with static (biological) concept of stability. Therefore, group1 stability parameters represent a static concept of stability and could be used as compromise methods that select genotypes with moderate yield and high stability. Therefore, stable genotypes according to these methods are adapted for those regions where growing conditions are unfavorable.

Group 2, which contains rank-sum RS and modified R_S^1 and R_S^2 were found to be positively and significantly correlated ($p<0.01$) to each other while moderately positively correlated with mean yield (Table7)**.** This group consists of statistics that were influenced simultaneously by both mean yield and stability. Yue *et al*., (1996) and Yue *et al*., *(*1997) have reported that the rank-sum is related to high yield performance. Therefore rank-sum stability statistics R_S^1 and R_S^2 are related to dynamic concept of stability. Becker and Leon (1988) suggested that a dynamic concept of stability does not require the genotypic response to environmental conditions to be equal for all genotypes. Group 3 contains only the mean yield. Group 4 contain only the coefficient of variation (CV) which showed no or a week negative correlation with all measures. This stability measure considered as static sense of stability, and that agreed with the classification of Lin *et al* (1986) of parametric stability measures.

The nonparametric stability methods $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$,$S_i^{(6)}$, $NP^{(1)}$, $NP^{(2)}$, $NP^{(3)}$, and $NP^{(4)}$ were positively and significantly correlated , indicating that these statistics were similar under different environmental conditions (Table 7). As a result, only one of these statistics would be sufficient to select stable genotypes in a breeding program. Scapim *et al*., (2000) found significantly positive correlations between the nonparametric measures, and negative correlation with yield in maize. Flores *et al*., (1998) also reported high positive rank correlation between the nonparametric in fababean and peas. Piepho and Lotito (1992) have reported that generally, the results for the large data sets are more constant than for the small data sets and they found strong positive linear relation between nonparametric in sugar beet.

In conclusion, several of parametric and nonparametric statistics that have been employed in this study quantified stability of genotypes with respect to yield, stability, and both of them. The results obtained indicates that the rank-sum and modified rank sum were the best stability measures that the plant breeder should considered because both yield and stability were considered simultaneously to exploit the useful effect of GEI and to make selection of the genotypes more precise and refined. Similar conclusions were drawn from Elsahooki (1996) who stated that either to do the analysis into two steps; first to identify high yielding genotypes through ANOVA then second, apply the appropriate, stability measure. Mohammadi and Amri (2008) ; Segherloo *et al*. (2008) stated that the stability values do not provide enough information for reaching definitive conclusion, and both stability and yield should be considered simultaneously.

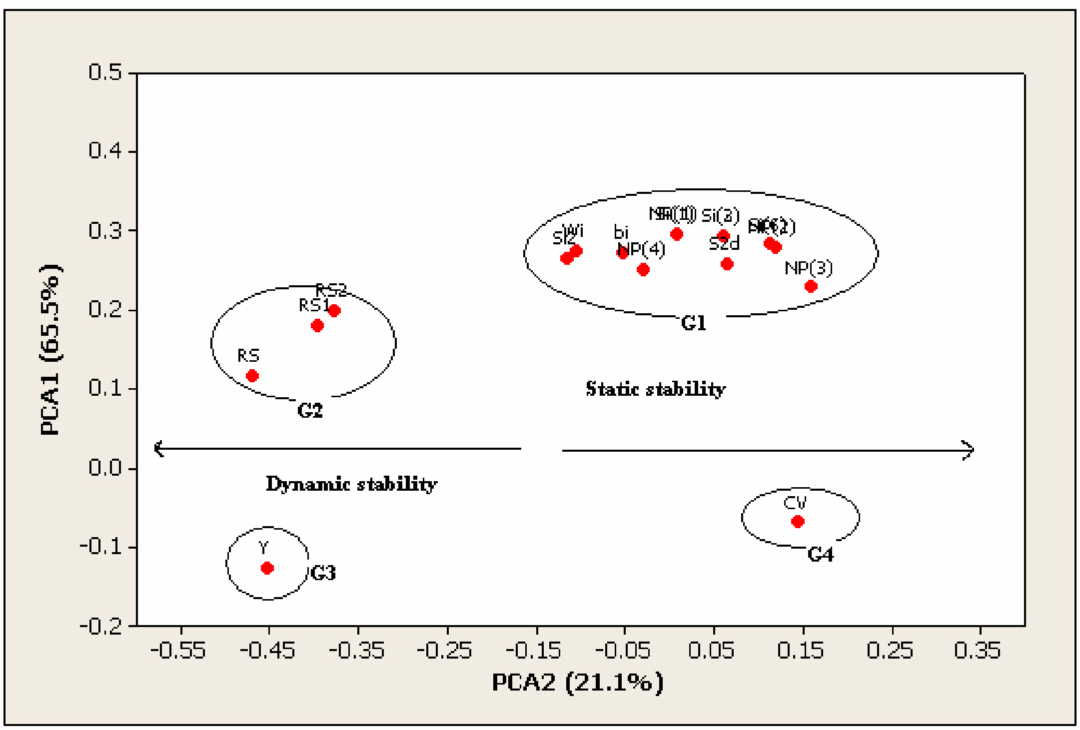

Figure 3. *Principle component analysis (PCA1 and PCA2) plot of the rank of stability yield as estimated parametric and nonparametric measures based on yield data from 7 rice genotypes grown in 6 environments showing the interrelationship between these parameters.*

Table 7. *Spearman's correlation coefficient between ranks of parametric and nonparametric stability measures for grain yield of rice genotypes.*

	Y	Si(1)	Si(2)	Si(3)	Si(6)	NP(1)	NP(2)	NP(3)	NP(4)	RS	RS1	RS2	CV	bi	S2d	Wi
Si(1)	-0.429															
Si(2)	-0.500	0.964														
Si(3)	-0.500	0.964	1.000													
Si(6)	-0.536	0.929	0.964	0.964												
NP(1)	-0.429	1.000	0.964	0.964	0.929											
NP(2)	-0.821	0.786	0.821	0.821	0.857	0.786										
NP(3)	-0.821	0.786	0.821	0.821	0.857	0.786	1.000									
NP(4)	-0.179	0.821	0.857	0.857	0.821	0.821	0.607	0.607								
RS	0.553	0.391	0.260	0.260	0.163	0.391	-0.228	-0.228	0.260							
RS1	0.408	0.612	0.510	0.510	0.408	0.612	0.068	0.068	0.544	0.917						
RS2	0.349	0.660	0.582	0.582	0.504	0.660	0.116	0.116	0.582	0.909	0.982					
CV	-0.143	-0.214	-0.250	-0.250	-0.036	-0.214	0.036	0.036	-0.500	-0.195	-0.306	-0.233				
bi	-0.357	0.857	0.893	0.893	0.857	0.857	0.571	0.571	0.679	0.456	0.544	0.660	-0.143			
S2d	-0.464	0.893	0.821	0.821	0.786	0.893	0.714	0.714	0.786	0.228	0.408	0.427	-0.357	0.679		
Wi	-0.286	0.893	0.857	0.857	0.821	0.893	0.536	0.536	0.643	0.586	0.646	0.737	-0.107	0.964	0.750	
Si2	-0.286	0.893	0.857	0.857	0.821	0.893	0.536	0.536	0.643	0.586	0.646	0.737	-0.107	0.964	0.750	1.00

REFERENCES

جدوع ، خضير عباس . 1999. ارشادات و نصائح في زراعة الرز . البرنامج الوطني لتطوير زراعة الرز في المنطقة الشلبية . وزارة الزراعة . نشرة رقم 6.

Akura, M. and Y. Kaya. 2008. Nonparametric stability methods for interpreting genotype by environment interaction of bread wheat genotypes (*Triticum aestivum* L.) . Genet. Molec. Biology, 31(4): 906-913

Atabe, S.D. 2008. Phenotypic stability for several rice varieties (*Oryza sativa* L.). Ph.D. Thesis. College of Agriculture, Univ.of Baghdad, Iraq. pp

Becker, H.C. 1981. Correlations among some statistical measures of phenotypic stability. Euphytica 30:835–840.

Becker, H.C., and J. Leon. 1988. Stability analysis in plant breeding. Plant Breed. 101:1–23.

Eberhart, S.A., and W.A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci. 6:36–40.

Elsahookie, M.M., 1996. Applications on stability analysis of genotypes. The Iraqi J. for Agri. Sci. 27:11-20.

Farshadfar, E. and J. Sutka. 2003. Multivariate analysis of drought tolerance in wheat substitution lines. Cereal Res. Commun., 31: 33-40.

Finlay, K.W., and G.N. Wilkinson. 1963. The analysis of adaptation in a plant-breeding program. Aust. J. Agric. Res. 14:742–754.

Flores, F., M.T. Moreno and J.I. Cubero. 1998. A comparison of univariate and multivariate method to analyze environments. *Field Crops Res.,* 56: 271-286

Francis, T.R. and L.W. Kannenberg, 1978. Yield stability studies in short-season maize. I. A descriptive method for grouping genotypes. Can. J. Plant Sci. 58: 1029-1034.

Giauffret, C., J., Lothrop, D., Dorvillez, B. Gouesnard, and M. Derieux, . 2000. Genotype x environment interactions in maize hybrids from temperate or highland tropical origin. *Crop Sci*., 40: 1004-1012.

Huehn, V.M. 1979. Beitrage zur erfassung der phanotypischen stabilitat. EDV Med. Biol. 10:112–117.

Huehn, M. 1996. Non-parametric analysis of genotype x environment interactions by ranks. P. 213–228. In M.S. Kang and H.G. Gauch (ed.) Genotype by environment interaction. CRC Press, Boca Raton, FL.

Huehn, M. 1990. Non-parametric measures of phenotypic stability: Part 1. Theory. Euphytica 47:189–194.

Kadhem ,F., I. S. Al-Nedawi, S. D. Al-Atabe, and F. Y. Baktash.2010 Use of nonparametric measures of phenotypic stability in Rice genotypes (*Oryza sativa L.*). Al-Anbar J. of Agric. (In press). 7(2): .

Kang, M.S. 1988. A rank–sum method for selecting high-yielding, stable corn genotypes. Cereal Res. Comm. 16:113–115.

Kang, M.S and H.N. Pham, 1991. Simultaneous selection for yielding and stable crop genotypes. Agronomy Journal, 83: 161-165.

Kearsey, M.J., and H.S. Pooni. 1996. The genetical analysis of quantitative traits. Chapman and Hall, London.

Lin, C.S., M.R. Binns, and L.P. Lefkovitch. 1986. Stability analysis: Where do we stand? Crop Sci. 26:894–900.

Mekbib, F., 2003. Yield stability in common bean (*Phaseolus vulgaris* L.) genotypes. Euphytica 130:147-153.

Mohammadi, R. and A. Amri. 2008. Comparison of parametric and nonparametric methods for selecting stable and adapted durum wheat genotypes in variable environments. *Euphytica,* 159: 419-432.

Mut Z, Aydın N, Bayramo_lu HO, Özcan H (2009). Interpreting genotype × environment interaction in Bread Wheat (*Triticum aestivum* L.) Genotypes Using Nonparametric Measures. Turk. J. Agric. For. 33(2): 127-137.

Nassar, R., and M. Huehn. 1987. Studies on estimation of phenotypic stability: Tests of significance for non-parametric measures of phenotypic stability. Biometrics 43:45–53.

Perkins, J.M. and J.L. Jinks. 1968. Environmental and genotype- environmental components of variability. III. Multiple lines and crosses. *Heredity* 23: 339-356.

Piepho, H.P. and S. Lotito, 1992.Rank correlation among parametric and nonparameric measure of phenotypic stability Euphytica 64:221-225.

Raiger, H.L. 1997.On stability concepts, stability assessments and improved procedures for varietal selection. *Ph. D. Thesis*, P.G. School, IARI, New Delhi.

Raiger, H. L and V.T Prabhakaran,. 2000 A statistical comparison between non-parametric and parametric stability measures. *Indian J. Genet*., 60(4), 417-432.

Rao, C.R. 1964. The Use and Interpretation of Principal Component Analysis in Applied Research. Sankhya A 26: 329 -358.

Rao, A.R. and V.T. Prabhakaran. 2000. On some useful interrelationships among common stability parameters. *Indian J. Genet*., 60(1), 25-36.

Scapim, C.A., V.R. Oliveira, A.L. Braccinil, C.D. Cruz, C.A.B. Andrade and M.C.G. Vidigal. 2000. Yield stability in maize (*Zea mays* L.) and correlations among the parameters of the Eberhart & Russell, Lin & Binns and Huehn models. Genet. Mol. Biol. 23: 387-393.

Segherloo, A.E., S.H. Sabaghpour, H. Dehghani and M. Kamrani. 2008. Nonparametric measures of phenotypic stability in chickpea genotypes (*Cicer arietinum* L.). *Euphytica,* 162: 221-229.

Shukla, G.K. 1972. Some aspects of partitioning genotype x environmental components of variability. Heredity 28:237–245.

Thennarasu, K. 1995. On certain non-parametric procedures for studying genotype–environment interactions and yield stability. Ph.D. thesis. P.J. School, IARI, New Delhi, India.

Truberg, B., and M. Huehn. 2000. Contribution to the analysis of genotype by environment interactions: Comparison of different parametric and non-parametric tests for interactions with emphasis on crossover interactions. Agron. Crop Sci. 185:267–274.

Wricke, G. 1962. _ber eine 31ethod zur erfassung der ökologischen Streubreite in feldversuchen. *Z. Pflanzenzüchtg*. 47: 92-96.

Yue, G., W.F. Heer, J.L. Moyer, L.D. Maddux, E.L. Sorensen and G.H. Liang. 1996. Comparison of nonparametric and parametric stability estimates to evaluate alfalfa cultivars. *J. Genet & Breed.*, 50: 67-74.

Yue, G.L., K.L. Roozeboom, W.T. Schapaugh Jr. and G.H. Liang. 1997. Evaluation of soybean cultivars using parametric and nonparametric stability estimates. Plant Breeding. 116: 271-275.

العلاقة بين معاييرالثبات المظهري المعيارية وغير المعيارية لتراكيب وراثية من الرز

(*Oryza sativa* L.)

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الخلاصة

من الضروري في تجارب مقارنة التراكيب الوراثية في بيئات مختلفة التركيز على مبدأين اساسين هما الانتاجية و الثباتية. وان اكثرالطرق شيوعا في دراسة التداخل الوراثي-البيئي هي الطرق المعلمية في قياس الثباتية واتي تعتمد على فرضيات احصائية متعددة منها التوزيع الطبيعي ، والتأثير الاضافي ، وتجانس تباينات البيئات. واذا لم يتم تحقيق هذه الفرضيات اعلاه في البيانات المأخوذة من التجارب المقامة في مواقع وسنوات مختلفة او الإخلال بإحداها فان نتائج معاييرالثبات المعلمية المستحصلة تكون غيردقيقة ومثيرة للجدل. لذا فان استعمال الطرق غير المعلمية هي الوسيلة الاكثر ضمانا لعدم اعتمادها على اية فرضية احصائية بالاضافة الى سهولة حسابها. في هذه الدراسة استخدمت 5 طرق معلمية و 11 طريقة غير معلمية لقياس الثباتية لدراسة وتحليل التداخل الوراثي- البيئي لمعدل حاصل البذور لسبعة تراكيب وراثية من الرز مزروعة في ثلاث محافظات وسط العراق ولمدة سنتين (2005 و 2006). وتهدف الدراسة الى دراسة العلاقة بين مختلف معايير الثبات المظهري المعلمية والغير معلمية واوجه الشبه والاختلاف بينهما وعلاقتهما بالحاصل وإختيار الطريقة الأمثل التي تحقق اهداف مربي النبات. ان قيم الثبات المظهري المستحصلة من الطرق المعلمية وغير المعلمية تؤكد بان التراكيب الوراثية ذات المتوسط الانتاج العالي ليست بالضرورة ان تكون ثابتة الحاصل عند تغير البيئة في معظم الحالات. وان النتيجة المستحصلة من معامل الارتباط للرتب (سبيرمان) تشير الى وجود علاقة موجبة بين معايير الثبات الغير معلمية $S_i^{(1)}, S_i^{(2)}, S_i^{(3)}, S_i^{(6)}, NP^{(1)}, NP^{(2)}, NP^{(3)}$, $NP^{(4)}$ وبين معايير الثبات المعلمية b_i, S^2_d, S^2_i, و W_i وعلاقة سالبة بين المعايير اعلاه ومتوسط الحاصل. وكذلك فان النتائج تشير فقط الى وجود علاقة موجبة بين معاير الثبات المظهري RS, R_S^1, R_S^2 ومتوسط الحاصل. وان نتائج تحليل المكون الاساسي تشير الى وجود

اربعة مجاميع اساسية مميزة. تضم المجموعة الاولى المعايير $S_i^{(1)}, S_i^{(2)}, S_i^{(3)}, S_i^{(6)}, NP^{(1)}$, و $NP^{(2)}, NP^{(3)}, NP^{(4)}$ و S^2_d, S^2_i, b_i, و W_i, وتضم المجموعة الثانية RS, R_S^1, R_S^2 ، وتضم المجموعة الثالثة متوسط الحاصل، وتضم المجموعة الرابعة معامل الاختلاف CV . وتوصي هذه الدراسة الى استعمال طريقة قياس الثبات المظهري الغير معلمية R_S^1, R_S^2 والتي تستعمل جمع رتب المقياس غير المعياري $S_i^{(1)}, S_i^{(2)}$ مع رتب متوسط الحاصل في حالة عدم التحقق من فرضيات الطرق المعلمية ولتحقيق رغبات مربي النبات بانتخاب التراكيب الوراثية التي تحقق الانتاجية العالية مع ثباتية واستقرار في الانتاج في مختلف البيئات.