EVALUATION OF PROMISING WHEAT GENOTYPES BY THE STABILITY ANALYSIS THROUGH PARAMETRIC & NON-PARAMETRIC METHODS

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ABSTRACT

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The purpose of the present study was to compare between the application of Non Parametric Stability Analysis (NPSA) and Parametric Stability Analysis (PSA) with appropriate tests in addition to utilization of exact size -α test in solving the stability measures for heterogeneous environments. NPSA vs. PSA statistics subsist some advantages and use of non parametric statistics $S_1^{(1)}$ and $S_2^{(2)}$ values, together with ranks of genotypes grown in different environments can be recommend to breeders and agronomists who make selection based upon genotype x environment interaction. The wheat performance trial (AYT) was conducted with ten promising lines along with two check varieties Kanchan and Shatabdi under optimum seeding time at Dinajpur, Jamalpur, Jessore, Ishurdi and Joydebpur. The experiments were laid out in Randomized Complete Block Design (RCBD) during 2002-2003 with four replicates at each location under the supervision of WRC (Wheat Research Center). The yields of wheat varieties are location invariant and hence the high yielding varieties against b_i, sd_i^2 values. From the statistical analysis we observe that no significant differences in rank stability were found among the ten genotypes grown in five environments. Genotypes 6 (BAW-1030) , 8 (BAW-1035) and 10 (BAW-1038) are the most stable and well adapted to all environments due to non significant Sd_i^2 value, $b_i \leq 1$ and lower $S_1^{(1)}$ values than other genotypes with mean yield ≥ grand mean. On the other hand, genotypes 4 (BAW-1028), 7 (BAW-1033) and 9(BAW-1036) have an increasing sensitivity to environmental change and greater specificity of adaptability to high-yielding environments. However, BAW-1021 (G3) was poorly adapted genotypes to all environments and only one genotype BAW-28 (G1) that response greater resistance to environmental fluctuation, and therefore increasing specificity of adaptability to low-yielding environments.

Keywords: Stability Statistics (parametric & nonparametric), Genotypic ranks, Heterogeneous environments, Exact size-α test.

INTRODUCTION

When varieties are compared over a series of environments for stability performance, the relative rankings usually differ. There are at least two possible approaches to this goal. Ideally, the growing region could be divided into a number of agro climatic zones which are uniform with respect to such characteristics as soil properties and weather. Genotypes could then be bred to meet the specific requirements of each zone. There are some drawbacks to this approach. While soil properties remain essentially constant at a given site, climate changes from year to year this causes difficulty in demonstrating the significant superiority of any variety. However, parametric method of stability for selection of genotypes is possible with the model Eberhart & Russel (1966) based on regression.

Several nonparametric methods proposed by Huhn (1979) are based on the ranks of genotypes in each environment and use the idea of homeostasis as a measure of the stability. Genotypes with similar rankings across environments are classified as stable. The statistical properties and significance for measures of nonparametric stability analysis (NPSA) were given by Nassar and Huhn (1987).

In most breeding programs the selections in a particular set of genotypes under test, it is important to choose those that have a high yield and are relatively stable over a more-or-less limited range of environments tested. For this purpose Petersen (1994) suggested to look for a high mean $\bar{y}_{i.}$, a relatively low ecovalence Wricke's (1962), W_i^2, (low contribution to the genotype by environment interaction) and a slope, b_i, of a linear regression on the environmental index Eberhart & Russel (1966) that is close to 1.00.

Lin et al. (1986) classified stability into three types in parametric stability measures. Type 1 stability follows the biological concept and is measured by the minimum variance across a range of environments. A genotype is considered to have Type 2 stability if its environmental response is parallel to the mean response of all genotypes in the test. A Genotype is considered to have Type 3 stability if its mean squares for deviation from regression are negligible. Lin and Binns (1988) proposed variance of genotypic means across unpredictable environments (years) averaged across predictable environments (locations) as a new stability parameter and designated as Type 4 by Jalaluddin and Harrison (1993).

Nonparametric measures for stability based on ranks provide a viable alternative to the above existing parametric measures based on absolute data. For many applications, including selection in breeding and testing programs, the rank orders of the genotypes are the most essential information. Stability measures based on ranks require no statistical assumptions about the distribution of the phenotypic values. They are easy to use and interpret and, compared with parametric measures, are less sensitive to errors of measurement. Furthermore, addition and deletion of one or a few observations is not as likely to cause great variation in the estimates as would be the case for parametric stability measures (Nassar and Huhn, 1987).

Fox *et al* (1990) suggest a nonparametric superiority measure for general adaptability. They used stratified ranking of the cultivars. Ranking was done at each location separately and the number of sites at which the cultivar occurred in the top, middle, and bottom third of the ranks was computed. A genotype that occurred mostly in the top third was considered as a widely adapted cultivar. Kang and Pham's (1991) rank-sum is another nonparametric stability statistics where both yield and Shukla's (1972) stability variance are used as selection criteria.

Dealing with the combined test-statistics based on other information from the separate trials Cohen and Sackrawitz (1989) have proposed exact tests, for testing equality of treatment contrasts, which are invariant, very easy to apply and in terms of powers have been shown to be far superior to usual F-tests Miah, 2004. These Exact tests are based on Cohen and Sackrawitz's (1989) followed by Zhou & Mathew (1993) and Mathew *et al* (1993). If an independent index based on environmental factors could be obtained and deviation mean squares were homogeneous, these tests should be proper F and t tests (Eberhart and Russel ,1966).

The objectives of this study were to (i) evaluate 10 promising wheat genotypes by NPSA over five environments and compare the results with parametric stability analysis (PSA), (ii) overcome limitation of the Stability Analysis by Eberhart and Russel's model (1966) applying exact size-α tests developed by Miah (2004) and model of NPSA due to Nassar and Huhn, (1987) (iii) compare (NPSA & PSA)'s result based on the plot by assessing visually these values how to vary rank measures vs. yield performances across five environments, and (iv) suggest of using stability statistics according to the nature of environment.

MATERIAL AND METHODS

The wheat performance trials were conducted with ten promising lines under optimum at Dinajpur, Jamalpur, Jessore, Ishurdi and Joydebpur along with two check varieties Kanchan and Shatabdi , average yield data over environments are shown in Table No.1. The experiments were laid out in RBD during 2002-2003 with four replicates at each location and to raise the yield of crop recommended package of practices was followed. The stability analysis according to the Eberhart & Russel model (1966) with 5 heterogeneous and 4 homogeneous locations were estimated. The exact size -α test (Miah, 2004) were employed as test statistics to the data.

Two rank stability measures from Nassar and Huhn (1987) were the statistic $S_1^{(1)}$ measures the mean absolute rank difference of a genotype over environments and the statistic $S_2^{(2)}$ gives the variance among the ranks over environments. For a genotype with maximum stability, $S_1^{(1)} = 0$. Zero variance is indication of maximum stability. If one adjusts the uncorrected yield data by genotypic effects; i.e. using the corrected values, then non parametric measures $S_1^{(1)}$ and $S_2^{(2)}$ are nearly perfectly correlated between each other.

The genotype with the highest yield was given a rank of 10 and a genotype with the lowest yield was assigned a rank of 1 (Table 4). Genwin42 & MS Excel soft wares (2000 & XP) was used to perform analysis of NPSA & PSA on the mean values of yield (kg ha^{-1}) obtained over environments. RANK of MS Excel was ranked genotypes based on means of genotypes within environment. Rank measures and means of yield were used to depict plot by this software.

Parametric stability analysis

Stability parameters were calculated for all environments using the model of Eberhart & Russel (1966) and the model is as follows:

$$Y_{ij} = \mu_I + \beta_I I_j + \delta_{ij} \; ; \quad \ldots\ldots (1)$$

i = 1,2,…., t ; varieties

j = 1,2, ….., s ; environments.

Where,

β_i = the regression coefficient of the ith variety on the environmental index which measures the response of this variety to varying environments.

I_j = the environmental index which is defined as the deviation of the mean of all the varieties at a given location from the overall mean

and $I_j = \sum Y_{ij} /t - \sum\sum Y_{ij} /ts$, with $\sum I_j = 0$.

δ_{ij} = the deviation from regression of the ith variety at jth environment.

The model was applied on yield trials with the following three hypothesis:

1) The significance of the differences among variety means

Ho: $\mu_1 = \mu_2 = \ldots\ldots\ldots = \mu_i$; Test Statistics, $F \approx MS_1 / MS_3$, where MS_3 is the pooled deviations.

2) The hypothesis that there are no genetic differences among varieties for their regression on the environmental index

$Ho: \beta_1 = \beta_2 = \ldots\ldots\ldots = \beta_i$; Test Statistics, $F \approx MS_2 / MS_3$.

3) The hypothesis that any regression coefficient does not differ from unity

$Ho: \beta_i = 1$; Test Statistics , $t = (b - 1)/ \sqrt{\Sigma\delta_{ij}^2} / \sqrt{\Sigma(I_j)^2}$ with (n-2) d.f.

$$\& \qquad F = \frac{\Sigma\delta_{ij}^2 / s\text{-}2}{\text{pooled error}}$$

Exact size α test for treatment effects

The combined test for testing the equality of the treatment effects with **Exact size α** (Miah, 2004) in series of trials of RCBD with one observation per cell (following Zhou and Mathew, 1993) is

$$\text{Exact size } \alpha \text{ Test} = \frac{\Sigma\square^{p-1}{}_{h(j)}\, e^{-Z(j)\square / \square h(j),}}{\square^{p}{}_{k=1\ h\ \square\ k}\,(\square_{h(j)} - \square_{k(j)})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The test statistics rejects the null hypothesis of the equality of treatment effects when (2) ≤ $\alpha(1+\eta)$; $0 < \alpha < ½$. The parameters □□Σ□h□p(p-1) ; h<k and □h□□ $\bar{y}_{h.j}\, y'_{k.j}$ □□ $\bar{y}_{h}.j$ □□□□ $\bar{y}_{k}.j$ □□Miah,2004) were calculated . The model to the test statistics can be considered as follows:

$$Y_{hij} = \mu + \alpha_h + \beta_{hi} + \tau_j + (\alpha\tau)_{hj} + e_{hij} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$h = 1, 2, \ldots\ldots\ldots\ldots, p ;\ i = 1,2, \ldots\ldots\ldots\ldots, b ;\ j = 1,2, \ldots\ldots\ldots\ldots, v$$

Where Y_{hij} is the observation of the jth treatment in the ith block of the hth place; μ, α_h, β_{hi} , τ_j, $(\alpha\tau)_{hj}$ are respectively the general mean, hth place effect, ith block effect at the hth place, jth treatment effect, and interaction of the jth treatment with hth place and e_{hij} are random effect distributed normally and independently with mean zero and variance σ_h^2 .

Non parametric stability analysis

Several nonparametric methods proposed by Huhn (1979) are based on the ranks of genotypes in each environment and genotypes with similar rankings across environments are classified as stable and the genotype with the highest rank is the most desirable one. In terms of linear model the phenotypic value of genotype i in environments j may be expressed under Ho as

$$xij = \mu + \beta j + eij \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where μ is the overall population mean, βj is the effect of environment j, and eij is the random error (with mean 0 and variance $\sigma 2$) and

Ho: all genotypes are equally stable i.e. there are no difference among genotypes and no genotype-environment interaction.

Test statistics for Z values of two non parametric stability measures

For a given genotype i, the ranks r_{ij} (j = 1… N) represent a random sample from a discrete uniform distribution over the range 1 to K (under the null hypothesis). From this distribution we calculated the mean and variance for each of the statistics $Si^{(1)}$ and $S_i^{(2)}$ given in Nassar and Huhn, (1987). If we assume that the distributions of the above statistics may be approximated (at least in the upper and lower tails) by a normal distribution, we expect that the statistic

$$Z_i^{(m)} = (S_i^{(m)} - E[S_i^{(m)}]^2 / var(S_i^{(m)}), \qquad m = 1,2, \qquad (5)$$

would have an approximate chi-squared distribution with 1 degrees of freedom.

Similarly, the statistic

$$S^{(m)} = \sum_{i=1}^{k} Z_i^{(m)}, \qquad m = 1,2, \qquad (6)$$

may be approximated by a chi-squared distribution with K degrees of freedom. This is true because for a given condition of K and N there was very little correlation among the $S_i^{(m)}$ statistics as determined by simulation. Under the null hypothesis, the means E $[S_i^{(m)}]$ and variances var $[S_i^{(m)}]$ may be computed from the discrete uniform distribution (1,2,…..,K) and may be expressed as follows and necessary steps were estimated as Nassar and Huhn, (1987)

$$S_i^{(1)} = 2 \sum_{j=i}^{N-1} \sum_{j'=j+1}^{N} \left| r_{ij} - rij' \right| / [N(N-1)] \tag{7}$$

$$S_i^{(2)} = \sum_{j=i}^{N} \left(r_{ij} - \overline{r_{i.}} \right)^2 / (N-1), \qquad \overline{r_{i.}} = \sum_{j=i}^{N} r_{ij} / N \tag{8}$$

$$E[S_i^{(1)}] = (K^2 - 1)/(3K), \tag{9}$$
$$E[S_i^{(2)}] = (K^2 - 1)/12, \tag{10}$$

$$\mathrm{Var}\,(S_i^{(2)}) = \frac{m_4}{N} - \left[\frac{N-3}{N(N-1)} \left(E[\mathrm{Si}^{(2)}] \right)^2 \right], \tag{11}$$

RESULTS AND DISCUSSION

Homogeneity of error variances

According to Eberhart and Russel model (1966), there is a need to test the homogeneity of error variances against each location before pooling those variances and the homogeneity was determined by Bartlett's test (approximate χ^2 test) shown in Table 1. The value of the test was χ^2_4 = 21.18** for 5 locations i.e. in this case agro climatic conditions were heterogeneous and error variances were not equal. Omitting error variance of Jamalpur, which was greater than error variances of other locations, the value of Bartlett's test χ^2_3= 7.168 non significant at 5% level and revealed that environment of other 4 locations were homogeneous. In Table 1, these values of χ^2 test and F test along with average yield of wheat crop are presented.

Stability parameters for both homogeneous & heterogeneous environments

Stability analysis using Eberhart and Russel model (1966) was done and the stability parameters b_i, sd_i^2 with mean yield of wheat grains are shown in Table 1. These stability parameters for all locations, whose EMS are heterogeneous, also presented in this table. Most of the genotypes except BAW- 1024, BAW-1030, BAW-1035 & BAW-1038 invalidated the linear prediction in both heterogeneous and homogeneous environments. The linear model of stability due to model (1) gave the misleading information in selecting these genotypes of this crop to release the new variety in p different agro climatic locations. It is clear from Table 1 that 50% of totals genotypes with high grain yield gave the b_i values around 1, whereas in homogeneous locations b_i values of two genotypes (BAW –1033 & BAW-1021) greater than 1, near 2.

Results on Exact Test

Exact test for testing the equality of treatment effects (effects of genotypes) in series of trials of RBD'S was calculated from the analysis of the individual trial of the experiment at h_{th} place. Results of the analysis based on the method described in section 2 are shown in Tables 2 & 3.

The value of the test statistics (2) in section 2 of exact size- α (α= .05) is found to be 6.04609E-12 which is much smaller than the value of $\alpha(1+\eta)$ = 0.099847 which also rejects the null hypothesis. This indicates that the yields of wheat varieties are location invariant and hence the high yielding varieties against b_i, sd_i^2 values shown in columns 3 and 4 (Table 1) can be recommended for cultivation. In this regard Eberhartt and Russel (1966) model gave misleading result about BAW 1033.

Some results on Test statistics for Z values

From Table: 4, genotypic ranks within environments revealed that genotype 2 entered top of ranking, with yield ranks of 4, 10, 10, 10 and 10 across five environments, respectively, prior to genotype 8. However, genotype 1 occupied bottom of the ranking, with yield ranks of 1, 1, 2, 3 and 3 over five environments**.**

For each genotype, $Z_1^{(1)}$ and $Z_2^{(2)}$ values were calculated based on these ranks of the corrected data (Table :4) and summed over genotypes to obtain Z values below. It is seen from Table: 5 that $Z_1^{(1)}$ sum = 16.759 and $Z_2^{(2)}$ sum = 12.197 Since both of these statistics were less than the critical value $\chi 2$ 0.05, 10 = 18.31, no significant differences in rank stability were found among the ten genotypes grown in five environments. On inspecting the individual Z values, it was found that no genotypes were significantly instable relative to others, because they showed small Z values, compared with the critical value $\chi 2_{0.01,\,1}$ = 6.63. Again from $S_1^{(1)}$ values it is clear that if we base on model (1) to evaluate elite genotypes then BAW 1033 (G7) will not be included due to its maximum $S_1^{(1)}$ value . This $S_1^{(1)}$ value also greater than average $S_1^{(1)}$ (2.62) value.

Table: 1 Comparison of Stability parameters b_i , Sd_i^2 and $S_1^{(1)}$ with Mean yield of Wheat grains , during optimum seeding time 2002/03.

Genotype	Mean yield over 5 heterogeneous locations	bi(5 locations) [Model (1)]	Sdi2(5 locations [Model (1)]	bi(4 locations) [Model (1)]	Sdi2(4 locations [Model (1)]	$S_1^{(1)}$ [Model (2)]
Kanchan (BAW-28)	3.802	1.142	0.084**	1.247	0.121**	1.2
Shatabdi(BAW-936)	4.518	1.172	0.047*	0.909	0.088**	2.4
BAW-1021	3.956	2.329	0.074**	2.315	0.119**	3.6
BAW-1028	4.208	0.017	0.059**	0.139	0.103**	3.6
BAW-1024 * (G5)	4.214	1.460	0.011ns	1.327	0.041**	2.8
BAW-1030* (G6)	4.306	1.112	-0.015ns	1.005	-0.004 ns	1.4
BAW-1033	4.216	1.701	0.056*	2.026	0.012ns	3.8
BAW-1035 (G8)	4.408	0.308	0.005ns	0.108	0.003 ns	2.2
BAW-1036	4.250	0.543	0.093**	0.109	0.044**	3.8
BAW-1038 (G10)	4.208	0.216	-0.018ns	0.814	0.007 ns	1.4
Mean	4.208			0.999		2.62
Test Statistics at (5%) & (1%) level of significance	Critical values of $\chi2$: $\chi2_{0.01,4} = 13.28$ $\chi2_{0.05,3} = 11.34$	Calculated values of $\chi2$: $\chi2_4 = 21.18^{**}$ $\chi2_3 = 7.168$ ns	$F_{(3,150)}$ test 2.67& 3.91		$F_{(2,120)}$ test 2.68 & 3.94	$\chi2_{0.01,1} = 6.63$

Table: 2 Calculation of $\square_{h(j)}$ values on Treatment SS + Error SS ($T_{h(j)}$) values

Location	Environmental index I_j	F ratio	P value F Dist (9,27)	Z value	Treat.+ Error ($T_{h(j)}$)	$T_{h(j)}$ / b(v-1)	$\square^2_{k(j)}$ = 1/Col. 7	$\square_{h(j)} = \square^2_{k(j)} / \square\square^2_{k(j)}$
Dinajpur (L1)	-0.118	16.77**	6.85066E-09	-18.7989	5.4469	0.0151	66.1789	0.1497
Jamalpur (L2)	0.086	2.88**	0.016023584	-4.13369	8.0531	0.0164	60.9756	0.1379
Jessore (L3)	0.170	3.91**	0.002800802	-5.87785	4.4696	0.0098	102.035	0.2309
Ishurdi (L4)	0.070	5.95**	0.000140211	-8.87236	3.1665	0.0076	131.771	0.2982
Joydebpur (L5)	-0.209	5.20**	0.000394515	-7.83785	5.2969	0.0124	80.9152	0.1831
Total							441.876	1.0000

Table: 3 Calculation of $Z_{(j)}$ value and Exact Tests

Location	$\square_i^{p-1} = \square_i^4$	$Z_{(j)}^{\square} / \square_{h(j)}$	$e^{-Z(j)\square / \square h(j)}$	$\square^{p-1}_{h(j)} e^{-Z(j)\square / \square h(j)}$	$\square^{p}_{k=1\ h \square k} (\square_{h(j)} - \square_{k(j)})$	Exact Test
Dinajpur	0.00050	58.91938	2.5801E-26	1.29811E-29	-4.73E-06	-2.74428E-24
Jamalpur	0.00036	63.94721	1.69075E-28	6.13056E-32	-7.911E-06	-7.74972E-27
Jessore	0.00284	38.21453	2.53304E-17	7.20173E-20	-2.425E-05	-2.9695E-15
Ishurdi	0.00791	29.59075	1.40897E-13	1.11426E-15	0.0001842	6.04906E-12
Joydebpur	0.00112	48.18895	1.17979E-21	1.32655E-24	-8.278E-06	-1.60246E-19
Total	0.01274	238.86082	1.40922E-13	1.11433E-15	0.000139	6.04609E-12

Table :4 Ranking of 10 wheat genotypes based on Yield within environment for NPSA Model (2)

			Rank § Of				Rank of				Rank of				Rank of
ENV	GEN	Yield	Yield	ENV	GEN	Yield	Yield	ENV	GEN	Yield	Yield	ENV	GEN	Yield	Yield
1	1	3325	1	3	3	4655	9	1	6	4075	5	4	8	4496	8
2	1	3688	1	4	3	3752	1	2	6	4422	7	5	8	4281	9
3	1	4001	2	5	3	3438	1	3	6	4467	6	1	9	4325	8
4	1	4211	3	1	4	4600	10	4	6	4431	7	2	9	4704	9
5	1	3781	3	2	4	4172	4	5	6	4125	8	3	9	3997	1
1	2	4025	4	3	4	4224	3	1	7	4225	6	4	9	4284	6
2	2	4719	10	4	4	4106	2	2	7	4016	2	5	9	3938	5
3	2	4764	10	5	4	3938	5	3	7	4570	7	1	10	4275	7
4	2	4551	10	1	5	3825	2	4	7	4537	9	2	10	4297	5
5	2	4531	10	2	5	4331	6	5	7	3719	2	3	10	4330	5
1	3	3875	3	3	5	4573	8	1	8	4375	9	4	10	4235	4
2	3	4047	3	4	5	4249	5	2	8	4610	8	5	10	3906	4
				5	5	4094	7	3	8	4274	4				

Yield of 10 genotypes have their ranking number according to their mean yield within an environment and rank 1 was for lowest mean yield and rank 10 for highest mean yield among 10 genotypes in this example. Ranking of genotypes were carried out as mentioned in the paper Kaya and Taner (2002).

Table 5. Stability parameters of Model (2) with mean yield

Genotypes	Mean Yield	Mean Rank	$S_1^{(1)}$	Z1(1)	$S_2^{(2)}$	Z2(2)
G1	3801.2	2	1.2	5.068966	1	3.472146
G2	4518	8.8	2.4	0.931034	7	0.072828
G3	3953.2	3.4	3.6	0.103448	11	0.429539
G4	4207.8	4.8	3.6	0.103448	10	0.138886
G5	4214.3	5.6	2.8	0.287356	5	0.574865
G6	4303.9	6.6	1.4	4.149425	1	3.190741
G7	4213.4	5.2	3.8	0.287356	10	0.138886
G8	4407.25	7.6	2.2	1.390805	4	1.030662
G9	4249.45	5.8	3.8	0.287356	10	0.138886
G10	4208.55	5	1.4	4.149425	2	3.009743
Sum				16.75862		12.19718

$E(S_1^{(1)}) = 3.3$, $Var(S_1^{(1)}) = 0.87$ and $E(S_2^{(2)}) = 8.25$, $Var(S_2^{(2)}) = 15.138$

Discussion on Non parametric stability analysis

Figures 1 and 2 below represent plots displayed by mean yield (kg ha-1) vs. $S_1^{(1)}$ and $S_2^{(2)}$ values respectively. Mean $S_1^{(1)}$ and $S_2^{(2)}$ values and grand mean yield divide both figures into four sections; section 1 refers that genotypes have high yield and small $S_1^{(1)}$ and $S_2^{(2)}$ values, section 2 signs that genotypes posses high yield and large $S_1^{(1)}$ and $S_2^{(2)}$ values, section 3 presents that genotypes exist low yield and large $S_1^{(1)}$ and $S_2^{(2)}$ values, and section 4 exhibits that genotypes are of low yield and small $S_1^{(1)}$and $S_2^{(2)}$ values.

According to these configurations, genotypes interesting in section 1 can be considered as stable. Section 1, both figures, contains that genotypes 6 (BAW-1030) , 8 (BAW-1035) and 10 (BAW-1038) are most stable, and well adapted to all environments due to non significant Sd_i^2 value, $b_i \leq 1$ and lower $S_1^{(1)}$ values than other genotypes with mean yield ≥ grand mean, the same result appeared from Table no.2. Genotypes 4 (BAW-1028), 7 (BAW-1033) and 9(BAW-1036) appear in section 2, where describes genotypes with increasing sensitivity to environmental change, and greater specificity of adaptability to high-yielding environments. However, BAW-1021 (G3) referring poorly adapted genotypes to all environments in graph 1 and in graph 2 of Section 3. Besides, Section 4, in both graphs includes only one genotype Kanchan: BAW-28 (G1) that response greater resistance to environmental fluctuation, and therefore increasing specificity of adaptability to low-yielding environments.

Fig.1 : Plot Of $S_1^{(1)}$ vs. mean yield (kg/ha) for 10 Wheat genotypes

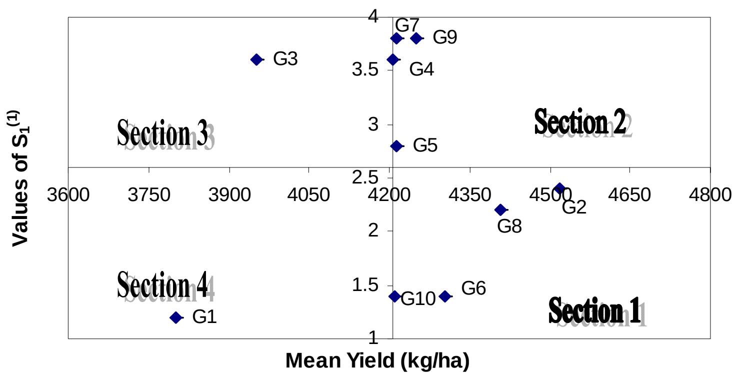
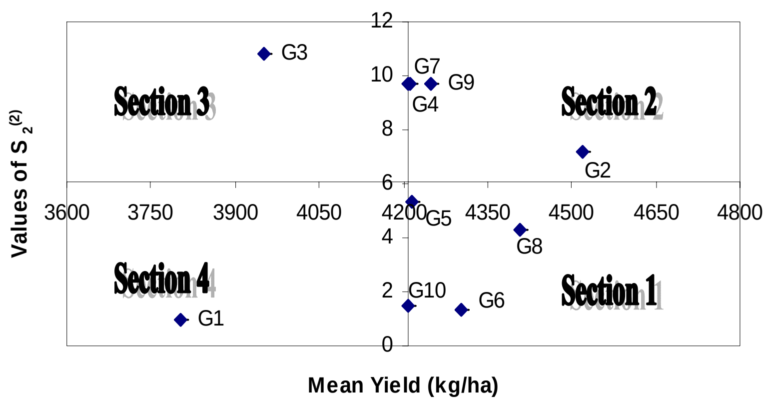


Fig.2: Plot Of $S_2^{(2)}$ vs. mean yield (kg/ha) for 10 Wheat genotypes over environments



CONCLUSIONS

In this paper an attempt has been made to show how the exact size-α test can be used to select genotypes with stability analysis (Eberhart & Russel, 1966) over heterogeneous environments i.e. without testing the homogeneity of error variances due to locations or environments. So, the exact size-α test (Miah, 2004) may be recommended to solve the heterogeneity problem of locations and help in interpretation of selecting better genotypes to release a new hybrid variety of any crop.

However, Nassar and Huhn (1987) suggest that $S_1^{(1)}$ statistic measure should be utilized in any case that a genotype represents unfair fluctuations among sections, regarding $S_1^{(1)}$ and $S_2^{(2)}$ values. From Table :1 genotypes 5,6,8 & 10 are suitable for all environments due to non significant S_{di}^2 values and the same results appeared from graph in case of non parametric stability. Genotypes 6 & 8 with regard to genotypes 2 and 5 may be selected as they have revealed mean value higher than grand mean yield with lower $S_1^{(1)}$, $S_2^{(2)}$, ns S_{di}^2 value and does not represent unfair fluctuation among sections , regarding $S_1^{(1)}$ and $S_2^{(2)}$.

Nonparametric measures for stability based on ranks provide a useful alternative to parametric measures currently used which are based on absolute data. Moreover, nonparametric vs. parametric stability statistics exist some advantages (see more details, Huhn, 1990b). As a consequence, for an estimation of the non parametric stability statistics of genotypes grown in different environments, use of non parametric statistics $S_1^{(1)}$ and $S_2^{(2)}$ values, together with ranks, can be recommend to breeders and agronomists who make selection based upon genotype x environment interaction. In addition, plots provided by mean yield (kg ha-1) against $S_1^{(1)}$ and mean yield (kg ha-1) against $S_2^{(2)}$ values are likely to enhance visual efficiency of selection and similar conclusion was drawn by Kaya and Taner (2002) in Bread wheat (*TRITICUM AESTIVUM* L.).

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