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# PERFORMANCE AND STABILITY OF NEWLY BRED WHEAT GENOTYPES UNDER RAINFED AND SALINE ENVIRONMENTS

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Ten bread wheat varieties or elite lines were evaluated in twelve regional yield trials at four locations through three successive seasons ended in 2001/2002. Two major stress environments i.e. rainfed conditions at Northwestern Coast of Egypt (Maryout and Ras El-Hekma) and salt affected soils (Ras Sudr-South Sinai and Siwa Oasis) used as major environments for estimating eleven phenotypic and genotypic stability parameters. Correlation coefficients among all possible pairs of these parameters were computed.

Wide range of variability between locations and high genotypic differences were detected. The genotype x environment interaction was significant and a major portion of this was accounted by the deviation from linear response. Mean performance of all genotypes averaged over the 6 saline environments (1.867 ton/fed) was higher than mean of grain yielding capacity over the six rainfed environments (0.816 ton/fed). The tested genotypes significantly varied among each other in each of the three environmental sets (rainfed, saline and combined data). However, local variety Sahel-1 and the exotic one Gomam (Gom.) surpassed all other genotypes whereas, Sids-7 gave the lowest grain yield under rainfed conditions. Meanwhile, the best genotypes in saline environments were Gomam and L-144. Over all environments, newly bred line, Maryout-5 (Mar-5) gave the highest grain yield being 1.485 ton/fed. indicating its high ability to avoid the fluctuated environmental influences.

High yield, small variation group can be considered as stable genotypes under rainfed (Mar-5, I-6 and L-263), saline conditions (L-144, Mar-5, L-263 and I-3) and over both stress environments (Mar-5, L-144 and I-3). With regard to the six rainfed environments variance statistic ($\sigma^2$) has low value for some genotypes indicating their stability, among them, Gom., I-3 and L-144. The integrating yield and stability of performance ($Ys_i$) showed stability for six genotypes i.e Gom., Gem-7, I-6, L-263, Mar-5 and Sahel-1. Superior and stable genotypes that considered more adapt to each of the stress environments tested were identified. These include L-144, Mar-5 and L-263 under saline environment and Gomam, Mar-5 and Sahel-1 at rainfed conditions. Under Maryout rainfed environment, Mar-5 and L-263 proved to be resistant genotypes for yellow strip rust and net blotch diseases. Such genotypes could be used directly for improving wheat productivity at similar aimed regions.

**Keywords:** stability parameters, *Triticum aestivum* L., rainfed condition, salt affected soils, newly bred lines

Knowledge of the genetic variability is important in plant improvement programs. Further, the material should be evaluated under different environments because in the absence of information on genotype x environment interaction, estimation of heritability and prediction of genetic advance become biased (Comstock and Moll, 1963). A wide range of variability among the environments under which evaluation of yield performance and stability of a set of varieties is being done is a prerequisite for proper selection decision. However, evaluation due to genotype x environment (GE) interaction makes it difficult for the breeder to decide which genotype should be selected. Yates and Cochran (1938) measured the adaptation of barley cultivars on the basis of regression analysis. Afterwards, Plaisted and Peterson (1959) estimated the mean variance components for pair wise GE interaction and calculated the individual contributes of each genotype to the total variance. They considered the average of the estimates for all contributions; include a variety in common, as a measure of adaptability (stability) of that variety. Finlay and Wilkinson (1963) adopted the linear regression technique of Yates and Cochran (1938) and determined a linear regression coefficient ($b_i$) for each genotype, as a parameter of stability of that variety, by regression individual genotype yield performance against environmental means. Eberhart and Russell (1966) defined a stable genotype as the one that has regression coefficient, $b_i$, equal to 1 and mean square deviation from regression, $S^2d$, equal to zero. Tai (1971) suggested partitioning genotype x environment interaction into two components: alpha ($\alpha_i$) statistic that measures the linear response to environmental effects and lambda ($\lambda_i$) statistic that measures the deviation from linear response. Stability variance parameters ($\alpha_i^2$ and $\sigma^2_i$) developed by Shukla (1972) has been frequently used as an efficient method for determining the contribution of each genotype to the genotype x environment interaction. Pinthus (1973) favored the coefficient of determination ($r^2_i$) over variance of deviations from regression ($S^2d_i$) as a measure of the predictability of the estimated response and stability of a genotype. Lin *et al.* (1986) concluded that, unless the concept of stability and the kind of environments that are included in the experiment are clearly understood, many stability statistics become of little usefulness and may be misleading. Many authors showed that several of the stability statistics probably measure similar aspect of phenotypic stability (Becker, 1981; Becker and Lean, 1988; Duarte and Zimmerman, 1995). Integration of stability of performance with yield is necessary for selecting high yielding and stable genotypes (Kang and Pham, 1991; Afiah, 2001). Kang (1993) and Kang and Magari (1995) proposed an integrated yield and stability of performance statistics ($Ys_i$) for simultaneous selection of yield and yield stability. Sharaan and Ghallab (2001) defined a stable variety as the one that has combined high yield and stability of performance, and the inconsistency of variety yield over environments is due to GE interaction effect. They propose three methods for determining phenotypic stability by measuring, sum square deviation of variety yield, the distance of its deviations, or both, in relation to environmental – genotypic mean deviation.

The present investigation aimed to identify the highest yielding and stable genotypes among ten wheat genotypes under rainfed or saline environments or both and to study the rank correlations among the most important statistical parameters and methods in estimating genotypic yield stability.

## MATERIALS AND METHODS

Twelve regional yield trials were conducted at four locations through three successive seasons lasted in 2001/2002. The four locations represents two major stress environments i.e. rainfed conditions at Northwestern Coast of Egypt (Maryout and Ras El-Hekma) and salt affected soils (Ras Sudr-South Sinai and Siwa Oasis). The genetic material used was ten bread wheat genotypes comprise: three local varieties [Sids-7, Gemmeiza-7 (Gem-7) and Sahel-1], one exotic variety introduced from CIMMYT (Gom.), two exotic lines introduced from ICARDA (I-3 and I-6) and four newly bred lines through Desert Research Center (DRC), Egypt wheat breeding program (L-144, L-606, L-263 and Mar-5). Pedigree and / or selection history of these genotypes are presented in table (1). At Maryout rainfed location, one supplemental irrigation was added at sowing date by the available agricultural drainage water (average ECe 3.3 $dSm^{-1}$). Soil of the experimental site characterized as sandy clay loam texture with pH 7.8, ECe 4.2 $dSm^{-1}$ and calcareous (41.5 Ca $CO_3$). The precipitated rain amount during each of the three growing seasons was 157, 120.4 and 188.3 mm, respectively. At Ras El-Hekma experimental site which located at the first agro-ecological zone, 66 km. east Marsa Matrouh Governorate. The effective rainfall precipitation (manual measured) reached 170.5, 123.0 and 158.0 mm in the three growing seasons, respectively. The two saline stressed locations were: 1) Ras Sudr Agric. Res. Station of DRC where, mean of soil and artesian irrigation water salinity averaged over the three growing seasons were 8.72 and 7.86 $dSm^{-1}$, respectively. 2) Private farm at El-Maraky village, Siwa Oasis where, mean of soil and artesian irrigation water salinity over the three growing seasons were 13.8 and 3.1 $dSm^{-1}$, respectively. Each experiment in a particular season at each rainfed or salinity stress location was laid out in a randomized complete blocks design with three replications.

General Agricultural practices were applied as recommended for each location in addition to inoculate wheat grains by the suitable biofertilizer at sowing containing *Azospirillum lipoferun*, *Azotobacter chroococcum*, *Bacillus polymixa* and *Bacillus subtilis*. At harvest, grain yield (ton/fed) was calculated on the plot mean basis.

**Statistical analysis**

Data were subjected to the combined analysis of variance for each major environment (rainfed and salinity) and over all environments as outlined by Sendecor and Cochran (1980). Significant differences were detected using least significant difference test (LSD) at level of significance. In the combined analysis, interaction between genotypes and environments (GE) variance was partitioned into heterogeneity (linear effect) of fitted regression for genotype mean on environmental index and residual component (non – linear effect) or pooled deviation from the fitted regression, and both components were tested using the pooled error (Shukla, 1972).

**Phenotypic stability**

The regression analysis was conducted using the model suggested by Eberhart and Russel (1966).

$$Y_{ijk} = \mu + d_i + E_j + B_i\, E_j + g_{ij} + e_{ijk}$$

Where: $Y_{ijk}$ is the grain yield of the $k^{th}$ replicate of the $i^{th}$ genotype in the $j^{th}$ environments, $\mu$ is the overall mean, $d_i$ is the contribution of $i^{th}$ genotype, $E_j$ is the $j^{th}$ contribution of the environment, $B_i$ is the linear regression coefficient of the $i^{th}$ genotype, $g_{ij}$ is the deviation from regression and $e_{ijk}$ is the random error.

The model provides two stability parameters: 1) the linear regression coefficient ($b_i$) of genotype mean yield on the average of all genotypes in each environment, and 2) the mean square of deviation from regression ($S^2d_i$) for each genotype. In this model, stable genotype is one with $b_i$ = 1.0 and $S^2d_i$ close to zero.

**TABLE (1). Name, origin and pedigree and/or selection history of ten bread wheat genotypes tested.**

| No. | Name | Origin | Pedigree and/or selection history |
|---|---|---|---|
| 1 | Gomam | CIMMYT | SWM 11619-2 AP-4 AP-1 AP-2 AP-0AP. |
| 2 | Sids 7 | Egypt | Maya "S" / Mon "S" // CMH 74 A. 592 /3/ Sakha 8 * 2 |
| 3 | I-3 | ICARDA | CM59456-3AP-1AP-2AP-1AP-0AP |
| 4 | L-144 | Egypt | CM 39816 / Sakha 8 Su144 - 16Su – 75u – 45u – 0Su. |
| 5 | Gem 7 | Egypt | CMH 74A – 630/Sx//Seri 82/3/Agent /C Gm 4611 2Gm-3Gm-16Gm-0Gm |
| 6 | I-6 | ICARDA | Buc "S" CM58808-6AP-2AP-1AP-1AP-0AP/ Dove "S" |
| 7 | L- 606 | Egypt | Atlas 66 / Nap Hall // (NE70117) Skores Pelka35 /3/ 2* RCB-61 Su606-13Su-2Su-5Su-0Su |
| 8 | L-263 | Egypt | Sids 1 / CM 33204 7Su-26SW-3SW-1SW-0SW |
| 9 | Mar. 5 | Egypt | Giza 162 // Bch's /4/ PI-ICW 79 Su5-11Mr-38Mr-1Mr-0Mr |
| 10 | Sahel-1 | Egypt | Ns. 732/Pima//Veery "S" SD735-4SD-1SD-1SD-0SD |

ICARDA; International Center for Agricultural Research in the Dry Areas
CIMMYT; Centro International de Mejoramiento de Maize Y Trigo (Mexico) = International maize and wheat improvement center.

The coefficient of determination ($r^2_i$) between the performance of individual genotypes and the environmental index, which determine the percentage of total variation in a character due to linear regression (Pinthus, 1973). The variance stability statistics $\delta^2_i$ as a measure for the contribution of a genotype to G x E interaction (Shukla, 1972). Data was subjected to yield-stability ($Ys_i$) analysis as outlined by Kang (1993) and according to BASICA program developed by Kang and Magari (1995), titled interactive program for calculating Shukla's stability variance and Kang's yield-stability statistics and select genotypes with $Ys_i$ > the mean $Ys_i$. Coefficient of variation (C.V.,%) proposed by Francis and Kannenberg(1978) was also used as stability parameter by many authors. Sharaan and Ghallab (2001) proposed three methods to determine relative deviation ($RD_i$), relative deviation distance ($RDD_i$) and half sum of relative deviation and deviation distance ($RHD_iDD_i$). In these three methods, if the result value equal about 1.0, below or above denote average, above, or below average of stability, respectively.

**Genotypic stability**

Genotypic stability analysis was performed as applied by Tai (1971), who partitioned genotype x environment interaction effect of the $i^{th}$ genotype into two statistics namely: $\alpha_i$ statistic that measures the linear response to environmental effects and $\lambda_i$ that measures deviation from linear response in terms of magnitude of the error variance. The values ($\alpha = -1$ and $\lambda = 1$) will be referred as perfect stability. However, the values ($\alpha = 0$ and $\lambda = 1$) will be referred as average stability, whereas the values ($\alpha > 0$ and $\lambda = 1$) as below average stability and the values ($\alpha < 0$ and $\lambda = 1$) as above average stability.

To clarify the natural of association between these methods and other stability parameters as well as their effectiveness, the correlation coefficients among all possible pairs of these parameters were computed according to Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

Analysis of variance and partitioning of genotype x environment interaction into components ($\sigma^2$) assignable to each genotype for grain yield of 10 wheat genotypes across 6 rainfed, 6 saline and all 12 environments revealed significant mean squares for each of the four locations and years (data not shown). Such results reflecting the seasonal fluctuation effects. Wide range of variability between locations and high genotypic differences were detected. Many authors previously detected significant environmental effects on wheat grain yield (Krenzer *et al.,* 1992; Sabry *et al.*, 1994; Hassan, 1997; Hassan *et al.,* 1999 and Sharaan and Ghallab, 2001). Salem *et al.* (2000) found large magnitude of genotype x year interaction and concluded that wheat genotypes fluctuated consistently in the rank performance for grain yield in the two years of their study.

Table (2) shows highly significant differences among genotypes and environments. The genotype x environment interaction was significant and a major portion of this was accounted for by the deviation from linear response. The deviation from linear response (non-linear regression) was significant under rainfed and over all environments suggesting the relatively unpredictable component of the genotype x environment interaction is of great importance than the relatively predictable component computed. Rasmusson and Glass (1967), Joppa *et al.* (1971), Clark (1983), Moshref (1988), Gad El-Karim and Abdel-Hakim (1995) and Afiah (2001) emphasized the importance and great influence of environment on the behavior of genotypes under different environments. Moreover, they concluded that genotype x environment (GxE) interaction should be considered one of the most important strategies for any breeding program to improve and develop newly bred wheat genotypes. However, GxE interaction variance components for wheat grain yield as much less importance than genotypic components in small sample of environments (Cox *et al.,* 1985). Mean squares from combined analysis of variance when stability parameters are estimated (joint regression) for grain yield (ton / fed) of 10 wheat genotypes under 6 rainfed, 6 saline and all environments are presented in table (3). Genotype x environment (linear) in all cases and pooled deviation from regression under rainfed and over all environments were significant. This lead to the conclusion that it is essential to determine the degree of stability for each genotype.

**TABLE (2). Mean squares (MS) of ANOVA across the 6 rainfed, the 6 saline and all of the 12 environments for grain yield (ton / fed) of 10 wheat genotypes tested.**

| Sources of variation | df | Rainfed environments | Saline environments | All environments | |
|---|---|---|---|---|---|
| | | MS | MS | df | MS |
| Total | 59 | 0.02875 | 0.22375 | 119 | 0.96113 |
| Genotypes(G) | 9 | 0.08683** | 0.57436** | 9 | 0.30739** |
| Environments (E) | 5 | 0.03369** | 1.13149** | 11 | 9.57301** |
| Interaction(GE) | 45 | 0.01659** | 0.05277* | 99 | 0.06369** |
| Heterogeneity (Linear) | 9 | 0.05064** | 0.07446 | 9 | 0.30707** |
| Residual (Non – linear) | 36 | 0.00808** | 0.04734 | 90 | 0.03935** |
| Pooled error | 120 | 0.0013 | 0.0341 | 240 | 0.0177 |

df: degrees of freedom.
* and ** denote significant at 0.05 and 0.01 probability levels, respectively.

**TABLE (3). Mean squares (MS) from combined analysis of variance when stability parameters are estimated (joint regression) for grain yield (ton / fed) of 10 wheat genotypes under 6 rainfed, 6 saline and all environments.**

| Sources of variation | df | Rainfed environments | Saline environments | All environments | |
|---|---|---|---|---|---|
| | | MS | MS | df | MS |
| Genotypes (G.) | 9 | 0.02890** | 0.1913** | 9 | 0.1024** |
| Env. + (G.× Env.) | 50 | 0.00609** | 0.0535** | 110 | 0.3382** |
| a) Env. (Linear) | 1 | 0.05632** | 1.8858** | 1 | 35.1033** |
| b)G.×Env. (Linear) | 9 | 0.0169** | 0.0248* | 9 | 0.1023** |
| c)Pooled deviation | 40 | 0.0024** | 0.0142 | 100 | 0.0118** |
| Gom. | 4 | 0.0035** | 0.0343* | 10 | 0.0217** |
| Sids 7 | 4 | 0.0029** | 0.0150 | 10 | 0.0091 |
| I-3 | 4 | 0.0022** | 0.0069 | 10 | 0.0125* |
| L-144 | 4 | 0.0021** | 0.0027 | 10 | 0.0076 |
| Gem.7 | 4 | 0.0013* | 0.0223 | 10 | 0.0095 |
| I-6 | 4 | 0.0022** | 0.0099 | 10 | 0.0237** |
| L-606 | 4 | 0.0036** | 0.0038 | 10 | 0.0073 |
| L-263 | 4 | 0.0023** | 0.0035 | 10 | 0.0050 |
| Mar.5 | 4 | 0.0021** | 0.0149 | 10 | 0.0070 |
| Sahel-1 | 4 | 0.0021** | 0.0287* | 10 | 0.0145** |
| Pooled error | 120 | 0.0004 | 0.0113 | 240 | 0.0059 |

df: degrees of freedom.
* and ** denote significant at 0.05 and 0.01 probability levels, respectively.

The mean performance of grain yield for ten wheat genotypes expressed as ton/fed average over the 6 rainfed, the 6 saline and all 12 environments are presented in table (4). The results clearly indicated that the tested genotypes significantly varied among each other in each of the three environmental sets. However, Sahel-1 surpassed all other genotypes (0.892 ton/fed.) whereas, Sids-7 gave the lowest grain yield (0.667 ton/fed) under rainfed conditions. Meanwhile, in saline environments, genotypes mean performance ranged from 1.663 ton/fed. for Gomam to 2.165 ton/fed for L-144. Over all environments, newly bred line, Mar-5 gave the highest grain yield being 1.485 ton/fed indicating its high ability to avoid the fluctuated environmental influences. The following highest yielding genotypes were L-144 and L- 263 (1.466 and 1.429 ton/fed, respectively). However, Sids-7 was the lowest yielding genotype over all environments (1.211 ton/fed), reflecting its low yielding potential under these agro-climatic conditions.

**TABLE (4). Mean values of grain yield (ton / fed) for 10 wheat genotypes grown under rainfed (E1 – E6) and saline environments (E7 – E12) over all seasons.**

| Genotypes | Maryout | | | Ras El-Hekma | | | Rainfed mean | Ras Sudr | | | Siwa Oasis | | | Salinity mean | Grand mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E 1 (Y1) | E2 (Y2) | E3 (Y3) | E4 (Y1) | E5 (Y2) | E6 (Y3) | | E7 (Y1) | E8 (Y2) | E9 (Y3) | E10 (Y1) | E11 (Y2) | E12 (Y3) | | |
| Gomam | 1.058 | 1.035 | 0.970 | 0.749 | 0.730 | 0.806 | 0.891 | 1.653 | 1.363 | 1.581 | 1.516 | 2.011 | 1.855 | 1.663 | 1.277 |
| Sids-7 | 0.644 | 0.661 | 0.600 | 0.637 | 0.728 | 0.734 | 0.667 | 1.571 | 1.544 | 1.493 | 2.061 | 1.873 | 1.991 | 1.756 | 1.211 |
| 1-3 | 0.913 | 0.914 | 0.874 | 0.693 | 0.671 | 0.773 | 0.806 | 1.883 | 1.803 | 1.741 | 1.834 | 1.987 | 2.029 | 1.880 | 1.343 |
| L-144 | 0.754 | 0.821 | 0.872 | 0.656 | 0.756 | 0.741 | 0.767 | 1.963 | 2.043 | 2.084 | 2.311 | 2.350 | 2.239 | 2.165 | 1.466 |
| Gemmeiza-7 | 0.848 | 0.777 | 0.764 | 0.728 | 0.793 | 0.758 | 0.778 | 1.469 | 1.582 | 1.659 | 2.088 | 1.937 | 1.753 | 1.748 | 1.263 |
| 1-6 | 0.811 | 0.863 | 0.923 | 0.791 | 0.877 | 0.848 | 0.852 | 1.277 | 1.466 | 1.407 | 1.888 | 2.036 | 2.159 | 1.706 | 1.279 |
| L-606 | 0.805 | 0.725 | 0.762 | 0.919 | 0.815 | 0.738 | 0.794 | 1.790 | 1.746 | 1.787 | 2.131 | 2.075 | 2.049 | 1.929 | 1.361 |
| L-263 | 0.766 | 0.796 | 0.831 | 0.826 | 0.879 | 0.910 | 0.835 | 1.811 | 1.859 | 1.862 | 2.243 | 2.202 | 2.163 | 2.023 | 1.429 |
| Maryout-5 | 0.972 | 0.914 | 0.858 | 0.823 | 0.881 | 0.813 | 0.877 | 1.726 | 2.059 | 1.957 | 2.163 | 2.299 | 2.354 | 2.093 | 1.485 |
| Sahel-1 | 0.892 | 0.935 | 0.994 | 0.858 | 0.837 | 0.838 | 0.892 | 1.580 | 1.468 | 1.568 | 1.639 | 2.197 | 1.810 | 1.710 | 1.301 |
| L.S.D. 0.05 | 0.098 | 0.074 | 0.052 | 0.049 | 0.030 | 0.044 | 0.027 | 0.310 | 0.333 | 0.313 | 0.371 | 0.249 | 0.310 | 0.298 | 0.061 |
| L.S.D. 0.01 | 0.134 | 0.101 | 0.71 | 0.067 | 0.041 | 0.060 | 0.037 | 0.425 | 0.456 | 0.429 | 0.508 | 0.341 | 0.425 | 0.408 | 0.084 |
| Mean over the 3 seasons | 0.845 | | | 0.787 | | | 0.816 | 1.693 | | | 2.041 | | | 1.867 | 1.342 |

Y1, Y2 and Y3 : (1999/2000), (2000/2001) and (2001/2002) growing seasons, respectively.

Mean performance of all genotypes averaged over the 6 saline environments (1.867 ton/fed) was higher than that of rainfed (0.816 ton/fed) because of favorable irrigation conditions in saline environments compared to the later. It was noticed that mean performance of Maryout and Siwa Oasis were higher than Ras El-Hekma and Ras Sudr, respectively (Table 4). The earlier results of Afiah (2002) were in harmony with these findings.

**Adaptability**

This part of the present study is an attempt to determine the stability of ten wheat genotypes for grain yield (ton/fed) using the widely used stability parameters ($b_i$, $S^2di$, $r^2$, C.V. %, $\sigma^2$, $\bar{Y}s_i$, $\alpha$ and $\lambda$) and the three proposed parameters of Sharaan and Ghallab (2001); $RD_i$, $RDD_i$ and $RHD_iDD_i$.

The term stable genotype has often been used to describe a genotype that has constant performance over environments. An obvious statistics is the coefficient of variation. Mean yield is plotted against C.V. in Figs. (1-a, b and c). Mean C.V. and grand mean yield divide the figure into four groups: 1) high yield, small variation, 2) high yield, large variation, 3) low yield, small variation and 4) low yield, large variation. High yield, small variation (group1)can be considered as stable genotypes under rainfed (Mar-5, I-6 and L-263), saline conditions (L-144, Mar-5, L-263 and I-3) and over both stress environments (Mar-5, L-144 and I-3)

According to Eberhart and Russel (1966) the stable genotype has a high mean yield over a range of environments, the regression coefficient ($b_i$) insignificantly different from unity and the deviation from regression ($S^2d$) near to zero. The results showed that all tested genotypes had $b_i$ values significantly different from unity, reflecting their unstability. These findings are more or less in harmony with the previous results of El-Morshidy *et al.* (2001). Regression coefficients are biased because the assumption of the regression analysis, that the independent variable is measured without error, could not be met. The biased depends on the number of genotypes tested and on the ratio of environmental variance to error variance (Sprint, 1969). In well-designed experiments e.g. a large number of replications, this ratio will be large and biase will be small (Wright, 1976). Furthermore, error variance could be estimated in replicated trials, hence, a correction is possible using Tai's (1971) $\alpha_i$ and $\lambda_i$ which can be regarded as especial form of $b_i$ and $S^2d_i$ when the environmental index is assumed to be random (Lin *et al.*, 1986). Concerning Tai's genotypic stability statistics i.e. $\alpha_i$ and $\lambda_i$ (Table 5 and Fig. 2-a) showed that all genotypes were out of the average stability area under rainfed conditions. While, Gemmeiza-7 was spotted in the above average stability area and genotypes; Sids-7, L-144, L-606, L-263 and Mar-5 had stability degree of below average for over all environments as shown in table (5) and Fig.(2-c).

With regard to the six rainfed environments, $RD_i$, $RDD_i$ and $RHD_iDD_i$ indicated that all studied genotypes were unstable for grain yield. On the other hand, variance statistic ($\sigma^2$) has low value for some genotypes indicating their stability, among them, Gom., I-3 and L-144 which exhibited high $r^2$ value. However, some authors suggested that $r^2_i$ is a better index than $\sigma^2_i$ for measuring the validity of the linear regression because its value always ranges between zero and one, regardless the measurement scale of 'y' (Teich, 1983). The present data revealed that all tested genotypes except Gom. and Sids-7 had cv % relatively small (less than 6 %) reflecting their stability. The integrating yield and stability of performance ($Ys_i$) showed stability for six genotypes i.e Gom., Gem-7, I-6, L-263, Mar-5 and Sahel-1.

**TABLE (5). Stability parameters of 10 wheat genotypes for grain yield across each of the three sets of environments.**

| Genotypes | $RD_i$ | $RDD_i$ | $RHD_iDD_i$ | $b_i$ | $S^2d_i$ | $r^2$ | cv % | $\alpha_i$ | $\lambda_i$ | $\delta^2$ | $Ys_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1) Rainfed environments (E1 – E6)** | | | | | | | | | | | |
| Gom. | 19.256 | 4.189 | 5.198 | 4.097 | 0.0031 | 0.872 | 6.080 | 3.196 | 6.208 | 0.003 | 4' |
| Sids-7 | 2.521 | 1.711 | 1.766 | -0.690 | 0.0024 | 0.189 | 7.830 | -1.741 | 5.590 | 0.003 | -10 |
| I-3 | 10.649 | 3.103 | 3.609 | 3.013 | 0.0018 | 0.853 | 3.800 | 2.076 | 4.105 | 0.002 | -4 |
| L-144 | 4.847 | 2.759 | 2.898 | 1.818 | 0.0017 | 0.682 | 5.290 | 0.838 | 4.346 | 0.002 | -9 |
| Gem-7 | 1.464 | 1.533 | 1.528 | 0.748 | 0.0008 | 0.382 | 2.730 | -0.257 | 2.564 | 0.001 | -1' |
| I-6 | 1.995 | 1.686 | 1.706 | 0.648 | 0.0018 | 0.210 | 2.520 | -0.363 | 4.527 | 0.002 | 1' |
| L-606 | 4.470 | 2.478 | 2.611 | -1.390 | 0.0031 | 0.432 | 2.430 | -2.463 | 6.726 | 0.003 | -6 |
| L-263 | 2.481 | 1.839 | 1.882 | -0.930 | 0.0018 | 0.349 | 3.130 | -1.995 | 4.253 | 0.002 | -1' |
| Mar-5 | 3.166 | 2.031 | 2.107 | 1.277 | 0.0017 | 0.515 | 4.130 | 0.288 | 4.374 | 0.002 | 3' |
| Sahel-1 | 3.444 | 2.005 | 2.101 | 1.411 | 0.0016 | 0.578 | 4.820 | 0.419 | 4.182 | 0.002 | 5' |
| **2) Saline environnants (E7 – E12)** | | | | | | | | | | | |
| Gom. | 1.466 | 1.527 | 1.508 | 0.859 | 0.0230 | 0.504 | 10.02 | -0.146 | 2.684 | 0.034 | -6 |
| Sids-7 | 1.645 | 1.338 | 1.433 | 1.152 | 0.0037 | 0.807 | 10.75 | 0.156 | 1.170 | 0.015 | 1 |
| I-3 | 0.318 | 0.669 | 0.561 | 0.415 | -0.0044 | 0.541 | 5.06 | -0.602 | 0.501 | 0.007 | 5' |
| L-144 | 0.654 | 0.912 | 0.832 | 0.773 | -0.0087 | 0.914 | 7.92 | -0.234 | 0.202 | 0.003 | 13' |
| Gem-7 | 1.403 | 1.459 | 1.442 | 0.965 | 0.0110 | 0.663 | 10.82 | -0.036 | 1.743 | 0.022 | 0 |
| I-6 | 3.597 | 2.078 | 2.545 | 1.840 | -0.0013 | 0.941 | 9.54 | 0.864 | 0.703 | 0.010 | -8 |
| L-606 | 0.987 | 0.907 | 0.871 | 0.841 | -0.0075 | 0.897 | 10.53 | -0.164 | 0.296 | 0.004 | 8' |
| L-263 | 1.049 | 1.018 | 1.027 | 0.987 | -0.0078 | 0.929 | 8.19 | -0.012 | 0.275 | 0.004 | 10' |
| Mar-5 | 1.431 | 1.480 | 1.465 | 1.055 | 0.0036 | 0.778 | 8.25 | 0.057 | 1.165 | 0.015 | 10' |
| Sahel-1 | 1.846 | 1.718 | 1.757 | 1.113 | 0.0174 | 0.671 | 10.86 | 0.116 | 2.244 | 0.029 | -3 |
| **3) Over all 12 environments (E1 – E12)** | | | | | | | | | | | |
| Gom. | 0.619 | 0.964 | 0.714 | 0.746 | 0.016 | 0.900 | 9.70 | -0.254 | 3.714 | 0.0217 | -7 |
| Sids-7 | 1.104 | 1.100 | 1.103 | 1.039 | 0.003 | 0.977 | 11.43 | 0.039 | 1.551 | 0.0091 | -4 |
| I-3 | 1.020 | 1.022 | 1.020 | 0.992 | 0.006 | 0.965 | 5.26 | -0.008 | 2.137 | 0.0125 | 3' |
| L-144 | 1.714 | 1.275 | 1.593 | 1.301 | 0.002 | 0.987 | 8.50 | 0.301 | 1.295 | 0.0076 | 4' |
| Gem-7 | 0.882 | 1.024 | 0.921 | 0.925 | 0.003 | 0.969 | 10.66 | -0.076 | 1.620 | 0.0095 | -4 |
| I-6 | 0.819 | 1.030 | 0.877 | 0.867 | 0.018 | 0.917 | 9.08 | -0.134 | 4.063 | 0.0237 | -6 |
| L-606 | 1.151 | 1.058 | 1.125 | 1.063 | 0.001 | 0.982 | 10.60 | 0.063 | 1.257 | 0.0073 | 6' |
| L-263 | 1.268 | 1.112 | 1.225 | 1.120 | - 0.001 | 0.989 | 8.30 | 0.120 | 0.861 | 0.0050 | 8' |
| Mar-5 | 1.346 | 1.160 | 1.295 | 1.152 | 0.001 | 0.985 | 8.40 | 0.152 | 1.197 | 0.0070 | 5' |
| Sahel-1 | 0.676 | 1.024 | 0.772 | 0.797 | 0.008 | 0.939 | 10.36 | -0.203 | 2.480 | 0.0145 | -4 |

$RD_i$ : relative deviation

$RDD_i$ : relative deviation distance

$RHD_iDD_i$ : half sum of relative deviation and deviation distance

$b_i$ : the linear regression coefficient of genotype mean yield on the average of all genotypes in each environment

$S^2d_i$ : the mean square of deviation from regression for each genotype

$r^2$ : The coefficient of determination between the performance of individual genotypes and the environmental index, which determine the percentage of total variation in a character due to linear regression (Pinthus, 1973)

cv% : Coefficient of variation

$\delta^2_i$ : a measure for the contribution of a genotype to G×E interaction (Shukla, 1972).

$\alpha_i$ : linear response to environmental effects

$\lambda_i$ : deviation from linear response in terms of magnitude of the error variance

$Ys_i$ :Kang's yield stability statistics

+ Denote selected genotypes on the basis of $Ys_i$.

Concerning the six saline environments, Tai's genotypic stability statistics showed that genotypes; Sids-7, I-6, Mar-5 and Sahel-1 had stability degree of below average whereas genotypes; I-3, L-144, Gemmeiza-7, L-606 and L-263 where spotted in the above average stability area (Table 5 and Fig 2-b).

Superior and stable genotypes that considered more adapt to each of the stress environments tested were identified. These include L-144, Mar. 5 and L-263 under saline environments and Gomam, Mar-5 and Sahel-1 at rainfed conditions. Under Maryout rainfed environment, Mar-5 and L-263 proved to be resistant genotypes for yellow strip rust and net blotch diseases through to successive seasons (Gowily *et al.*, 2002). Such genotypes could be used directly for improving wheat productivity at similar aimed regions.

**Correlation among all stability parameters**

Significant correlation coefficients among the eleven stability measurements, i.e. $b_i$, $S^2d_i$, $\sigma^2$, $r^2$, $RDD_i$, $RD_i$, $RHD_iDD_i$, $\alpha$, $\lambda$, cv%, and $Ys_i$ were shown in table(6). Number of significant relations over all 12 environments were 41 out of 55 cases. $b_i$, $RDD_i$, $RD_i$, $r^2$, $\alpha$ and $RHD_iDD_i$ were positively associated with each other. $Ys_i$ was positively correlated with $b_i$, $RD_i$, $r^2$, $\alpha$ and $RHD_iDD_i$, whereas it was negatively correlated with $\sigma^2$, $S^2d_i$ and $\lambda$. $\sigma^2$ was positively correlated with $\lambda$ statistic parameter. It is worthy to note that $RD_i$, $RDD_i$ and $RHD_iDD_i$ were strongly associated with each other. This may be due to the similarity of their computation basis. Such three stability parameters were negatively correlated to $\sigma^2$, $\lambda$ and $S^2d_i$ supporting the above discussion of stability determinations. Negatively associations were observed between $r^2$ and each of $S^2d_i$, $\lambda$, $\sigma^2$ and cv%. These results are in line with those obtained by Metin Kara (1997) who recorded similar positive relations between cv% and $S^2d_i$ and negative one's between $r^2$ and $S^2d_i$ and are more or less in harmony with the previous results of Sharaan and Ghallab (2001).

## CONCLUSION

It could be concluded that: 1) all the statistical parameters studied exhibited different stability estimates in the three sets of environments. 2) great similarity of the results was observed between $b_i$, $\alpha$, $RD_i$, $RHD_iDD_i$ and $r^2$ over all environments. 3) $S^2d_i$, $\sigma^2$, $Ys_i$ and $\alpha$ and $\lambda$ resulted the greatest number of stable genotypes under rainfed and saline environments, respectively. This finding reflects the efficiency of these parameters as stability measurements at the aimed conditions.

**TABLE (6): Simple correlation coefficients between all possible pairs of the stability parameters used over both rainfed and salinity environments.**

| Stability parameter | $b_i$ | $S^2d_i$ | $\alpha_i$ | $\lambda_i$ | $RD_i$ | $RDD_i$ | $RHD_i$-$DD_i$ | $r^2$ | $\delta^2$ | $Y_{Si}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $S^2d_i$ | -0.756* | | | | | | | | | |
| $\alpha_i$ | 0.998** | -0.756* | | | | | | | | |
| $\lambda_i$ | -0.782** | 0.999** | -0.780** | | | | | | | |
| $RD_i$ | 0.994** | -0.700* | 0.994** | -0.729** | | | | | | |
| $RDD_i$ | 0.919** | -0.587 | 0.918** | -0.620 | 0.946** | | | | | |
| $RHD_iDD_i$ | 0.991** | -0.693** | 0.993** | -0.723* | 0.999** | 0.955** | | | | |
| $r^2$ | 0.865** | -0.964** | 0.865** | -0.968** | 0.812** | 0.693* | 0.804** | | | |
| $\delta^2$ | -0.782** | 0.999** | -0.782** | 0.997** | -0.729* | -0.617 | -0.723* | -0.968** | | |
| $Y_{Si}$ | 0.790** | -0.771** | 0.790** | -0.779** | 0.759* | 0.580 | 0.746* | 0.797** | -0.781** | |
| C.V.% | -0.254 | 0.010 | -0.254 | 0.011 | -0.262 | -0.130 | -0.253 | -0.104 | 0.008 | -0.444 |

$RD_i$ : relative deviation
$RDD_i$ : relative deviation distance
$RHD_iDD_i$ : half sum of relative deviation and deviation distance
$b_i$ : the linear regression coefficient of genotype mean yield on the average of all genotypes in each environment
$S^2d_i$ : the mean square of deviation from regression for each genotype
$r^2$ : The coefficient of determination between the performance of individual genotypes and the environmental index, which determine the percentage of total variation in a character due to linear regression (Pinthus, 1973)
cv% : Coefficient of variation
$\delta^2_i$ : a measure for the contribution of a genotype to G×E interaction (Shukla, 1972).
$\alpha_i$ : linear response to environmental effects
$\lambda_i$ : deviation from linear response in terms of magnitude of the error variance
$Ys_i$ :Kang's yield stability statistics
+ Denote selected genotypes on the basis of $Ys_i$.

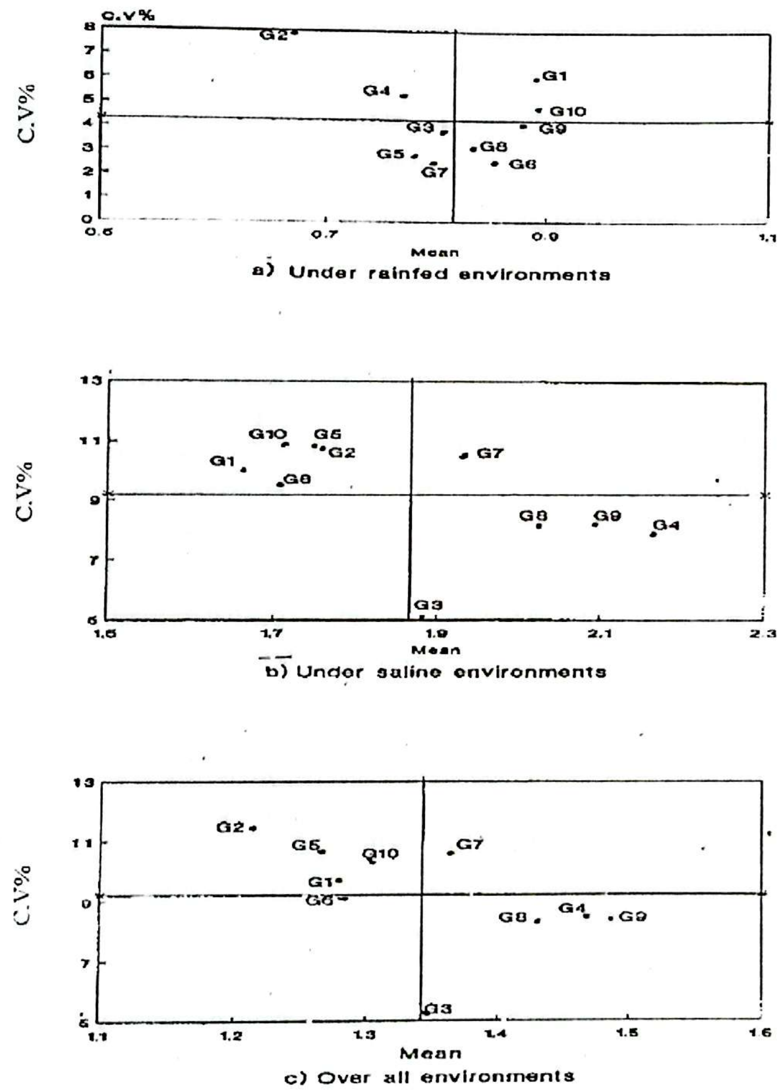


Fig. (1). Grain yield (ton/fed) plotted against C.V.% from the three growing seasons

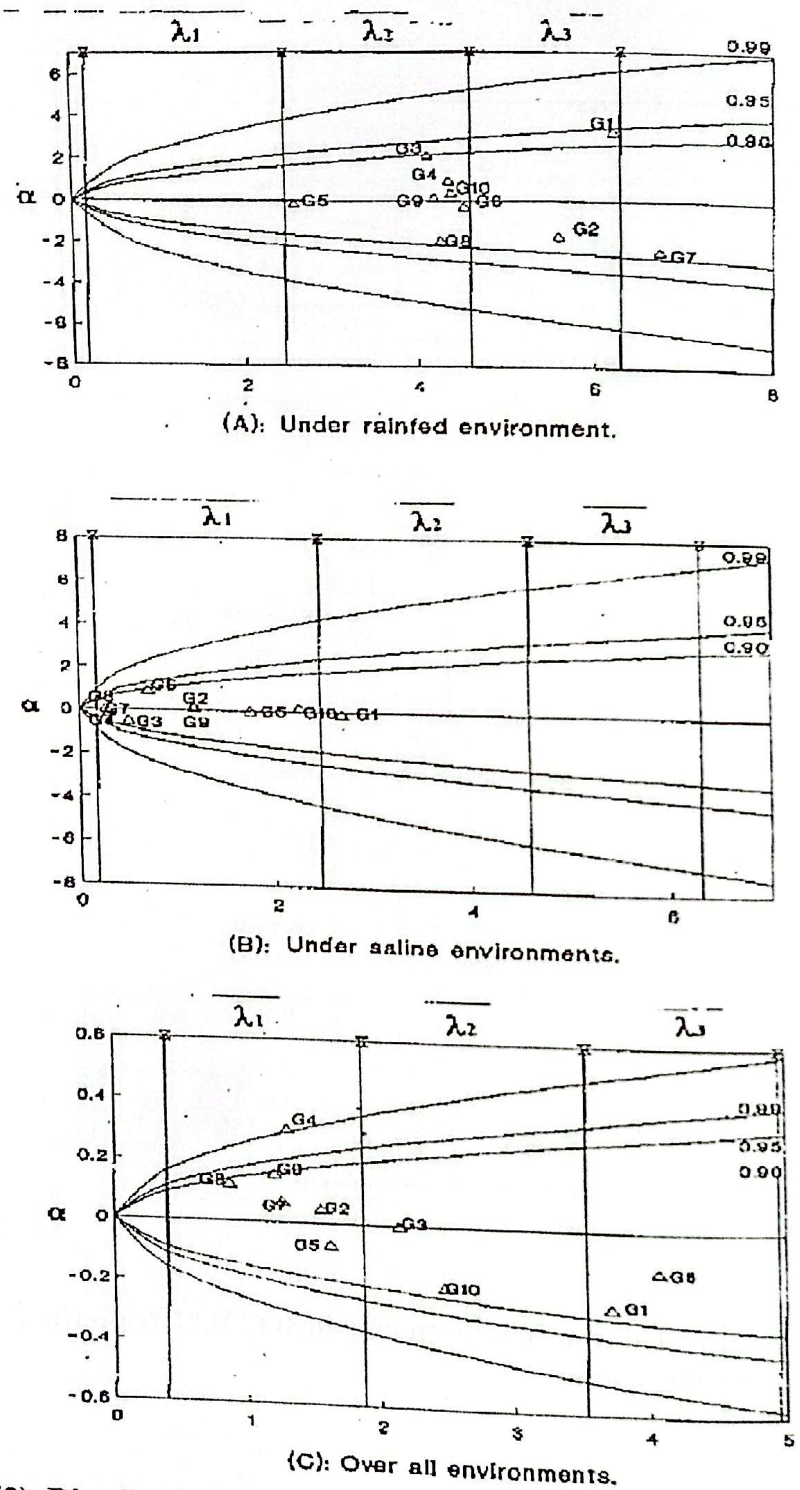


**Fig. (2). Distribution of genotypic stability statistics of ten wheat genotypes.**

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# سلوك وثبات تراكيب وراثية مرباة حديثا من القمح تحت بيئات مطرية وملحية

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تم تقييم عشرة تراكيب وراثية من قمح الخبز (أصناف وسلالات مختارة) من خلال اثنى عشر تجربة محصولية فى اربعة مناطق على مدى ثلاث مواسم متتالية انتهت فى ٢٠٠١/٢٠٠٢ ويمكن تقسيم مناطق الدراسة الى بيئتى اجهاد اساسية وهى ١) منطقتين للزراعة المطرية بالساحل الشمالى الغربى (رأس الحكمة ومريوط) ٢) منطقتين للزراعة فى أراضى متأثرة بالملوحة (واحة سيوة ورأس سدر) وقد تم استخدام احد عشر من معايير ثبات الأداء الوراثى و المظهرى و تحديد درجة الارتباط بين هذه المعايير واهميتها لتقييم تراكيب القمح الوراثية تحت الدراسة ويمكن تلخيص اهم النتائج فيما يلى :

١- اوضحت بيانات تحليل التباين مدى واسع من الاختلافات بين المواقع وكذلك بين التراكيب الوراثية المختبرة كما كان التفاعل بين البيئة والتركيب الوراثى عالى المعنوية ويعتبر الجزء الاكبر منه دالة خطية للتأثيرات البيئية.

٢- كان المتوسط العام للمحصول تحت البيئات الملحية (١.٨٦٧ طن/فدان)اعلى من نظيره تحت ظروف الزراعة المطرية (٠.٨١٩ طن/فدان).

٣- اختلفت التراكيب الوراثية المختبرة فيما بينها فى محصول الحبوب حيث تفوق الصنف المحلى ساحل (١) والصنف المستورد جومام أما الصنف سدس (٧) فكان هو الاقل محصولا تحت ظروف الزراعة المطرية بينما اعطت السلالات المرباة حديثا ضمن برنامج مركز بحوث الصحراء (١٤٤ ومريوط ٥ والسلالة ٢٦٣) اعلى انتاجية تحت ظروف الزراعة فى الاراضى المتأثرة بالملوحة اما فى التحليل التجميعى لبيانات الاثنى عشر تجربة فقد أعطت السلالة مريوط ٥ أعلى متوسط لمحصول الحبوب (١.٤٨٥ طن / فدان) مما يؤكد ثباتها وقدرتها على مقاومة التأثيرات السيئة لتقلب الظروف البيئية بالمناطق الصحراوية حديثة الاستصلاح .

٤- على اساس معامل الاختلاف البيئى ومتوسط المحصول للتراكيب الوراثية موضع الدراسة تم تقسيمها الى اربعة مجموعات كان افضلها المجموعة الاقل اختلافا والاعلى محصولا ووقع تحتها التراكيب الوراثية التالية : مريوط ٥ و ايكاردا (٦) والسلالة ٢٦٣ تحت الظروف المطرية ، السلالة ١٤٤و مريوط (٥) والسلالة ٢٦٣ ثم ايكاردا (٣) تحت الظروف الملحية ، والسلالة مريوط (٥) يليها السلالة ١٤٤ ثم ايكاردا (٣) على مستوى كافة البيئات المدروسة .

٥- فى مواقع الزراعة المطرية حققت التراكيب الوراثية جومام وايكاردا (٣)، السلالة رقم ١٤٤ اقل تباين مما يؤكد ثباتها الوراثى بغض النظر عن كفاءتها المحصولية .

٦- وعموما يمكن تحديد التراكيب الوراثية المناسبة للزراعة بالأراضي المتأثرة بالملوحة في ثلاثة سلالات مرباة حديثا هي السلالة ١٤٤ ومريوط (٥) والسلالة ٢٦٣ ، وتحت ظروف الزراعة المطرية في الصنفين ساحل (١) وجومام والسلالة مريوط (٥).

و مما هو جدير بالذكر أن السلالتين ناتج برنامج التربية بمركز بحوث الصحراء [٢٦٣، مريوط (٥)] تم اختبارهما لتحمل الأمراض خلال موسمين متتاليين بموقع الزراعة المطرية في مريوط وقد تم توصيفهما ضمن مجموعة التراكيب الوراثية المقاومة لمرضى الصدأ المخطط (الأصفر) والتبقع الشبكي للأوراق – لذا يمكن الاستفادة منهما مباشرة في تحسين إنتاجية قمح الخبز بالمناطق المستهدفة.