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Stability Analysis of Maize Yield by using Unvariate Statistical Method

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ABSTRACT: High interaction effect of G × E may necessitate the creation of additional zones and as a result, make increase in cost of important commercial cultivars. Researchers have used different parameters to determine and introduce stability cultivars. 15 maize hybrids were investigated in complete randomized block design with four replications in three locations (Karaj, Mashhad and Jiroft) in two consecutive years (2011 and 2012). Variances indicated that interaction effect of genotype and environment (GE) was significant (α≤0.01) that represents yield volatility in different environments. Accordingly, to study interaction effect and determine stable hybrid, different stability statistics method was used: Romer environmental variance, genotypic coefficient of variation, Rick Ecovalance method, Shukla stability variance, Lin and Binns within location variance, Eberhart and Russell regression method and simultaneous selection of stability and yield method. In the most used methods in this study, KSC705 and K74.2-2-1-22-1-1-1 XK19 genotypes were identified as stable genotypes with 11.364 and 11.071 yields, respectively.

Keywords: Maize, genotype-environment interaction, stability parameters

INTRODUCTION

Crop plants yield have changes in different environments; so, inbreeding of cultivars with stability seems necessary for seed yield. Major difference in genotypes stability is due to crossover interaction effect of genotype and environment; therefore, changes in their rank are various in different environmental conditions. There are various methods for stability analysis and investigation the interaction effect of genotype × environment (Asgariniya *et al*., 2008; Akbarpour *et al*., 2011). Stability analysis is a general solution for genotypes reaction to environmental changes (Chogan, 2011). Stability analysis methods can be divided into univariate and multivariate. Also, univariate methods can be separated to parametric and nonparametric groups and parametric univariate can be divided into stability analysis based on variance and regression analysis.

Phenotypic stability is calculating by Romer and one genotype variance in different environment (Farshadfar, 1998). In fact, environment variance is measuring deviation of one genotype from its mean in all environments. Rick suggested that interaction effect of genotype × environment is used as stability for each genotype (Bakhshayeshi-Gheshlagh, 2011). Stability parameter method based on the remaining effect of bidirectional table of genotype and environment was calculated by Shukla (Shukla, 1972). According to this method, the genotype that has the lowest variance is stable genotype (Lin, 1986). In fact, Shukla stability variance is the same with Rick method but interaction effect variance is used instead of the sum of squares of interaction effect.

For the first time, the coefficient of variation method was presented to determine maize varieties stability by Francis and Kannenberg (Francis and Kannenberg, 1978). In fact, CV_i is measuring one genotype deviation from the mean of one genotype in all environments. In Finaly and Wilkinson method, regression coefficient and genotype yield are used for determining genotype stability. They demonstrated that b_i parameter in addition to stability, represents compatibility regions. If a genotype have regression coefficient of 1 and high yield mean, consider it as a genotype with good general stability by agronomic stability (Finlay and Wilkinson, 1963). Eberhart and Russell have used three factor for stable varieties recognition: yield mean, Finaly and Wilkinsons' regression coefficient (Finlay and Wilkinson, 1963) and deviation of regression. In their opinion, ideal variety should have regression coefficient and deviation of regression equal to 1 and zero, respectively (Roy, 2000). Higher than 1 regression coefficients indicated that genotypes are very sensitive to environmental changes and have special adaptation to environment with high yield. Lower than 1 regression coefficients are criterion of genotype high resistance to environmental changes, and so high adaptability to environments with low yield. Pinthus suggested using coefficient determination (R_i^2) for estimating genotypes stability instead of deviation squares mean in 1973 (11); and in fact R_i^2 is strongly linked to S_{di}^2. Lin and Binns considered location and year as controllable and unpredictability factors, respectively. They stated the variety is stable which has less vitality during investigated years.

So, the mean variance between years of within location was suggested as stability parameter. Combining stability and yield for selecting stable genotypes with high yield has attracted researchers' attention; yield and stability traits must be simultaneously considered in order to decrease genotype-environment effects, do more accurate and appreciable selections. In this regard, limited number of simultaneous selection method is proposed. This experiment was performed to introduce top hybrids (hybrids with higher and stability yield than control in many regions) to farmers.

MATERIAL AND METHODS

The experiment carried out in three locations (Seed and Seedling Breed and Production Research center of Karaj, Agricultural and Resource Research center of Mashhad and Jiroft, Iran) during two growing seasons (2011-2012). After all there were six environments (Table 1). In each experimental location a 1500 m^2 field prepared and fertilized with urea, ammonium phosphate and potassium sulphate base on soil test and recommendation of Soil and Water Research Center of Iran. 15 mid and long seasons maize hybrids (Table 2) hand seeded at rows with 75 cm spaces as complete randomized block deign with four replications. Each row contains 16 hollows with 35 distances. Four seeds were placed in each hollow and after reaching to 4 leaves level, plants thinned and 2 plants remained. The final populations were 76000 plants per ha. Grain yield measured by harvesting a total area 8.4 m^2 for each treatment. Grain yield corrected base on 14% humidity.

Table 1: Different environments which studied during experiment.

Code	Location	Year
S1	Karaj	2011
S2	Karaj	2012
S3	Mashhad	2011
S4	Mashhad	2012
S5	Jiroft	2011
S6	Jiroft	2012

Table2: Characteristics of studied hybrids.

Code	**Pedigree/Name**
G1	KLM76003/2-1- 1-2-1-1-1-1 X MO17
G2	K47/2-1-1-3-3-1-1-1-1 X MO17
G3	K74/2-2-1-22-1-1-1-1X K3615/2
G4	KLM77002/10-1 X MO17
G5	K74/2-2-1-4-2-1-1-1-1 x k18
G6	KLM76005/2-3-1-1-1-1X M017
G7	K3547/5 XK19/1
G8	KLM8026/1-2-1-2-3 X MO17
G9	KLM77020/7-1 -1-2-1-1-1-1X K19
G10	K74/2-2-1-22-1-1-1 XK19
G11	K3547/3 X K3615/2
G12	K3615/2 X MO17
G13	K3615/2 X K19/1
G14	KSC705
G15	KSC704

The grain yield data were subjected to analysis of variance in each environment. Then the combined analysis performed. Coefficient of variance (CV_i) estimated in combined analysis of variance. Thus univariate statistical method applied to investigate genotypes stability. SAS and EXCEL software used for calculating these methods.

RESULTS AND DISCUSSION

Results of combined variance analysis indicated that the interaction effect of genotype, year and location was significantly affected grain yield (α≤0.01), and the effect of year, location, genotype-location interaction and genotype-year interaction was not significant for it. No significant effect of genotype-location interaction suggesting that trend of genotype changes for grain yield was similar in investigated location. No significant effect of genotype-year interaction indicating that trend of genotype changes for grain yield was similar in investigated years (Table 3). Genotype significant effect represented genetically differences between studied genotypes. From significant genotype-year-location interaction effect can be deduced that cultivars yield were fluctuated in different environments, and for closer look at these interaction effects, finding adapted hybrids to different environment condition and definite recommendation, stability analysis should be done.

Table 3: Combined variance analysis of 15 maize hybrids across 6 environments.

Source of Variations	Df	Mean of squares	F
Location	2	811	259ns
Year	1	36.27	11.59n.s
Year × location	2	82.86	26.48*
Year × location × rep	18	17.1	5.47
Genotype	14	21.28	6.8**
Genotype × location	28	8.41	2.69n.s
Genotype × year	14	12.48	3.99n.s
Genotype × location × year	28	6.09	1.59**
Error	252	3.12	
Total	359	3797	
Cv%: 16.24			

ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.

Table 4: Results of univariate method base on variance analysis of maize hybrids.

Genotypes	Yield mean (ton/ha)	Stability variance	Rick Ecovalance	Coefficient of variation	Environmental variance	Within location variance	Coefficient of within location variation
1: KLM76003/2-1- 1-2-1-1-1-1 X MO17	10.746	1.86	10.37	21.78	5.48	59.90	42
2: K47/2-1-1-3-3-1-1-1-1 X MO17	13.02	2.32	12.37	18.39	5.73	55.70	33
3: K74/2-2-1-22-1-1-1-1X K3615/2	10.943	2.11	11.44	14.16	2.4	13.13	19
4: KLM77002/10-1 X MO17	10.207	6.31	29.74	31.35	10.24	49.29	40
5: K74/2-2-1-4-2-1-1-1-1 x k18	12.575	3.58	17.85	18.01	5.13	22.86	22
6: KLM76005/2-3-1-1-1-1X M017	11.32	1.23	7.62	23.04	6.80	26.01	26
7: K3547/5 XK19/1	10.644	0.72	5.41	30.39	10.46	33.12	31
8: KLM8026/1-2-1-2-3 X MO17	10.686	1.37	8.23	28.92	9.55	11.21	18
9: KLM77020/7-1 -1-2-1-1-1-1X K19	9.439	0.08	2.62	30.28	8.17	31.94	35
10: K74/2-2-1-22-1-1-1 XK19	11.071	1.61	9.27	26.99	8.93	65.58	42
11: K3547/3 X K3615/2	10.013	0.73	5.47	31.02	9.65	32.82	33
12: K3615/2 X MO17	10.271	2.23	12	33.63	11.93	48.45	39
13: K3615/2 X K19/1	10.35	0.63	5.01	28.68	8.75	68.79	46
14: KSC705	11.364	0.78	5.68	27.38	9.68	32.97	29
15: KSC704	10.37	0.41	4.07	26.32	7.45	29.16	30

According to stability, environmental variance and coefficient of variation parameters (type I parameter), a genotype consider stable which is allocated less amount to itself. Genotypes with low yield usually show further stability in terms of these two parameters which is the advantages of method. According to (S^2_i) method or Romer environmental variance, hybrids of No. 3, 5, 1, 2, 6, 15, 9, 13 and 10 had the lowest variance, respectively, but hybrids of No. 3, 5, 2, 6, and 10 were considered as stable hybrids because of having higher mean yield than total yield. The highest variance amount (S^2_i) belonged to hybrids of 12, 7 and 4, respectively, which reflect these hybrids low stability in the investigated environments and yield fluctuation. The coefficient of variation results showed that genotypes of No. 3, 5, 2, 1, 6, 15, 10 and 14 had higher yield than total mean. Based on CV_i method, six genotypes were introduced as stable genotypes. According to the stability results of type I, hybrids of No. 3, 5, 2, 6 and 10 were the best ones for sowing in the all studied regions with yield of 10.943, 12.575, 13.02, 11.32 and 11.07 ton/ha, respectively. Then the hybrid of No. 14 with lower stability than five above genotypes was appeared as stable genotypes (Table 4). According to the results of Shukla stability variance and Rick ecovalance (type II parameters), genotypes of No. 9, 15, 13, 7, 11, 14, 6, 8 and 10 had the lowest variance ecovalance amount, respectively. Between them genotypes of No. 14, 6 and 10 were considered as stable genotypes by having higher yield than mean yield with 11.36, 11.32 and 11.07, respectively, and the lowest amount of variance and ecovalance. Genotype of No. 4 with the highest variance amount and lower mean (10.207) than total mean was considered the most unstable genotype (Table 4). For investigation cultivars stability by Lin and Binns method (type IV parameters), each cultivars variance was separately calculated in each regions during studying years; variances mean were calculated in the 6 regions; mean squares of years within location ($MS_{y/1}$) were used for the checking of cultivars adaptation. Also, within location coefficient of variation was calculated by using mean squares of within location and each cultivars mean (Lin *et al*., 1986). Based on the mentioned method, genotypes of No. 8, 3, 5, 6, 15, 9, 11 and 14 were the most stable ones with the lowest variance amount and coefficient of variation, respectively. Among them genotypes No. 3, 5, 6 and 14 were identified as superior and stable genotypes with the lowest variance, lowest coefficient of variation and higher yield than total mean with 10.943, 12.57, 11.32 and 11.36 ton/ha, respectively. Genotype of number 13 with the highest variance and lower yield than total mean was known as unstable genotype (Table 4).

Table 5: Simultaneous selection for yield and stability of maize hybrids.

Genotypes	yield	Yield ranking	Yield ranking correction	Modified ranking	Stability variance	Stability amount	Combined effect of stability and yield
1: KLM76003/2-1- 1-2-1-1-1-1 X MO17	10.746	9	-1	8	1.86	0	8+
2: K47/2-1-1-3-3-1-1-1-1 X MO17	13.02	15	2	17	2.32	0	17+
3: K74/2-2-1-22-1-1-1-1X K3615/2	10.943	10	1	11	2.11	0	11+
4: KLM77002/10-1 X MO17	10.207	3	-1	2	6.31	0	2
5: K74/2-2-1-4-2-1-1-1-1 x k18	12.575	14	2	16	3.58	0	16+
6: KLM76005/2-3-1-1-1-1X M017	11.32	12	1	13	1.23	0	13+
7: K3547/5 XK19/1	10.644	7	-1	6	0.72	0	6
8: KLM8026/1-2-1-2-3 X MO17	10.686	8	-1	7	1.37	0	7
9: KLM77020/7-1 -1-2-1-1-1-1X K19	9.439	1	-2	-1	0.08	0	-1
10: K74/2-2-1-22-1-1-1 XK19	11.071	11	1	12	1.61	0	12+
11: K3547/3 X K3615/2	10.013	2	-1	1	0.73	0	1
12: K3615/2 X MO17	10.271	4	-1	3	2.23	0	3
13: K3615/2 X K19/1	10.32	5	-1	4	0.63	0	4
14: KSC705	11.364	13	1	14	0.78	0	14+
15: KSC704	10.37	6	-1	5	0.41	0	5
mean	10.87						7.87
							LSD 5% = 0.99

+ superior genotypes

Researchers have presented several methods for simultaneous investigation of yield. Kang proposed and used simultaneous selection methods for yield and Shukla stability variance and ranking method for stability (Kang, 1993; Kang, 1988). In this method, the genotypes with higher ys_i than mean are selected. So, genotypes No. 2, 5, 14, 6, 10, 3 and 1 were known as superior ones. Among these genotypes No. 2, 5, 14, 6 and 10 were identified more superior than the other because of having high yield and stability combined effect with 17, 16, 14, 13 and 12, respectively. Genotypes number 3 and 1 revealed high yield and stability combined effect after 5 mentioned genotypes (Table 5). In Eberhart and Russell regression method for investigation cultivars stability, three factors must be simultaneously noted: yield, regression coefficient (bi) and mean squares of deviation from regression (S_{di}^2) or determination coefficient (R_i^2). In this condition, a hybrid is stable which have regression coefficient equal to 1, mean squares of deviation from regression equal to zero and high mean yield. T-student test with mistake freedom degree L-2 (which in the test was equal to 4) was used for significant test of regression coefficient. According to results (Table 6), none of the hybrids with regression coefficient of 1 (=1b) had not significant difference.

Deviation of regression mean squares were significant for genotypes of No. 4, 5 and 6 which indicated yield scattering around regression line; so these genotypes were not considered in cultivars stability determining. Genotypes of number 2, 14, 10 and 3 allocated higher yield mean to itself with 13.02, 11.36, 11.07 and 10.94 ton/ha, respectively, and all of them had non-significant regression coefficient and deviation of regression line. Therefore, they had optimal adaptation but genotypes of No. 14 and 3 showed lower deviation of regression line; they had higher stability (No. 14 had the lowest deviation of regression line and the highest determination coefficient). Genotypes of No. 9, 11, 13, 12, 15, 7, 8 and 1 were identified as middle stability and weak adaptation ones, respectively, with low yield mean and non-significant regression coefficient with 1. Genotypes of No. 7, 8 and 1 were known as stable genotypes with middle adaptation by having closer yield mean and non- significant regression coefficient. Based on the results of regression model, No. 7 and 9 allocated the highest determination coefficient to itself and were considered among stable genotypes. But this parameter could not separately represent stable ones because it only shows regression model fitting. Therefore, regression model should be considered for obtaining better results in its use.

Table 6: Stability parameters of Eberhart and Russell regression method and determination coefficient.

Genotypes	Yield mean (t/ha)	Eberhart and Russell's regression coefficient (bi)	S_{di}^2	R_i^2
1: KLM76003/2-1-1-2-1-1-1-1 X MO17	10.746	0.77	1.42ns	0.67
2: K47/2-1-1-3-3-1-1-1-1 X MO17	13.02	0.85	1.38ns	0.72
3: K74/2-2-1-22-1-1-1-1X K3615/2	10.943	0.49	0.3ns	0.63
4: KLM77002/10-1 X MO17	10.207	0.82	6.72	0.41
5: K74/2-2-1-4-2-1-1-1-1 x k18	12.575	0.67	2.04	0.55
6: KLM76005/2-3-1-1-1-1X M017	11.32	0.83	2.03	0.65
7: K3547/5 XK19/1	10.644	1.26	-0.16ns	0.95
8: KLM8026/1-2-1-2-3 X MO17	10.686	1.13	1.17ns	0.83
9: KLM77020/7-1 -1-2-1-1-1-1X K19	9.439	1.10	-0.12ns	0.93
10: K74/2-2-1-22-1-1-1 XK19	11.071	1.07	1.38ns	0.8
11: K3547/3 X K3615/2	10.013	1.19	0.15ns	0.92
12: K3615/2 X MO17	10.271	1.27	1.43ns	0.85
13: K3615/2 X K19/1	10.32	1.26	0.45ns	0.91
14: KSC705	11.364	1.19	0.22ns	0.91
15: KSC704	10.37	1.04	0ns	0.9

CONCLUSION

According to variance and regression analysis, stability analysis of maize hybrids yield was conducted. In the methods based on variance analysis (YS_i, $CV_{y/1}$, $MS_{y/1}$, oi^2, wi^2, cv_i and Si^2 parameters), genotypes of No. 6, 14, 5 and 10 were identified as stable ones. Results of Eberhart and Russell regression analysis showed that No. 2, 14, 10 and 3 had optimal adaptation with higher yield mean than total mean, regression coefficient and non-significant deviation of regression line. Genotypes of No. 14 and 10 as stable genotypes in many of the used methods with 11.364 and 11.071 ton/ha yield mean, respectively.

REFERENCES

Akbarpour, A., Dehghani, H., Sorkhiallahlo, B. (2011). Univariate andmulti variate Stability Study of promising genotypes of barley in cold climates. *Iranian Journal of Field Crop Science.* **42**(1): 23-32.

Asgariniya, P., Saaidi, Gh., Rezaie, A. (2008). Investigation genotype-environment interaction effect of wheat by using regression and path coefficient analysis. *Crop Production Journal.* **1**: 64-83.

Bakhshayeshi-Gheshlagh, M. (2011). Study adaptation and stability of grain yield of wheat in cold and temperate climates of Iran. *Journal of Crop Improvement*. **13**(2): 41-49.

Chogan R. (2011). Final report of research project. Investigation advanced maize hybrids yield of late and medium maturity in the semifinals.

Farshadfar, A.A. (1998). Quantitative genetics application in plant breeding. Tagh Bostan press, Razi university, Kermanshah, Iran. Pp. 396.

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

Francis, T.R., Kannenberg, L.W. (1978). Yield stability studies in short season maize: 1. Adescriptive method for grouping genotypes. *Plant Sci.* **58**: 1029-1034.

Kang, M.S. (1993). Simultaneous selection for yield and stability in crop performance genotype–environment interaction 239 trials: consequences for growers. *Agronomy Journal*. **85**: 754–757.

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

Lin, C.S., Binns, M.R., Lefkovitch, L.P. (1986). Stability analysis where do we stand? Crop sci. 26:894-899.

Pinthus, M.J. (1973). Estimate of genotypic value: A proposed method. *Euphytica*. **22**: 121-123.

Roy, D. (2000). Plant breeding analysis and exploitation of variation. Alpha science International Ltd.U.K. **35**:12-18.

Shukla, G.K. (1972). Some statistical aspects of partitioning genotype-environmental vomponents of variability. *Heredity.* **29**: 237-245.