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Stability of Bread Wheat Recombinant Inbreed Lines Derived from across Zagros and Norstar

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ABSTRACT: Genotype × environment interaction is important in developing and releasing new varieties of crop plants. To study genetic diversity and stability of wheat recombinant inbreed lines (RILs), 38 RILs derived from across between Zagros (facultative type, early maturing and drought resistant) and Norstar (winter type, late maturing and cold resistant) along parental lines were evaluated in randomized complete block design (RCBD) with three replications during of 2010-2011 and 2011-2012 cropping seasons. Based on combined analysis of variance significant differences were observed between lines for grain yield and 1000 grain weight. Line × year interaction was significant for number of grain per spike, number of spike per square meter and 1000 grain weight. Using environmental variance and coefficient of variation, lines number 23, 95, 293 and 296 and based on non-parametric parameter of Ketata and Ecoavalance of Rick, lines number 28, 31 and 281 were the most stable lines with high grain yield.

Keywords: Bread wheat, Genotype × year interaction, Grain yield, Recombinant inbreed line, Stability analysis.

INTRODUCTION

Wheat is the most important crop that widely cultivated in many countries, including Iran. Bread wheat was domesticated 1,200 years ago in the fertile areas (Salamini *et al.,* 2002). Cultivated land and crop yield of wheat in Iran during 2012 were 7 million hectares and 13.5 million tonnes, respectively. World's area under wheat cultivation and its production were 216 million hectares and 675 million tonnes, respectively (FAO, 2012).

Genotype × environment interaction shows degree of uncertainty in measurement of each genotype. This uncertainty increases by enlarging the interaction (Delacy *et al.,* 1996). Branocurt and Hulmel (2000) stated that genotype × environment interaction is the main reason for adaptability of different genotypes to different environments. Increasing wheat production is an important goal to ensure food security. An ideal genotype should not only have the highest average performance, but also must be stable (Yan and Kang, 2003).

The breeding strategies adopted during the last decades have contributed to reduce the interaction of genotypes with environments selecting genotypes with better stability across a wide range of locations and years and modern genotypes outperformed the old ones in all test environments with a strong adaptability to improved fertility. Genotype × Environment (GE) interaction results in genotype rank changes from an environment to another, a difference in scale among environments, or a combination of these two situations (Aycicek and Yildirim, 2006). Mustatea *et al.* (2009) showed that high yielding cultivars usually show different behavior in stability of performance and suggest that yield stability and high grain are mutually exclusive. Therefore introduction of new varieties not only needs high yield, but also require their stability in target environment. Reliable stability of yield under different environmental conditions is important (Kan *et al.,* 2010). So many studies have been conducted to investigate stability of wheat genotypes under different environments (Akcura *et al.,* 2009; AL-Otayk, 2010; El Ameen, 2012).

Lin and Binns (1991) offered four types of stability for univariate stability of parameters. They called the environmental variance and coefficient of variation as stability parameters of type I or biological stability. Ecoavalance of Rick (1962) and the variance of Shukla (1972) are as stability parameters of type II. In order to determine stability, Eberhart and Russell (1966) used two parameters regression coefficient belonging to type II and mean square deviation from the regression line belonging to type III. Lin and Binns (1991) offered a statistic as stability parameter of type IV. In addition to the above parametric methods, the breeders in order to evaluate the stability of genotypes use non-parametric methods such as ranking method (Ketata, 1988).

Our objectives were to evaluate yield and yield component of bread wheat recombinant inbreed lines to measure the genotype × environment interaction, identify and develop more stability genotypes with using from parametric methods and also non-parametric method to reduce the bias caused by outliers, no assumptions are needed about the distribution of the observed values, they are easy to use and interpret, and additions or deletions of one or few genotypes do not cause much variation of results.

MATERIAL AND METHODS

Plant materials consisted of 38 bread wheat recombinant inbreed lines derived from a across between Zagros (a spring variety, resistant to terminal drought and heat) and Norstar (a winter variety, cold resistant and tall) varieties along with parental lines (Kindly provided by Center of Excellence in Cereal Molecular Breeding, University of Tabriz, Iran). The genotypes were evaluated in a randomized complete block design (RCBD) with three replications during 2010-2011 and 2011-2012 cropping seasons at Agricultural Research station of University of Tabriz. The measured traits included yield, number of grain per spike, number of spike per square meter and 1000 grain weight. Combined analysis of variance was performed based on two years data. Before analysis of variance, assumptions of analysis of variance were assessed and all the traits except number of grain fulfilled the assumptions. Logarithmic transformation was used for number of grain per spike. Environmental variance, environmental coefficient of variation and Ecoavalance of Rick and non-parametric method Ketata were used to analyze stability of genotypes over two years. Environmental variance was calculated following Lin *et al.* (1986):

$$S_i^2 = \sum_{j=1}^{q} \frac{\left(X_{ij} - \bar{X}_{i.}\right)^2}{q-1}$$

Where, S_i^2: environmental variance, q: number year of assessment, $\bar{X}_{i.}$: lines mean studied in average of two years. Ecoavalance of Rick was calculated as:

$$W_i^2 = \sum_{j=1}^{q} \left(X_{ij} - \bar{X}_{i.} - \bar{X}_{.j} + \bar{X}_{..}\right)^2$$

Where, W_i^2 : Ecoavalance of Rick,
X_{ij}: line of i in year of j mean,
$\bar{X}_{i.}$: line of i mean in two years,
$\bar{X}_{.j}$: all of lines mean in year of j,
$\bar{X}_{..}$: all of lines mean in two years.

RESULTS AND DISCUSSION

Combined analysis of variance (Table 1) revealed significant differences between years for number of grain per spike, number of spike per square meter and 1000 grain weight. Differenced among lines were significant for grain yield and 1000 grain weight. Line × year interaction was significant for number of grain per spike, number of spike per square meter and 1000 grain weight. For a more detailed examination of these interactions and finding superior and adaptation lines stability analysis should be performed in different years (Farshadfar, 1998). Based on the Ketata (Fig. 1) and Rick, lines of 8, 15, 23, 45, 51 and 182 addition to more number of grain per spike, most stable lines or lines were with high relatively stability. It is noteworthy that line of 15 in terms of all stability parameters and the number of grain per spike was superior (Table 2).

lines of 102 and 296 with respect to the environmental variance and coefficient of variation and the lines of 183, 184, 239, 293 and 328 based on Ketata non-parametric method (Fig. 2) and line of 239 according to Ecoavalance of Rick were most stable and superior lines in terms of number of spikes per square meter (Table 3).

Based on Ketata non-parametric method (Fig. 3) and Ecoavalance of Rick, lines of 46, 93 and 159 were most stable lines and had high 1000 grain weight. Lines of Zagros and 145 with high 1000 grain weight were lines with high relatively stability (Table 4).

Lines of 23, 95, 293 and 296 with respect to the environmental variance and the coefficient of variation as most stable and superior lines and lines of 28, 31 and 281 according to Ecoavalance of Rick and Ketata ranking method (Fig. 4) most stable and superior lines were identified in terms of grain yield (Table 5).

Table 1: Combined analysis of variance in recombinant inbreed lines derived from across Zagros × Norstar.

Sources	DF	Mean Square			
		No. of grain per spike	No. of spike per square meter	1000 grain weight	Grain yield
Year	1	2204.022*	1158704.07**	2484.97**	115573.78ns
Yea/Repeatr	4	311.50	61991.07	21.97	145288.59
Line	39	73.45ns	11991.28ns	34.27**	9090.69**
Line×Year	39	51.53**	10969.47**	11.58**	3093.67ns
Error	156	21.96	5428.92	6.65	3579.91
Coefficient of Variation (%)		14.32	18.17	7.45	17.6

ns, * and **: not significant and significant at 5% and 1% probability levels, respectively.

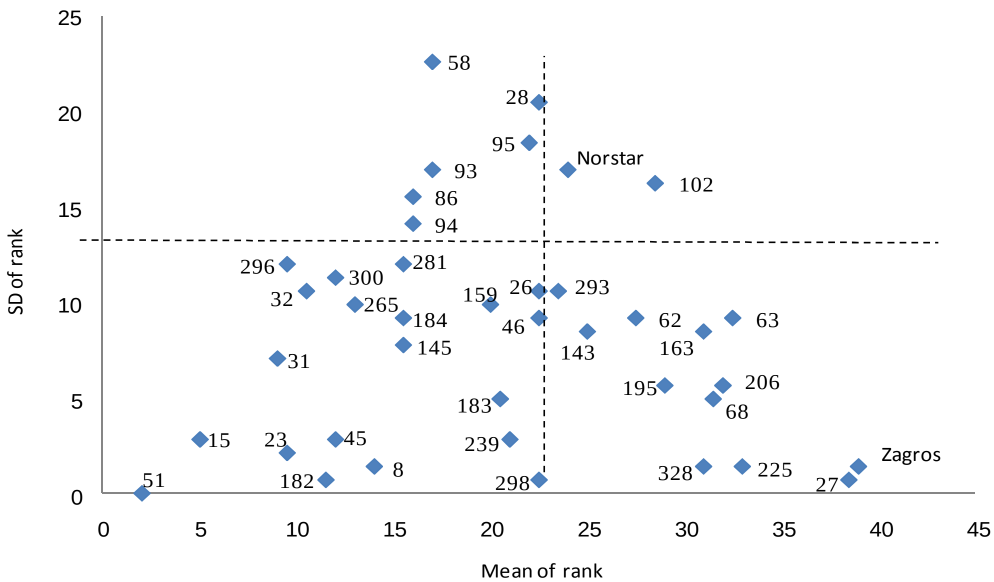

Fig. 1. Graph ranking of Ketata method in terms number of grains per spike for evaluated lines.

Table 2: Value of stability different parameters for number of grain per spike in bread wheat recombinant inbreed lines derived from across Zagros × Norstar.

No. of lines	Means of two years	Environmental variance	Environmental coefficient of variation	Rank mean	SD rank Ketata	Ecoavalance of Rick
Zagros	25.33	38.14	24.38	39	1.41	3.57
Norstar	31.43	81.92	28.79	24	16.97	22.71
8	34.33	21.34	13.46	14	1.41	0.11
15	37.95	3.83	5.15	5	2.83	5.43
23	35.82	20.69	12.70	9.5	2.12	0.07
26	31.83	48.68	21.92	22.5	10.61	7.24
27	26.13	11.52	12.99	38.5	0.71	0.79
28	32.02	4.21	6.40	22.5	20.51	40.15
31	36.30	1.39	3.25	9	7.07	9.65

No. of lines	Means of two years	Environmental variance	Environmental coefficient of variation	Rank mean	SD rank Ketata	Ecoavalance of Rick
32	38.00	118.58	28.66	10.5	10.61	43.61
45	35.15	27.13	14.82	12	2.83	0.85
46	31.60	43.56	20.89	22.5	9.19	5.35
51	41.36	38.14	14.83	2	0.00	3.57
58	37.85	292.01	45.15	17	22.63	163.91
62	30.28	3.13	5.84	27.5	9.19	6.34
63	28.00	68.05	29.46	32.5	9.19	15.71
68	29.20	30.42	18.89	31.5	4.95	1.51
86	34.00	90.67	28.01	16	15.56	27.42
93	33.68	5.45	6.93	17	16.97	43.81
94	34.05	88.45	27.62	16	14.14	26.20
95	32.37	2.42	4.81	22	18.38	34.12
102	29.05	5.01	7.71	28.5	16.26	42.57
143	31.18	40.80	20.48	25.5	8.49	4.42
145	33.87	2.42	4.59	15.5	7.78	7.45
159	32.85	0.53	2.22	20	9.90	12.64
163	29.40	49.34	23.89	31	8.49	7.50
182	35.63	19.22	12.30	11.5	0.71	0.01
183	31.87	34.72	18.49	20.5	4.95	2.58
184	33.92	51.68	21.20	15.5	9.19	8.43
195	29.52	8.41	9.82	29	5.66	1.92
206	28.85	6.60	8.91	32	5.66	2.95
225	28.60	19.22	15.33	33	1.41	0.01
239	32.47	10.58	10.02	21	2.83	1.07
265	35.18	0.05	0.60	13	9.90	16.59
281	34.12	0.25	1.45	15.5	12.02	14.37
293	31.27	0.38	1.96	23.5	10.61	13.49
296	37.95	9.53	8.14	9.5	12.02	54.37
298	31.72	19.85	14.05	22.5	0.71	0.03
300	35.17	71.20	23.99	12	11.31	17.24
328	29.15	15.13	13.34	31	1.41	0.16

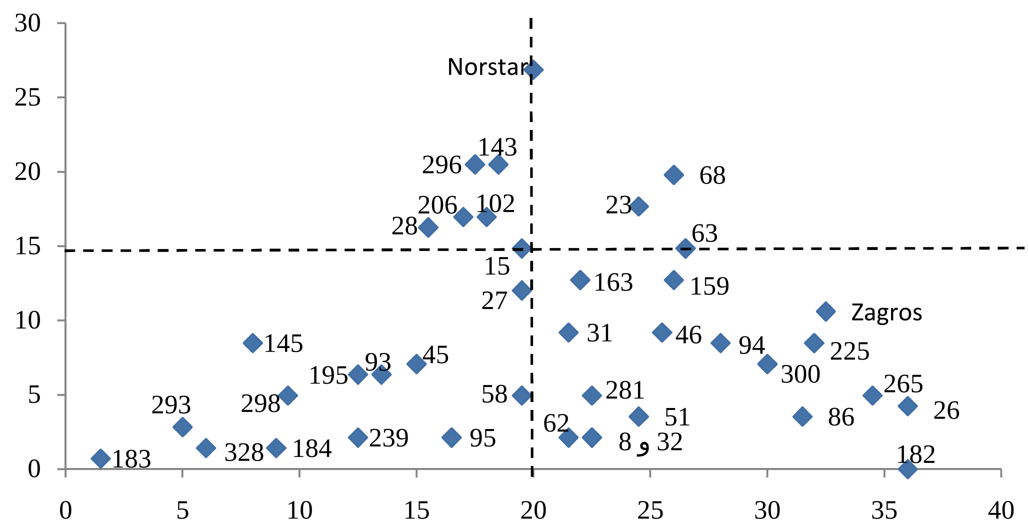

Fig. 2. Graph ranking of Ketata method in terms number of spike per square meter for evaluated lines.

Table 3: Value of stability different parameters for number of spike per square meter in bread wheat recombinant inbreed lines derived from across Zagros × Norstar.

No. of lines	Means of two years	Environmental variance	Environmental coefficient of variation	Rank mean	SD rank Ketata	Ecoavalance of Rick
Zagros	322.83	0.50	0.22	32.5	10.61	9517.86
Norstar	384.17	5724.50	19.69	20	26.87	30250.62
8	401.17	10512.50	25.56	22.5	2.12	18.18
15	426.50	29524.50	40.29	19.5	14.85	5411.12
23	371.25	78.13	2.38	24.5	17.68	7997.33
26	321.67	11755.04	33.71	36	4.24	103.10
27	420.33	25088.00	37.68	19.5	12.02	3615.05
28	423.33	938.74	7.24	15.5	16.26	4573.50
31	398.83	3444.50	14.72	21.5	9.19	1566.32
32	399.33	8106.46	22.55	22.5	2.12	67.74
45	439.33	20537.56	32.62	15	7.07	2028.85
46	391.25	17391.13	33.71	25.5	9.19	1129.55
51	391.33	13338.34	29.51	24.5	3.54	296.70
58	410.17	5583.07	18.22	19.5	4.95	554.45
62	401.83	10415.57	25.40	21.5	2.12	14.36
63	378.58	24162.61	41.06	26.5	14.85	3269.17
68	385.00	43218.00	54.00	26	19.80	12017.15
86	356.50	8756.94	26.52	31.5	3.54	21.98
93	431.08	5706.32	17.52	13.5	6.36	516.49
94	364.25	2211.13	12.91	28	8.49	2625.95
95	427.17	10512.50	24.00	16.5	2.12	18.18
102	403.00	648.00	6.32	18	16.97	5301.41
143	430.00	38825.70	45.82	18.5	20.51	9756.65
145	483.00	28003.98	34.65	8	8.49	4771.67
159	374.33	696.76	7.05	26	12.73	5165.34
163	410.33	24052.82	37.80	22	12.73	3228.86
182	332.00	7279.42	25.70	36	0.00	167.63
183	505.50	18366.78	26.81	1.5	0.71	1388.12
184	462.83	14620.50	26.13	9	1.41	512.96
195	464.67	19866.22	30.33	9.5	4.95	1821.67
206	436.33	34322.00	42.46	17	16.97	7568.19
225	334.50	953.10	9.23	32	8.49	4542.00
239	440.33	10082.00	22.80	12.5	2.12	4.59
265	342.08	11678.50	31.59	34.5	4.95	96.05
281	393.33	5904.58	19.54	22.5	4.95	459.05
293	477.17	18624.50	28.60	5	2.83	1459.62
296	408.00	22.18	1.15	17.5	20.51	8752.97
298	433.17	6013.75	17.90	12.5	6.36	429.25
300	372.00	15842.00	33.83	30	7.07	761.67
328	474.50	16020.50	26.67	6	1.41	801.20

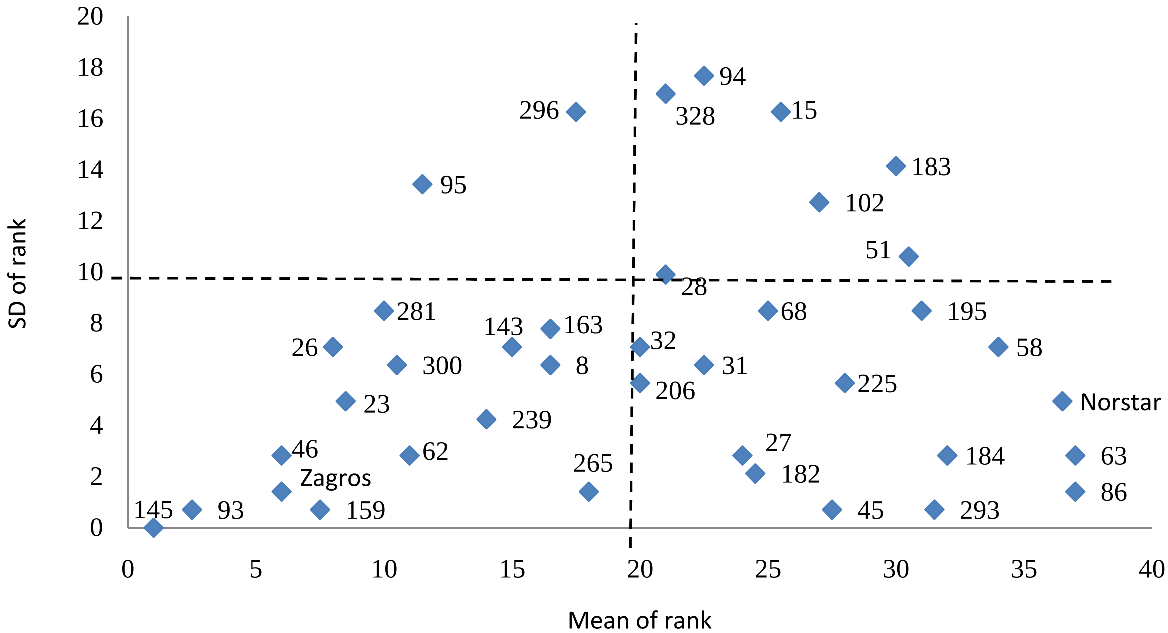

Fig. 3. Graph ranking of Ketata method in terms 1000 grain weight for evaluated lines.

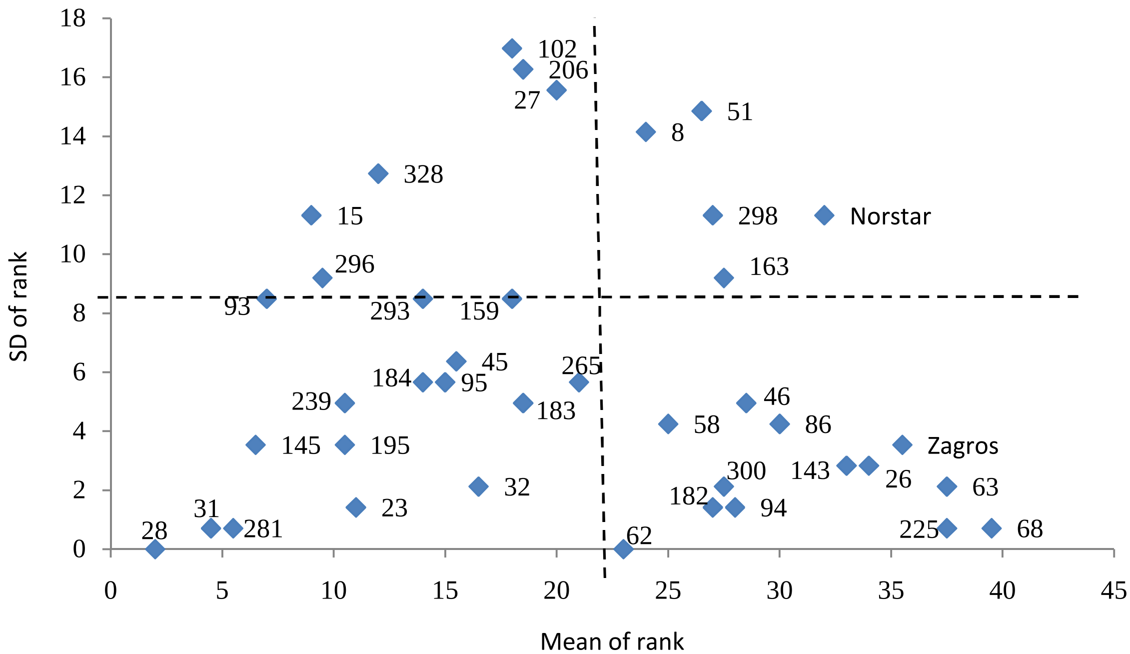

Fig. 4. Graph ranking of Ketata method in terms grain yield for evaluated lines.

Table 4: Value of stability different parameters for 1000 grain weight in bread wheat recombinant inbreed lines derived from across Zagros × Norstar.

No. of lines	Means of two years	Environmental variance	Environmental coefficient of variation	Rank mean	SD rank Ketata	Ecoavalance of Rick
Zagros	38.16	34.56	15.41	6	1.41	1.76
Norstar	30.69	4.71	7.07	36.5	4.95	5.66
8	35.20	13.53	10.45	16.5	6.36	0.76
15	33.73	46.50	20.22	25.5	16.26	5.14
23	36.65	10.55	8.86	8.5	4.95	1.70
26	36.89	7.93	7.63	8	7.07	3.01
27	33.87	26.12	15.09	24	2.83	0.31
28	34.15	5.70	6.99	21	9.90	4.68
31	34.20	31.39	16.38	22.5	6.36	1.11
32	34.63	11.24	9.68	20	7.07	1.44
45	33.20	19.80	13.40	27.5	0.71	0.01
46	37.89	20.47	11.94	6	2.83	0.00
51	32.86	42.42	19.82	30.5	10.61	3.85
58	31.72	33.05	18.12	34	7.07	1.43
62	36.53	32.07	15.50	11	2.83	1.24
63	30.62	5.19	7.44	37	2.83	5.16
68	33.56	7.65	8.24	25	8.49	3.19
86	30.90	7.84	9.06	37	1.41	3.07
93	39.15	30.58	14.12	2.5	0.71	0.96
94	33.82	0.83	2.69	22.5	17.68	13.26
95	37.32	67.67	22.04	11.5	13.44	13.51
102	32.86	3.06	5.33	27	12.73	7.84
143	35.54	32.47	16.03	15	7.07	1.32
145	40.35	47.24	17.03	1	0.00	5.39
159	38.06	34.88	15.52	7.5	0.71	1.84
163	35.25	35.50	16.90	16.5	7.78	1.98
182	33.65	17.29	12.36	24.5	2.12	0.15
183	32.46	57.89	23.44	30	14.14	9.35
184	32.27	21.14	14.25	32	2.83	0.00
195	32.13	6.51	7.94	31	8.49	4.00
206	34.38	30.91	16.17	20	5.66	1.02
225	33.14	30.10	16.56	28	5.66	0.87
239	35.61	14.15	10.56	14	4.24	0.62
265	34.96	18.41	12.27	18	1.41	0.07
281	37.64	58.08	20.25	10	8.49	9.43
293	32.22	14.42	11.79	31.5	0.71	0.57
296	36.09	75.97	24.15	17.5	16.26	17.35
298	32.14	11.19	10.41	32	2.83	1.45
300	36.24	9.19	8.36	10.5	6.36	2.31
328	33.91	0.71	2.48	21	16.97	13.75

Table 5: Value of stability different parameters for grain yield in bread wheat recombinant inbreed lines derived from across Zagros × Norstar.

No. of lines	Means of two years	Environmental variance	Environmental coefficient of variation	Rank mean	SD rank Ketata	Ecoavalance of Rick
Zagros	289.72	2451.40	17.09	35.5	3.54	341.39
Norstar	272.72	2616.54	18.76	32	11.31	6754.71
8	332.22	166.35	3.88	24	14.14	1930.07
15	394.01	10349.29	25.82	9	11.31	4998.00
23	365.70	164.89	3.51	11	1.41	331.02
26	292.76	2742.44	17.89	34	2.83	455.11
27	334.22	6213.90	23.59	20	15.56	2284.20
28	418.93	1171.28	8.17	2	0.00	10.17
31	401.28	1401.32	9.33	4.5	0.71	40.95
32	349.23	826.21	8.23	16.5	2.12	5.25
45	350.77	1813.22	21.14	15.5	6.36	133.33
46	310.08	2117.05	14.84	28.5	4.95	224.30
51	316.55	162.00	4.02	26.5	14.85	1915.19
58	327.01	2812.50	16.22	25	4.24	483.92
62	335.96	1175.64	10.21	23	0.00	10.58
63	280.75	1726.37	14.80	37.5	2.12	110.56
68	256.96	2829.02	20.70	39.5	0.71	490.78
86	308.60	2127.48	14.95	30	4.24	227.70
93	388.38	377.58	5.00	7	8.49	2546.84
94	319.69	725.42	8.42	28	1.41	16.82
95	362.35	80.52	2.48	15	5.66	486.82
102	353.19	628.71	7.10	18	16.97	3148.21
143	302.78	2108.60	15.17	33	2.83	221.55
145	400.32	2363.97	12.15	6.5	3.54	309.26
159	346.04	0.25	0.15	18	8.49	994.58
163	318.30	4356.18	20.74	27.5	9.19	1222.65
182	321.54	650.88	7.93	27	1.41	30.50
183	344.80	1723.43	12.04	18.5	4.95	109.82
184	352.56	1915.19	12.41	14	5.66	162.00
195	366.20	1173.22	9.35	10.5	3.54	10.35
206	339.24	6296.66	23.39	18.5	16.26	2334.49
225	280.44	1241.51	12.56	37.5	0.71	17.64
239	371.95	14.31	1.02	10.5	4.95	742.67
265	337.64	2135.96	13.69	21	5.66	230.48
281	397.25	1346.29	9.24	5.5	0.71	32.00
293	368.18	0.98	0.27	14	8.49	1025.59
296	377.90	89.38	2.50	9.5	9.19	1639.35
298	317.10	31.21	1.76	27	11.31	1341.10
300	313.36	1629.06	12.88	27.5	2.12	86.99
328	377.94	6987.98	22.12	12	12.73	2762.47

CONCLUSIONS

In general, each group of researchers use one or combination of these methods in their studies in order to find stable and high yielding varieties. Parametric parameters of environmental variance and coefficient of variation and Ecoavalance of Rick more emphasis on Genotype × environment interaction and select the genotypes that have biological stability but not great performance. These results correspond with comments of Lin and Binns (1988) and Backer (1981). Lin and Binns (1991) stated parametric parameters of environmental variance and coefficient of variation have the heritability and more reliable. Environmental coefficient of variation due to the introduction of high yield varieties that also have biological stability has a relative stability compared to other methods (Rao and Probhakaram, 2000). Finally Due to the interactions between genotype and environment, selecting varieties only in an environment is not appropriate criterion, so recommended tested varieties are evaluated in different locations and years. Information obtained from estimating the adaptability and stability genotypes function increase the performance of selection and introduction varieties.

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