The Grain Yield Performance and Stability Characters of Several Spring Wheat Genotypes in Transylvanian Plain Conditions

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Abstract

The current study presents some stability parameters (coefficient of variation, environment variation, regression coefficient, deviation from regression, coefficient of determination and ecovalence) of grain yields and the main components of its. Twenty-two spring wheat cultivars were tested in yield trials during three years being analyzed the number of grains per spike, thousand kernel weight and spike density The genotypes: Durom and Marcius indicated over the experimental years, a high stability for grain yield, based on three or more parameters (CV, s^2, b, s_d^2) and a good adaptation. Corso and Henica genotypes have a good stability for number of grains per spike with a medium number of grains, and TD 1524-71 is the most unstable genotype for thousand kernel weight. Regarding the correlation between stability parameters for analyzing characters there is a different and additional reaction according to differently performance of genotype.

Keywords: grain yield, performance, stability, yield components

Introduction

the value of genotype is given by the productivity performance which involves his adaptability to different conditions. In the current global context, the yield performance and yield stability of cereals represent an important aspect and the increasing yield without affecting yield stability is a major challenge for wheat breeding (Mustățea *et al*., 2009). The global warming is characterized by frequently shifts of weather patterns and extreme climatic events (Lobell *et al*., 2012; Semenov and Shewry, 2011; Sillmann and Roeckner, 2008), subjecting genotypes to supplimentary stress. However, the intrinsic uncertainty of climate change predictions poses a challenge to plant breeders and crop scientists who have limited time and resources and must select the most appropriate traits for improvement (Foulkes *et al*., 2011; Semenov and Halford, 2009; Zheng *et al*., 2012) Genotype x environment interaction is a major problems being a challenge issue for plant breeders improving high-yielding, stable genotypes for variable environments (Cruz *et al.,* 2012; Barros *et al.*, 2010; Kara, 2000). In the current population explosion, the food safety is seriously tried, caused especially by reduction of agricultural areas (Reisch *et al*., 2013). Even though the winter form of wheat is predominating in Europe due the favorable conditions, many times caused by the lack of soil water or due to the late issuance of land for previous crop which make impossible establishment of a crop in optimal conditions, the spring wheat occur important areas (Semenov *et al.,* 2014). Spring wheat yield capacity is often comparable with the winter crop, especially when in the fall of the year climatic conditions are unfavorable to grow and to develop the first stages of winter wheat plants.

Li *et al.* (2014) characterized the spring wheat ecotype as an optimal wheat genotype with a maximum potential for grain yield production under optimal growing conditions, compared with his short vegetation period.Wheat grain yield is a complicated quantitative parameter and it is the product of its interaction with environment and several yield attributes affecting grain yield (Anwar *et al*., 2009). Grain yield is highly affected by environmental stresses like drought stress caused by unavailability of water, less rainfall and heat stress because over 50% of the total wheat is sown late which results in terminal heat stress. The interaction between the traits of grain yield with the environment is very complex and non-linear making the objective assessment of the cultivar very difficult (Tsenov *et al*., 2014) There is great variability in the expression of many characteristics related to wheat quality and yield in different environments which accounts for the environmental effect on these characteristics (Castillo *et al.,* 2012).

High temperature accompanied with drought stress determine a reduced duration of maturation, grain filling period, grain yield capacity, mean grain weight per spike, grain number per spike and 1000 kernel weight (Kaur and Behl, 2010).

The stability parameters are specific to genetic value of each genotype and depend on the genotypes adaptability performance (Dewi *et al.*, 2014). If the main components of grain yield have some different stability parameters, the grain yield stability is the one that offers a complete information. The stability parameters offer important data about the performance of genotype in relationship with the environment conditions; both mean yield and stability might be considered simultaneously to exploit the useful effect of G^{x} E interaction (Bantayehu, 2009; Saad *et al.*, 2013). The knowledge of behavior of the main yield components, such as the number of grains per spike, thousand kernel weight and the spikes density per square meter helps to identify or setting the productivity elements allowing outside intervention in order to improve these characters.

The mean performance and the coefficient of regression were used as production response indices, while the deviation from regression, the coefficient of determination and the ecovalence were used as stability indices (Showemimo, 2007).

The aim of this study was to estimate the capacity of adaptability of some spring wheat varieties reflected in grain yield and yield components stability under three different years conditions.

Materials and methods

Twenty-two spring wheat varieties of different origins (Romania, Rusia, Hungary and Poland) were tested in the environmental conditions from Transylvanian Plain, Romania (520.5 mm average annual precipitation, 9.1 °C multi-annual mean temperature, longitude 23° 47'; latitude 46°35'; altitude 427 m). The study was realized during three years (2011-2013) in the yield trial field grown in randomized complete block design in three replications in Wheat Breeding Department of Agricultural Research and Development Station from Turda (Cluj, Romania). Even if the sum of precipitation is almost the same in the studied years (Tab. 1) the allocation of those by critical vegetation periods was different and the highest yield was recorded in 2012.

The yields and the main yield components as: number of grains/spike, spike density and thousand kernels weight were analyzed by ANOVA.

Characterization of genotypes stability for mentioned characters was achieved using the following statistics parameters:

coefficient of variation (cv%):

$$cv\ \% = \frac{s \times 100}{\bar{x}}$$

the environment variance (s^2):

$$s_i^2 = \sum\left(R_j - m_i\right)^2 / \left(e-1\right) \quad s_i^2 = \sum\left(R_{ij} - m_i\right)^2$$

where R_{ij}- observed genotype yield response in the environment *j*,

m_i – genotype mean yield across environments and

e – number of environments.

Highest stability is s^2 = 0.

Table 1. The rainfall conditions during experimental years

Year/ Month	2011		2012		2013		Multi-annual mean
	mm	Deviation from mean ±	mm	Deviation from mean ±	mm	Deviation from mean ±	
March	15.3	-7.8	5.3	-17.8	57.9	34.8	23.1
April	22.6	-22.1	78.4	33.7	53.3	8.6	44.7
May	41.4	-26.3	89.2	21.5	79.3	11.6	67.7
June	116.8	32.3	67.4	-17.1	86.2	1.7	84.5
July	130.4	53.7	52.4	-24.3	37.6	-39.1	76.7
Sum	326.5		292.7		314.3		296.7

regression coefficient [(b) Finlay and Wilkinson (1963)]:

$$\frac{\sum xy - \frac{\sum x \sum y}{N}}{\left(\sum x^2 - \frac{\sum x^2}{N}\right)} \qquad b_{y/x} = \frac{\sum xy - \frac{\sum x \times \sum y}{N}}{\left(\sum x^2 \times \frac{\sum x^2}{N}\right)}$$

The coefficient of regression and the mean yield in all environments were used to classify the varieties for stability. Finlay and Wilkinson (1963) concluded that a variety with b = 1 has average stability. A variety with b = 1 and above average yield was considered having general adaptation, while a variety with b = 1 and below average yield was classified as poorly adapted to all environments. b > 1 describes a variety with increased sensitivity to environmental changes, having lower stability and greater adaptability to high yielding environments. Regression coefficient less than 1.00 describes a variety with greater resistance to environmental changes, therefore, it has above average stability and specific adaptability to low yielding environments (Wu *et al*., 2014).

- deviations from regression [(Eberhart and Russell,1966]:

$$s_d^2 = \frac{1}{n-2}\left[\left(\sum F_j^2 - \frac{\left(\sum F_{ij}\right)^2}{n}\right) - \frac{\left(\sum F_j t_j\right)^2}{\sum t_j^2}\right] - \frac{\sigma_E^2}{r}$$

where n = number of environments, r = number of repetition, = the variance of error, = the mean of genotype *i* in environment *j*, = the effect of *j* environment.

A better stability of genotype is given by a small value of deviations from regression, approaching 0.

coefficient of determination (r^2- Pinthus, 1973):

$$r_i^2 = 1 - \frac{s_d^2}{s_x^2}$$

Pinthus (1973) proposed to use the coefficient of determination () instead of deviation of deviation mean squares to estimate stability of genotypes, because is strongly related to deviation mean squared (Becker, 1981).

Coefficients of determination (r^2) were obtained from the linear regression of individual yield in different environments on the mean yield of all the genotypes in each environment. Greatest stability is $r^2 = 1$.

- Wricke's ecovalence (W^2):

$$W_i^2 = \sum \left(R_j - m_i - m_j + m\right)^2$$

where R_{ij} is the observed yield response (averaged across experiment replicates), m_i and m_j correspond to previous notations, and m is the grand mean. Greatest stability is $W^2 = 0$.

Wricke's ecovalence (1962) evaluates stability on the basis of each genotype contributions to the total GEI (genotype x environment interaction) sum of squares. The genotypes with a low W_i value have a smaller deviation from the mean across environments and are thus more stable.

Results and discussions

The results from Tab. 2 highlighted the major influence of year growth conditions over the experimental years. The genotype influence is close to GE interactions which means that sensibility of cultivars was high, the grain yield or the other main yield components being dependent

Table 2. Analysis of variance for grain yield and main yield components of 22 spring wheat genotypes tested across three years in Transylvanian Plain conditions (Turda)

Source of variation	df	Grain yield	Number of grain/spike	1000- kernels weight	Spike density
Year	2	120.82**	240.31**	504.73**	6630.62**
Genotype	21	2.35**	68.73**	27.38**	56.22**
Year x genotype	42	3.20**	59.37**	12.30**	52.60**
Total	197				

Table 3. Grain yield and variation in studied spring wheat cultivars

Genotypes	Average yield	2011	2012	2013	Amplitude*
			($t\ ha^{-1}$)		
Lona	4.36	2.96	6.47	3.66	4.26
SG 106-01	4.32	2.87	5.84	4.24	3.23
Prif 3	4.27	2.60	6.65	3.56	4.56
Marcius	4.26	2.17	6.52	4.07	5.01
Corso	4.23	2.97	5.70	4.01	3.23
SG 5-01	4.21	2.66	6.20	3.78	4.13
PF 70-35-4	4.17	2.60	6.20	3.71	4.00
Jota	4.16	3.51	5.85	3.11	3.31
Jara	4.14	3.14	5.94	3.35	3.66
SG V 773	4.12	2.37	6.12	3.86	4.10
Henica	4.09	3.06	5.64	3.57	3.70
Sigma	4.07	3.52	5.67	3.03	3.40
Silva	3.92	2.98	5.67	3.12	3.18
Pădureni	3.87	2.60	5.46	3.57	3.66
Uralocica	3.87	2.98	5.30	3.34	3.42
Beloterkovskaia	3.84	2.86	5.63	3.04	3.23
GK Tavasz	3.82	2.45	5.62	3.38	3.72
Mario	3.77	3.02	5.25	3.05	3.40
Prif 4	3.75	2.51	5.00	3.75	2.94
TD 1524-71	3.67	1.78	5.63	3.61	4.50
Brome	3.64	2.56	5.19	3.17	3.22
Durom	3.63	2.90	4.82	3.16	2.51

* including repetition

of climatic conditions. The lack of water or high temperatures during the main plant phenophases (emergence, heading, flowering, grain filling and maturity) reduced the performances of genotypes (number of grains per spike, weight of grains per spike and thousand kernel weight) and finally the grain yield.

The variation of grain yields in tested cultivars is presented in Tab. 3. Environmental conditions determined a large fluctuation for grain yield especially for Marcius variety whose grain yield has recorded a biggest amplitude (5.013 t/ha^{-1}).

The smallest amplitude was registered by Durom variety (2.51 $t\ ha^{-1}$) but this reduced variation was caused by the poor potential of the genotype. The average capacity of spring wheat group for yield was between 2.5 -4.0 $t\ ha^{-1}$, but in favorable conditions the capacity of production of some genotypes can raise to 6-7 $t\ ha^{-1}$. Similar results for grain yield were reported by Kiliç (2012) in a multi-environments study for twenty-five bread spring wheat genotypes. Large amplitude regarding grain yields was obtained by Sapega and Tursumbekova (2013) in an ample study with spring wheat varieties and their adaptability in contrasting conditions.

The coefficient of variability showed a high variability for all genotypes regarding the grain yield (tab. 4). The other stability parameters (s^2, b, r^2 and W^2) indicated a specific stability for each genotype. Regarding the stability of grain yield of the studied spring wheat genotypes, the stability parameters s^2 and b indicated a high stability for Durom and Prif 4 varieties.

Based on Wricke's coefficient (W^2) the most stable varieties are GK Tavasz, Brome and Pădureni, and the most unstable genotypes are GK Marcius, followed by TD 1524-71 and Sigma. Amin

Table 4. Several stability parameters of grain yield for 22 spring wheat genotypes

Genotypes	$\overline{\mathbf{x}}\overline{\mathbf{x}}$ (t/ha)	CV (%)	s^2	b		r^2	W^2
Lona	4.36	40.0	3.	1.20	0.02	0.99	0.53
SG 106-01	4.32	33.1	2.0	0.94	0.23	0.91	0.95
Prif 3	4.27	45.0	3.7	1.32	0.10	0.98	1.44
Marcius	4.25	47.0	4.0	1.35	1.48	0.95	2.24
Corso	4.23	30.1	1.6	0.87	0.04	0.98	0.35
SG 5-01	4.21	39.2	2.7	1.14	0.05	0.99	0.39
PF 70-35-4	4.17	40.7	2.9	1.17	0.05	0.99	0.50
Jota	4.16	33.9	2.0	0.91	0.32	0.87	1.35
Jara	4.14	35.8	2.2	1.01	0.09	0.97	0.38
SG V 773	4.12	42.1	3.0	1.18	0.14	0.96	0.91
Henica	4.09	32.6	1.8	0.89	0.17	0.93	0.79
Sigma	4.07	33.5	1.9	0.87	0.37	0.84	1.65
Silva	3.92	35.6	1.9	0.95	0.09	0.96	0.40
Pădureni	3.88	36.5	2.0	0.97	0.06	0.98	0.23
Uralocica	3.87	32.1	1.5	0.84	0.10	0.95	0.69
Beloterkovskaia	3.84	37.5	2.1	0.98	0.09	0.96	0.37
GK Tavasz	3.82	39.2	2.2	1.03	0.02	0.99	0.09
Mario	3.77	34.8	1.7	0.86	0.20	0.91	1.00
Prif 4	3.75	31.3	1.4	0.78	0.13	0.92	1.04
TD 1524-71	3.67	47.8	3.1	1.15	0.39	0.90	1.81
Brome	3.64	36.1	1.7	0.91	0.02	0.99	0.17
Durom	3.63	27.9	1.0	0.69	0.03	0.98	1.11
Mean	4.01	36.9	2.3	1.00	0.19	0.95	0.84

et al. (2005) found for 10 spring wheat genotypes grown in 9 locations from Pakistan the regression coefficient (b_i) value between 0.367 to 1.626, and deviation from regression between 0.065-0.601.

The present results for grain yield are in accordance for one or more of the studied parameters (*CV*, s^2, b_i , , r^2 and W^2) have been reported by Kilic *et al.* (2010), Akcura *et al*. (2006) and Hugo Ferney *et al.* (2007).

The stability of grain yield depends on stability of the main elements of productivity (Yagdi, 2009; Andersen *et al.* 2011). Thus, the stability of number of grain per spike had small values to medium according to variability coefficient (tab. 5). The coefficient of variability for number of grains per spike ranged between 2.02 by Corso variety to 24.9 at TD 1524-71. Environmental variance (s^2) had oscillating values between 0.42 at the same Corso variety to 56.1 by Lona genotype, with an average value of this parameter by 24.1 units. Based on b and r^2 values the most stability genotype is Henica, followed by GK Tavasz and Corso varieties.

The values of deviations from regression for number of grains per spike (δ^2) also offers some additional information but somewhat different, such that relating to this parameter the GK Tavasz genotype are the most instable cultivars contrary with intercept appreciation, but in concordance with Wricke's coefficient.

Generally, thousand kernel weight is a stable character by winter wheat, but in case of spring wheat the variability of this character is fluctuating being dependent by environment conditions (Kaya and Akcura, 2014), especially rainfall. The large variation of coefficient of variability (12.3% at Pădureni variety up to 24.8 by TD 1524-71) can be caused by high sensibility of those wheat genotype (Tab. 6).

The same instability of TKW can be observed in case of environment variability parameter (s^2) for TD 1524-71 genotype (94.19) compared with small value of this parameter at Marcius variety (21.32). The same data regarding the stability of thousand kernel weight was obtained by the coefficient of regression, highlighting those two cultivars (TD 1524-71 and Marcius) as a contrasting reaction. Deviations from regression (δ^2) and ecovalence (W^2) offers different information regarding the most stable or unstable genotypes, meanwhile the coefficient of determinations ranks the cultivars with the same responses (Alberts, 2004).

Table 5. The stability parameters for number of grain per spike for 22 spring wheat genotypes

Genotypes	$\bar{x}$	CV (%)	s^2	b		r^2	W^2
SG 5-01	36.4	9.4	11.8	0.79	4.35	0.71	20.4
Prif 3	35.1	15.1	28.2	1.12	14.02	0.60	56.6
PF 70-35-4	34.4	13.0	20.0	1.09	4.99	0.80	20.4
SG V 773	34.1	7.5	6.6	0.32	6.56	0.21	56.9
Corso	32.3	2.0	0.4	0.07	0.45	0.16	59.5
Jota	32.1	9.9	10.1	0.38	10.20	0.20	66.0
Marcius	32.1	15.3	24.2	0.88	17.27	0.43	70.6
SG 106-01	32.0	15.3	24.1	1.23	4.52	0.85	21.6
Lona	32.0	23.4	56.1	1.97	4.48	0.94	82.5
Sigma	31.9	13.8	19.3	0.89	10.71	0.56	43.1
Pădureni	31.4	13.7	18.5	1.07	3.81	0.83	15.6
GK Tavasz	31.2	14.5	20.3	0.08	25.29	0.00	157.8
Brome	31.1	16.7	26.9	1.18	10.20	0.70	43.5
Henica	30.9	7.7	5.6	0.03	7.04	0.00	91.4
Beloterkovskaia	30.8	21.2	42.6	1.49	15.55	0.71	78.8
Jara	30.8	17.8	30.0	1.42	3.32	0.91	25.6
Prif 4	30.7	21.9	44.1	1.72	4.94	0.91	55.7
Durom	30.1	11.5	12.0	0.83	3.26	0.78	15.0
Silva	29.5	16.5	23.8	1.02	12.20	0.59	48.6
TD 1524-71	29.3	24.9	53.3	1.78	13.02	0.80	93.8
Uralocica	29.3	17.2	25.4	1.25	5.22	0.84	25.5
Mario	29.3	18.0	27.8	1.37	3.11	0.91	22.1
Mean	31.6	14.8	24.1	1.00	8.39	0.61	53.2

Table 6. The stability parameters for thousand kernel weight of 22 spring wheat genotypes

Genotypes	$\bar{x}\bar{x}$ (g)	CV (%)	s^2	b		r^2	W^2
TD 1524-71	39.1	24.8	94.2	1.56	1.18	0.99	64.50
Uralocica	38.1	13.1	24.8	0.78	1.57	0.95	15.41
Pădureni	38.0	12.3	22.0	0.75	0.38	0.99	13.47
Durom	36.5	13.2	23.0	0.76	1.09	0.96	15.54
Prif 4	36.3	21.3	59.9	1.23	1.80	0.98	17.64
Lona	36.3	20.3	54.2	1.18	0.79	0.99	9.42
Silva	36.0	22.4	64.5	1.28	1.83	0.98	22.51
Brome	35.7	13.8	24.4	0.79	0.48	0.98	10.37
Corso	35.7	14.9	28.2	0.84	1.67	0.95	11.88
Marcius	35.4	13.1	21.3	0.71	2.78	0.90	27.85
Mario	35.2	23.1	66.2	1.29	2.47	0.97	26.43
SG 106-01	34.9	13.5	22.3	0.75	0.60	0.98	14.16
Jota	34.5	18.7	41.4	1.03	0.77	0.99	3.28
Jara	34.5	18.3	39.6	0.98	3.19	0.94	12.82
GK Tavasz	34.4	13.6	21.8	0.73	1.50	0.94	19.84
PF 70-35-4	34.3	16.9	33.6	0.93	0.61	0.99	3.44
Henica	34.3	19.4	44.2	1.06	1.62	0.97	7.11
Beloterkovskaia	33.7	24.1	66.0	1.29	3.09	0.96	27.98
Prif 3	32.9	21.4	49.6	1.11	3.21	0.95	15.03
SG 5-01	32.8	15.3	25.2	0.79	1.27	0.96	13.21
SG V 773	32.8	17.9	34.6	0.94	0.40	0.99	2.20
Sigma	32.8	23.6	59.7	1.22	3.16	0.96	21.94
Mean	35.2	18.0	41.7	1.00	1.61	0.97	17.09

Table 7. The stability parameters for spikes density per unit area for 22 spring wheat genotypes

Genotypes	$\bar{x}$	CV (%)	s^2	b		r^2	W^2
SG 106-01	564.6	38.9	48237.6	1.30	2895.6	0.95	23874.1
SG V 773	558.7	41.7	54158.3	1.40	1513.4	0.98	27430
Jota	548	33.8	34306.3	1.09	2766.7	0.94	12116.8
Henica	544.5	39.5	46219.5	1.27	2946.5	0.95	21804.1
Silva	542	33.9	33782.6	1.09	1616.3	0.96	7684.3
Jara	530.8	29.0	23719.2	0.89	2917.1	0.90	13364.9
Uralocica	530.3	30.2	25599.4	0.96	652	0.98	2798.7
Prif 3	518.9	37.9	38731.7	1.19	591.1	0.99	7141.3
Mario	512.8	24.9	16345	0.76	959.2	0.95	11784.4
PF 70-35-4	507.6	38.2	37545.7	1.17	428.3	0.99	5677.4
Sigma	507.5	25.5	16774.3	0.78	523.0	0.98	8866.5
Prif 4	506.4	33.9	29402.8	1.04	219.6	0.99	1072.4
SG 5-01	505.7	30.3	23413.6	0.92	442.5	0.99	2581.6
Lona	500.3	25.8	16665.8	0.77	608.0	0.97	9464.2
Brome	498.7	33.5	27929.5	1.01	411.4	0.99	1659.3
Pădureni	494.6	31.4	24051.6	0.93	964.1	0.97	4586.5
Corso	489.2	37.0	32829.8	1.08	1604.1	0.96	7251
Beloterkovskaia	488.8	23.3	13015.5	0.66	1664.3	0.90	22671.7
TD 1524-71	486.2	35.4	29546.4	1.02	1489.0	0.96	6022.5
Marcius	475.9	37.1	31209.3	1.01	4654.6	0.88	18614.5
Durom	470.5	25.4	14325.7	0.70	1524	0.91	18702.6
GK Tavasz	469.8	34.5	26276	0.98	326.4	0.99	1362.3
Mean	511.4	32.8	29276.6	1.00	1441.7	0.97	10751.4

Ayed *et al.* (2016) have obtained higher value for deviation from regression and lower value for coefficient of determination in his study using durum wheat, bread wheat and barley. A small coefficient of variability was founded by Chang *et al*. (2010) analyzing 13 cultivars in a multi-location study in China.

The density of spikes per square meter depends mainly by soil water reserves, tillering capacity and also in some wise by grain size (Madani *et al*., 2010). The average of spikes density per square meter was close by the number of grains seeded, which means that the capacity of spring wheat to make some fertile tillers are very low. As a stability parameter for this element of productivity, the coefficient of variability, environment variance and regression coefficient highlight the same genotypes as a stable - Beloterkovskaia and unstable -SG V 773 (Tab. 7).

Deviations from regression parameter varied from 219.6 for Prif 4 to 4656.6 by Marcius as the most instable cultivars for spikes density per square meter, strengthened data also by the coefficient of determination (0.88). Also, Wrike's coefficient had large variations from 1072.4 by Prif 4 genotype to 23874.1 for SG 106-01. Aycicek and Yildirim (2006) have obtained superior value for spike number per unit area, but similar results for b_i, and r^2 in a two years study for high-yielding and stable wheat cultivar in two growing locations.

The significant positive correlation (P ≤0.05) was obtained between mean grain yield and environment variance-s^2 (tab. 8). A stronger relationship (P ≤0.01) was observed between regression coefficient and grain yield, coefficient of regression and variability coefficient, and also with s^2.

Table 8. Correlations between stability parameters for different quantitative parameters

Correlated character	CV	s^2	b		r^2	W^2
Grain yield (t ha^{-1})						
$\bar{x}$	0.22	0.53*	0.54**	0.55**	0.04	0.11
CV	1	0.93**	0.93**	0.94**	0.18	0.34
s^2		1	0.99**	1.00**	0.20	0.39
b			1	0.99**	0.31	0.25
				1	0.18	0.34
r^2					1	-0.62**
W^2						1
Number of grains/spike						
$\bar{x}$	-0.47*	-0.35	-0.29	-0.34	-0.20	-0.12
CV	1	0.96**	0.89**	0.99**	0.67**	0.13
s^2		1	0.89**	0.97**	0.63**	0.20
b			1	0.90**	0.90**	-0.27
				1	0.68**	0.12
r^2					1	-0.61**
W^2						1
Thousand kernel weight (g)						
$\bar{x}$	-0.16	0.13	0.08	0.07	0.18	0.45*
CV	1	0.95**	0.97**	0.97**	0.27	0.43*
s^2		1	0.99**	0.99**	0.31	0.63**
b			1	1.00**	0.35	0.55**
				1	0.32	0.56**
r^2					1	-0.11
W^2						1
Spikes/density per unit area						
$\bar{x}$	0.38	0.65**	0.62**	0.24	0.13	0.37
CV	1	0.94**	0.96**	0.27	0.26	0.12
s^2		1	0.99**	0.31	0.23	0.33
b			1	0.23	0.33	0.19
				1	-0.80**	0.66**
r^2					1	-0.61**
W^2						1

***** significant at the 0.05 probability level
****** significant at the 0.01 probability level

Deviation from regression can be strongly associated with mean, coefficient of variability, environment variance and coefficient of regression.

A negative relation (R=-0.62) was obtained between Wricke's coefficient and determination coefficient.

The stability parameters for number of grains per spike were highly correlated for the most cases except the relations with grain yield and Wricke's coefficient, where in case of relationship between grain mean and coefficient of variability (-0.47), coefficient of determination and Wricke ecovalence appear a strongly significant negative correlation (-0.61). Similar results were obtained by Akcura *et al*. (2006) for durum wheat.

For thousand kernel weight the association of stability parameters was different, probably caused by high genetic determination of this character.

Thus, some strong relations were maintained while the negative relation between ecovalence and r^2 were poorly. In this case, the high correlation between ecovalence and deviation from regression suggest that the covariance usually explains only a small part of W^2 (Hill *et al*., 1998).

High negative significance was noted between r^2 and **,** and between r^2 and Wricke's ecovalence in case of spikes density per square meter, while between s^2 and mean value, s^2 and CV, b and mean, b and CV, and b and s^2 was recorded a high positive correlation which means that the stability can be appreciated by each of these parameters.

Conclusion

Our research demonstrated the applicability of stability parameters to other quantitative traits than yield, such as number of grains per spike, thousand kernel weight and spike density per unit area. Correlations between stability parameters showed that any of stability indices could be used without to lose the yield efficiency.

The genotypes: SG 106-01, SG 5-01, Prif 3, Sigma, Jota, Henica, Lona, Corso and Marcius, indicated high stability and adaptation. These genotypes can be recommended for cultivation in Transylvanian Plain conditions, or in other European environments with appropriate climatic factors.

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