Original Article

ADAPTABILITY AND STABILITY OF SOYBEAN YIELD IN TWO SOYBEAN PRODUCING REGIONS

ADAPTABILIDADE E ESTABILIDADE DA PRODUTIVIDADE DE SOJA EM DUAS REGIÕES SOJÍCOLAS

Leonardo Gonçalves OLIVEIRA[1]; Osvaldo Toshiyuki HAMAWAKI[2]; Gustavo André SIMON[3]; Larissa Barbosa de SOUSA[4]; Ana Paula Oliveira NOGUEIRA[5]; Daniela Freitas REZENDE[6]; Cristiane Divina Lemes HAMAWAKI[7]

1. Monsanto Ltda, Mestre em fitotecnia, Universidade Federal de Uberlândia - UFU, Uberlândia, MG, Brasil, leonardo.oliveira@monsanto.com . 2. Professor, Doutor, Bolsista de Produtividade em Desenvolvimento Tecnológico e Extensão Inovadora do CNPq, Instituto de Ciências Agrárias – ICIAG, Universidade Federal de Uberlândia - UFU, Uberlândia - MG, Brasil; 3. Professor, Doutor, Professor, Universidade de Rio Verde, Rio Verde – MT, Brasil; 4. Doutoranda em Agronomia, ICIAG - UFU, Uberlândia, MG, Brasil. 5. Professora, Doutora, ICIAG - UFU, Uberlândia, MG, Brasil. 6. Professora, Mestre em fitotecnia, Universidade Luterana do Brasil - ULBRA Itumbiara, GO, Brasil.7. Professora, Mestre, Universidade de Uberaba, Uberaba-MG, Brasil.

RESUMO: O objetivo desse trabalho foi avaliar a adaptabilidade e estabilidade de genótipos de soja cultivados em duas micro-regiões sojícolas 301 e 401, nas safras agrícolas 2006/2007 e 2007/2008. Foram estudados 16 genótipos de soja (6 linhagens do programa de melhoramento de soja da Monsoy Ltda e 10 cultivares comerciais). Os experimentos foram conduzidos em delineamento de blocos completos ao acaso, com três repetições. Foram realizadas análises de variância individual e conjunta e estimados os parâmetros de adaptabilidade e estabilidade pelos métodos propostos por Eberhart e Russel, Annicchiarico, Linn e Binn e Centroide. Os resultados evidenciaram interação genótipos e ambientes evidenciando comportamento diferenciado dos genótipos frente às oscilações ambientais. Os métodos de Annicchiarico, Linn e Binns, modificado por Carneiro e Centróide, apresentaram coerência entre si e permitiram identificar, entre os genótipos avaliados, os de maior estabilidade e adaptabilidade. As cultivares M-SOY 7908 RR, M-SOY 8199 RR e VALIOSA RR são de adaptabilidade e estabilidade geral. As linhagens LG4 e LG5, e a cultivar M-SOY 7908 RR comportaram-se como alta adaptabilidade e estabilidade em ambientes favoráveis e a testemunha M-SOY 8199 RR para ambientes desfavoráveis e a linhagem LG4 apresentou alta adaptabilidade e estabilidade em ambientes favoráveis. As cultivares MSOY 8199 RR e BRS Valiosa tiveram respectivamente adaptação à ambiente desfavorável e geral, considerando os quatros métodos avaliados neste estudo.

PALAVRAS-CHAVE: *Glycine max*. Interação genótipos e ambientes. Adaptabilidade e estabilidade.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is among the most cultivated plants in the world and Brazil is a major producer of grain crop, placing the country as the second largest producer, processor and exporter (EMBRAPA, 2008). However, obtaining high yields of grain has been limited due to diseases that attack the crop and the environment in which genotypes are grown.

The soybean phenotype depends on the genotype, the environment and the genotype (G) x Environment (E) interaction. This interaction occurs due to inconsistency of the genotype performance in various environments, reflecting the different responses to the same environmental changes (PELÚZIO et al. 2008).

The GxE interaction assumes a key role in the phenotypic manifestation of soybeans, because of the frequent exposure of plants to different environmental conditions (PRADO et al., 2001) and constitutes one of the major problems of breeding programs either in the phase selection or cultivar recommendation. Among the alternatives to mitigate the influence of this interaction the use of cultivars with wide adaptability and good stability has been recommended (BARROS et al., 2010).

Adaptability is the ability of the genotypes to advantageously make use of environmental stimulation; stability is the ability of the genotypes of showing a highly predicTable behavior as a function of environmental stimulation (CRUZ et al. 2006). For the evaluation of the genotypes and in order to study the adaptability and stability, it is necessary to conduct experiments and also in a wide range of environmental conditions and is one of the most important, laborious and costly steps in a breeding program (SILVA; DUARTE, 2006; MAIA et al., 2006; ROCHA et al., 2005; NUNES et al., 2002; ATROCH et al., 2000; PRADO et al., 2001).

The employment of an adaptability and stability methodology of genotypes provides information that enables the identification of predicTable and responsive genotypes in the face of

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environmental fluctuations. There are several methods for studying adaptability which differ as to the statistical principles and ease of interpretation; nevertheless, there are alternative and complementary methods (CRUZ et al., 2004). Among the most used methods of studies on soybeans there are those based on regression such as Eberhart and Russel (1966) and the nonparametric methods of Linn and Bins (1988) modified by Carneiro (1998) and Annicchiarico (1992).

This study aimed to evaluate by different methods the adaptability and stability of soybean genotypes in two soybean producing micro-regions (301 and 401), in the harvest seasons of 2006/2007 and 2007/2008.

MATERIAL AND METHODS

The trials were installed in Macro-region sojícola 3, more specifically in the micro-region 301 and in the soybean producing Macro-region 4, micro-region 401, for two consecutive harvest seasons (2006/2007 and 2007/2008) (Table 1).

Table 1. Regions and geographic location of the cities where sixteen soybean genotypes were evaluated during the harvest seasons of 2006/2007 and 2007/2008.

Enviroment	Region	City	State	Altitude	Latitude	Crop	Month sowing
1	301	Edéia	GO	521 m	17° 38' 13" S	2006/2007	nov
2	301	Santa Helena de Goiás	GO	572 m	17° 50' 45" S	2006/2007	nov
3	301	Araporã	MG	560 m	18° 21' 16" S	2006/2007	nov
4	301	Barretos	SP	500 m	20° 28' 34" S	2006/2007	nov
5	401	Rio Verde	GO	852 m	18° 04' 55" S	2006/2007	out
6	401	Jataí	GO	860 m	18° 04' 55" S	2006/2007	out
7	401	Mineiros	GO	967 m	17° 21' 18 S	2006/2007	out
8	401	São Gabriel do Oeste	MS	650 m	19° 40' 03" S	2006/2007	out
9	301	Edéia	GO	527 m	17° 39' 16" S	2007/2008	nov
10	301	Goiatuba	GO	560 m	18° 21' 37" S	2007/2008	nov
11	301	Santa Helena de Goiás	GO	565 m	17° 48' 41" S	2007/2008	nov
12	301	Barretos	SP	510 m	18° 28' 46" S	2007/2008	nov
13	401	Rio Verde	GO	828 m	18° 04' 56" S	2007/2008	out
14	401	Jataí	GO	740 m	17° 52' 42" S	2007/2008	out
15	401	Mineiros	GO	905 m	17° 33' 55" S	2007/2008	out
16	401	Montividiu	GO	817 m	17° 26' 38" S	2007/2008	out
17	401	São Gabriel do Oeste	MS	680 m	19° 32' 35" S	2007/2008	out
18	401	Costa Rica	MS	650 m	18° 50' 25" S	2007/2008	out
19	401	Chapadão do Sul	MS	790 m	18° 60' 45" S	2007/2008	out
20	401	Sonora	MS	445 m	17° 60' 53" S	2007/2008	out

Six lineages were evaluated in the trials. The lineages came from the Monsoy breeding program, more specifically the Morrinhos - GO research station, and ten commercial cultivars were evaluated (M-SOY 7908 RR; M-SOY8000 RR; CD 219 RR; BRS FAVORITA RR; M-SOY 8045 RR; M-SOY 8199 RR; M-SOY 7211 RR; TMG103 RR; BRS VALIOSA RR and M-SOY 7578 RR).

The experimental design that was utilized was a randomized complete block design with three replications. The experimental plot was consisted of four rows of plants with 5.0 m of length, spaced at 0.5 m, with a total area of 10 m^2.

The soil preparation was done in a conventional manner, i.e. with two plowing and harrowing. Before the sowing, the area was plowed and fertilized. As for the cultural practices employed in weed control, herbicides were used in pre- and post-emergence phases supplemented with hand weeding as necessary, as recommended for soybean crops (EMBRAPA, 2004).

The yield was evaluated after harvesting the usable area of each plot and weighing of the grains obtained after the tracks of bundles of plants and the cleaning of the grain. The data (grams per plot) were converted to kg ha^{-1} and this yield was corrected for a moisture content of 13%.

The analysis of variance was held using the F test for each growing site separately and subsequently the combined analysis was performed. The adaptability and stability methodology was determined by: Eberhart and Russell, Lin and Binns, Annicchiarico and the Centróide. The Eberhart and Russell (1966) method is based on a simple linear regression analysis in which the effect of the environment is the independent variable and the average yield of each genotype in each environment represents the dependent variable. The parameters regression coefficient (βi), average yield (μ_i) and variance of the regression deviations (σ^2_{di}) are used in the evaluation of each individual genotype, whose estimators are:

$$\overline{Y_j} = \frac{\sum_j Y_{ij}}{a}$$

$$Y_{ij} = \mu + \beta_i I_j + \sigma_{ij} + \varepsilon_{ij}$$

$$\hat{\beta}_i = \frac{\sum_j Y_{ij} I_j}{\sum_j I_j^2}$$, in which Y_{ij} refers to the genotype average i (i=1,2,...,g) in the environment j (j=1,2,...,n) and

$$I_j = \frac{\sum_j Y_{ij}}{g} - \frac{\sum_i \sum_j Y_{ij}}{ng}$$ is the environmental index;

$$\hat{\sigma}^2_{di} = \frac{\left[\sum_j Y_{ij}^2 - \left(\sum_j Y_{ij}\right)^2 / n\right] - \left(\sum_j Y_{ij} I_j\right)^2 / \sum_j I_j^2}{n-2}$$

The method proposed by Lin and Binns (1988) sets as a measure of stability the parameter Pi as being the maximum extent of superiority of one genotype. This parameter represents the average square of the distance between the response of a specific genotype with respect to the response of the genotype which has maximum yield among all genotypes in a given environment. The shorter the distance between the genotype and response of maximum yield, i.e. the lower P_i, more sTable is the genotype. An advantage of this methodology is that it attempts to combine stability with adaptability in just one parameter (P_i).

$$P_i = \frac{\sum_{j=1}^{n} (X_{ij} - M_j)^2}{2n}$$

In which: P_i corresponds to the estimate of adaptability and stability of the genotype i; X_{ij} is the yield of ith genótipo in the jth place; M_j is the maximum response observed between all genotypes in the place *j* e *n* is the number of places. The sTable genotype is the one that presents the lowest P_i.

In the method proposed by Annicchiarico (1992), the stability is measured by the superiority of the genotype compared with the average of each environment. The method is based on the estimation of a confidence index (or recommendation index) from a given genotype to show a relatively higher behavior (CRUZ et al., 2006).

In this method both the performance of the genotype and its stability are considered so that the recommendation index values are obtained for those of higher and lower deviation percentage. In the method proposed by Annicchiarico (1992), the following model was used:

$$I_i = \overline{Y}_i - Z_{(1-\alpha)} S_i$$

In which: I_i is the confidence index (%); $\overline{Y}_i$ is the general average of cultivar *i* in average environmental percentage; S_i is the standard deviation of the percentage values of the genotype i, Z is the percentile (1-α) the cumulative normal distribution function and α is the pre-determined significance level.

The Centroid Method facilitates the interpretation of the data and the selection of the genotype that is closest to the ideal genotype. First, it is assumed the existence of four referentials or ideotypes and through clustering techniques based on distances to the ideotypes which seeks to classify the different genotypes. The ideotypes were defined on the basis of experimental data, such as:

Ideotype I: offers maximum overall adaptability, with the highest values observed in all environments.

Ideotype II: has maximum adaptability to the specific favorable environment with maximum response in a favorable environment and minimal response to unfavorable environment.

Ideotype III: has maximum specific adaptability to unfavorable environment showing maximum response in an unfavorable environment and minimum response in a favorable environment.

Ideotype IV: has minimal adaptability by presenting minimum values observed in all environments.

The following index was used to classify favorable or unfavorable environments:

In which:

Y_{ij}: average of the genotype i in the environment j;

$Y_{..}$: total of observations;

a : number of ambientes; and
g : number of genotypes.

A cluster analysis was performed by calculating the euclydean distances of each genotype to the centroids established by:

$$D_{ik} = \sqrt{\sum_{j=1}^{a}(X_{ij} - C_{ijk})^2}$$

In which: D_{ik} is the distance of the genotype i to the centroid k (k = 1,2,3 e 4).

In possession of the values of D_{ik} the following classification is performed:

General adaptability: when D_{i1} is the lowest value that was obtained.

Specific adaptability to favorable environments: when D_{i2} and the lowest value.

Specific adaptability to unfavorable environments: when D_{i3} is the lowest value that was obtained.

Not adapted: when D_{i4} is the lowest value that was obtained.

The statistical analyzes and biometrics of stability and adaptability were processed with the aid of computer application in genetics and statistics (GENES), developed by Cruz (2006).

RESULTS AND DISCUSSION

The result of the analysis of joint variance for the grain yield revealed significant effects at 1% probability for all sources of variation, ie, genotypes, location and interaction of genotype and environment. The experimental coefficient of variation was of low magnitude (4.9%), indicating good experimental precision, and is therefore below the limit suggested by Carvalho et al. (2003) which proposed maximum coefficient of variation of 16% for grain yield in soybeans grown under field conditions.

The result of a significant interaction between genotypes x environment highlights the different behavior of the genotypes according to environmental fluctuations which justifies the studies of phenotypic adaptability and stability. Studies of this nature contribute to the identification and selection of genotypes of predicTable behavior and that are responsive to changes in environments.

In the Table 2, is the classification of environments favorable and unfavorable in relation to environmental index as the methodology of Annicchiarico (1992). It was found that the soybean producing region 401 was classified as unfavorable in 58%.

Table 2. Average yield of soybeans in 20 environments, in the harvests years of 2006/2007 and 2007/2008 of the soybean producing micro-regions 301 and 401, based on the methodology of Annicchiarico (1992).

Environment	Region	City	Yield (kg.ha^{-1})	ω_i	Class
1	301	Edéia	3475,56	-182,60	Unfavorable
2	301	Santa Helena de Goiás	3679,34	21,18	Favorable
3	301	Araporã	4043,56	385,40	Favorable
4	301	Barretos	3847,74	189,59	Favorable
5	401	Rio Verde	4300,44	642,28	Favorable
6	401	Jataí	2838,24	-819,92	Unfavorable
7	401	Mineiros	3704,19	46,03	Favorable
8	401	São Gabriel do Oeste	3963,41	305,26	Favorable
9	301	Edéia	3943,78	285,62	Favorable
10	301	Goiatuba	3793,69	135,54	Favorable
11	301	Santa Helena de Goiás	3910,25	252,09	Favorable
12	301	Barretos	3950,55	292,40	Favorable
13	401	Rio Verde	3007,21	-650,95	Unfavorable
14	401	Jataí	3432,78	-225,38	Unfavorable
15	401	Mineiros	3538,17	-119,99	Unfavorable
16	401	Montividiu	4138,36	480,20	Favorable

17	401	São Gabriel do Oeste	3921,79	263,64	Favorable
18	401	Costa Rica	2814,48	-843,67	Unfavorable
19	401	Chapadão do Sul	3490,88	-167,28	Unfavorable
20	401	Sonora	3368,69	-289,47	Unfavorable

As to the adaptability and stability in accordance with the methodology of Annicchiarico (1992) the genotype that has the best performance is the one of highest recommendation (Wi), and is therefore the most appropriate. In the soybean producing micro-regions 301 and 401, in the harvest years of 2006/2007 and 2007/2008, the genotypes MSOY 7908 RR, MSOY 8199 RR, BRS Valiosa RR and MSOY 7578 RR behaved adapted to unfavorable environments with confidence indexes higher than 100 (Table 3).

Table 3. Parameters of adaptability and stability of 16 genotypes of soybean for average grain yield (AY) in the harvest years of 2006/2007 and 2007/2008 in the soybean producing regions 301 and 401, based on the methodology of Annicchiarico (1992).

Genotypes	General analysis		Analysis favorable environment		Analysis unfavorable environment	
	AY ($kg.ha^{-1}$)	W_i	AY ($kg.ha^{-1}$)	W_i	AY ($kg.ha^{-1}$)	W_i
Strain 1 (LG1)	3778,48	100,80	4130,19	102,98	3250,93	97,69
Strain 2 (LG2)	3124,08	82,78	3286,49	81,14	2880,46	85,42
Strain 3 (LG3)	3402,74	91,33	3530,16	87,98	3211,62	97,18
Strain 4 (LG4)	3790,37	100,23	4159,28	102,66	3237,01	96,77
Strain 5 (LG5)	3814,26	101,09	4156,84	103,99	3300,39	97,20
Strain 6 (LG6)	3489,70	91,87	3773,44	93,12	3064,09	89,99
M-SOY 7908 RR	3911,82	105,16	4230,58	106,25	3433,67	103,54
M-SOY 8000 RR	3427,57	91,09	3768,49	93,80	2916,19	87,25
CD 219 RR	3574,50	94,97	3743,39	92,01	3321,16	99,66
BRS Favorita RR	3806,99	100,46	4117,76	100,96	3340,84	99,54
M-SOY 8045 RR	3594,83	95,62	3807,42	93,61	3275,94	98,87
M-SOY 8199 RR	3799,40	101,83	4030,47	101,02	3452,79	103,52
M-SOY 7211 RR	3767,12	100,64	4089,11	101,34	3284,13	99,78
TMG 103 RR	3506,89	93,34	3756,05	93,02	3133,15	93,69
BRS Valiosa RR	3897,29	102,92	4227,94	104,94	3401,31	100,14
M-SOY 7578 RR	3844,46	102,32	4121,87	101,78	3428,35	103,02

Under favorable environmental conditions and also by the general analysis, the best genotypes were the strains LG1, LG4 e LG5 and the cultivars M-SOY 7908 RR, BRS FAVORITA RR, M-SOY 8199 RR, M-SOY 7211 RR, BRS VALIOSA RR and M-SOY 7578 RR (Table 3), present values of Wi above 100 and elevated average grain yield.

The classification of environments as favorable and unfavorable adopting the methodology of Eberhart and Russell (1966) observed the same result obtained by the method of Annicchiarico (1992) as shown in Table 2. For Eberhart and Russell (1966) the ideal genotype is one that has high average yield, regression coefficient equal to the unit ($\beta 1 = 1$), and deviation regression the lowest possible ($\sigma^2_d = 0$).

By Table 4, it was observed that all genotypes showed low stability since all deviations of regression (σ^2_d) were different from zero, at 1% level of probability by the F test, indicating therefore low predictability of behavior of the genotypes in the studied environments. However, Duarte (1988) emphasizes that the coefficient of determination can be used to replace the variance of the regression deviations in the evaluation of a given genotype.

It was noted that the genotypes LG1, LG4, LG5, MSOY 7908 RR and M-SOY 7578 RR were adapted to favorable environments since values of β1 were greater than the unit ($\beta_{1i} > 1$), and the coefficient of determination higher than 70% (Table 4). Thereby, these genotypes are indicated in environments whose employed technology index are high and, furthermore, are considered as high risk for cultivation in regions of low technology and/or subjected to variations in climate and soil, since they reduce their grain yield under conditions of unfavorable environment.

Table 4. Estimates of the stability and adaptability parameters of grain yield, based on the methodology of Eberhart and Russell (1966) in 16 soybean genotypes, the harvest years of 2006/2007 and 2007/2008 in the soybean producing micro-regions 301 and 401.

Genotypes	Yield (kg ha^{-1})	β_1	σ^2_d	R^2 (%)
Strain 1	3778,48	1,35*	56127,16**	83,19
Strain 2	3124,08	0,59*	125438,76**	31,51
Strain 3	3402,74	0,45*	43219,65**	40,81
Strain 4	3790,37	1,42*	119419,19**	73,78
Strain 5	3814,26	1,33*	97721,98**	74,83
Strain 6	3489,70	1,04^{ns}	171326,10**	51,66
MSoy 7908 RR	3911,82	1,13*	35443,38**	83,43
MSoy 8000 RR	3427,57	1,09^{ns}	86751,41**	68,77
CD 219 RR	3574,50	0,70*	173052,93**	32,47
BRS Favorita RR	3806,99	1,34*	185879,63**	62,23
MSoy 8045 RR	3594,83	0,86*	146253,22**	46,13
MSoy 8199RR	3799,40	0,73*	63323,57**	56,63
MSoy 7211RR	3767,12	0,94^{ns}	117500,44**	55,58
TMG103 RR	3506,89	0,87*	123071,62**	50,57
BRS VALIOSA RR	3897,29	0,91^{ns}	207017,95**	40,69
MSoy 7578 RR	3844,46	1,25*	105241,03**	71,12

*: significant at 5% of probability by the t test; **: significant at 1% of probability by the F test; ns: not significant.

The genotypes LG6, M-SOY 8000 RR, M-SOY 7211 RR and BRS VALIOSA RR showed a regression coefficient equal to the unit ($\beta_{1i} = 1$), at the level of 5% of probability by the t test, demonstrating that they are genotypes of overall adaptability (Table 4), however it was found that the coefficients of determination were lower than 70%, in which this percentage is a reference for the regression to satisfactorily explain the behavior of the genotype according to the environment (CRUZ et al. 2006).

It was verified that the strains LG2 e LG3 and the cultivars CD 219 RR, M-SOY 8045 RR, M-SOY 8199 RR and TMG103 RR show regression coefficient smaller than the unit, thus being adapted to unfavorable environments (Table 4). On the other hand, it is worth emphasizing that the coefficients of determination were all of low magnitude.

By the methodology of Lin and Binns (1988) modified by Carneiro (1998) the genotypic performance is estimated by the parameter (P_i), which relates the distance of genotype in analysis to the best genotype so that the lower is its value, the higher will the adaptability and stability behavior of genotype be. In Table 5, it was verified that the cultivars M-SOY 7908 RR, M-SOY 8199 RR; BRS VALIOSA RR e M-SOY 7578 RR showed general adaptation because they had higher average grain yield and lower values of the Pi general parameter. This result indicates that these genotypes have the ability to maintain accepTable performance, even under unfavorable environmental conditions.

In conditions of favorable environments, the most sTable and adapted genotypes were the strains LG4 and LG5 and the cultivars M-SOY 7908 RR and M-SOY 7578 RR since they showed lower value of the parameter P_i (Table 5). In favorable environments, the best genotypes were the cultivars M-SOY 7908 RR, M-SOY 8199 RR, BRS VALIOSA RR and M-SOY 7578 RR, indicating genotypes that are more responsive to this type of environment.

The centroid method differs from other methods of study of adaptability by not being subjective in the ordering and the use of spatial probability estimates which allows to infer about the reliability of the genotype. It is a nonparametric method that aims to facilitate the recommendation of genotypes, it allows the aiming of genotypes in relation to environmental variation, it dispenses the analysis of various parameters, such as that occurring in regression-based methods, and allows no ambiguity in the interpretation observed in the methodology of Lin and Binns (1988).

Table 5. Parameters of stability and adaptability of 16 genotypes of soybean in the harvest years of 2006/2007 and 2007/2008 in the soybean producing regions 301 and 401, based on the metodology of Lin e Binns (1988) modified by Carneiro (1998).

Genotypes	Average	P_i general	P_i Favorable	P_i Unfavorable
Strain 1	3778,48	2264642,80	2030963,23	2615162,15
Strain 2	3124,08	3881897,94	4113535,46	3534441,65
Strain 3	3402,74	3132577,12	3440746,14	2670323,60
Strain 4	3790,37	2279797,43	2025755,79	2660859,87
Strain 5	3814,26	2224933,70	1982563,01	2588489,72
Strain 6	3489,69	2952355,22	2851610,70	3103471,99
M-SOY 7908 RR	3911,82	1984512,68	1833830,45	2210536,03
M-SOY 8000 RR	3427,57	3075655,76	2847095,71	3418495,85
CD 219 RR	3574,50	2770382,63	2975174,69	2463194,55
BRS Favorita RR	3806,99	2259127,55	2137459,52	2441629,60
M-SOY 8045 RR	3594,83	2708939,22	2817620,08	2545917,91
M-SOY 8199 RR	3799,40	2209106,60	2235496,49	2169521,76
M-SOY 7211 RR	3767,12	2319965,02	2197329,85	2503917,79
TMG 103 RR	3506,89	2885348,04	2879410,74	2894253,99
BRS Valiosa RR	3897,29	2074800,11	1891062,84	2350406,01
M-SOY 7578 RR	3844,46	2142146,77	2077779,83	2238697,18

Table 6, shows the results for the centroid method where it was found that 44% of the genotypes were classified in Group I, with probabilities ranging from 0.28 to 0.34. The genotypes LG1, M-SOY 7908 RR, BRS FAVORITA RR, M-SOY 8199 RR, M-SOY 7211 RR, BRS VALIOSA RR, 16 M-SOY 7578 RR presented general adaptability (group I). The strains LG1 and CC4 showed adaptability to specific environments since they showed higher probability of belonging to group II. The cultivars CD 219 RR and M-SOY 8045 RR had adaptation to unfavorable environments (group III). The strains LG2, LG3, L6 and the cultivars M-SOY 8000 RR and BRS Valiosa RR were classified in group IV and is therefore not adapted.

Tabela 6. Parameters of stability and adaptability of 16 genotypes of soybean in the harvest years of 2006/2007 and 2007/2008 in the soybean producing regions 301 e 401, based on the centroid methodology.

Genotypes	Average	Classif.	Prob (I)[1]	Prob (II)[1]	Prob (III)[1]	Prob (IV)[1]
Strain 1	3778,48	II	0,29	0,29	0,20	0,20
Strain 2	3124,08	IV	0,15	0,17	0,24	0,44
Strain 3	3402,74	IV	0,19	0,19	0,30	0,32
Strain 4	3790,37	II	0,29	0,30	0,20	0,21
Strain 5	3814,26	I	0,31	0,28	0,21	0,20
Strain 6	3489,70	IV	0,22	0,26	0,23	0,29
M-SOY 7908 RR	3911,82	I	0,34	0,27	0,20	0,18

M-SOY 8000 RR	3427,57	IV	0,21	0,25	0,24	0,30
CD 219 RR	3574,50	III	0,23	0,22	0,29	0,26
BRS Favorita RR	3806,99	I	0,32	0,27	0,21	0,19
M-SOY 8045 RR	3594,83	III	0,24	0,24	0,26	0,26
M-SOY 8199 RR	3799,40	I	0,32	0,24	0,24	0,20
M-SOY 7211 RR	3767,12	I	0,28	0,26	0,23	0,22
TMG 103 RR	3506,89	IV	0,23	0,24	0,26	0,27
BRS Valiosa RR	3897,29	I	0,34	0,25	0,21	0,18
M-SOY 7578 RR	3844,46	I	0,32	0,27	0,21	0,19
General average	3658,16					

Classif.: classification; 1–Probability of belonging to the indicated class; Class I: general adaptability; Classe II: Specific adaptability to favorable environments; Class III: Specific adaptability to unfavorable environments; Class IV: poorly adapted.

The different methods available for studies of the adaptability and stability differ as to statistical principles, number of parameters and ease of interpretation, however, the concomitant use of several methods, provides information that allows us to infer with greater certainty about the behavior of the studied genotypes. According to Oliveira et al., (2003), the correlation between the estimates of parameters of adaptability and/or stability contributes to better predict the behavior of the evaluated genotypes.

Comparing the four methods used in this study, there was an agreement the classification of the strain LG 4 for greater adaptability and stability in a favorable environment. These results corroborate with those obtained by Pelúzio et al. (2010) which verified and agreement of results of adaptability and stability by adopting the methods of Eberhart and Russel (1966) and Centroid in the evaluation of ten soybean genotypes.

The strain LG5 and the cultivar MSOY 7908 RR also adapted to favorable environments considering the methodologies of Eberhart e Russel, Annicchiarico and Lin and Binns. In studies with various statistical methods to evaluate the adaptability and stability in 28 soybean genotypes, Duarte Silva (2006) found a strong association between the methods of Annicchiarico and Lin and Binns, resulting in very similar genotypic classifications.

The cultivars MSOY 8199 RR and BRS Valiosa respectively had adaptation to general and unfavorable environments considering simultaneously the four methods evaluated in this study. Additionally, there was coincidence of three methods for the classification of genotypes of adaptability, which were MSOY 7908, MSOY 8199 and MSOY 7578 RR.

For the unfavorable environment only the cultivar MSOY 8199 RR showed good adaptability by the four studied methods. The BRS Valiosa RR also showed general adaptation by the four methods.

The employed methods used allowed to identify more sTable and responsive genotypes, as well as the most productive; the methods of Annicchiarico, Linn Binns, modified by Carneiro, Centroid were consistent with each other and allowed to identify among the evaluated genotypes the highest stability and adaptability.

CONCLUSIONS

The methods of Annicchiario, Eberhart and Russel (1966), Linn and Binns (1988) modified by Carneiro (1998) and the Centróide AMMI allowed to discriminate the soybean genotypes to their adaptive behavior and phenotipic stability.

The strain CC4 showed high adaptability and stability in favorable environments. The cultivars MSOY 8199 RR and BRS Valiosa RR respectively had adaptation to general and unfavorable environments considering simultaneously the four methods evaluated in this study.

ABSTRACT: The aim of this study was to evaluate the adaptability and stability of soybean genotypes grown in two soybean producing micro-regions (301 and 401), in the harvest seasons of 2006/2007 and 2007/2008. 16 soybean genotypes were studied (six soybean lines of the breeding program of Monsoy Ltda. and 10 cultivars). The experiments were conducted in a randomized complete block design, with three replications. Individual and group analyses were performed and the parameters of adaptability and stability were estimated by the methods proposed by Eberhart and Russel, Annicchiarico, Linn and Binn and Centroide. The results showed interaction of genotypes and environments showing different behavior of the genotypes according to environmental fluctuations. The methods of Annicchiarico, Linn and Binns modified by Carneiro and Centroid, were consistent with each other and allowed to identify among the genotypes, the highest stability and adaptability. The cultivars M-SOY 7908 RR, M-SOY 8199 RR and BRS Valiosa RR have general adaptability and stability. The Strains LG4 and LG5, and cultivar M-SOY 7908 RR showed high adaptability and stability in favorable environments and the control M-SOY 8199 RR for unfavorable environments and the strain CC4 showed high stability and adaptability in favorable environments. The cultivars MSoy 8199 RR and BRS Valiosa RR had adaptation to unfavorable and general environments, considering the four methods that were evaluated in this study.

KEYWORDS: *Glycine max*. Genotypes and environment interaction. Adaptability and stability.

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