Adaptability and Stability of Soybean Genotypes in the States of Maranhão, Piauí, Tocantins and Bahia

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ABSTRACT. The soybean crop has a substantial importance for Brazil's agribusiness and economy. Besides, breeding programs have contributed to the development of the crop in the country allowing grain yield increase and, at the same time, intensifying the production of new cultivars that show both yield predictability and wide adaptation. This study was aimed at evaluating the agronomic performance, adaptability, and stability of soybean genotypes in the states of Maranhão, Piauí, Tocantins, and Bahia. The genotypes were evaluated to the extent of grain yield in the municipalities of Chapadinha (MA), Balsas (MA), Bom Jesus (PI), Porto Nacional (TO), and Formoso do Rio Preto (BA) under complete randomized block design, with three repetitions. Data were submitted to joint analyses and to studies of adaptability and stability by Wricke (1965), Eberhart and Russel (1966), and Annicchiarico (1992) methods. The genotypes UFUS 504, UFU 506, UFU 508, UFU 512, UFU 514, UFU 516, UFU 518, UFU 519, UFU 520, UFU 521, UFU 523, and UFUS Imperial showed wide stability and adaptability, whereas UFU 503, UFU 505, and UFUS Impact were adapted to favorable conditions.

Key words: *Glycine max*; Genotype-environment interaction; Wricke; Annicchiarico; Eberhart and Russel

INTRODUCTION

The soybean [*Glycine max* (L.) Merrill] belongs to Fabaceae family and is originated from the northeast region of China (Silva et al., 2016). The crop was introduced to Brazil in the end of the XIX century and had a quick territorial expansion. It is socially and commercially important as soybean crop is the base of many products for human and animal feed, it is responsible for promoting the creation of jobs, and it is a crucial commodity for a favorable trade balance. The internal consumption and exportation of this crop have significantly promoted the national agribusiness and economy (Castro et al., 2015).

Soybean breeding programs have contributed to the expansion of cultivated area in Brazil and to the increase in grain yield, acting intensively in the development of new cultivars with adaptation to different regions of the country (Matsuo et al., 2012; Borém and Miranda, 2013; Val et al., 2014). The Middle West region is the largest producer of soybeans in Brazil (CONAB, 2015), but other regions have expanded their cultivated areas. In the Northeast region, for instance, from 376.8 thousand of hectares in 1990, to 1,857.1 thousand of hectares in 2010 were cultivated with the crop (Miranda, 2012). Over the years, this has enriched the soybean production scenario in the country as the performance of the soybean crop in diverse producing regions has led to a rise of 10.4% in the growing season of 2014/15 comparing to the previous year (CONAB, 2015).

The soybean became widely cultivated in regions of Brazil, yet there are variations on growth conditions that include differences in soil characteristics, temperature, photoperiod, and rainfall over the country. The performance of cultivars is influenced by the occurrence of genotype and environment interaction (GxE), that leads to difficulties in identifying superior and stable cultivars in all growing regions (Branquinho et al., 2014). The GxE interaction refers to the differential behavior of genotypes over environmental oscillations. When detected, it is necessary the study of adaptability and stability in order to particularize the productive behavior of each genotype. The adaptability consists of the ability of a certain genotype to respond advantageously to an environmental stimulus, while the stability is the capacity of a genotype to show a behavior highly predictable in function of the environment (Barros et al., 2010).

The study of GxE interaction is crucial for indicating genotypes to each locality (Hamawaki et al., 2015). Consequently, in plant breeding programs, the selection and recommendation of genotypes are preceded by trials in diverse environments because it is usually observed that a given genotype better suitable to a specific environment is not necessarily the best appropriate to another (Pelúzio et al., 2010). The recommendation of new soybean cultivars need desirable characteristics such as height of first pod insertion, plant height at maturity, among others, together with high grain yield, production stability, and wide adaptation to diverse environments, whose variations can be found in regions where they are indicated (Polizel et al., 2013). To this end, the goal of this research was to evaluate the agronomic performance, adaptability, and stability of soybean genotypes in the states of Maranhão, Piauí, Tocantins, and Bahia.

MATERIAL AND METHODS

It was evaluated 24 soybean lines and four commercial cultivars (BRSMG Garantia, UFUS Impacta, UFUS Imperial, and MSOY 8787) in five environments over the 2009/2010 growing season. The lines of this study are of medium-late / late cycle and were developed by the Soybean Breeding Program of the Federal University of Uberlândia. Those lines are assessed through a series of Cultivation Value and Use trials. Those experiments were carried out in the municipalities of Balsas-MA, Chapadinha-MA, Bom Jesus-PI, Formoso do Rio Preto-BA, and Porto Nacional-TO (Table 1).

Table 1. Characterization of five soybean growing environments in the study of phenotypic adaptability and stability during the growing season of 2009/2010.

Municipality	State	Latitude	Longitude	Altitude
Balsas	Maranhão	07° 31’ 58” S	46° 02’ 09” W	247m
Chapadinha	Maranhão	03° 44’ 31” S	43° 21’ 36” W	105m
Bom Jesus	Piauí	09° 04’ 28” S	44° 21’ 31” W	277m
Formoso do Rio Preto	Bahia	11° 02’ 53” S	45° 11’ 35” W	490m
Porto Nacional	Tocantins	10° 42’ 28” S	48° 25’ 01” W	212m

In each experiment, a complete randomized block design was adopted, with three repetitions. Each experimental plot was composed of 4 soybean plant rows with 5 m length, spaced at 0.45 m within rows, totalizing 9 m^2. The soil preparation was done by one plowing and two harrowing right before grooving and fertilizing the soil. The fertilizer formulation used at sowing was NPK 2-28-18 and zinc sulfate, at the dosages of 400 kg ha^{-1} and 1.2 kg ha^{-1}, respectively. Before sowing, it has proceeded the seed inoculation with Biomax® product in the proportion of 7 x 10^8 cells mL^{-1} per seed, using 150 mL of the commercial product to each 50 kg of seeds. Furthermore, the inoculant strains were SEMIA 5079 and SEMIA 5080 and the seeding depth was 2 cm and 15 seeds per linear meters were distributed uniformly. Also, it was conducted, whenever necessary, manual weeding control until canopy closure of the crop. Insecticide and herbicide applications recommended to the crop were done in order to control pests and diseases throughout the conduction of trials. The experiments were harvested manually when plants reached the R8 stage, according to Fehr and Caviness (1977) scale, in both central lines of each plot, eliminating 0.5 m of each line edge. Subsequently, it has proceeded the soybean threshing and drying of grains (to 13% moisture). After drying, for determining the grain yield, the grains from each useful plot had their mass weighed and extrapolated to kg ha^{-1}.

It was tested ANOVA presuppositions for variance homogeneity and residual normality of grain yield trait with the usage of the Prophet Program. Next, it was conducted the individual analyses of variance through Sisvar program (FERREIRA, 2014), followed by joint analysis of variance (having met the homogeneity of residual variances). When differences on the effect of treatment were observed by F test (P<0,05), it was used Scott-Knott (P<0,05) test for grouping the averages. The analyses of adaptability and stability were done by the ecovalence method (Wricke, 1965), simple linear regression (Eberhart and Russel, 1966), and confidence index (Annicchiaricho, 1992) using the Stability program (Ferreira, 2000).

The Wricke (1965) methodology, known as Ecovalence (wi) parameter, is estimated by decomposing the sum of squares of GxE interaction into isolated genotype parts. The partition was done through a statistical ωi, given by:

$$\omega_i = r\Sigma\, GA^2_{ij} = \sum_{j=1}^{q} (Y_{ij} - \bar{Y}_{i.} - \bar{Y}_{.j} + \bar{Y}_{..})^2 \quad \text{— (Equation 1)}$$

In which:

Yij: mean of genotype i in the environment j.
Yi.: mean of genotype i.
Y.j: mean of the environment j.
Y overall mean.

The method proposed by Eberhart and Russell (1966) is based on the adjusting of a simple linear regression of the mean of each genotype in such environment as a function of the environmental index, which is determined by the difference between the mean of a given environment and the overall mean in all environments. The coefficients of regression and regression deviations provide estimates of adaptability and stability parameters, respectively. The mathematical model can be found below:

$$Yij = \mu_i + \beta_i I_j + \delta_{ij} + \varepsilon_{ij} \quad \text{(Equation 2)}$$

In which:

Yij: mean of genotype i in the environment j;
μi: mean of genotype i in all environments;
βi: coefficient of linear regression, that describes the response of genotype i to all environments;
Ij: environmental index;
δij: regression deviation of genotype i in the environment j;
εij: error associated to the mean.

According to Eberhart and Russel (1966), the ideal genotype is the one that has high grain yield standards, a coefficient of regression equals to one unit, and regression deviation practically null (non-significant).
The confidence index proposed by Annicchiaricho (1992) for the recommendation of cultivars considers the probability risk upon a recommendation index that incorporates the cultivar mean and the stability concept. In this case, the genotypic means represent a percentage of environmental mean values. The mean and the standard deviation of each genotype were calculated to all environments based on this information. The Ii index represents the estimate of the lowest grain yield, expressed as a percentage of the environmental mean obtained through the probability 1- α for the genotype i:

$$I_i = \bar{Y}_{i.} - Z_{(1-\alpha)} S_i \quad \text{(Equation 3)}$$

The Z value is the percentile of standardized normal distribution by which accumulated distribution function is 1- α. Such index is known as the confidence index.

RESULTS AND DISCUSSION

It was observed significant effects for the source of variation of genotypes, environments, and occurrence of genotype by environment interaction at 1% probability level by F test (Table 2). This fact indicates the differential behavior of soybean genotypes, regarding grain yield, against environmental oscillations. The same behavior was also verified in trials conducted by Soares et al. (2017) and Silva et al. (2017).

Table 2. Summary of joint variance analyses for grain yield character evaluated over 27 genotypes cultivated in five municipalities during the growing season of 2009/2010.

Source of Variation	Degrees of Freedom	Mean Square
Blocks/environment	10	243128.82^{ns}
Genotype (G)	27	1705690.18**
Environment (E)	04	57229954.96**
G x E	108	810240.68**
Error	255	350432.52
Coefficient of variation (%)	20.29	

** Significant at 1% level of probability by F test; ^{ns} Non-significant.

The coefficient of variation (CV) found in the current study was 20.29%. Carvalho et al. (2013) evaluating the phenotypic stability of soybean cultivars concerning grain yield, in environmental stratifications of Tocantins state, found a CV equals to 14.94%. A study conducted in the south part of Tocantins, with 20 soybean cultivars in four sowing seasons, achieved a CV between 18.69 and 22.77% (Peluzio et al., 2008). When there is the occurrence of GxE interaction, it is justified studies of adaptability and stability to obtain detailed information of each genotype about to the environmental variation. This interaction was found by Vasconcelos et al. (2015), in the state of Mato Grosso indicating that all variation found on grain yield cannot be explained singly and suggests that there is a differential genotypic behavior in the studied environments.

Studies carried out by Branquinho et al. (2014) with conventional and transgenic soybean cultivars of early, medium, and late cycle in the Federal District of Brazil, Bahia, Goiás, Mato Grosso do Sul, Minas Gerais, and São Paulo, during seven agricultural years (2002/2003 to 2008/2009), also mentioned the occurrence of this type of interaction for grain yield. Likewise, Pelúzio et al. (2010), by means of three trials during off season of 2006, in the municipality of Formoso do Araguaia-TO, found significant effects of cultivars, environments and GxE interaction to soybean grain yield. In Table 3, it is shown the average performance of each genotype in five environments, whose means were separated into groups in each studied environment, except for the municipality of Bom Jesus-PI. It can be noticed that the favorable environments to soybean grain yield were Balsas-MA and Bom Jesus-PI, whose means were superior to 3,500.00 kg ha^{-1}, being above the Brazilian national average of 2009/2010 growing season (2,952.00 kg ha^{-1}) (CONAB, 2010).

Carvalho et al. (2013) affirm that a favorable environment is the one which allows a production higher than the overall mean of all trials, resulting in positive indexes. In their researches, they accomplished an overall grain yield equals to 2,931.00 kg ha^{-1} and Peluzio et al. (2012), achieved an average of 2,809.00 kg ha^{-1}, both located in the state of Tocantins.

Table 3. Grain yield averages (kg ha^{-1}) of soybean genotypes cultivated in 5 environments during growing season of 2009/2010.

	Cultivation sites					
Genotypes	Formoso do Rio Preto (BA)	Chapadinha (MA)	Porto Nacional (TO)	Balsas (MA)	Bom Jesus (PI)	Means
UFU 501	2413.67 aB	2693.33 aB	3657.67 aA	4241.67 aA	3240.67 aB	3249.40
UFU 502	2895.33 aA	3327.00 aA	3166.33 aA	3544.33 bA	4074.00 aA	3401.40
UFU 503	1324.67 bB	2460.33 bA	2935.00 bA	3437.67 bA	3611.33 aA	2753.80
UFU 504	1277.00 bC	2577.67 aB	2412.00 bB	3326.33 bA	4259.33 aA	2770.47
UFU 505	1421.33 bB	2981.67 aA	3157.33 aA	3948.00 aA	3796.33 aA	3060.93
UFU 506	1573.00 bC	1778.67 bC	2680.67 bB	3916.33 aA	3518.33 aA	2680.00
UFU 507	1626.00 bC	2619.33 aB	2995.33 bB	4566.67 aA	3611.00 aA	3083.67

UFU 508	1905.67 bB	2239.00 bB	3333.33 aA	2828.00 bA	3703.67 aA	2801.93
UFU 509	1572.00 bB	3062.33 aA	2657.33 bA	2159.33 cB	3333.33 aA	2556.87
UFU 510	1220.00 bA	2566.67 aB	3116.00 aB	3042.67 bB	4074.00 aA	2803.87
UFU 511	2150.67 bB	2092.67 bB	3356.67 aA	1069.33 dB	3148.00 aA	2363.47
UFU 512	1203.00 bB	2037.00 bB	2435.33 bA	3490.00 bA	2870.33 aA	2407.13
UFU 513	1775.00 bB	2315.67 bB	3717.33 aA	3167.00 bA	3518.33 aA	2898.67
UFU 514	1648.00 bC	2522.33 aB	3106.67 aB	3090.00 bB	4444.33 aA	2962.27
UFU 515	3486.00 aA	3243.67 aA	3592.67 aA	3627.67 bA	3611.00 aA	3512.20
UFU 516	1299.67 bB	1641.67 bB	2893.67 bA	2633.00 bA	3518.33 aA	2397.27
UFU 518	1726.00 bB	2108.33 bB	3088.00 aA	3674.00 bA	4166.33 aA	2952.53
UFU 519	1911.67 bB	1791.67 bB	2467.33 bB	3711.00 bA	3518.33 aA	2680.00
UFU 520	1021.33 bC	2557.33 aB	2787.00 bB	4177.67 aA	3426.00 aA	2793.87
UFU 521	1554.67 bC	2906.33 aB	3838.00 aA	4778.00 aA	3888.67 aA	3393.13
UFU 522	1938.67 bB	2372.33 bB	3713.00 aA	2862.00 bB	3703.67 aA	2917.93
UFU 523	1666.67 bB	2274.00 bB	2379.33 bB	3510.00 bA	3888.67 aA	2743.73
UFU 524	1356.67 bB	2051.00 bB	2153.00 bB	3575.00 bA	3426.00 aA	2512.33
UFU 525	1480.33 bC	2663.00 aB	2727.00 bB	4734.33 aA	3333.33 aB	2987.60
BRSMG Garantia	2104.67 bD	3312.00 aC	3495.67 aC	5331.00 aA	4352.00 aB	3719.07
UFUS Impacta	1253.67 bC	2667.33 aB	2907.67 bB	4212.00 aA	4351.67 aA	3078.47
UFUS Imperial	1840.67 bB	2772.00 aB	3625.33 aA	3419.00 bA	3611.00 aA	3053.60
MSOY 8787	909.00 bC	3239.67 aB	3259.00 aB	4517.00 aA	3703.67 aB	3215.67
eans	1698.39	2534.86	3055.42	3592.46	3703.63	2916.95

[1]Means followed by the same lowercase letter (column) and by the same uppercase letter (line) do not statically differ at 5% level of significance by Scott and Knott test.

Over the growing season of 2009/2010, it was observed high rainfall indexes in the evaluated locations (INMET, 2009), favoring the occurrence of Asian soybean rust, that was responsible for reducing yields up to a maximum baseline level of 4,000.00 kg ha^{-1}. This disease is one of the most severe ones that can damage the crop and has a high economic impact oscillating from 10% to 90% in diverse regions where there are reports (Hartman et al., 2015). Moreover, the expansion of the crop towards other areas, as well as the huge areas cultivated under monoculture and genetically similar cultivars, have enlarged the incidence of diseases caused by the fungus as such Asian soybean rust mentioned previously. Pelúzio et al. (2010) evaluated the grain yield, the adaptability, and the stability of ten soybean cultivars in three trials over the off-season of 2006 in the municipality of Formoso do Araguaia (TO). It was verified that the average grain yield fluctuated from 1,023.00 kg ha^{-1} (Formoso I) to 1,234.00 kg ha^{-1} (Formoso III), with an overall mean across the environments of 1,142.00 kg ha^{-1}. Another study by Pelúzio *et al.* (2008) assessed the performance, adaptability, and stability of soybean genotypes in four growing seasons in Gurupi (TO) and the average grain yield shifted from 1,058.00 kg ha^{-1} (Gurupi IV) to 2,159.50 kg ha^{-1} (Gurupi I). In both scenarios, the yield averages were inferior to the ones found in this study, which was 3,055.42 kg ha^{-1} in Porto Nacional, also in Tocantins state.

It was evaluated the phenotypic adaptability and stability according to the estimate of Ecovalence (Wricke, 1965). By this methodology, it is possible to make inferences only about to the stability of a given genotype, which the most stable is that one who has lower estimates of Wi (%); in other words, it can be inferred that the genotype contributed less to the occurrence of GxE interaction (Cavalcante et al., 2014). In this study, it was observed by Wricke methodology, that the genotypes showed a similar pattern for stability since the estimates of Wi oscillated between 3.55% to 3.77% (Table 4). A study carried out by Bruzi (2006) achieved the same behavior, which is, it was not possible to differentiate the genotypes regarding stability by this method, and according to him, this estimate was of low magnitude; therefore, being necessary to estimate the repeatability of this parameter. Nevertheless, Ceron (2016) detected differences among lines concerning the yield stability in different regions of Mato Grosso state.

Table 4. Grain yield and stability parameters by Wricke (1965) and Annicchiarico (1992) methodologies of 28 soybean genotypes cultivated in five localities (Formoso do Rio Preto-BA, Bom Jesus-PI, Balsas-MA, Porto Nacional-TO, and Chapadinha-MA), during 2009/2010 growing season.

Genotypes	**Means (kg ha^{-1})**	**Wricke**	**Annicchiaricho**	
		Wi%	**I(i)**	**Deviation (%)**
UFU 501	3249.40	3.56	84.57	22.49
UFU 502	3401.40	3.58	60.11	29.66

UFU 503	2753.80	3.55	54.55	19.39
UFU 504	2770.47	3.55	61.72	19.76
UFU 505	3060.93	3.56	60.57	23.64
UFU 506	2680.00	3.55	57.39	16.86
UFU 507	3083.67	3.58	57.54	21.62
UFU 508	2801.93	3.55	81.61	11.28
UFU 509	2556.87	3.65	23.87	35.12
UFU 510	2803.87	3.58	38.86	25.54
UFU 511	2363.47	3.77	-9.89	53.70
UFU 512	2407.13	3.56	39.30	23.00
UFU 513	2898.67	3.57	57.88	22.88
UFU 514	2962.27	3.55	77.78	14.12
UFU 515	3512.20	3.58	58.11	40.83
UFU 516	2397.27	3.54	69.92	11.16
UFU 518	2952.53	3.55	81.45	13.62
UFU 519	2680.00	3.55	84.68	13.01
UFU 520	2793.87	3.56	61.29	24.01
UFU 521	3393.13	3.55	96.08	12.68
UFU 522	2917.93	3.56	77.23	18.93
UFU 523	2743.73	3.55	63.46	18.05
UFU 524	2512.33	3.56	71.41	19.11
UFU 525	2987.60	3.56	80.53	16.00
Garantia	3719.07	3.57	94.40	17.90
UFUS Impacta	3078.47	3.56	77.33	20.00
UFUS Imperial	3053.60	3.55	84.13	14.34
MSOY 8787	3215.67	3.60	47.25	33.34

α= 25%

Through the method proposed by Annicchiarico (1992), the stability is estimated by the superiority of a given genotype in relation to the average in each environment. The method is based on the estimation of a confidence index of a certain genotype that shows relatively a superior behavior (Cruz et al., 2014). Using this methodology, it can be approached the probability risk of selecting a cultivar. Hence, this should present, at least, a confidence index equals to 100, which corresponds to a response equivalent to the mean (Polizel, 2007). It was verified that none of the evaluated genotypes showed confidence index superior to the mean of each environment, wherein the materials UFU 501, UFU 508, UFU 518, UFU 519, UFU 521, UFU 525, BRSMG Garantia, and UFUS Imperial accomplished indexes superior to 80%. UFU 521 and BRSMG Garantia stood out among them with 96.08% and 94.40%, respectively (Table 4). The lack of superior indexes higher than 100% suggests the risk of adopting the evaluated genotypes (Polizel, 2007).

Carvalho et al. (2013), appraised the grain yield, phenotypic adaptability, and stability of soybean cultivars in eight municipalities of Tocantins during growing seasons of 2008 to 2012. Among studied cultivars, three of which showed recommendation index to favorable environments (higher than 100), being, therefore, adapted to favorable environmental conditions (M 8527 RR, TMG 132 RR, and M 9144 RR). Three cultivars indicated recommendation index to unfavorable environments higher than 100, which represents the adaption to unfavorable conditions (TMG 131 RR, TMG 115 RR, M 8925 RR, and M 9144 RR), by Annicchiarico (1992) method. Additionally, five cultivars of this study did not show indexes superior to 100%, corroborating with the results found by the present study of not reaching desired confidence level. Polizel et al. (2013), evaluated the phenotypic adaptability and stability of soybean genotypes in the state of Mato Grosso by Annichiarico (1992) method. They did not identify genotypes that revealed confidence index equal or superior to 100; however, the one by which reached the highest value was the line UFU 23 with 97.79%, like the highest value accomplished by the current study (UFU 521 - 96.08%).

The ideal genotype according to the method of Eberhart and Russel (1966), is the one that shows high grain yield, a coefficient of regression ($\beta 1i$) close to one unit, and null regression deviation (σ^2_{di}). By means of the coefficient estimation of $\beta 0$, $\beta 1i$, and $\sigma^2_{di,}$ for grain yield in this study (Table 5), it was observed that the genotypes UFUS 504, UFU 506, UFU 508, UFU 512, UFU 514, UFU 516, UFU 518, UFU 519, UFU 520, UFU 521, UFU 523, and UFUS Imperial were stable and demonstrated wide adaptability as they had non-significant regression deviations and β1i statistically equals to 1. These results make them interesting since they showed high grain yield and predictability of behavior in different growing localities.

According to Sediyama et al. (2016), it should be considered, for purposes of recommendation, the average grain yield of a genotype as it is not always that the most stable genotype will be the one that shows higher grain yield averages. Thus, the line 521 stood out among the genotypes classified as being wide adapted by this method, overcoming the control UFUS Imperial (Table 5). This behavior of just a few genotypes meet the assumptions of Eberhart and Russel (1966) was verified by Silveira *et al.*, (2016) as out of ten studied genotypes, only one (SYN 9070) demonstrated high grain yield, a predictability of production, and adaptability to environmental oscillations.

Table 5. Estimates of β0, β1i, and σ^2_{di} coefficients using Eberhart and Russel (1966) method for grain yield (kg ha^{-1}), in five growing regions (Formoso do Rio Preto-BA, Bom Jesus-PI, Balsas-MA, Porto Nacional-TO, and Chapadinha-MA).

Genotypes	**Grain yield (kg ha^{-1})**			
	β_0	β_{1i}	$\sigma^2(d_i)$	R^2 (%)
UFU 501	3249.40	0.59*	162946.95^{ns}	53.69
UFU 502	3401.40	0.50*	419167.92**	30.68
UFU 503	2753.80	1.46*	-58675.40^{ns}	97.20
UFU 504	2770.47	1.26^{ns}	140426.51^{ns}	85.26
UFU 505	3060.93	1.48*	87358.29^{ns}	90.98
UFU 506	2680.00	1.24^{ns}	75087.92^{ns}	88.40
UFU 507	3083.67	0.97^{ns}	656888.05**	53.23
UFU 508	2801.93	0.88^{ns}	60407.26^{ns}	80.49
UFU 509	2556.87	0.14**	1044066.01**	1.65
UFU 510	2803.87	1.36^{ns}	517850.84**	73.45
UFU 511	2363.47	0.16**	2969766.02**	0.810
UFU 512	2407.13	1.36^{ns}	142037.11^{ns}	87.06
UFU 513	2898.67	0.97^{ns}	397258.81**	62.94
UFU 514	2962.27	1.39^{ns}	-33356.08^{ns}	95.62
UFU 515	3512.20	0.11**	-77564.75^{ns}	22.61
UFU 516	2397.27	0.83^{ns}	18357.15^{ns}	82.72
UFU 518	2952.53	1.25^{ns}	119497.21^{ns}	86.25
UFU 519	2680.00	1.06^{ns}	90636.09^{ns}	83.75
UFU 520	2793.87	1.24^{ns}	165053.98^{ns}	83.82
UFU 521	3393.13	1.21^{ns}	134081.92^{ns}	84.67
UFU 522	2917.93	0.58*	97261.03^{ns}	59.55
UFU 523	2743.73	0.85^{ns}	152712.95^{ns}	71.78
UFU 524	2512.33	0.84^{ns}	247502.27*	64.57
UFU 525	2987.60	1.23^{ns}	253350.90*	79.34
BRSMG Garantia	3719.07	1.19^{ns}	428391.87**	70.97
UFUS Impacta	3078.47	1.62**	-97623.10^{ns}	99.23
UFUS Imperial	3053.60	0.88^{ns}	93554.89^{ns}	77.46
MSOY 8787	3215.67	1.36^{ns}	804327.88**	65.33

^{ns} Non-significant, ** and * significant at 1% and 5% probability level by t test; ** and * significant at 1% and 5% probability level by F test.

A study conducted by Cavalcante et al. (2014) with soybean genotypes of late cycle grown in three consecutive years in Porto Alegre do Norte – MT, using this methodology, identified 11 lines and one cultivar with high grain yield average, non-significant regression deviation, and coefficient of linear regression equals to one. To this end, those materials stood out by their good performance, stability, and wide adaptation to the considered environments.

The genotypes UFU 503, UFU 505, and UFUS Impacta showed adaptability to environments with favorable conditions (β1i > 1). The cultivar MYSOY 8787, by this method, was considered stable regarding the predictability of yielding behavior (significant σ^2_{di}).

Marques et al. (2011) evaluated the performance of seven soybean cultivars of the Soybean Breeding Program of UFU during three different sowing seasons in Uberlândia-MG. Through Eberhart and Russell (1966) methodology, the cultivar UFUS Xavante revealed the highest grain yield average, a coefficient of linear regression higher than 1, non-significant regression deviation and high determination coefficient, specific adaptability to favorable environments, and high stability. Besides, the other cultivars were classified as having wide adaptability.

CONCLUSION

In conclusion, the genotypes UFUS 504, UFU 506, UFU 508, UFU 512, UFU 514, UFU 516, UFU 518, UFU 519, UFU 520, UFU 521, UFU 523, and UFUS Imperial showed behavior predictability and wide adaptation, and, the line UFU 521 deserves prominence for presenting high grain yield (3393.13 kg ha^{-1}). Considering favorable environmental conditions, it is recommended the genotypes UFU 503, UFU 505, and UFUS Impacta. The cultivar MYSOY 8787, in this study, was unstable against the environmental oscillations.

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