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Adaptability and yield stability of cowpea elite lines of semi-prostrate growth habit in the cerrado biome[1]

Adaptabilidade e estabilidade produtiva em linhagens elite de feijão-caupi de porte semiprostrado no Cerrado brasileiro

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ABSTRACT - The effects of the genotype × environment interaction can be reduced by using cultivars with high adaptability and good yield stability. Studies on this subject allow identification of genotypes of predictable behavior, and responsive to environmental variations in specific and general conditions, in favorable or unfavorable environments. The objective of this work was to evaluate the adaptability and phenotypic stability of cowpea elite lines of semi-prostrate growth habit in the Cerrado biome in Brazil. Twenty cowpea genotypes of semi-prostrate growth habit were evaluated in nine VCU (value for cultivation and use) tests from 2010 to 2012. Grain yield data were subjected to analysis of variance, and stability and adaptability analyses were carried out by the methods of Eberhart and Russell (1966), Lin and Binns (1988) (modified), Wricke (1965), and Annicchiarico (1992). The method of Wricke (1965) was not very descriptive, since it indicates only the contribution of each genotype to the genotype × environment interaction. The results obtained by the methods of Lin and Binns (1988) (modified), Annicchiarico (1992) and Eberhart and Russell (1966) were more descriptive, and similar in indicating the most promising cultivar (BRS-Xiquexique) and lines (Pingo-de-Ouro-1-2, MNC02-676F-1, MNC01-649F-2-1 and MNC02-677F-2). These lines have potential for the development of new cultivars because they present adaptability and yield stability in the Cerrado biome of Brazil.

Key words: *Vigna unguiculata*. Genotype × Environment Interaction. Grain yield.

RESUMO - Os efeitos da interação genótipos por ambientes podem ser reduzidos, utilizando-se cultivares com ampla adaptabilidade e boa estabilidade produtiva. O estudo desse tema possibilita a identificação de genótipos de comportamento previsível e que sejam responsivos às variações ambientais, em condições específicas (ambientes favoráveis ou desfavoráveis) ou amplas. Este trabalho foi realizado com o objetivo de avaliar a adaptabilidade e estabilidade fenotípica de linhagens elite de feijão-caupi de porte semiprostrado na região de Cerrado do Brasil. Foram avaliados vinte genótipos de feijão-caupi em nove ensaios VCU (Valor de Cultivo e Uso) de porte semiprostrado, no período de 2010 a 2012. Os dados de produtividade de grãos foram submetidos a análises de variância e em seguida a análises de estabilidade e adaptabilidade pelos métodos de Eberhart e Russell (1966), Lin e Binns (1988) modificado, Wricke (1965) e Annicchiarico (1992). A metodologia de Wricke (1965) demonstrou ser pouco informativa, por indicar apenas a contribuição de cada genótipo para a interação genótipo × ambiente. Os resultados obtidos pelos métodos Lin e Binns (1988) modificado, Annicchiarico (1992) e Eberhart e Russell (1966), foram mais informativos, sendo coincidentes em indicar o cultivar BRS Xiquexique e as linhagens Pingo-de-Ouro-1-2, MNC02-676F-1, MNC01-649F-2-1 e MNC02-677F-2 como os mais promissores. Essas linhagens possuem potencial para lançamento como cultivares, por apresentarem adaptabilidade e estabilidade produtiva na região do cerrado brasileiro.

Palavras-chave: *Vigna unguiculata*. Interação Genótipos × Ambientes. Produtividade de Grãos.

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INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is cultivated in the Northeast, North and Center-West regions of Brazil. However, the average productivity of cowpea crops varies greatly among different regions, mainly due to environmental variations and the use of genetic materials that are not very productive or with undesirable characteristics (FREIRE FILHO *et al*., 2011).

One of the main challenges in genetic improvement of species is to understand genotype × environments interaction (G×E), which is assessed by the evaluation of the genotypes in different environments (CRUZ; CARNEIRO; REGAZZI, 2014). The evaluation of G×E is very important because of the possibilities of genotypes behave differently in different environments due to G×E (RESENDE; DUARTE, 2007). This behavior affects the selection gain and makes it difficult to recommend cultivars with wide adaptability.

Studies on adaptability and stability of plant species provide tools to identify genotypes that present high productivity in different environmental conditions (FIGUEIREDO *et al*., 2015, PEREIRA *et al.*, 2012). The adaptability and stability of cowpea genotypes have been the goal of several studies (BARROS *et al*., 2013; NUNES *et al*., 2014; ROCHA *et al*., 2007; SANTOS *et al*., 2016; VALADARES *et al*., 2010). These studies have subsidized the improvement and release of cultivars in several states of the North, Northeast and Center-West regions of Brazil (FREIRE FILHO *et al*., 2011).

There are several methods to evaluate the G×E and to determine the adaptability and yield stability of the cultivars. According to the Eberhart and Russell (1966) method, based on simple linear regression, an ideal cultivar presents overall adaptability and stability while maintaining a good performance when the environmental conditions are unfavorable. However, when the data do not fulfill the assumptions of the regression analysis, an alternative would be the use of non-parametric analyzes such as the method of Lin and Binns (1988) (modified) described by Cruz, Carneiro and Regazzi (2014). This method allows the identification of the most stable genotypes by a single parameter of stability and adaptability, and includes the deviations in relation to the maximum yield obtained in each environment; making it possible to detail this information for favorable and unfavorable environments. Other examples are the method of Annicchiarico (1992), which presents an easy application and is based on the estimation of a risk index for the recommendation of a given cultivar; and the method of Wricke (1965), called ecovalence, which is estimated by the distribution of the sum of squares of the G×E into parts due to single genotypes. This method has an easy interpretation; however, the data need to be balanced to meet the assumptions of a regression analysis (CARVALHO *et al*., 2016).

Choosing the method to characterize genotypes regarding adaptability and stability depends on the available experimental data, the required precision, and the type of information desired by the breeder (CRUZ; CARNEIRO; REGAZZI, 2014). Each one of these methods has peculiarities that can contribute to improve the analysis; and in some cases, these methods may be complementary to each other, therefore, it is important to use more than one method (PEREIRA *et al*., 2009). In this context, the objective of this study was to evaluate the adaptability and phenotypic stability of cowpea elite lines of semi-prostrate growth habit in the Cerrado biome in Brazil.

MATERIAL AND METHODS

Twenty cowpea genotypes of semi-prostrate growth habit from VCU (value for cultivation and use) tests were evaluated, where fifteen lines were from the Embrapa Mid-North Cowpea Breeding Program and five were commercial cultivars (Table 1). Nine experiments were conducted under rainfed conditions, in the 2010, 2011 and 2012 crop seasons, in three locations: Balsas and São Raimundo das Mangabeiras in the State of Maranhão (MA), and Primavera do Leste in the state of Mato Grosso (MT) (Table 2).

All experiments were conducted in a complete randomized block experimental design with four replications. The randomization was performed individually for each environment. The plots of the experiments consisted of four 5.0-meter rows spaced 0.80 m apart, with 0.25 m between plants, and the evaluation area consisted of the two central rows. Weed, pest and disease control was carried out according to the recommendations for cowpea (FREIRE FILHO; LIMA; RIBEIRO, 2005).

The statistical analysis was carried out assuming that each combination of years with locations represents an environment, making nine environments. The yield data were subjected to analysis of variance, considering the mixed model with effect of treatments as fixed and the others as random. A joint analysis of the environments was performed after evaluating the homogeneity of the residual variances. According to Pimentel-Gomes (2000), if the ratio between the largest and the smallest mean square of the residue is less than seven, the residual variances are homogeneous. However, due to the lack of homogeneity of variance, the degrees of freedom of

Table 1 - Cowpea genotypes of semi-prostrate growth habit evaluated in nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

Genotype code	Genotype type	Commercial Subclass
MNC01-649F-1-3	Line	Rajado
MNC01-649F-2-1	Line	Rajado
MNC01-649F-2-11	Line	Rajado
MNC02-675-4-9	Line	Mulato
MNC02-675F-9-5	Line	Mulato
MNC02-676F-1	Line	Mulato
MNC02-677F-2	Line	Sempre verde
MNC02-677F-5	Line	Mulato
MNC02-680F-1-2	Line	Sempre verde
MNC02-689F-2-8	Line	Sempre verde
MNC02-701F-2	Line	Branco
MNC03-736F-2	Line	Branco
MNC03-736F-6	Line	Branco
MNC03-761F-1	Line	Sempre verde
Pingo-de-ouro-1-2	Line	Canapu
BRS Xiquexique	Cultivar	Branco
BRS Juruá	Cultivar	Verde
BRS Aracê	Cultivar	Verde
BR17 Gurguéia	Cultivar	Sempre verde
BRS Marataoã	Cultivar	Sempre verde

Table 2 - Geographic coordinates, average annual precipitation and soil class of the sites used for nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

Location/State	Elevation	Latitude (S)	Longitude (W)	[1/] Average annual precipitation	Soil
Balsas MA	324 m	07º54’	45º96’	1190 mm	Oxisol
São Raimundo das Mangabeiras MA	511 m	06º53’	45º39’	1157 mm	Oxisol
Primavera do Leste MT	636 m	15°33’	54°17’	1784 mm	Oxisol

[1/] Source: www.climate-data.org

the mean error and the G×E were adjusted according to the method of Cochran (1954). The Scott-Knott test at 5% probability was used to identify the existence of homogeneous groups, by minimizing the variation within, and maximizing between groups.

The evaluation of genotype adaptability and stability was performed using the following methods: Eberhart and Russell (1966), Lin and Binns (1988) (modified) (CRUZ; CARNEIRO; REGAZZI, 2014), Wricke (1965) and Annicchiarico (1992).

In the method of Eberhart and Russell (1966), the adaptability was given by the estimation of the parameter β_{1i} and by the average yield β_{0i}; and the stability by the variance of the regression deviations δ_{ij}, according to the following model $Y_{ij} = \beta_{0i} + \beta_{1i}I_j + \delta_{ij} + \Sigma_{ij}$, where: Y_{ij} is the average grain yield (kg ha^{-1}) of genotype i in environment j; β_{0i} is the overall mean; β_{1i} is the linear regression coefficient; I_j is the environmental index; δ_{ij} is the variance of the regression deviations; and Σ_{ij} is the mean experimental error.

According to the method of Lin and Binns (1988) (modified) described by Cruz, Carneiro and Regazzi (2014), the decomposition of P_i in the parts related to favorable and unfavorable environments was performed. The estimate of P_i was given by the equation: $P_i = \frac{\sum_{j=1}^{n}(Y_{ij} - M_j)}{2x}$, where: P_i is the estimation of the adaptability and stability of the genotype i; Y_{ij} is the yield of the genotype i in the environment j; M_j is the maximum observed response among all genotypes in the j environment; and α is the number of environments.

In the Annicchiarico method (1992), the confidence index I_i was calculated for the favorable and unfavorable environments according to the equation: $I_i = \bar{Y}_i - Z_{(1-\alpha)}S_i$, wherein $\bar{Y}_i$ is the overall mean of genotype i in percentage; Z is the percentile (1-α) of the cumulative normal distribution function; α is the level of significance; and S_i is the standard deviation of the percentage values. The coefficient of confidence was 75%, i.e., α = 0.25.

The stability parameter proposed by Wricke (1965) was estimated using the statistic ω_i, through the equation: $\omega_i = r\Sigma_f \hat{G}A^2_{IJ} = r\Sigma_f(Y_{ij} - \bar{Y}_{i.} - \bar{Y}_{.i} + \bar{Y}_{..})^2$, where: Y_{ij} is the mean of the genotype i in the environment j; $\bar{Y}_{i.}$ is the mean of genotype i; $\bar{Y}_{.i}$ is the mean of the environment j; and $\bar{Y}_{..}$ is the overall mean.

The individual and joint analysis of variance, and tests of comparison of means, stability and adaptability were performed using the software GENES (CRUZ, 2013).

RESULTS AND DISCUSSION

The genotypes presented significant differences ($p<0.05$) by the analysis of individual variances, in all environments, except Balsas in 2010 (Table 3). This result denotes genetic variability among the genotypes evaluated, which is essential to proceed with the genotype selection process.

The coefficient of variation (CV) of the experiments evaluated ranged from 13.85 to 36.10% (Table 3). The means and CV of the tests varied, denoting the different conditions to which the genotypes were subjected. The coefficient of variation (CV) is an estimate of the experimental error of the overall mean of the test, and an indication of the experimental accuracy. According to Pimentel-Gomes (2000), observed CV can be classified as low (lower than 10%), average (10% to 20%), high (20% to 30%), and very high (higher than 30%). The CV values found in this work were within the range found in other studies on cowpea, such as Barros *et al*. (2013), Benvindo *et al*. (2010), Bertini, Teófilo and Dias (2009), and Silva and Neves (2011).

The joint analysis of variance showed significant differences ($p<0.01$) for the sources of variation of environments, genotypes, and G×E (Table 4). The significant effect of the G×E indicates the different response of the genotypes to the environments, thus requiring analyzes of adaptability and phenotypic stability.

The grain yield of the genotypes presented homogeneous groups by the Scott-Knott test ($p<0.05$) (Table 5). The edaphoclimatic conditions of São Raimundo das Mangabeiras MA, affected the performance of the genotypes, decreasing their productive performance.

Table 3 - Individual analysis of variance of the grain yield (GY) of 20 cowpea genotypes of semi-prostrate growth habit evaluated in nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

Experiment	Grain Yield		
	Mean (kg ha^{-1})	Mean Square	CV (%)
Year 2010			
Balsas	1657.38	216471.26^{ns}	23.28
Primavera do Leste	1398.97	249295.42**	13.85
São Raimundo das Mangabeiras	767.41	194414.47**	24.48
Year 2011			
Balsas	1976.72	148775.03**	16.35
Primavera do Leste	1103.32	204804.67**	19.55
São Raimundo das Mangabeiras	1113.26	391413.48*	36.10
Year 2012			
Balsas	1146.25	204175.44**	25.83
Primavera do Leste	1248.67	426068.87**	29.03
São Raimundo das Mangabeiras	627.35	161742.90**	25.61

** = significant at 1% probability; * = significant at 5% probability; and ^{ns} = not significant by the F test; CV = coefficient of variation (%)

Table 4 - Joint analysis of variance of the grain yield (kg ha^{-1}) of 20 cowpea genotypes of semi-prostrate growth habit evaluated in nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

Source of Variation	DF	Mean Square
Block/Environment	27	231841.49
Environment (E)	8	13829048.67**
Genotypes (G)	19	685650.21**
G×E	113[1/]	254147.92**
Residual	366[1/]	120566.11
Mean (kg ha^{-1})		1226.59
CV (%)		28.30

** = significant at 1% probability, and * = significant at 5% probability by the F test; CV = coefficient of variation (%); [1/] DF adjusted by the method described by Cochran (1954)

Table 5 - Estimates of adaptability and phenotypic stability by the methods of Eberhart and Russel (1966) and Wricke (1965) for 20 cowpea genotypes of semi-prostrate growth habit evaluated in nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

Genotypes	Mean[1/]	Eberhart and Russell			Wricke	
		$\beta^{2/}_{1i}$	Wi	Wi(%)	$\sigma^{2\,3/}_{di}$	R²(%)
BRS Xiquexique	1451.20 a	0.83^{ns}	1402892	4.88	23235*	75
MNC02-701F-2	1439.61 a	1.39**	2404072	8.37	32845*	88
MNC02-675-4-9	1324.23 b	1.11^{ns}	2253794	7.85	56209**	76
MNC02-677F-5	1323.40 b	1.27*	1577257	5.49	20179^{ns}	88
MNC02-676F-1	1308.84 b	0.88^{ns}	699581	2.44	656^{ns}	87
Pingo-de-ouro-1-2	1299.41 b	0.80^{ns}	902563	3.14	3119^{ns}	84
MNC01-649F-1-3	1298.85 b	1.05^{ns}	1628026	5.67	36047*	79
MNC01-649F-2-11	1282.84 b	0.70*	2174646	7.57	38410**	62
MNC02-675F-9-5	1243.80 b	0.72*	1225799	4.27	6783^{ns}	78
MNC01-649F-2-1	1241.37 b	0.83^{ns}	647764	2.26	4041^{ns}	89
MNC02-677F-2	1239.02 b	1.19^{ns}	1326516	4.62	18648^{ns}	87
BRS Marataoã	1233.84 b	1.33**	2127175	7.41	32685*	87
MNC02-689F-2-8	1219.27 b	1.18^{ns}	687196	2.39	-3592^{ns}	94
MNC03-761F-1	1211.27 b	0.73*	1128896	3.93	4692^{ns}	80
MNC03-736F-2	1183.71 b	1.22^{ns}	1030329	3.59	5523^{ns}	92
BR17 Gurguéia	1141.99 c	1.01^{ns}	871283	3.03	9559^{ns}	87
MNC02-680F-1-2	1131.18 c	0.78^{ns}	1183909	4.12	11901^{ns}	79
MNC03-736F-6	1087.52 c	1.41**	1912348	6.66	12679^{ns}	92
BRS Aracê	1031.32 c	0.80^{ns}	1653783	5.76	29855*	71
BRS Juruá	839.15 d	0.70*	1880888	6.55	27992*	66
Overall Mean	1226.60		28718716	100		

** = significant at 1% probability; * = significant at 5% probability; and ^{ns} = not significant by the t test; [1/] Means followed by the same letter belong to the same class ($p \leq 0.05$); [2/]H_0: $\beta_{1i} = 1$; [3/]H_0: $\sigma^2_{di} = 0$

Regarding the average grain yield, the line MNC02-701F-2 (1451.20 kg ha^{-1}) and the cultivar BRS-Xiquexique (1439.60 kg ha^{-1})—both from the *branco* commercial subclass—stood out from the others, presenting promising yields, with good adaptation to the edaphoclimatic conditions of the cerrado biome in Maranhão. However, the overall average yield found in this study (1226.60 kg ha^{-1}) is lower than the averages found by Teixeira *et al.* (2010) (1307.00 kg ha^{-1}) and Silva and Neves (2011) (1436.35 kg ha^{-1}) in cowpea crops also in the Cerrado biome.

The regression coefficient (β_{1i} = 1) of the model proposed by Eberhart and Russell (1966), measures the adaptability of the genotypes, and the stability of their behavior is measured by the variance of regression deviations (σ^2_{di} = 0) and by the coefficient of determination (R^2). According to Cruz, Carneiro and Regazzi (2012), the R^2 assists in the evaluation of stability, when the σ^2_{di} are significant. The lines MNC02-676F-1, MNC01-649F-2-1, MNC02-677F-2 and Pingo-de-Ouro-1-2 presented high grain yields, wide adaptability (β_{1i} = 1), high stability (σ^2_{di} = 0) and coefficient of determination (R^2) greater than 84 (Table 5).

In the evaluation using the method of Wricke (1965), the most stable genotypes, those that contributed least to the interaction, were MNC01-649F-2-1, MNC02-689F-2-8, MNC02-676F-1 and Pingo-de-Ouro-1-2 and BR17-Gurguéia (Table 5). However, the results were not very descriptive in detecting stable and adapted genotypes. The limitation of this methodology is that it indicates only the contribution of each genotype to the G×E; thus, it cannot show the performance of the genotypes, requiring complementation by other methodologies of adaptability analysis.

According to the methodology of Lin and Binns (1988) (modified) (CRUZ; CARNEIRO; REGAZZI, 2014), which classifies genotypes for adaptability and phenotypic stability in favorable and unfavorable environments, the most stable genotype is the one that shows the smallest deviation in maximum yield in each environment, i.e., the smallest P_i. Therefore, the lines MNC04-677F-5, MNC02-701F-2 and MNC02-676F-1, and the cultivar BRS-Xiquexique, in addition to presenting the lowest overall P_i, also presented the first positions for the parameters P_i, favorable and unfavorable (Table 6).

The cultivar BRS-Xiquexique was the most stable, the second most responsive to the favorable environments, and the most adapted to unfavorable environments. The line MNC02-701F-2 was the most responsive to the favorable environments. The most stable and adapted genotypes are the most productive ones.

According to Pereira *et al.* (2009), an advantage of the method of Lin and Binns (1988) is the immediate identification of more stable genotypes due to the use of the single parameter P_i. Nunes *et al.* (2014) and Shiringani and Shimelis (2011) evaluated cowpea crops and found similar results regarding the parameter P_i, thus confirming that the most adapted and stable genotypes always have the highest yields.

According to the method of Annicchiarico (1992), the genotypes BRS-Xiquexique, MNC02-676F-1, MNC02-701F-2, Pingo-de-Ouro-1-2, MNC01-649F-1-3 and MNC01-649F-2-11 were identified with confidence indexes (W_i) greater than 100% (Table 6). The genotypes BRS-Xiquexique, MNC02-701F-2, MNC02-675-4-9, MNC02-677F-5, MNC02-676F-1, MNC01-649F-1-3 and MNC02-677F-2 stood out in favorable environments (W_{if}); and in unfavorable environments (W_{id}), 45% of the genotypes surpassed the average of the environments, especially BRS-Xiquexique and Pingo-de-Ouro-1-2.

The Eberhart and Russell (1966) methodology was efficient to indicate genotypes of wide adaptability and high stability, especially the genotypes MNC02-676F-1, MNC01-649F-2-1, MNC02-677F-2 and Pingo-de-Ouro-1-2. This is probably the most appropriate method, since it considers the productivity, adaptability and stability of each cultivar. The genotypes MNC02-676F-1, MNC01-649F-2-1 are among the most stable genotypes, according to methodology of Wricke (1965). This result is similar to that found by Mendes de Paula *et al.* (2014), where the methods of Wricke (1965) and Eberhart and Russell (1966) tended to select the most stable genotypes.

On the other hand, the method based on non-parametric statistics of Lin and Binns (1988) (modified), and the method of Annicchiarico (1992) indicate the genotypes BRS-Xiquexique and MNC02-701F-2 as those that had the highest yields with high instability and responsiveness to favorable environments. This result is an advantage of this method over methods based on analysis of variance. Conversely, Pereira *et al*. (2009) reported that the methods of Lin and Binns (1988) (modified) and Annicchiarico (1992) are indicated to be used singly, because they are simple to use and allow the classification of favorable and unfavorable environments, and identification of the most stable and adapted genotypes among the most productive ones. According to the same author, the joint use of methods that presented high correlation is not recommended; in this case, the method of Eberhart and Russell (1966) must be used together with the method of Lin and Binns (1988) (modified) or the method of Annicchiarico (1992), since there was no correlation between these methods.

Table 6 - Estimates of adaptability and phenotypic stability by the method of Lin and Binns (1988) (modified), with distribution of P_i (parameter of stability and adaptability) in favorable (P_{if}) and unfavorable (P_{id}) environments; and by the method of Annicchiarico (1992) (W_i - confidence index), with distribution in favorable (W_{if}) and unfavorable (W_{id}) environments, of 20 cowpea genotypes of semi-prostrate growth habit evaluated in nine experiments conducted in Balsas MA, São Raimundo das Mangabeiras MA, and Primavera do Leste MT, in the 2010, 2011 and 2012 crop seasons

	Mean[1/]	Lin and Binns modified						Annicchiarico					
		P_i(x10³)	C[2/]	P^{if}(x10³)	C	P_{id}(x10³)	C	E_i	C[2/]	W_{if}	Rank	W_{id}	Rank
BRS Xiquexique	1451.20 a	48	1	44	2	51	1	116	1	112	2	120	1
MNC02-701F-2	1439.61 a	62	2	21	1	94	7	108	2	118	1	101	8
MNC02-675-4-9	1324.23 b	108	7	49	5	154	15	100	7	111	3	92	10
MNC02-677F-5	1323.40 b	93	4	65	4	116	10	99	10	109	4	91	12
MNC02-676F-1	1308.84 b	81	3	85	3	77	5	105	3	101	7	109	4
Pingo-de-ouro-1-2	1299.41 b	94	5	143	9	55	2	104	4	97	11	112	2
MNC01-649F-1-3	1298.85 b	104	6	67	6	135	9	101	6	105	6	97	9
MNC01-649F-2-11	1282.84 b	114	8	130	10	102	8	102	5	100	8	103	7
MNC02-675F-9-5	1243.80 b	125	11	171	14	89	4	100	8	91	14	109	3
MNC01-649F-2-1	1241.37 b	124	10	157	12	98	3	99	9	94	12	105	5
MNC02-677F-2	1239.02 b	118	9	70	7	157	17	92	13	106	5	81	17
BRS Marataoã	1233.84 b	134	13	107	8	156	16	87	17	100	9	79	18
MNC02-689F-2-8	1219.27 b	129	12	113	11	141	12	93	12	99	10	88	15
MNC03-761F-1	1211.27 b	141	14	205	17	89	6	98	11	90	15	104	6
MNC03-736F-2	1183.71 b	151	15	153	13	149	14	90	14	92	13	88	13
BR17 Gurguéia	1141.99 c	164	16	193	16	141	13	88	15	88	17	88	14
MNC02-680F-1-2	1131.18 c	169	17	246	18	107	11	88	16	84	18	91	11
MNC03-736F-26f-6	1087.52 c	217	18	177	15	250	19	78	19	90	16	71	19
BRS Aracê	1031.32 c	246	19	302	19	202	18	80	18	76	19	84	16
BRS Juruá	839.15 d	401	20	438	20	371	20	64	20	68	20	61	20
Overall Mean	1226.60												

[1/] Means followed by the same letter belong to the same class ($p \leq 0.05$); [2/] Genotype stability classification.

CONCLUSIONS

1. Considering the results obtained by the joint use of the methods Lin and Binns (1988) (modified), Annicchiarico (1992) and Eberhart and Russell (1966) is important for analyses in cowpea, since each one has peculiarities that can contribute to the choice of adapted, stable and productive genotypes;
2. The cultivar BRS-Xiquexique and the lines Pingo-de-ouro-1-2, MNC02-676F-1, MNC01-649F-2-1 and MNC02-677F-2 were considered promising. The lines of the commercial subclasses *canapu*, *mulatto*, *rajado* and *sempre-verde* have potential to be released as commercial cultivars, because they have adaptability and stability for the evaluated environments. The line MNC02-701F-2 presented adaptability and stability for the Cerrado biome, however, it does not have potential as commercial cultivar, since it does not exceed the cultivar BRS-Xiquexique, both belonging to the *branco* commercial subclass.

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