Genetic parameters estimate, phenotypic and environmental correlations in sunflower at Distrito Federal Savanna

Estimativa de parâmetros genéticos, correlacões fenotípicas e ambientais no girassol do Cerrado do Distrito Federal

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ABSTRACT
The purpose of this study was to evaluate the estimation of genetic parameters, phenotypic, environmental correlations, and the temporal effect on the morphoagronomic characteristics of sunflower genotypes in the Brazilian Savanna of the Federal District. The characters evaluated were: grain yield, chapter size, weight of a thousand achenes, plant height and days for initial flowering. The genotypes analyzed were GNZ Neon, MG 360, BRS 323, SYN 3950, MG 305, ADV 5504, Aguará 06, SYN 045, Paraíso 20, Aguará 04, CF 101, HLA 2012, M 734 (T), Hélio 250, Hélio 251 and BRS G42. Highly significant differences were found between genotypes for all morpho-agronomic characteristics evaluated. The high coefficient of genetic variation highlights the possibility of obtaining genetic gains for all characteristics analyzed except in chapter size. All characteristics evaluated presented statistical differences between genotypes. The Neon GNZ (3606 kg ha^{-1}) and CF 101 (3606 kg ha^{-1}) hybrids stand out for their grain yield characteristics. Among the genotypes evaluated, promising materials were identified for possible exploitation in improvement programs and, also, the implementation in irrigated production system in the Brazilian Savanna.

Keywords: *Helianthus annuus* L., agronomic characters, genetic diversity.

RESUMO
O propósito deste trabalho foi avaliar a estimativa de parâmetros genéticos, correlações fenotpicas, ambientais, e o efeito temporal sobre as características morfoagronômicas de genótipos de girassol no Cerrado do Distrito Federal. Os caracteres avaliados foram: rendimento de grãos, tamanho do capítulo, peso de mil aquênios, altura de plantas e dias para floração inicial. Os genótipos analisados foram GNZ Neon, MG 360, BRS 323, SYN 3950, MG 305, ADV 5504, Aguará 06, SYN 045, Paraíso 20, Aguará 04, CF 101, HLA 2012, M 734 (T), Hélio 250, Hélio 251 e BRS G42. Foram constatadas diferenças altamente significativas entre os genótipos para todas as características morfoagronômicas avaliadas. O alto coeficiente de variação genética destaca a possibilidade de obter ganhos genéticos para todas as características analisadas salvo em tamanho de capítulo. Todas as características avaliadas apresentaram diferenças estatísticas entre os genótipos. Sobressaíram-se os híbridos GNZ Neon (3606 kg ha^{-1}) e CF 101 (3606 kg ha^{-1}) para a caraterística de rendimento de grãos. Dentre os genótipos avaliados, materiais promissores foram identificados para possível exploração em programas de melhoramento e, também, a implementação em sistema de produção irrigado no Cerrado.

Palavras-chave: *Helianthus annuus* L., caracteres agronômicos, diversidade genética.

1 INTRODUCTION

Sunflower (*Helianthus annuus* L.) stands out among oilseeds, not only for its high oil content, but also for its tolerance to drought, low and high temperatures, which gives it wide adaptability to different soil and climate conditions (Castro et al., 2005). The crop has important agronomic characteristics; it develops well in most soils, has a short vegetative cycle, which varies from 90 to 130 days. Besides that it is cultivated on five continents, with great importance in the world economy (FAOSTAT, 2019).

The crop has adaptability to different regions, and with genotype x environment interaction, varied results are obtained in different locations and growing seasons (Ungaro et al., 2000). The search for materials adapted to the growing conditions is fundamental for the success of sunflower improvement programs (Lira et al, 2021). With this there is need for evaluation of genetic parameters, phenotypic and environmental correlations in each region for agronomic characterization and recommendation of cultivars (Amabile et al, 2021).

This work aims to estimate the genetic parameters, phenotypic and environmental correlations in sunflower in the Brazilian Savanna of the Federal District, and to evaluate the temporal effect on morphoagronomic characteristics of sunflower genotypes in second crop.

2 MATERIAL AND METHODS

The experiments were conducted in the Experimental Field of Embrapa Cerrados (CPAC), Planaltina-DF, located at 15º35'30" South latitude and 47º42'30" West longitude, at an altitude of 1,007 m, in a typical dystrophic, clayey OXISOL RED. A trial was evaluated in the second crop, where 16 sunflower genotypes were tested under irrigation system via central pivot.

The following genotypes were evaluated: GNZ Neon, MG 360, BRS 323, SYN 3950, MG 305, ADV 5504, Aguará 06, SYN 045, Paraíso 20, Aguará 04, CF 101, HLA 2012, M 734 (T), Helio 250, Helio 251 and BRS G42.

The experimental design used was randomized block design with four repetitions. According to the results of soil analysis, 350 kg ha^{-1} of the formulation 4-30-16 were applied in the sowing furrow and 50 kg ha^{-1} of cover crop urea were added. The Genes program (Cruz, 2007) was used to compare means, using the Skott-Knott test at 5% significance level.

The following agronomic traits were evaluated: 1. grain yield - REND (kg ha^{-1}); 2. capitulum size - TC (cm); 3. weight of one thousand achenes - PMA (g); 4. plant height - ALT (cm); 5. days to initial flowering - DFI (days).

3 RESULTS AND DISCUSSION

The estimation of genetic parameters and the quantification of genetic variability are fundamental for the planning and execution of a breeding program. By estimating the genetic parameters it is possible to know the genetic structure and evaluate the efficiency of different breeding strategies, maintaining an appropriate genetic base and promoting an adequate selection of genotypes, in addition to stipulating the weight that should be assigned to each characteristic, separately or together, in the selection (Cruz and Carneiro, 2006).

The F value has been used as an indicator of the degree of experimental accuracy (Cargnelutti Filho and Storck, 2009) and according to Resende and Duarte (2007) the F value of genotypic evaluation trials should be greater than 2.0. The F values found in this study ranged from 3.38 to 80.82, being adequate and fitting the class of accuracy given as high to very high, according to Resende and Duarte (2007).

According to Resende and Duarte (2007) the accuracy obtained for the characteristics studied was high for TC and very high for the other characteristics (REND, PMA, ALT, DFI).

The coefficients of environmental variation (CV_e) showed small magnitude. This characteristic is highly influenced by the environment and also presents difficulty of determination due to the lack of visual acuity. The analysis of the CV_e value should consider the particularities of the crop being evaluated and, mainly, the nature of the character being analyzed, to have a better understanding of the results. The CV_e values ranged from 2.10% for DFI to 8.91% for TC indicating high experimental precision.

The coefficient of genetic variation (CV_g) is a parameter that allows deducing the magnitude of genetic variability present in populations and in different characters (Resende, 2002). Thus, it was observed in the results obtained that the values of CV_e differed more than the CV_e, in the same way that the genetic variance when compared to the environmental variance, for the characters REND, PMA, ALT and DFI. However, it was lower than the CV_e for the TC character suggesting a condition not very favorable for phenotypic selection for this character.

The CV_r coefficients were greater than 1, except for the TC character (Table 1), indicating that for most traits measured there is the possibility of success in phenotypic selection since the genetic variance exceeded the environmental variance.

Another important parameter to analyze the experimental accuracy is heritability. It was observed in Table 1, that the estimates of heritability in the broad sense, for the characters REND, PMA, ALT and DFI, recorded values greater than 90%, indicating a predictive correspondence between the phenotypic value and genetic value as reported by Vencovsky and Barriga (1992) and Falconer and Mackay (1996).

The highest heritability estimate was seen for the PMA character (98.76%). The heritability for the other traits was for REND (98.41), TC (70.47%), ALT (98.20%) and DFI (98.73%). Thus, it is assumed that under Brazilian Savanna's conditions, there was efficient control of environmental variation, better expression of genetic differences and, therefore, higher heritability.

In the analyses of variance of morphoagronomic characteristics (Table 2), grain yield ranged from 1944 kg ha^{-1} (Aguará 04) to 3606 kg ha^{-1} (GNZ Neon). The genotypes SYN 3950 (3463 kg ha^{-1}), GNZ Neon (3606 kg ha^{-1}), MG 305 (3344 kg ha^{-1}) had the highest yields and were statistically similar to the witness M743 (3445 kg ha^{-1}), showing the high potential for productivity of the cultivars evaluated. Considering these data, it should be noted that these high yields exceeded the average national production of sunflower in the 2019/2020 crop, which was about 1590 kg ha^{-1} (CONAB, 2021).

According to Castro and Farias (2005), chapter diameter is among the quantitative and morphological characteristics of sunflower and the differences are due to the intrinsic characteristics of each genotype and are greatly influenced by different environmental conditions and the management adopted in the crop. In the trials, the CT showed seven genotypes with the largest chapter sizes (GNZ Neon; MG 360; BRS 323; SYN 3950; MG 305; Paraíso 20; BRS G42) that did not differ statistically from the witness M743 (17.25 cm).

Regarding PMA, no genotype outperformed the witness M743 (71.25 g), but the genotypes GNZ Neon (69.50 g), SYN 3950 (69.00 g), SYN 045 (69.50 g) and BRS G42 (67.25 g) were statistically similar to it. The difference in mass can be justified by the level of competition between the plants.

As for the characteristic Height, the genotypes GNZ Neon (165 cm) and SYN 3950 (163.75 cm) expressed the greatest heights, statistically diverging from the control M743 (135 cm), while the genotypes that presented the smallest heights were BRS 323 (106.25 cm) and BRS G42 (107.50 cm). It is important to note that the smaller size of the plants is desirable, since it can avoid plant breakage and facilitate harvesting.

The DFI characteristic showed great variation among the genotypes, with the GNZ Neon genotype being the later, with 65.25 days, and BRS G42 (45.50 days) the earlier. Both were statistically different from the witness M743 (56.50 days). A short production cycle is a desirable characteristic for the second crop in the Brazilian Savanna, provided that the adequate physiological process of grain production is ensured, to avoid problems in flowering due to water stress.

4 CONCLUSIONS

Highly significant differences were found among genotypes for all morphoagronomic traits evaluated. The most promising genotypes (GNZ Neon, BRS 323, SYN 045, MG 305, and BRS G42) were identified for future use in breeding programs.

The high coefficient of genetic variation highlights the possibility of genetic gains for all traits analyzed except for chapter size.

Genetic materials with potential for the agronomic traits researched were found in this work, and can be cultivated in the irrigated production system in the Brazilian Savanna.

Table 1. Genetic parameters of grain yield (REND) in kg ha^{-1}, capitulum size (TC) in cm, weight of a thousand achenes (PMA) in g, plant height (ALT) in cm and days to initial flowering (DFI) in days in second crop. Embrapa Cerrados, Planaltina, DF.

Genetic Prarameters	REND (kg ha^{-1})	TC (cm)	PMA (g)	ALT (cm)	DFI (days)
QMg	1,085,839.023958	7.66667	409.733333	1,522.057292	111.516667
QMe	17,243.401736	2.26389	5.069444	27.335069	1.408333
F	62.9713	3.3865	80.8241	55.6815	79.1834
σ_f^2	271.459,75599	1,916667	102.433333	380.514323	27.879167
σ_g^2	267,148.905556	1.350694	101.165972	373.680556	27.527083
σ_e^2	4,310.850434	0.565972	1.267361	6.833767	0.352083
h_a^2 (%)	98.412	70.471	98.7627	98.2041	98.7371
Cv_e (%)	4.796124	8.916282	3.932826	3.670992	2.107405
CV_g (%)	18.87800	6.8871	17.5688	13.5729	9.317
CV_r (%)	3.9361	0.7724	4.4672	3.6973	4.4211
$\hat{r}_{gg}$	0.9920	0.83947	0.99379	0.99098	0.99367
Mean	**2737.92**	**16.87**	**57.25**	**142.42**	**56.31**

Table 2. Mean values of grain yield (REND) in kg ha^{-1}, capitulum size (TC) in cm, weight of a thousand achenes (PMA) in g, height (ALT) in cm and days to initial flowering (DFI) in days. Embrapa Cerrados, Planaltina, DF.

Genotype	REND (kg ha^{-1})		TC (cm)		PMA (g)		ALT (cm)		DFI (days)	
GNZ Neon	3,606.75	a	17.00	a	69.50	a	165.00	a	65.25	a
MG 360	2,846.75	b	17.50	a	58.00	c	137.50	c	57.50	d
BRS 323	2,467.75	c	20.00	a	63.75	b	106.25	e	48.50	f
SYN 3950	3,463.50	a	18.50	a	69.00	a	163.75	a	58.75	c
MG 305	3,344.25	a	17.50	a	51.00	d	128.75	d	58.25	c
ADV 5504	2,143.75	d	16.50	b	60.25	d	157.50	b	53.50	e
Aguará 06	2,587.50	c	15.75	b	46.50	e	165.00	a	61.50	b
SYN 045	3,048.50	b	16.25	b	69.50	a	157.50	b	59.50	c
Paraíso20	2,943.50	b	18.00	a	43.50	f	158.75	a	55.50	d
Aguará 04	1,944.50	e	16.50	b	42.25	f	150.00	b	53.50	e
CF 101	2,408.00	c	15.5	b	46.75	e	132.50	c	48.50	f
HLA 2012	2,506.75	c	16.00	b	54.00	d	155.00	b	58.50	c
M 734 (T)	3,445.00	a	17.25	a	71.25	a	135.00	c	56.50	d
Hélio 250	2,121.75	d	14.50	b	52.25	d	123.75	d	59.50	c
Hélio 251	2,499.50	c	15.50	b	51.25	d	135.00	c	60.75	b
BRS G42	2,429.00	c	18.00	a	67.25	a	107.50	e	45.50	g

*Means followed by the same lower case letter in the column belong to the same grouping by the Scott-Knott criterion (P> 0.05).

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