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STUDY OF PHENOTYPIC AND GENETIC VARIABILITY IN MAIZE CROSSINGS BETWEEN INBRED LINES (CYCLE I) AND ELITE LINES (CYCLE II)

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Abstract

Maize inbred lines derived from local populations (Cycle I lines) were tested using cycle II elite inbred lines. In the crossing system, the hybrids have a large variability for yield (6,601-10,571 kg/ha), the largest differences between hybrids are due to the non-additive genetic effects; undesirable traits transmitted by cycle I inbred lines are weak resistance to stalk breaking and fallen plants; for the percentage of unbroken plants, the genetic variability is high, the percentage of unbroken plants for simple hybrids has a range value between 65.02% and 89.70%. Correlation coefficients were calculated between the "per se" values of the inbred lines in the cross system and the values of additive genetic effects calculated in the "m x n" cross system. Positive correlations were identified between "per se" values and positive genetic effects for yield, ear weight, ear length, number of grains per ear, TKW, grain depth. These high positive correlation values indicate the possibility of using phenotypic markers in the process of creating inbred lines.

Key words: *GCA, inbred lines, maize, SCA, yield.*

INTRODUCTION

More than 135,000 maize progenies are kept in gene banks worldwide, according to the latest data from the CGIAR Genebank Platform. These sources of germplasm and the collections of gene banks, research institutes and private companies creating maize hybrids might contribute as an inexhaustible source of diversity for the creation of inbred lines, and also avoid narrowing the genetic base (Troyer, 1999; 2004; Carena et al., 2010). These germplasm sources are also of great importance in maize breeding programs due to their involvement in the creation of new varieties with higher yield potential (Byerlee & Edmeades, 2021; Paudel et al., 2022), higher tolerance to biotic and abiotic stress (Katengeza & Holden, 2021; Prasanna et al., 2021). Maize breeding programs began at the very beginning of modern breeding (Sprague, 1983; Hallauer & Miranda, 1988) by inbreeding some varieties and local populations, but in these situations inbreeding depression led to some discouraging results.

In Romania, modern maize breeding has encountered the same problems: massive segregation of recessive genes, obtaining inbred lines with low yield, low resistance to breaking and falling, phenotypic manifestation of some deficient genes in the grains.

The establishment of the Institute of Maize Breeding Fundulea (N.A.R.D.I. Fundulea) and Agricultural Research and Development Stations (A.R.D.S.) Saftica, Simnic, Turda and Podu-Iloaiei meant a new stage in the reconsideration of obtaining inbreed lines from local populations and was a real challenge for the researchers (Sarca, 1985; Ciocazanu et al., 1995; Has et al., 1999).

The perseverance of Romanian maize breeders led to the creations of double, trilinear and simple hybrids, where at least one of the parental inbreed lines was obtained from maize varieties or local populations: N.A.R.D.I. Fundulea (DC 310, SC 330, DC 225, DC 305), A.R.D.S. Turda (Turda 213- SC, Turda 115-DC, Turda Super-TWC, Turda 160-SC), A.R.D.S. Suceava (Suceava 96-DC, Suceava 108-TWC), A.R.D.S. Lovrin (Lovrin 400-SC), A.R.D.S. Podu Iloaiei (PI 205-TWC).

The use of germplasm from second cycle led to easier breeding of performant inbred lines but with consequences in narrowing the genetic base for the creation of hybrids (Cabulea, 2004; Sarca, 2004; Carena et al., 2010).

In Central and Eastern Europe, after the introduction of maize crop, a wide germplasm base was created, with high genetic variability but also with introgression of different population that were introduced in this territory more than 400 years ago (Has et al., 2006; Sarca et al., 2007; Has et al., 2010; Knezevich-Jaric et al., 2010; 2014; Simeonovska et al., 2013). Existing germplasm from gene banks and breeders collections can form the basis for obtaining genetically differentiated inbred lines from the elite lines currently in use on the breeding programs.

The aim of this work was to study the behavior of cycle I lines (obtained directly from varieties and local populations) in crosses with elite inbred lines (cycle II) in order to find new sources of heterotic germplasm.

MATERIALS AND METHODS

Testing of crosses and hybrids was carried out at the Maize Breeding Laboratory from A.R.D.S. Turda. The experimentation of inbred lines and hybrids, presented in this paper, was carried out in 2019 and 2020.

The inbred lines used as testers (n) (elite inbred lines - cycle II) were obtained by selection from commercial hybrids (TC344 and TC356), respectively from a composite hybrid combination based on Lancaster type inbred lines (TC385A). Except for the composite line TC316, which was obtained from a hybrid combination of a cycle I line and cycle II line, all other lines studied are cycle I, and originate from Transylvanian local populations (T291, T141, T157 and T164), the crossing of two varieties (T145), one variety (T139) and from a southern German flint population (D105) (Table 1).

The studied inbred lines were used as maternal parents, and the tester inbred lines as paternal ones.

The data obtained from inbred lines and hybrid experimental plots were processed by using the analysis of variants. The variance of genotypes (for simple hybrids) was non-orthogonal decomposed in the variance of testers (s^2, $\hat{g}_m$), variance of the cycle I lines (s^2, $\hat{g}_m$) and the genetic variation due to non-additive interactions "tester x cycle I inbred lines" (s^2 $\hat{s}_{mxn}$) (HAS V. et al., 2010).

The phenotypic value for each character in each combination is given by:

$$HS\ x_{mxn} = \mu + \hat{g}_m + \hat{g}_n + \hat{s}_{m\,x\,n} + e_{m\,x\,n\,x\,k}$$

where:

x_{mxn} - simple hybrids m x n;

μ - mean of the experimental system;

$\hat{g}_m$ - general combining ability of "m" inbred lines (tester lines);

$\hat{g}_n$ - general combining ability of "n" inbred lines (tester lines);

$\hat{s}_{m\,x\,n}$ - specific combining ability of "m x n" cross;

$e_{m\,x\,n\,x\,k}$ - experimental error (Cabulea, 2004).

Table 1. Inbred lines used in cyclical crossbreeding system "m x n" (8 x 4)

No	Inbred lines	Inbred lines origin
1.	TC316	S 54 (population Smolice - Polonia) x Mo17
2.	D105	Flint population (I) from southern Germany
3.	T291	Population of Ungheni
4.	T141	Population of Copsa Mica
5.	T145	ICAR 54 x Romanian of Studina (variety x variety)
6.	T139	Portocaliu de Targul Frumos (variety)
7.	T157	Population of Dumbravioara
8.	T164	Population of Batos
Inbred lines tester (n)		
9.	TA367	F32 x F19
10.	TC344	Selection from commercial hybrid
11.	TC385A	Syn. SRR - Comp. B
12.	TE356	Selection from commercial hybrid

RESULTS AND DISCUSSIONS

Results regarding the inbred lines

The analysis of variance for the 12 inbred lines, for yield, dry matter content at harvest and percentage of unbroken plants at harvest is shown in Table 2. There are significant differences for yield due to the experimental years and also for the three analyzed characters due to the genotype and the interaction "experimental year x genotype".

The differences between the experimental years for the yield of the inbred lines is a consequence of reduced ability in response to the environment of this homozygous genotypes; mainly, cycle I inbred lines responded categorically to environmental conditions. These results confirmed the data presents by Duvick (1984) and Russell (1986), that inbred lines obtained directly from varieties and local populations have more genes with additive genetic effects that react to environmental changes.

Table 2. Analysis of variance for phenotypic characters of the inbred lines from cyclical crossbreeding system "m x n" (8 x 4) Turda, 2019-2020

Source of variability		**Yield**		**Dry matter**		**Unbroken plants**	
	DF	s^2	F test	s^2	F test	s^2	F test
TOTAL	71	-		-		-	
Experimental years (Y)	1	92500400	289.85**	3.56	0.43	512.00	10.53
Repetition	2	-		-		-	
Genotypes (G)	11	17991810	150.60**	32.35	14.15**	495.67	14.17**
Year x Genotype (YxG)	11	2266014	18.97**	13.28	5.81**	115.22	3.29**
Error (Y)	2	319131		2.35		48.63	

Eight yield characters, percentage of unbroken plant and grain dry matter content at harvest are presented in Table 3.

The yield of the tester lines ranged from 4,930 kg/ha to 5,774 kg/ha, while for the inbred lines of cycle I, the yield amplitude was significantly higher. The least productive inbred line was found to be T145 (1,142 kg/ha), while the yield of inbred lines TC316 and T291 was at the level of tester inbred lines (5,945 kg/ha, respectively 5,943 kg/ha).

Ear weight had a similar reaction as the yield, as most of the studied inbred lines had only one well developed ear. The highest ear weight was found in the case of lines TC316 and T291, their weight exceeded 100 g, while the rest of the "m" lines had much lower weights. The weight of the ears was higher in the case of the elite lines, three of them exceeding 100 g (TA367, TC344 and TC385A).

Ear length ranged between 12.9 cm and 16.7 cm for the tester inbred lines and 9.5 cm, respectively 16.9 cm for cycle I lines; the average length at the cycle I lines is lower than the average of cycle II inbred lines. For the eight cycle I inbred lines the average ear length was 11.3 cm, while for the cycle II inbred lines (tester inbred lines) the average length of was 15.2 cm.

For the tester inbred lines, the mean of the values for the number of kernel rows per ear were between 13.3 and 17.2, while for cycle I lines it was between 12.1 and 14.6.

For the thousand kernel weight the range of values was between 207.4 g and 267 g for the tester inbred lines and between 96.2 g and 293.3 g for the cycle I lines. It should be noted that the inbred line with the lowest T.K.W. (T139) comes from the Portocaliu de Targu Frumos variety, a microsperma flint variety with small grain.

Neither for the tester inbred lines, nor for the cycle I lines, was the grain depth very high; in cycle I lines there were four genotypes with small depth grain: T141, T139 (0.5 cm), T145 and T164 (0.6 cm).

The shelling percentage values for the tester inbred lines varied between 74.2% and 80.5%, while for the cycle I inbred lines the amplitude for this character was significantly higher: between 63.0% for T145 and 77.3% for D105.

The average percentage of unbroken plants was 82.8% for the tester inbred lines and 72.1% for the cycle I lines; in the cycle I lines the range for this character was between 58.3% for T157 to 85.5% for T141.

The range of grain dry matter content at harvest was between 77.1% and 82.5% for tester lines and 79.0% and 84.5% for the cycle I lines; these values indicate that both categories of inbred lines are composed of early and mid-early inbred lines (FAO 300 - 400).

Table 3. Analysis of variances for some phenotypic characters of the inbred lines
in the cyclic crossing system “m x n” (8 x 4) Turda, 2019-2020

No.	Character		**TC316**	**D105**	**T291**	**T141**	**T145**	**T139**	**T157**	**T164**	**TA367**	**TC344**	**TC385A**	**TE356**	**Mean**	**P5%**
1.	Yield (kg/ha)	a±	5,945 (2015)	3,281 (-649)	5,943 (2013)	2,316 (-1614)	1,142 (-2788)	1,818 (-2112)	2,909 (-1021)	2,820 (-1110)	5,234 (1304)	5,047 (1117)	5,774 (1844)	4,930 (1000)	3,930	402
2.	Ear weight (g)	a±	117.6 (38)	64.7 (-13.9)	116.3 (36.7)	52.2 (-27.4)	38.1 (-41.5)	33.4 (-46.2)	59.4 (-20.2)	61.3 (-18.3)	100.3 (20.7)	113.3 (33.7)	113.8 (34.2)	83.2 (3.6)	79.6	7.94
3.	Ear length (cm)	a±	16.9 (3.8)	11.5 (-1.6)	12.5 (-0.6)	12.2 (-0.9)	9.7 (-3.4)	11.2 (-1.9)	9.5 (-3.6)	12.3 (-0.8)	15.7 (2.6)	15.6 (2.5)	16.7 (3.6)	12.9 (-0.2)	13.1	0.76
4.	Number of rows	a±	13.6 (-0.5)	12.1 (-2)	13.3 (-0.8)	12.3 (-1.8)	14.6 (0.5)	12.1 (-2)	14.9 (0.8)	14.1 (0)	17.2 (3.1)	16.8 (2.7)	13.3 (-0.8)	14.4 (0.3)	14.1	0.79
5.	Number grains/row	a±	29.5 (4)	24.2 (-1.3)	26.4 (0.9)	20.7 (-4.8)	17.5 (-8)	25.2 (-0.3)	19.1 (-6.4)	26.7 (1.2)	29.3 (3.8)	27.5 (2)	30.1 (4.6)	29.5 (4)	25.5	1.92
6.	TKW (g)	a±	270.1 (55.3)	212.8 (-2)	293.3 (78.5)	218.0 (3.2)	140.5 (-74.3)	96.2 (-118.6)	223.4 (8.6)	182.9 (-31.9)	215.2 (0.4)	251.1 (36.3)	267.4 (52.6	207.4 (-7.4)	214.8	20.67
7.	Grain depth (cm)	a±	0.7 (0)	0.7 (0)	0.8 (0.1)	0.5 (-0.2)	0.6 (-0.1)	0.5 (-0.2)	0.7 (0)	0.6 (-0.1)	0.7 (0)	0.8 (0.1)	0.7 (0)	0.8 (0.1)	0.7	0.10
8.	Shelling percentage (%)	a±	76.5 (3)	77.3 (3.8)	76.5 (3)	66.0 (-7.5)	63.0 (-10.5)	67.0 (-6.5)	74.3 (0.8)	73.4 (0.1)	77.3 (3.8)	74.2 (0.7)	76.4 (2.9)	80.5 (7)	73.5	6.74
9.	Unbroken plants (%)	a±	72.5 (-3.1)	71.6 (-4)	65.4 (-10.2)	85.5 (9.9)	76.9 (1.3)	67.3 (-8.3)	57.3 (-18.3)	80.1 (4.5)	83.2 (7.6)	85.3 (9.7)	76.7 (1.1)	85.8 (10.2)	75.6	6.87
10.	Dry matter (%)	a±	79.0 (-2)	79.2 (-1.8)	79.2 (-1.8)	80.7 (-0.3)	84.8 (3.8)	84.6 (3.6)	82.6 (1.6)	81.3 (0.3)	81.3 (0.3)	77.1 (-3.9)	80.0 (-1)	82.5 (1.5)	81.0	1.76

a± = *per se* values compared to the mean

As expected, yield for cycle II lines (testers) was superior to most cycle I lines; with one exception, T291 inbred line, obtained from the Ungheni population, which appears to be derived from the American Dent variety, introduced in Austro-Hungarian Empire in the first decade of the 20th century (Cabulea et al., 1975). Instead, inbred lines obtained from populations or flint varieties had a low yield, also emphasized by Roman (1976) following a study of inbred lines obtained from synthetic populations of local populations.

The characters that cycle I inbred lines were deficient are: ear length, number of kernels on the ear, grain depth, the shelling percentage and resistance to plant breaking at maturity. Most of the deficiencies were as well noted before (Hallauer & Miranda, 1981; Sprague, 1983; Has, 2001).

For yield, only the non-additive genetic interactions were statistically significant, an aspect also mentioned by other authors (Hallauer & Miranda, 1981; Duvick, 1984; Has, 2004; Carena et al., 2010), regarding cycle I lines; it was noted that cycle II lines did not have a stronger differentiation at the additive level for yield.

Results regarding the "m x n" crossings

The analysis of variance table (Table 4) for cycle I hybrids highlight the differences between experimental years for yield and dry matter content at harvest.

For the yield, dry matter and unbroken plants, the analysis of variance between genotypes was statistically significant, while the interaction "experimental years x genotype" was significant only for dry matter content of the grains at harvest and the percentage of unbroken plants.

Non-orthogonal variance decomposition indicates the significance of non-additive genetic interactions for yield, the presence of additive interactions due to the tester inbred lines and cycle I lines, as well as the non-additive genetic interactions for dry matter content of the grains at harvest and the lack of genetic actions and interactions for the complex heredity character: percentage of unbroken plants.

Table 4. Analysis of variance for yield, dry matter and resistance to unbroken plants for the cyclical crossbreeding system type "m x n" (8x4), Turda, 2019-2020

Source of variability		**Yield**		**Dry matter**		**Unbroken plants**	
	DF	s^2	F test	s^2	F test	s^2	F test
TOTAL	191	-		-			
Experimental years (Y)	1	903796300	519.05**	263.73	56.23*	47.70	0.24
Repetition	2	-		-		-	
Error (Y)	2	1741267		4.67		195.90	
Genotypes (G)	31	4653763	2.68**	10.88	14.55**	277.78	6.43**
- additive actions - lines (Am)	(7)	(2054669)	1.18	(4.46)	5.97**	(32.96)	0.76
- additive actions – testers (An)	(3)	(263136)	0.15	(6.65)	8.90**	(327.39)	0.02
- non-additive interactions (NA)	(21)	(6147357)	3.53**	(13.58)	18.17**	(352.31)	0.0001
Years x genotype (YxG)	31	2513101	1.45	1.65	2.21**	71.22	1.65*
Error (G)	124	1739064		0.75		195.90	

Table 5 presents the general and specific combining ability for the hybrid crosses between cycle I and tester inbred lines.

The range for the general combining ability of tester inbred lines (cycle II) was between 8,510 kg/ha for TA367 and 8,892 kg/ha for TC385A; for the cycle I inbred lines the values of the simple hybrids were between 6,601 kg/ha for T139 x TE356 hybrid and 10,571 kg/ha for T291 x TC385A.

Table 5. General ($\hat{g}_m$, $\hat{g}_n$) and specific ($\hat{S}_{mn}$) combining ability for yield at the cyclical crossbreeding system "m x n" (8 inbred lines x 4 testers x 2 years), Turda, 2019-2020

No	Inbred line	TA367	TC344	TC385A	TE356	GCA
		SCA				"m" lines
1.	TC316	9,366	9,887	8,275	9,661	9,297
2.	D105	8,679	7,995	9,395	9,801	8,967
3.	T291	10,221	9,428	10,571	9,798	10,004
4.	T141	7,625	8,025	8,646	9,406	8,426
5.	T145	8,328	9,430	9,113	8,366	8,809
6.	T139	7,740	8,237	7,790	6,601	7,592
7.	T157	8,641	8,363	8,653	8,678	8,584
8.	T164	7,479	8,279	8,692	8,767	8,304
GCA – "n" lines – tester		8,510	8,705	8,892	8,885	8,748

LSD 5%= 1,508; LSD 1%= 1,993; LSD 0.1%= 2,564

Table 6 shows the additive and non-additive genetic effects of the yield. Differences between the tester inbred lines for additive genetic effects are relatively low, while for the cycle I lines are higher but statistically insignificant. The highest values for additive genetics effects of cycle I lines were transmitted by T291 (1,256 kg/ha) and TC316 (549 kg/ha), while the lowest values by T139 inbred line (-1,156 kg/ha) and T164 inbred line (-444 kg/ha).

Table 6. The additive ($\hat{g}_m$, $\hat{g}_n$) and non-additive ($\hat{s}_{ij}$) genetic effects involved in yield determinism, Turda, 2019-2020

No	Inbred lines	TA367	TC344	TC385 A	TE356	$\hat{g}_m$
		$\hat{s}_{ij}$				
1.	TC316	311	507	693	686	549
2.	D105	-19	177	363	356	220
3.	T291	1,018	1,214	1,400	1,393	1,256
4.	T141	-561	-365	-178	-186	-322
5.	T145	-177	19	205	198	61
6.	T139	-1,394	-1,198	-1,012	-1,019	-1,156
7.	T157	-402	-207	-20	-28	-164
8.	T164	-682	-486	-300	-307	-444
$\hat{g}_n$		-238	-43	144	137	0

LSD 5%= 1,508; LSD 1%= 1,993; LSD 0.1%= 2,564

The additive genetic effects of testers and cycle I lines and the non-additive genetic effects for unbroken plants are presented in Table 7. The additive genetic effects of testers have values between -4.76% (TC385A) and 8.97% (TE356) and for cycle I lines between -3.62% (T157) and 3.86% (TC316). For some hybrid combinations non-additive genetic effects are statistically significant.

Table 7. The additive ($\hat{g}_m$, $\hat{g}_n$) and non-additive ($\hat{S}_{ij}$) genetic effects involved in unbroken plants determinism, Turda, 2019-2020

No.	Inbred lines	TA367	TC344	TC385A	TE356	$\hat{g}_m$
		$\hat{S}_{ij}$				
1.	TC316	-0.58	4.08	-0.91	12.82 **	3.86
2.	D105	-3.12	1.54	-3.45	10.28 **	1.31
3.	T291	-7.55	-2.89	-7.88 ^{0}	5.85	-3.12
4.	T141	-6.74 ^{0}	-2.09	-7.07	6.65	-2.31
5.	T145	-4.75	-0.09	-5.08	8.65 *	-0.32
6.	T139	-3.73	0.92	-4.06	9.67 *	0.70
7.	T157	-8.05 ^{0}	-3.40	-8.38 ^{0}	5.35	-3.62
8.	T164	-0.92	3.73	-1.25	12.47 **	3.51
$\hat{g}_n$		-4.43	0.22	-4.76	8.97 *	0

LSD P 5% = 7.51; LSD 1% = 9.93; LSD 0.1%= 12.78

Table 8. The “per se” value (a) for 10 characters of inbred lines from crossbreeding system and additive genetic effects (b). Correlations between *per se* values of the characters and additive genetic effects, Turda, 2019-2020

No.	Character	Inbred lines m+n													Correlations between a and b
			TC316	D105	T291	T141	T145	T139	T157	T164	TA367	TC344	TC385A	TE356	
1.	Yield (kg/ha)	a	5,945	3,281	5,943	2,316	1,142	1,818	2,909	2,820	5,234	5,047	5,774	4,930	0.63*
		b	549.22	219.51	1256.30	-322.37	61.18	-1155.87	-164.32	-443.66	-238.16	-42.55	143.91	136.80	
2.	Ear weight (g)	a	117.6	65.7	116.3	52.2	38.1	33.4	59.4	61.3	100.3	113.3	113.8	83.2	0.76**
		b	22.93	-5.33	27.26	-10.65	-7.07	-25.53	3.67	-5.27	-0.08	17.84	-2.02	-15.75	
3.	Ear length (cm)	a	16.9	11.5	12.5	12.2	9.7	11.2	9.5	12.3	15.7	15.6	16.7	12.9	0.69*
		b	1.96	-0.62	0.24	0.92	-1.04	-0.63	-1.73	0.90	-0.15	0.86	0.3	-1.01	
4.	Number of rows	a	13.6	12.1	13.3	12.3	14.6	12.1	14.9	14.1	17.2	16.8	13.3	14.4	0.69*
		b	0.45	-1.74	-0.43	-0.98	1.28	-0.08	0.50	1.00	0.62	1.71	-1.48	-0.84	
5.	Number of grains/row	a	29.5	24.2	26.4	20.7	17.5	25.2	19.1	26.7	29.3	27.5	30.1	29.5	0.57
		b	0.97	-1.47	1.40	0.95	-2.09	0.62	-1.75	1.38	0.25	-0.22	0.03	-0.06	
6.	TKW (g)	a	270.1	212.8	293.3	218.0	140.5	96.2	223.4	182.9	215.2	251.1	267.4	207.4	0.75**
		b	18.71	38.30	22.99	-14.40	-7.71	-48.13	12.96	-22.72	-8.63	-0.92	18.68	-9.14	
7.	Grain depth (cm)	a	0.7	0.7	0.8	0.5	0.6	0.5	0.7	0.6	0.7	0.8	0.7	0.8	0.73**
		b	0.03	0.00	0.04	-0.07	0.02	-0.08	0.07	-0.02	-0.03	0.02	-0.04	0.05	
8.	Shelling percentage (%)	a	76.5	77.3	76.5	66.0	63.0	67.0	74.3	73.4	77.3	74.2	76.4	80.5	-0.02
		b	-11.02	2.89	1.48	0.22	0.66	1.13	2.61	2.04	1.61	-5.30	0.42	3.26	
9.	Unbroken plants (%)	a	72.5	71.6	65.4	85.5	76.9	67.3	57.3	80.1	83.2	85.3	76.7	85.8	0.30
		b	3.86	1.31	-3.12	-2.31	-0.32	0.70	-3.62	3.51	-4.43	0.22	-4.76	8.97	
10.	Dry matter (%)	a	79.0	79.2	79.2	80.7	84.8	84.6	82.6	81.3	81.3	77.1	80.0	82.5	0.55
		b	-1.89	-0.43	-0.65	1.02	1.41	0.28	0.62	-0.36	-1.03	0.01	-0.22	1.23	

a = *per se* value
b = $\hat{g}$ (genetic effects)

P 5% = 0.58

Table 8 shows the *per se* (a) values for the 10 studied characters of the inbred lines in the crossbreeding system, the additive genetic effects (b) for each of the inbred lines in the system and the correlation between "per se" values for the studied inbred lines and their additive genetic effects. Statistically significant positive values were calculated for correlations between the two parameters for the following characters: ear weight (r=0.76**), T.K.W. (r=0.75**), grain depth (r=0.73*), ears length (r=0.69*), the number of kernels rows (r=0.69*), yield (r=0.63*).

The yield of hybrids, in some cases is quite high, but there are two problems:

- In most parental forms of cycle I "per se", yield values are quite low, making them unsuitable as parental genotypes (this problem also had to be solved by the first breeders who used to hybridization between inbred lines (Hallauer & Miranda, 1981).
- Hybrids with high yield have lower unbroken plants percentage, making the hybrids unsuitable for the mechanical harvest.

The solution would require the use of elite lines that transmit resistance to breaking and falling at the additive level, while in hybrid combinations it should encourage the manifestation of non-additive genetic effects for this character (Cabulea et al., 1981).

The calculated correlations indicate that phenotypic selection for some production characters can be very effective, while selection for dry matter is less effective and for unbroken plants at harvest even less.

Statistically significant positive correlations between the *per se* values and the additive genetic effects for the corresponding lines are an indication of the possibilities of use in the selection of inbred lines, including those obtained from cycle I germplasm, with easily detectable characters (ear length, number of kernel rows, grain depth) and thus these inbred lines to participate in obtaining valuable hybrids.

CONCLUSIONS

Cycle I inbred yield is quite low, and resistance to plant breaking is inadequate in order to obtain hybrids that are both productive and resistant to breakage. Combining high yield and resistance to broken plants in the same simple hybrid is difficult, few hybrid combinations can achieve both.

Our results may contribute to an impetus to continuing the difficult activity of creating inbred lines from cycle I germplasm.

It is necessary to improve the local populations though recurrent selection or by obtaining synthetic population/composite in which the resistance to plants breaking can be improved.

Correlations between *per se* values for some characters and additive genetic effects indicate the possibilities of achieving, at the phenotypic level, progress in creating advanced inbred lines.

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