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STUDY OF YIELD POTENTIAL OF MAIZE SIMPLE HYBRIDS IN CYCLIC CROSS SYSTEM

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Abstract:

Maize has an important role in the Romanian agriculture, as a result of its multiple uses and optimal conditions from our country. According to the National Institute of Statistics, in the year 2011, the area cultivated with maize in Romania was of 2.613.500 hectares, with a total production of 11.666.400 tonnes of grains, placing our country on the 1st place in the European Union for the area cultivated with maize and the 2nd place for production, after France, due to an inferior yield. Otherwise, the maize yield achieved by Romania is smaller than the one achieved by the other Member States, with only 4464 kg/ha grains beside the average from the European Union of 6902 kg/ha. Yield potential can be considered genetically, the most complex characteristic. We can appreciate that the heredity of this trait is the expression of the entire genetic system of the plant, which directly or indirectly controls all fundamental involved processes (metabolic, growth and development). This paper presents the obtained results of the maize experiments fields conducted at Agricultural Research and Development Station Turda, using simple hybrids in cyclic cross system, between 2011-2012. The objectives of this paper are to highlight the genic effects involved in the heredity of the production capacity at the hybrids derived from crossings of inbred lines resulted by inbreeding, from commercial hybrids, with inbred testers, from Lancaster heterotic group. The analysis of variance for grain yield indicates significant differences between the tested maize hybrids. Comparing the general combining ability of the tested lines, reveals significant differences, the tester inbred lines being from the Lancaster germplasm group and the tested inbred lines from other heterotic groups. Also, were highlighted the effects of the specific combining ability. The effects values for the general combining ability (GCA) of the testers ranged from -85 kg/ha to +143 kg/ha. At the tested inbred lines, the value ranged between -508 kg/ha and +1141 kg/ha. The effects for the specific combining ability (SCA) was between -669 kg/ha and +589 kg/ha. Between inbred lines used as testers, production differences are not statistically significant. Among the tested inbred lines, the highest achieved average production in crosses with three testers, conducted to TA 452. The average yield was 9550 kg/ha and the additive effects for this line production capacity were, for this experimental system, of 1141 kg/ha. Regarding to the inbred lines obtained from Raissa hybrid, the highest production capacity from this experimental system was transmitted by TE 317. Our results highlight that in the production potential heredity are involved, mainly, the additive genic effects, but the non-additive genic effects are also important.

Keywords: *yield potential, general combining ability, specific combining ability.*

INTRODUCTION

Maize breeding for production capacity was a constant concern of breeders (HALLAUER and MIRANDA, 1981; TROYER, 2001; SARCA TR., 2004). The study of inbred lines crossbreeding in cyclic crossing systems and diallel crossing systems have provided answers on general combining ability and on specific combining ability (CĂBULEA, 2004). Grouping the inbred lines by specific combining ability provides to breeders information on heterotic groups where those can be fit. This grouping of inbred lines helps then, in the hybrids creation process, to achieve more easily, performance hybrid combinations, saving of important research funds by making logical crossings, pottentially heterotic (HAȘ, 1992, 2004; Haș et al. 1994).

The objectives of this paper are to highlight the genic effects involved in the heredity of the production capacity at the hybrids derived from crossings of inbred lines inbreeding resulting, from commercial hybrids, with inbred testers, from Lancaster heterotic group.

MATERIAL AND METHODS

In the experimental years 2011 and 2012 were studied in compared culture with 24 variants, simple hybrids derived from crosses between inbred lines obtained from commercial hybrids (by inbreeding), as maternal forms, and testers inbred lines, from Lancaster Sure Crop germplasm group, as paternal forms. Test crosses were made in 2010, at the Agricultural Research and Development Station Turda, and the hybrids experimentation were performed, as we described above, in 2011-2012, in comparative culture, where the 21 experimental hybrids (seven hybrids made with each tester line), were studied compared with three control hybrids (Turda 201, Turda Favorit and PR39 D81).

Tester and tested inbred lines are presented in Table 1. All the inbred lines used in crosses were created at ARDS Turda, Maize Breeding Laboratory (HAS VOICHITA et al., 2011). Testers inbred lines are belonging to Lancaster germplasm group, TD 268 being created by the crossing of TC 208 and C 103 (both of lines belonging to Lancaster Sure Crop group), and TC 385A and TC 399 from B Composite (in the composition of this composite, the lines C 103 and Mo 17 had a 50% share).

Four of the tested inbred lines were obtained from commercial hybrid Raissa of Pioneer, and the other three (TA 452, TE 330A and TE 335) from other commercial hybrids. After the phenotypic appearance, all seven tested inbred lines seemed to have relatedness with inbred lines of SSS germplasm groups (HAS VOICHITA et al., 2011).

Tabel 1

Maize inbred lines used to crosses in cyclic system

Inbred Line		Created at	The origin of line (Pedigree no.)
Tester inbred lines			
1.	TD 268	ARDS Turda	Sel. from TC208xC103 / 5370-2-2-4-2-
2.	TC 385A	ARDS Turda	Sel. from Comp B (C103, Mo17, T248, TC208, W633) / H60-1-1-1
3.	TC 399	ARDS Turda	Sel. from Comp B (C103, Mo17, T248, TC208, W633) / H84-6-7-2
Tested inbred lines			
1.	TE 229	ARDS Turda	Sel. from Raissa / 6597-3-6-
2.	TE 202B	ARDS Turda	Sel. from Raissa / 6600-1-1-1-
3.	TA 452	ARDS Turda	Sel. from commercial hybrid / 9390-5-1-2
4.	TE 330A	ARDS Turda	Sel. from commercial hybrid / 9626-3-1
5.	TD 364	ARDS Turda	Sel. from Raissa / 8340-1-1-3-
6.	TE 317	ARDS Turda	Sel. from Raissa / 8345-1-5-1-
7.	TE 335	ARDS Turda	Sel. from commercial hybrid / 9509-1-5-3-1-

Analysis of variance was performed according to the classical model, the experimental years and the 24 hybrids were considered factors in a two-factor system. Genotypes variance was decomposed non-orthogonal, after the model that Haș et al. (2010) have described, into the variance due to simple hybrids and the variance due to control hybrids. The variance of the simple hybrids was decomposed in the variance due the testers (T), the variance due the tested inbred lines (L) and the variance due the „tester x tested inbred line” interaction (TxL).

Genic effects were calculated according to the 2nd „North Carolina” model (COMSTOCK and ROBINSON, 1952), improved by CĂBULEA (2004).

Grain yield of each hybrid from experimental system is described by the following model:

$$SH_{mxn}\text{ yield} = \mu + \hat{g}_m + \hat{g}_n + \hat{s}_{mxn}$$

where:

μ = the average of experienced simple hybrids;

$\hat{g}_m$ = general combining ability due parent „m” (the additive effects because of parent „m”);

$\hat{g}_n$ = general combining ability due parent „n” (the additive effects because of parent „n”);

$\hat{s}_{mxn}$ = specific combining ability due to „m x n” interbreeding (non-additive effects due to „m x n” interbreeding).

RESULTS AND DISCUSSIONS

The analysis of variance and the non-orthogonal decomposition of genotypes variance are presented in Table 2. For simple hybrids are shown the 2nd degree orthogonal decompositions, that highlight statistically highly significant differences between tested inbred lines, and differences at the interaction „tester x tested inbred line”.

Tabel 2

Analysis of variance for production capacity at the hybrids from the cyclic cross system

Variability cause	SP	GL	s²	Sample F according to:	
				Error	Variance of interaction „genotypes x years”
Total	562871791,00	239			
Repetitions	4489627,00	4			
Columns	2219918,00	4			
Years	437102649,00	1	437102649,00	1920,97**	497,98**
Genotypes	57003468,00	23	2478412,00	10,89**	2,82
Simple hybrids (SH)	52604517,49	(20)	2630225,87	11,56**	3,00**
Testers (T)	1296188,11	((2))	648094,06	2,85	0,74
Lines (L)	40480320,60	((6))	6746720,10	29,65**	7,69**
TxL Interactions	10828008,78	((12))	902334,06	3,97**	1,03
Control hybrids (CH)	23664,33	(2)	11832,17	0,05	0,01
SH-CH Comparisons	4375286,17	(1)	4375286,17	19,23**	4,98**
Years x Genotypes	20188379,00	23	877755,60	3,86	
Error	41867751,00	184	227542,10		

The productive capacity of tested simple hybrids, the effects of general combining ability and the effects of specific combining ability are presented in tabel 3.

Tabel 3

Productive capacity, general combining ability effects ($\hat{g}_{m,n}$) and specific combining ability effects ($\hat{s}_{mxn}$) at the cyclic cross between maize inbred lines

Tester inbred line / Tested inbred line	TD 268		TC 385A		TC 399		Average production of inbred line (n)	Line G.C.A.($\hat{g}_n$)
	kg/ha	$\hat{s}_{mxn}$	kg/ha	$\hat{s}_{mxn}$	kg/ha	$\hat{s}_{mxn}$	$\hat{s}_{mxn}$	$\hat{g}_n$
TE 229	7954	-84	8037	-229	8379	313	8124	-286
TE 202B	8151	279	8142	42	7579	-321	7957	-452
TA 452	9548	83	9705	12	9398	-95	9550***	1141
TE 330A	7148	-669	8633	589	7924	80	7902	-508
TD 364	8543	237	8639	106	7990	-344	8391	-19
TE 317	8771	-60	9087	27	8892	33	8917	507
TE 335	8156	214	7622	-548	8304	334	8027	-382
Average production of tester (m)	8324		8552		8352		8410	
Tester G.C.A. ($\hat{g}_m$)		-85		143		-57		
DL	P = 5% 543				P = 1% 716		P = 0,1% 923	

Between inbred lines used as testers, production differences are not statistically significant; this situation is normal, given the relatedness degree between those inbred lines.

Among the tested inbred lines, the highest achieved average production in crosses with three testers, conducted to TA 452. The average yield was 9550 kg/ha and the additive effects for this line production capacity were, for this experimental system, of 1141 kg/ha. Have exceeded the average of experimental system, the interbreedings of the line TE 317, but the additive effects of 507 kg/ha was not statistically significant.

With high values for non-additive effects, with positive or negative values, were noted the following hybrid combinations:

⇒ TE 330A x TC 385A, $\hat{s}_{mxn}$ = + 589 kg/ha;

⇒ TE 330A x TD 268, $\hat{s}_{mxn}$ = - 669 kg/ha.

The simple hybrids with the highest production owe those values due the effects:

HS $_{TA452xTC385A}$ = 9705 kg/ha = μ(8410 kg/ha)+$\hat{g}_m$(143 kg/ha)+$\hat{g}_n$(1141 kg/ha)+$\hat{s}_{mxn}$(12 kg/ha);
HS $_{TA452x\ D268}$ = 9548 kg/ha = μ(8410 kg/ha)+$\hat{g}_m$(-85 kg/ha)+$\hat{g}_n$(1141 kg/ha)+$\hat{s}_{mxn}$(83 kg/ha);
HS $_{TA452xTC399}$ = 9398 kg/ha = μ(8410 kg/ha)+$\hat{g}_m$(-57 kg/ha)+$\hat{g}_n$(1141 kg/ha)+$\hat{s}_{mxn}$(-95 kg/ha).

Concerning to simple hybrids that achieved the lowest yield of experimental system, the production values were influenced by the following types of genic effects:

HS $_{TE330AxTD268}$ = 7148 kg/ha = μ(8410 kg/ha)+$\hat{g}_m$(-85 kg/ha)+$\hat{g}_n$(-508 kg/ha)+$\hat{s}_{mxn}$(-669 kg/ha);
HS $_{TE202BxTC399}$ = 7579 kg/ha = μ(8410 kg/ha)+$\hat{g}_m$(-57 kg/ha)+$\hat{g}_n$(-452 kg/ha)+$\hat{s}_{mxn}$(-321 kg/ha).

The review of additive and non-additive genic effects involved in achieving production capacity at the most productive hybrids emphasizes the additive effects role in this process; at hybrids with the lowest yield, the additive and non-additive effects, seems that played a balanced role.

We can say that only TA 452 inbred line can be firmly classified in a different heterotic group in terms of hybrid reaction than Lancaster Sure Crop. On the other studied inbred lines, obtained from valuable commercial hybrids, probably one of the parental forms belonged to the group where the tester inbred lines are in, or other non SSS group (HAȘ, 2004).

Regarding to the inbred lines obtained from Raissa hybrid, the highest production capacity from this experimental system was transmitted by TE 317; our results show that this hybrid combination is possible being retained from a ”SSS x Lancaster Sure Crop” heterotic cross, only that the initial corn cob of segregated population that began the process of creating these lines, was closer to SSS germplasm.

CONCLUSIONS

1. The 2nd type North Carolina cyclic cross system illustrates the general combining ability of tested inbred lines, even if the tester inbred lines are genetically related.
2. From the commercial hybrids can be obtained valuable inbred lines, but it is desirable to carry out tests in order to classify them in heterotic groups in the first generations of inbreeding.
3. In the production capacity heredity are involved, mainly, the additive genic effects, but the non-additive genic effects are also important.
4. Among the tested inbred lines, the highest combining ability was recorded on TA 452, followed by TE 317.

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