THE CYTOPLASM ORIGIN INFLUENCE, THE TESER INFLUENCE AND THE NUCLEUS-CYTOPLASM INTERACTIONS INFLUENCE ON EAR AND KERNEL TRAITS FOR ISONUCLEAR LINES

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Abstract: *Maize is one of the most important agronomi crops in the world. The kernel provides feed, food,and a resource for many unique industrial and commercialproducts. By utilizing genetic variation, the composition of the kernel can be altered for both the quantity and quality (structure and chemical diversity) of starch, protein, and oil throughout kernel development. The ability of future generations of plant breeders/plant scientists to use existing genetic variation and to identify and manipulate commercially important genes will open new avenues for designing novel variation in grain composition. This will provide the basis for the development of the next generation of specialty maize and of new products to meet future needs(*BALCONI *et al.,2007). The maize grain are used in the alcohol industry, also in obtaining starch, dextrin, glucose and other products (syrup, pectin, lactic acid, acetone, plastics, coloring agents, synthetic rubber, beer, coffee substitutes, drops frosting substances, a.s.o.). The maize grain are used in the alcohol industry, also in obtaining starch, dextrin, glucose and other products (syrup, pectin, lactic acid, acetone, plastics, coloring agents, synthetic rubber, beer, coffee substitutes, drops frosting substances, a.s.o.). The maize sprouts are used to obtain a high quality diet oil which prevents the blood cholesterol accumulation. Most of the traits that contribute to the achievement of maize yield / plant (the ear size, the ear length, kernel rows/ ear, kernel number/ row, thousand kernel weight) are genetically induced mostly at nucleus level. There have been studied the following maize ear traits for five isonucleus inbred lines: ear weight (g), kernel weight per ear (g), kernel rows per ear, kernel number per row, ear diameter(cm), rachides diameter(cm), thousand kernel weight (g), kernel depth and the kernel yield per ear. The research has been conducted in the experimental field provided by the Maize Breeding laboratory from Agricultural Research and Development Station Turda. The value of inbred lines is reflected in single-crosses, triliniar-crosses or double-crosses of which forms part as parental inbred lines. For inbred isonuclear lines their genetic value will be enhanced by their use in single-cross combinations as maternal forms.*

Key words**:** *inbred isonuclear lines, the nucleus-cytoplasm interactions influence, genetic determinism*

INTRODUCTION

In the specialty literature is mentioned that most of the traits which are yield determinative (the ear size, length, kernel rows/ear, kernel number/raw, thousand kernel weight) are genetically induced mostly at nucleus level, but there are also assertions saying that the heritability of some of these traits is due to some genes located in the cytoplasm (STUBER et al., 1992; HAŞ, 1992; CĂBULEA et al.., 1994; CĂBULEA et al.., 1999; TROYER, 2001; CĂBULEA, 2004; SARCA, 2004; HAŞ, 2004).

MATERIAL AND METHODS

The research has been conducted in the experimental field provided by the Maize Breeding laboratory from Agricultural Research and Development Station Turda in 2009

There have been studied the following maize ear traits for five isonucleus inbred lines: ear weight (g), kernel weight per ear (g), kernel rows per ear, kernel number per raw, ear diameter (cm), rachides diameter (cm), thousand kernel weight (g), kernel depth and the kernel yield per ear. The transfer has been realized through 10 cross-breeding procedures with the nucleus donor inbred line in 1992-2004 time period. After that, the isonucleus inbred lines maintenance has been realized through self-pollination and SIB pollination. Through the 10 times cross-breeding procedures with the nucleus donor line we can appreciate that the nucleus has been transferred 99,9% on the new cytoplasm (CHICINAŞ et al.., 2009). The nucleus donor inbred lines were: TC 209, TC 243, TC 221, TB 367 şi D 105, and the cytoplasm sources inbred lines were: T 248, TC 243, TC 298, TC 209, K 1080, TC 316, TB 329, TC 221, K 2051, T 291, A 665, W 633 şi TC 177. Each nucleus donor inbred line has been studied on six cytoplasm sources, the nucleus donor line being assumed as control line. The name assignment for the new created lines has been done after the nucleus donor line and the cytoplasm source has been mentioned in brackets: TC 209 (cyt. A 665), TC 243 (cyt. T 248), TC 221 (cyt. K 1080), TB 367 (cyt. K 2051), D 105 (cyt. TB 329). Testing inbred isonuclear lines was done by crossing each of the inbred lines with tester inbred lines. Tester inbred lines were: TC 344, LO3 Rf, TB 329, TD 233, T 291 and TC 209. The results of the experimental field and laboratory measurements and determinations have been than statistically processed through the ANOVA test (CIULCĂ, 2006). For the comparing crops where the common „inbred line x tester" cross-breeds have been studied the genotypes variance has been orthogonally split in the following categories: the cytoplasm source influence, the tester influence, the "cytoplasm x tester" interaction influence. For each studied single cross and trait the phenotypic value is described by the following relation:

$HS_{cit.\ i\ x\ tester\ j} = \mu + \hat{g}_{cit.\ i} + \hat{g}_{tester\ j} + \hat{s}_{ixj,}$ where:

-μ= experimental mean;

-$\hat{g}_{cit.\ i}$= the overall combining capacity of the mother inbred lines with the „i" cytoplasm, respectively the overall „i" cytoplasm combining capacity;

-$\hat{g}_{tester\ j}$= the „j" tester inbred line overall combining outcomes;

-$\hat{s}_{ixj}$= the peculiar combining capacity outcomes between the „i" mother cytoplasm source and the „j" tester gene.

RESULTS AND DISCUSSIONS

For ear and kernel traits, the experimental results and the effects of the overall combining capacity (due to the cytoplasm and the testers) and the effects of the peculiar combining capacity (due to the "cytoplasm x tester" interaction influence) are presented in the following tables.

Table 1 presents the cytoplasm source influence on ear weight at single-crosses between isonuclear line TC 243. Trait amplitude of the cytoplasm source influence ranged between -17,61 g (TC 243) and +17,17g for TC 243(cyt. TC 221). A high value of the cytoplasm source influence was recorded at TC 243(cyt. K 2051). The overall combining capacity due to the tester influence ranged between -24,64 g for TD 233 and +38,04 g for TC 344. The effects of the peculiar combining capacity ranged between -22,00 g and +26,53 g.

The single-crosses with the highest ear weight had the following cross formula:

TC 243(cyt. TC 221) x TC 344

TC 243(cyt. K 2051) x TC 344

In yield determinism recorded for this single-crosses have been involved the following effects:

270,43 g=208,01 g (μ) + 17,17 g ($\hat{g}_{cit}$) + 38,04 g ($\hat{g}_{tester}$) + 7,22 g ($\hat{s}_{cit.x\ tester}$)

296,04 g= 208,01 g (μ) + 16,79 g ($\hat{g}_{cit}$) + 38,04 g ($\hat{g}_{tester}$) + 6,84 g ($\hat{s}_{cit.x\ tester}$)

Table 1

The influence of the type of cytoplasm on the ear weight for hybrids with isonuclear lines TC 243 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	TC 344		Lo3 Rf		TB 329		TD 233		Cytoplasm average	
	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{g}_{cit}$
TC 243	242,33	13,90	166,27	-14,76	174,63	-11,75	178,37	12,61	190,40	-17,61
TC 243(cit. A665)	221,33	-14,44	186,30	-2,06	212,43	18,72	170,87	-2,22	197,73	-10,27
TC 243(cit. T248)	238,83	2,16	200,20	10,94	182,97	-11,65	172,53	-1,46	198,63	-9,37
TC 243(cit. TC208)	246,03	-4,39	189,50	-13,51	207,33	-1,03	206,67	18,93	212,38	4,38
TC 243(cit. TC221)	270,43	7,22	212,60	-3,20	222,33	1,18	195,33	-5,20	225,18	17,17
TC 243(cit. K1080)	233,67	-11,30	193,43	-4,12	229,43	26,53	171,17	-11,11	206,93	-1,08
TC 243(cit. K2051)	269,67	6,84	242,13	26,71	198,77	-22,00	188,60	-11,55	224,79	16,79
Tester average $\hat{g}_t$	246,04	38,04	198,63	-9,37	203,99	-4,02	183,36	-24,64	208,01	

LDS P=5%	33,31
LDS P=1%	44,41
LDS P= 0,1%	57,34

Kernel weight per ear is presented for testing of inbred isonuclear lines D 105 (table 2). Values for the overall combining capacity ranged between -4,65 g for the line D 105(cyt. T 291) and +8,82 g for the line D 105(cyt. T 248).

The highest value for the overall combining capacity wad determined at tester T 291(+16,64 g). The effects of the nucleus-cytoplasm interactions influence ranged between -12,54 g and +14,05 g. The single-cross with the highest kernel weight per ear was D 105 x T 291 (172,33 g/ ear) and on this trait determinism were involved the following factors:

172,33 g=144,01 g (μ) -2,37 g ($\hat{g}_{cit}$) + 16,64 g ($\hat{g}_{tester}$) + 14,05g ($\hat{s}_{cit.x\ tester}$)

At single-cross which yield ranged in second place, D 105(cyt. TC 209) X T 291 were involved the following factors:

171,25 g=144,01 g (μ) +4,83 g ($\hat{g}_{cit}$) + 16,64 g ($\hat{g}_{tester}$) + 5,76 g ($\hat{s}_{cit.x\ tester}$)

An important trait of the increase grain production is the ear length. This trait has a high degree of variability with values ranging 10-12 cm at early forms and 40-45 cm at later forms from Southern SUA- Northern Mexic (CRISTEA, 2004).

The cytoplasm source influence on ear length is presented at single-crosses between isonuclear line TC 221, an inbred line with long ear (table 3).

The highest values for the cytoplasm source influence registered at inbred lines TC 221 (cyt. TC 316)-0,84 cm and TC 221 (cyt. T 248) -0,63 cm and the lowest values at TC 221

(-0,88 cm). The tester influence ranged between -0,35 cm for TC 209 and +0,32 cm for TD 233. The nucleus-cytoplasm interaction influence ranged between -1,41 cm and +0,99 cm.

The single-crosses with the longest ears were:

TC 221 (cyt. K 1080) x TD 233 (21,40 cm)

TC 221 (cyt. TC 208) x TC 209 (21,29 cm)

At this single-crosses the contribution of genetic factors was:

21,40 cm=20,27 cm (μ) +0,84 cm ($\hat{g}_{cit}$) + 0,32 cm ($\hat{g}_{tester}$)- 0,03 cm ($\hat{s}_{cit.x\ tester}$)

21,29 cm=20,27 cm (μ) +0,38 cm ($\hat{g}_{cit}$) -0,35 cm ($\hat{g}_{tester}$) + 0,99 cm ($\hat{s}_{cit.x\ tester}$)

Along with ear length, kernel rows per ear can contribute substantially to achieve yield at maize single-crosses (SARCA, 2004).

In fact, the most productive early single-crosses is achieved by additional crosses

between inbred lines regarding ear length and kernel rows per ear (HAŞ, 2004).

Table 2

The influence of the type of cytoplasm on the kernel weight for hybrids with isonuclear lines D 105 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	T 291		TC 209		TD 233		Cytoplasm average	
	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{g}_{cit}$
D 105	172,33	14,05	129,58	-12,54	123,00	-1,51	141,64	-2,37
D 105 (cit. T 2941)	147,33	-8,67	135,08	-4,76	135,67	13,44	139,36	-4,65
D 105 (cit. T 248)	159,08	-10,39	157,08	3,76	142,33	6,63	152,83	8,82
D 105 (cit. T 243)	160,00	2,05	146,25	4,46	117,67	-6,51	141,31	-2,70
D 105 (cit. TC 209)	171,25	5,76	153,61	4,28	121,67	-10,05	148,84	4,83
D 105 (cit. K 1080)	158,75	0,21	147,78	5,39	119,17	-5,60	141,90	-2,11
D 105 (cit. TB 329)	155,83	-3,01	142,08	-0,60	128,67	3,60	142,19	-1,82
Tester average $\hat{g}_t$	160,65	16,64	144,50	0,49	126,88	-17,13	144,01	

LDS P=5%	15,76
LDS P=1%	21,07
LDS P= 0,1%	27,70

Table 3

The influence of the type of cytoplasm on the ear length for hybrids with isonuclear lines TC 221 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	T 291		TC 209		TD 233		Cytoplasm average	
	cm	$\hat{s}_{cxt}$	cm	$\hat{s}_{cxt}$	cm	$\hat{s}_{cxt}$	cm	$\hat{g}_{cit}$
TC221	18,38	-1,04	19,63	0,59	20,16	0,45	19,39	-0,88
TC 221(cit. T 248)	20,86	-0,06	20,79	0,24	21,03	-0,18	20,90	0,63
TC 221(cit. TC 243)	20,65	0,68	18,19	-1,41	21,00	0,73	19,95	-0,32
TC 221(cit. TC 208)	20,50	-0,18	21,29	0,99	20,17	-0,80	20,65	0,38
TC221(cit. TC 209)	20,99	0,76	19,44	-0,41	20,17	-0,35	20,20	-0,07
TC221(cit. K 1080)	19,61	-0,11	19,28	-0,06	20,18	0,17	19,69	-0,58
T 221(cit. TC 316)	21,10	-0,04	20,83	0,07	21,40	-0,03	21,11	0,84
Tester average $\hat{g}_t$	20,30	0,03	19,92	-0,35	20,59	0,32	20,27	

LDS P=5%	1,48
LDS P=1%	1,98
LDS P= 0,1%	2,60

To illustrate the cytoplasm source influence role in the inheritance of kernel rows per ear was chosen the comparative culture where are the single-crosses between isonuclear line TC 209 (table 4).

The highest overall combining capacity at cytoplasmic level was found to be the inbred line TC 209 which contributed to the nucleus transfer on different cytoplasm types of the group. Only in one case, TC 209 (cyt. A 665), kernel rows per ear is close to the original line. In all other cases, the overall combininig capacity due to the cytoplasm source influence was significantly lower to the control, in some cases the overall combining capacity values were -0,67 for TC 209(cyt. TC 177) and -0,65 for TC 209(cyt. T 291).

A high amplitude was recorded in case of the overall combining capacity for the tester

influence: -2,26 for TD 233 and +4,54 for TC 344. The peculiar combining capacity value ranged between -3,10 and +1,01.

The single-cross with the highest kernel rows per ear was TC 209 x TC 344 (23,33) and the one with the lowest kernel rows per ear was TC 209 (cit. T 248) x TD 233 (13,67).

On this trait determinism contributed the following factors:

$22,33=17,49\ (\mu) +0,98\ (\hat{g}_{cit}) + 4,54\ (\hat{g}_{tester})- 1,25\ (\hat{s}_{cit.x\ tester})$

$13,67=17,49\ (\mu) -0,30\ (\hat{g}_{cit}) -2,26\ (\hat{g}_{tester})- 1,26\ (\hat{s}_{cit.x\ tester})$

Table 4

The influence of the type of cytoplasm on the number of rows/ ear for hybrids with isonuclear lines TC 209 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	TC 344		Lo3 Rf		TB 329		TD 233		Cytoplasm average	
	nr	ŝcxt	nr	ŝcxt	nr	ŝcxt	nr	ŝcxt	nr	ĝcit
TC 209	23,33	-1,25	16,80	-0,23	17,87	0,24	15,87	-0,34	18,47	0,98
TC209 (cit A665)	22,27	-2,15	17,33	0,47	17,10	-0,36	16,50	0,46	18,30	0,81
TC 209 (cit T291)	22,13	-0,83	14,83	-0,57	15,20	-0,80	15,20	0,62	16,84	-0,65
TC 209 (cit 248)	22,40	-0,90	16,17	0,42	16,50	0,16	13,67	-1,26	17,18	-0,30
TC 209 (cit W633)	20,17	-3,10	16,00	0,29	16,53	0,22	15,90	1,01	17,15	-0,34
TC 209 (cit TC177)	21,73	-1,20	14,33	-1,04	15,73	-0,24	15,47	0,91	16,82	-0,67
TC 209 (cit D105)	22,20	0,01	16,87	0,66	17,60	0,79	14,00	-1,39	17,65	0,16
Tester average ĝt	22,03	4,55	16,05	-1,44	16,65	-0,84	15,23	-2,26	17,49	

LDS P=5%	1,18
LDS P=1%	1,58
LDS P=0,1%	2,03

Another important repercussion on yield is thousand kernel weight. It is influenced by genotype, environment and genotype x environment interaction (CIOCĂZANU et al., 1996; HAŞ,1999).

For this trait, the obtained results at single-crosses between isonuclear line TB 367 are presented in table 5.

The overall combining capacity due to the cytoplasm source influence ranged between +9,98 g for TB 367 and -15,40 g for TB 367(cyt. TC 221), statistically significant differences. The overall combining capacity due to the tester influence had values quite high, ranged between -25,97 g for TC 209 and +15,99 g for T 291. The nucleus-cytoplasm interactions influence ranges between -20,59 g and +17,67 g.

The highest value for thousand kernel weight registered at single-cross TB 367(cyt. T 248) x T 291 (317,42 g). On this trait determinism contributed the following factors:

$317,42\ g=276,83\ g\ (\mu) +6,94\ g\ (\hat{g}_{cit}) + 15,99\ g\ (\hat{g}_{tester})+ 17,67\ g\ (\hat{s}_{cit.x\ tester})$

Another important trait involved in achieving yield on maize is kernel depth per ear. This trait was reconsidered in recent years when have been promoted the single-crosses from dentiformis convariety, single-crosses with thin rachides and high kernel per ear, components which will be found on the next analysed trait- kernel depth per ear. (DUVICK, 1992; SARCA, 2004).

To illustrate the cytoplasm source influence, the tester influence and the nucleus-cytoplasm interactions influence on kernel depth per ear are presented the results at single-crosses between isonuclear line D 105 (table 6).

Table 5

The influence of the type of cytoplasm on the mass of a thousand grains for hybrids with isonuclear lines TB 367 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	T 291		TC 209		TD 233		Cytoplasm average	
	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{s}_{cxt}$	g	$\hat{g}_{cit}$
TB 367	296,40	-6,40	257,72	-3,12	306,31	9,52	286,81	9,98
TB 367(cit. T 248)	317,42	17,67	237,20	-20,59	296,67	2,93	283,76	6,94
TB 367(cit. TB 329)	291,16	-3,66	253,63	0,76	291,72	2,90	278,84	2,01
TB 367(cit. TC 208)	295,41	2,19	261,83	10,56	274,47	-12,74	277,24	0,41
TB 367(cit. TC 221)	282,98	5,57	229,89	-5,57	271,40	0,00	261,42	-15,40
TB 367(cit. TC 209)	275,27	-12,88	249,80	3,61	291,41	9,27	272,16	-4,66
TB 367(cit. K 2051)	291,06	-2,48	265,94	14,36	275,65	-11,88	277,55	0,73
Tester average $\hat{g}_t$	292,81	15,99	250,86	-25,97	286,80	9,98	276,83	

LDS P=5%	24,83
LDS P=1%	33,19
LDS P= 0,1%	43,63

The cytoplasm source influence and the nucleus-cytoplasm interactions influence had low values, below the significance limit. More important from a statistical viewpoint are the tester influence, ranged between +0,06 cm for TC 209 and -0,08 cm for TD 233.

The single-cross with the highest kernel depth per ear was D 105(cyt. TC 209) x TC 209 (+0,96 cm) and with the lowest kernel depth per ear, D 105(cyt. TC 209) x TD 233 (0,73 cm).

The contribution of genetic factors in the determinism of this two single-crosses was:

0,96 cm=0,86 cm (μ) +0,01 cm ($\hat{g}_{cit}$) + 0,06 cm ($\hat{g}_{tester}$)+0,04 cm ($\hat{s}_{cit.x\ tester}$)

0,73 cm=0,86 cm (μ) +0,01 cm ($\hat{g}_{cit}$) -0,08 cm ($\hat{g}_{tester}$)-0,04 cm ($\hat{s}_{cit.x\ tester}$)

Table 6

The influence of the type of cytoplasm on the kernel depth for hybrids with isonuclear lines D 105 (ARDS Turda, 2009)

(tester) (t) ♂ / (cytoplasm) (c) ♀	T 291		TC 209		TD 233		Cytoplasm average	
	cm	$\hat{s}_{cxt}$	cm	$\hat{s}_{cxt}$	cm	$\hat{s}_{cxt}$	cm	$\hat{g}_{cit}$
D 105	0,92	0,04	0,90	-0,03	0,77	-0,01	0,86	0,00
D 105 (cit. T 2941)	0,84	-0,04	0,91	0,00	0,81	0,04	0,85	0,00
D 105 (cit. T 248)	0,85	-0,03	0,94	0,01	0,81	0,02	0,87	0,01
D 105 (cit. T 243)	0,90	0,00	0,93	0,00	0,79	0,00	0,88	0,02
D 105 (cit. TC 209)	0,89	0,01	0,96	0,04	0,73	-0,05	0,86	0,01
D 105 (cit. K 1080)	0,90	0,03	0,91	0,00	0,74	-0,03	0,85	-0,01
D 105 (cit. TB 329)	0,83	-0,01	0,87	-0,01	0,76	0,02	0,82	-0,03
Tester average $\hat{g}_t$	0,87	0,02	0,92	0,06	0,77	-0,08	0,86	

LDS P=5%	0,07
LDS P=1%	0,09
LDS P= 0,1%	0,12

CONCLUSIONS

At single-crosses with the highest ear weight are involved the environmental effects, the nucleus-cytoplasm interaction influence are less.

For kernel weight per ear are involved the environmental effects, the tester influence and in a lesser extent, the nucleus-cytoplasm interaction influence.

For ear length are important the environmental effects and the cytoplasm source influence. An important role have also the nucleus-cytoplasm interaction influence.

It can be said that for kernel number per ear are involved the environmental effects, the tester influence, the cytoplasm source influence and the nucleus-cytoplasm interaction influence.

In genetic determinism of kernel number per ear are involved the environmental effects, the cytoplasm source influence and in a lesser extent, the nucleus-cytoplasm interaction influence.

In genetic determinism of thousand kernel weight are involved the environmental effects, the cytoplasm source influence, the tester influence and the nucleus-cytoplasm interaction influence.

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