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STUDY OF PHYSIOLOGICAL REACTIONS PARTICULARIES OF LEAF APPARATUS OF MAIZE HYBRIDS AND ITS PARENTAL FORMS IN DROUGHT CONDITIONS

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Abstract

The paper presents the results of the studies, that allows to compare specificity of manifestation of water regime parameters of leaf at 15 registered hybrids and 30 parental lines of maize, which has been grown in field conditions with contrast temperature regime (drought/norm). For the first time, in a physiological aspect, the level of heterosis manifestation has been studied according to three parameters of water regime of maize leaf.

Experimentally, has been proof, that undergoing of physiological diagnosis of water regime of maize leaf apparatus (water-holding capacity, electrical resistance of leaf tissues and coefficient of leaf thickness stability), in conjunction with interpretation of heterosis effect manifestation according to mentioned above parameters is sufficiently sensitive methodology to identify not only contrast forms, but also drought tolerant hybrid forms of maize. On a comprehensive assessment of all three studied parameters of water regime of leaf, registered hybrid of maize Porumbeni 359 AMRf and its parental form Flavia M are recommended as the genotypes with high tolerance to drought.

INTRODUCTION

In the list of potential problems of global warming, climate change impact on global agriculture become one of the most important [1]. In last decades, increased frequency of drought vegetation period is distinguished both, globally and in Republic of Moldova [3].

In this regard, the problem of creating of drought-tolerant maize hybrids for Republic of Moldova is one of the biggest priorities for autochthon plant breeders. The optimal criterion for selecting of drought-tolerant forms of maize is the level of grain yield under drought conditions for the appropriate selected sample. However, the climatically conditions of the alternating seasons of vegetation are not identical. Therefore, every year, regardless of condition of vegetation seasons, laboratory of biochemistry and physiology of Institute of Crop Production "Porumbeni" perform intermediately diagnosis of potential for drought-tolerance of

experimental breeding samples and competitive maize hybrids – in laboratory conditions, accordingly to parameters of water regime [4]. So far, studies that could allow us to compare specificity of manifestation of water regime parameters of maize samples, grown in field conditions with contrast temperature regime (drought/norm) has not been performed.
Due to mentioned reasons, the purpose of this study was to perform experimental development of declared problem. Moreover, analysis of water regime condition of maize leaf apparatus has not been limited at physiological assessment of just registered hybrids. Also, we set the aim to perform analysis of parental forms of these hybrids, which would allow for the first time in physiological aspect, to study the level of manifestation of heterosis effect accordingly to water regime parameters at maize leaf.

MATERIAL AND METHODS

In experiment were used 57 genotypes of maize, including: 30 inbreed parental lines, 12 hybrid parental combinations (9 simple hybrids participating as maternal parental forms and 3 as paternal parental forms) and 15 registered maize hybrids (6 simple hybrids, 1 simple modificate hybrid, 5 triple hybrids and 3 double hybrids).
The experiment was carried out within two years with contrast environmental.
conditions in maize pollination period:

- year 2007 – drought conditions, in July amount of rainfall compared with multiannual average has decreased by 60 mm;
- year 2008 – normal conditions, in July amount of rainfall compared with multiannual average has decreased by 8,4 mm

During the experiment, a physiological method has been used for determination of water regime of leaf tissue: determination of water-holding capacity (WHC), assessment of electrical resistance of leaf tissues (ERLT) and determination of coefficient of leaf thickness stability (CLTS). Assessment of drought-tolerance has been calculated by mark system for complex estimation of drought-tolerance of hybrids and its parental forms after water regime parameters of maize leaf [4]. Estimation of manifestation of heterosis effect level was performed through methods of calculation and expressed by H_{hyp} – hypothetical heterosis value [2].

REZULTS AND DISCUSSION

The results of physiological assessment of water regime parameters (table 1) testify that water-holding capacity (WHC) of maize leaf for 92% of the total studied genotypes samples increase in drought conditions. When comparing the absolute values of the limits of variation of WHC parameter, were noted that in conditions of thermal stress, the range of variation of this parameter is expanding for both

parental lines, as well as for hybrids, compared to normal environment conditions of 2008 year.

Evaluation of maize hybrids and its parental forms on electrical resistance of leaf tissues (ERLT) indicates that for 93% of studied genotypes drought conditions reinforce this biophysical parameter. Other the range of variation of absolute values of ERLT can judge about the differences between genotypic reaction of studies maize hybrids and its parental lines at drought conditions: at hybrids, compared with the lines, limits variations of ERLT parameter presents more range of variations.

One of the most interesting parameters of complex assessment of water regime of maize leaf is the coefficient of leaf thickness stability (CLTS). In contrast to the earlier discussed parameters of water regime (WHC and ERLT), by initial values of the CLTS coefficient were revealed the following groups of specific response of different genotypes of maize at drought conditions:

- for 79% of the studied hybrids and lines, drought conditions determine an increase of this coefficient;
- for 8% of the samples, were marked the significant genotypic tolerance to this type of stress (-0,009 < CLTS < +0,0009);
- for 13% of samples, were established that increase of temperature in environment has an inhibiting effect at CLTS coefficient.

In accordance with generally accepted methodology of integrated assessment of tolerance potential of maize breeding forms at drought conditions on the mentioned above water regime parameters the evaluation has been made on a five-point system of average drought-tolerance degree for each from 27 hybrid forms of maize (table 1).

In the dry condition of 2007 year the most drought-tolerant registered hybrid as a result of physiological assessment was Porumbeni 359 AMRf and its parental form Flavia M (3.7 points), in the second category (3.0 points) entered registered hybrids Porumbeni 457 MRf, Chişiniovschi 401 L, Moldavschi 425 AMRf and its parental hybrid form Lada C.

In the stress period of plant growing in 2007 year evaluation of water regime parameters in laboratory condition has allowed to classify the studied hybrids into three groups:

1. Medium drought-tolerant – 2 genotypes (registered hybrid Porumbeni 359 AMRf and its parental hybrid form Flavia M);
2. Low drought-tolerant – 5 genotypes (registered hybrids Porumbeni 457 MRf, Chişiniovschi 401 L, Moldavschi 425 AMRf, and their parental hybrid forms Braila and Lada C);
3. Not resistant at drought conditions – 18 genotypes (11 registered hybrids and 9 parental hybrid forms)

In 2008 year – the season favourable on temperature factor, the highest mark on a comprehensive assessment of drought-tolerance were characterized registered

hybrids Porumbeni 457 MRf, Chişiniovschi 297 wx, Chişiniovschi 401 L, Moldavschi 425 AMRf and its parental hybrid form Lada C.

Table 1

Characteristics of drought-tolerance according to physiological parameters of water regime of maize leaf at registered hybrids and their parental forms under thermal contrast conditions

Group	Hybrid	WHC, %		ERLT, kom		CLTS, mkm		Mean (in points)		Drought-Tolerance *	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
I (SH)	Moldavschi 291 MRf	75.0	31.3	651	355	0.74	0.72	2.7	4.0	NR	MR
	Moldavschi 450 MRf	37.1	32.2	576	300	0.68	0.77	2.3	4.0	NR	MR
	Porumbeni 457 MRf	52.4	28.4	571	471	0.99	0.86	3.0	4.7	LR	R
	Chişiniovschi 307 PL	85.2	30.3	530	385	0.68	0.79	2.3	4.0	NR	MR
	Chişiniovschi 297 wx	41.8	28.9	516	358	0.68	0.81	2.3	4.7	NR	R
	Chişiniovschi 401 L	62.1	31.2	474	303	0.82	0.72	3.0	4.3	LR	R
II (SMH)	Moldavschi 425 AMRf	73.5	28.6	527	264	0.81	0.76	3.0	4.3	LR	R
III (TH)	Porumbeni 212 CRf	62.5	29.2	520	258	0.73	0.82	2.7	4.7	NR	R
	Moldavschi 257 CRf	69.4	25.9	465	163	0.76	0.80	2.7	4.3	NR	R
	Porumbeni 351 AMRf	54.9	27.9	523	454	0.74	0.73	2.7	4.3	NR	R
	Porumbeni 359 AMRf	53.5	29.7	50	385	0.75	0.66	3.7	4.0	MR	MR
	Moldavschi 411 MRf	54.5	34.7	670	423	0.74	0.66	2.7	3.7	NR	MR
IV (DH)	Bemo 182 CRf	53.6	28.9	528	257	0.75	0.75	2.7	4.3	NR	R
	Moldavschi 215 MRf	58.8	25.6	517	356	0.66	0.72	2.3	4.3	NR	R
	Nemo 216 CRf	48.6	27.0	470	433	0.79	0.77	2.7	4.3	NR	R
V (♀SH)	Drujba C	86.2	31.0	486	324	0.75	0.75	2.7	4.0	NR	MR
	Liana M	66.7	29.4	520	364	0.74	0.65	2.7	4.0	NR	MR
	Braila	69.7	31.8	462	368	0.81	0.77	3.0	4.0	LR	MR
	Lara	58.8	26.0	568	461	0.74	0.75	2,7	4.3	NR	R
	Flavia	46.5	27.4	55	395	0.75	0.66	3.7	4.0	MR	MR
	Lavanda C	60.7	31.8	473	399	0.77	0.74	2.7	4.0	NR	MR
	Lada C	46.7	27.8	520	420	0.82	0.75	3	4.3	LR	R
	Ladia M	37.0	27.9	515	356	0.78	0.75	2.7	4.3	NR	R
	Muza M	94.7	31.2	435	312	0.75	0.72	2.7	4.0	NR	MR
VI (♂SH)	Landîş CB (Bemo)	50.0	26.4	147	433	0.69	0.78	2.7	4.3	NR	R
	Lion (Nemo)	50.0	28.6	147	319	0.69	0.68	2.7	4.0	NR	MR
	Lion (M215 AMRF)	48.7	28.6	145	320	0.67	0.68	2,.7	4.0	NR	MR

*:**R**- Resistant; **NR** – Not Resistant; **M** – Medium resistant; **L** – Low resistant

In the performed experiment of 2008 year studied hybrids were classified just into two groups:

1. High drought-tolerant – 10 registered hybrids (among them, distinguished in 2007 in group of low drought-tolerant, Porumbeni 457 MRf, Chişiniovschi 401L, Moldavschi 425 AMRf), and also 4 parental hybrid forms;
2. Low drought-tolerant – 5 registered hybrids and 8 parental hybrid combinations.

Extremely interesting is the fact that in the latter group were included registered hybrid Porumbeni 359 AMRf and its parental hybrid form Flavia M. Both of these genotypes in the drought conditions of 2007 year on water regime of leaf apparatus were classified in a similar Medium drought-tolerant group, which allows concluding about high tolerance at drought conditions of mentioned genotypes according to water regime of leaf.

As been remarked in the introductory part of this study, in addition to the direct physiological assessment of 27 maize hybrids and their parental hybrid forms and inbreed lines, for the first time were studied manifestation of hypothetical heterosis effect ($H_{hyp)}$ according to water regime of maize leaf.

Were established that according to water regime of leaf apparatus at maize level of manifestation of heterosis effect in contrasting conditions of temperature factor of the environment, primarily is determined by the genetic nature of the studied genotypes. This conclusion is based on performed analysis data of H_{hyp}, which allows to distribute the studied hybrids combinations into three groups with high level of hypothetical heterosis effect, adaptive nature of heterosis effect and partial blocking of heterosis manifestation at studied hybrids, taking into consideration the specifics of the growing period in drought conditions in 2007 year and under normal conditions in 2008 year.

Similar dependences are traced also during the performing of the analysis of hypothetical heterosis according to electrical resistance of leaf tissues.

In drought conditions has been marked the highest hypothetical heterosis effect for 8 registered hybrids, adaptive nature of heterosis effect according to ERLT ($-3\% < H_{hyp} < +3\%$) is set for 2 registered simple hybrids Moldavschi 450 MRf and Chişiniovschi 401 L and 1 parental hybrid form Lion. The negative impact of drought conditions on the expression of a hypothetical heterosis according to ERLT is set for 5 registered hybrids and almost for the whole samples of parental simple hybrid forms (with the exception of genotype Lara).

Thus, the readout of ERLT according to two contrasting climatic conditions of the growing season allows to clarify the role of genotypic potential of water regime in manifestation of heterosis effect of corresponding hybrid combination.

A comparative evaluation of the level of heterosis expression according to coefficient of stability CLTS again, and even in more pronounced form, confirms the leading role of genotype in the specificity of heterosis manifestation among the 27 studied hybrid forms. This affirmation can be justified by the following facts. In

drought conditions the effect of hypothetical heterosis increases at 3 registered hybrids and their 5 parental hybrid forms according to CLTS. Tolerant nature of heterosis effect according to CLTS (-3% < H_{hyp} < +3%) is set for 7 registered hybrids and 4 simple parental hybrid forms under two contrasting growing seasons. The remaining 8 registered hybrids and hybrid combinations from studied samples expressed an inhibited reaction of its heterosis potential during the drought conditions of 2007 year.

CONCLUSIONS

1. The direct physiological assessment for the majority of maize genotypes at high temperatures allows:

a) to ascertain the tendency to maximal mobilization of genotype physiological responses at drought stress accordingly to water regime parameters;
b) to use physiological coefficient of leaf thickness stability (CLTS) for the detection of restricted complexes (in our experiment – 8%) among the studied genotypes, that manifest tolerance reaction at drought conditions;
c) to recommend (according to comprehensive assessment of all three studied parameters of water regime) registered hybrid Porumbeni 359 AMRf and its parental hybrid form Flavia M as genotypes with high tolerance to drought conditions.

2. Using the value, characterizing the level of hypothetical heterosis manifestation according to studied physiological parameters, in contrast temperature factor conditions, reveals greater opportunities in maize breeding for drought-tolerance based on:

a) assessment of heterosis effect according to water regime of leaf apparatus (water-holding capacity and coefficient of leaf thickness stability);
b) study of genotipical specificity of response reaction of studied maize hybrids on the physiological heterosis, which allows identification of genotypes with positive, tolerant and negative reaction of H_{hyp} at drought conditions.

3. Performing of physiological diagnosis of water regime of maize leaf apparatus combined with interpretation of heterosis effect on these parameters is sufficiently sensitive methodology for identifying not only contrast, but also drought-tolerant hybrids of maize.

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