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SELECTION OF RESISTANT MAIZE GENOTYPES UNDER SALT STRESS AND DROUGHT CONDITIONS

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Summary. The variability of the characters "seedling length" and "root length" at the initial stages of plant development depended significantly on the factors "genotype", "abiotic stress" and on the interaction "genotype x stress". The effect of the factor "genotype" was at a high level for the characters "number of branches in the panicle" and "panicle length". The values of the effect of the factor "genotype" for the characters "number of rows per cob" and "number of grains per row" were at an average level. Under osmotic stress conditions only two hybrids with the maternal line L1866 had the relatively high values of the «pollen grain diameter» character. Under saline stress conditions, the effects of both the "stress" factor and the "genotype x stress" interaction were significant. The highest values of the studied character demonstrated hybrids with paternal genotypes lines B73 and W23.

Key words: maize, NaCl stress, drought, stress resistance, male gametophyte.

Introduction

Currently, the main objective of corn breeding under climate change conditions is to improve drought resistance [1]. Resistance genes to environmental factors have been identified in maize [2]. Some researchers note the importance of many breeding criteria for drought resistance [3]. Malenica et al presented genetic approaches to improve tolerance to multiple stresses [4]. Gemonic regions associated with salt stress tolerance have been determined [5]. Resistance genes to abiotic stress factors have been identified in maize seedlings [6]. Ling Lei et al demonstrated that *ZmPMP3g* gene expression has an important role in drought tolerance of corn, improving root growth, antioxidant capacity and regulation of intracellular osmotic pressure [7]. Taking into account mentioned above 3 objectives of this study were formulated:

- to estimate the variability and heritability of salinity and drought resistance characters during the initial period of growth and development of corn plants
- to analyze the resistance of genotypes at the first stages of ontogenesis and at the male gametophyte level
- to select resistant genotypes with high values of productivity characters.

Material and methods

Inbred lines (28 genotypes P101, P502, MK01, P523, B73, Mo17, W23, N6, P165, XL12, P346wx1wx1, Rf7, W47, 092, M11, A239, L276, 4nW23, A285, L1866, L459, MK390, MK159, P346, L1362, Co125, F2, P343), hybrids (15 genotypes) including 10 hybrid genotypes obtained by the gametic selection method were grown in field conditions. In laboratory conditions, sodium chloride solutions (in concentrations up to 15%) and osmotic solutions (with osmotic pressure values up to 10,5 MPa) were used to determine the resistance to salinity and drought. At the initial stages of plant development under abiotic stress conditions were estimated: the frequency of seed germination, the length of seedlings , roots and the number of roots. With the use of immature (16-21 days after polinization) embryos under stress conditions the variability of the characters "seedling length" and "root length" was used for the analysis of resistance. At the haploid level the variability of “pollen grain diameter" character was studied. The characters "number of rows per

cob", "number of grains per row", "panicle length", "number of branches in the panicle" were also evaluated. The values of the trait "pollen grain diameter" (in eyepiece micrometer units) were determined using the ocular micrometer MOB-1-15x). The experiments were carried out according to the schemes of one- and two-factor analysis of variance. Statistical processing (ANOVA) of data was performed using STATISTICA 7 software.

Rezults and discussions

The bifactorial dispersion analysis of the variability of the resistance characters of the studied genotypes (inbred lines and hybrids) of corn at the initial stages of plant development demonstrated (table 1) that the lines were characterized by higher values of the effects of both "genotype" factors , "abiotic stresses (drought and salinity)" as well as the interaction of the factors "genotype"x"abiotic stresses" compared to hybrids. The values of the effect of the "genotype" factor for the variability of the characters "seedling length" and "root length" (inbred lines) were practically equal. In hybrids, the values of the effect of both the factor "genotype" and the interaction "genotype"x"abiotic stresses" proved to be two times higher for the character "root length".

Table 1

Results of the bifactorial dispersion analysis of the variability of the resistance characters

Character	Hybrids F_1			Inbred lines		
	η^2 %	Effect Size (η^2_p)	R^2	η^2 %	Effect size (η^2_p)	R^2
Seedling length	Genotype 11,6*	0,135**	0,51**	51,1***	0,71***	0,88***
	Stresses 4,48*	0,057*		9,2***	0,29***	
	Genotype x stresses 9,72*	0,116*		17.9***	0,45***	
Root length	Genotype 21,22**	0,28***	0,68***	45,2***	0,69***	0,89***
	Stresses 4,7**	0,08**		11,9***	0,37***	
	Genotype x Stresses 20,1***	0,27***		22,8***	0,53***	

** - p<0,05, ** - p<0,01, *** - p<0,001.*

The hybrids with the parental line N6 demonstrated the highest average indexes of the characters "seedling length (3.29 cm) and "root length" (3.1 cm). In lines and hybrids (table 2) the coefficients of correlation, regression and determination of the studied traits under conditions of osmotic stress were higher than similar indicators under NaCl stress. The lowest values of correlation and regression coefficients were registrated in hybrids under salt stress conditions.

The immature embryos of the hybrids with the parental line L1866 (2 genotypes) demonstrated relatively high indexes of the "seedling length" and "root length" characters. Also, these characters correlated significantly positively at the average level with the regression coefficient b_{yx}=1.36***.

Table 2

The results of correlation and regression analysis

Characters	Osmotic stress		NaCl stress	
	Seedling length , lines	Root length, lines	Seedling length, lines	Root length ,lines
Seedling length , lines	-	r = 0,9056*** b_{yx}=1,0425***	-	r =0,7023*** b_{yx}=0,5235***
Root length, lines	r^2 =0,8201*** b_{xy}=0,7867***	-	r^2 =0,4932*** b_{xy}= 0,9422***	-
Characters	Seedling length , hybrids	Root length,hybrids	Seedling length, hybrids	Root length,hybrids
Seedling length, hybrids	-	r =0,6795*** b_{yx}=0,8538***	-	r =0,3834*** b_{yx}=0,2957***
Root length,hybrids	r^2 =0,4617*** b_{xy}=0,5407***	-	r^2 =0,147*** b_{xy}=0,4973***	-

***- *p<0,001*

The significant and approximately equal effects of the factors "genotype" and "abiotic stresses (drought and salinity) on the germination capacity of immature embryos were established (table 3).

Table 3

The results of two-factor ANOVA and correlation , regression analysis

Germination (%)	MS	F	Effect size	R^2	Coefficients of correlation, regression, determination		
Genotype A	1426,6	46,6	0,91***	0,983***	Osmotic Stress	Seedling length	Root length
Stresses B	12563,7	410	0,91***		Seedling length	-	r =0,64*** b_{yx} =0,305***
AxB	9878,2	35,8	0,88***		Root length	r^2=0,41*** b_{xy}=1,4***	-

***- *p<0,001*

The analysis of productivity characters demonstrated that the effect of the "genotype" factor was at a high level (ηp=0.66***-0.87***) and the highest values were recorded in hybrids with parental lines A285, N6.

At the halpoid level (Fig.2), the value of the effect of the "abiotic stresses" factor was 6 times higher than the value of the effect of the "genotype" factor. Under stress conditions, the

average values (143.1 and 144.7 un.oc.mic.) of the character "diameter of the pollen grain" yielded significantly to the average value in the control variant (164.8 un.oc.mic.). The value of the heritability coefficient of the parental line L1866 under saline stress conditions was low (0.1133*). It was established that the correlation of the "pollen grain diameter" character values in the stress variants was significant, positive, weak (r =0.12*).

Table 4

The results of two-factor ANOVA

	MS	F	Effect size	R^2	Pollen grains diameter (un.oc.mic)			
					genotype	control	osmotic stress	stress NaCl
Factors: Genotype	322	2,66	0,08***	0,73***	19(2)	168,5	134,5	124
					29(2)	189,5	143	127
					su_2	190	160	154
Abiotic stresses	24206	199	0,48***		L1866	173	157	142
					29(2)	178,5	148	145
					30(1)	168	144	157
Factors: genotype	302	2,5	0,114**	0,74***	33(1)	179	140	150
					46(1)	184	156	140
					35(1)	170	159	156
Osmotic stress	35343	289	0,5***		14	184	153	156
					26(2)	160	157	139
					7(4)	182	153	162
Factors: stress NaCl	37249	290	0,5***	0,73***	4(2)	176	152	144
					5(2)	174	153	148
Genotype x stress NaCl	224	1,75	0,08*		18(2)	177	138	127
					15(1)	172,5	159,5	111

**** - p<0.001 un.oc.mic. - units of ocular micrometer*

Conclusions

The variability of the characters "seedling length" and "root length" at the initial stages of plant development depended significantly on the factors "genotype", "abiotic stress" and on the interaction "genotype x stress". Inbred lines were characterized by higher values of the influence of the studied factors compared to hybrids. Likewise, the effects of both the "stress" factor and the "genotype x stress" interaction for the "root length" character were higher than the similar values for the "seedling length" character. In hybrids, the effect values of both the "genotype" factor and the "genotype x stress" interaction proved to be twice as high for the character "root length" and the effect values were approximately equal.

In conditions of saline and osmotic stress, inbred lines were characterized by higher values of the correlation and regression coefficients of the studied characters. Correlation links in hybrids were two times weaker under saline stress conditions compared to the values of correlation coefficients under osmotic stress conditions. The analysis of the frequency of the character "germination capacity of immature embryos" demonstrated that the values of the effects of the factors "genotype", "stress" and the interaction "genotype x stress" were significant and approximately equal. The variability of the "seedling length" and "root length" characters under osmotic stress conditions was significantly determined by the "genotype" factor, but for the "root length" character the effect value was found to be higher.

The "saline stress" factor determined low values of the characters "seedling length" and "root length" compared to similar values under osmotic stress conditions. It should be mentioned that the effect of the factor "genotype" was at a high level for the characters "number of branches in the panicle" and "panicle length". The values of the effect of the factor "genotype" for the characters "number of rows per cob" and "number of grains per row" were at an average level. The highest indices of productivity characters were recorded in hybrids with parental lines A285 and N6.

The study of the variability of the "pollen grain diameter" values only under osmotic stress conditions demonstrated that the value of the effect of the "stress" factor was 5 times higher than the value of the effect of the "genotype" factor. Only two hybrids with the maternal line L1866 had the relatively high values of the studied character. Under saline stress conditions, the effects of both the "stress" factor and the "genotype x stress" interaction were significant. The value of the effect of the "stress" factor was 6 times higher compared to the value of the effect of the interaction of the factors. The highest values of the studied character demonstrated hybrids with paternal genotypes lines B73 and W23.

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