INHERITANCE OF PHYSIOLOGICAL PARAMETERS IMPLIED IN MAIZE DROUGHT RESISTANCE

Ion. Ciocăzanu, Maria Țerbea, Gheorghe Micuț, Cătălin Lazăr

ABSTRACT

Quantification of drought tolerance in field crops was generally carried out on the basis of differences between yield obtained in irrigated and rainfed environments. In the last years a relationship between drought stress tolerance and some physiological parameters determined on seedling has been found. The present paper reports the genetic variability among maize inbred lines for some physiological traits (cell membrane stability, cuticular transpiration, dry matter accumulation), estimation of a relationship between field superiority index and these traits and inheritance of these traits.

The complexity of genic actions and interactions implied in the determination of the investigated physiological traits was underlined.

Key words: cell membrane stability, cuticular transpiration, drought, inheritance.

INTRODUCTION

Quantification of drought tolerance in field crops was generally carried out on the b sis of the differences between yields obtained in irrigated and rainfed environments.

Based on this approach, Fischer and Maurer (1978) proposed a drought stress susceptibility index S. Lin and Binns (1988) proposed a new formula for evaluation of the plant drought resistance, based on the productivity of the genotypes in different environments. Their method uses the yields of the best genotype from each location as reference terms. In both cases, the evaluation of drought tolerance supposes large field trials and this represents a serious limiting factor for a screening method.

Some physiological traits may contribute to a better understanding of the drought tolerance (Blum, 1988; Clarke, 1992; Clarke et al., 1991a, 1991b; Haley et al., 1993). Residual transpiration, cell membrane stability and assimilate translocation were already succesfully used in wheat breeding (Blum, 1988; Clarke et al., 1991a, 1991b, Clarke, 1992; Balotă, 1995). Bolanos and Edmeades (1993) used the field data obtained in eight selection cycles for studying the relationship of the drought response with some physiological parameters: chlorophyll concentration in drought stressed leaves, plant temperature, water potential, and the size of the roots.

Identification of low-cost tests for the morfophysiological traits implied in maize drought resistance, started at RICIC – Fundulea, several years ago. The results obtained in field trials for residual transpiration and cell membrane stability were found to be correlated to rainfed yield or to the differences between yields obtained under irrigated and rainfed conditions in years with drought stress (Țerbea et al., 1996).

Taking into account the difficulties resulting from year-to-year variation of the meteorological conditions, as well as the considerable amount of work and the large expensses required by field experimentation, a relationship between drought stress tolerance and some physiological parameters determined on seedlings would be of a great interest for large scale screening of early breeding material (Țerbea et al., 1996).

The objectives of the present paper were:

- evaluation of genetic variability among maize inbred lines for physiological traits, potential useful in seedling screening tests;
- estimation of a relationship between field superiority index (PFSI) and these traits;
- estimation of the inheritance of these traits.

MATERIALS AND METHODS

Field experiments

Sixteen maize inbred lines were cultivated under rainfed and irrigated conditions in three locations differing in rainfall amount and temperature: Fundulea, Caracal and Valu lui Traian.

The experimental design was the random blocks in three replications and the cultivation technology was similar to that applied in field crops. The plant populations were 45.000 pl/ha under rainfed conditions and 65.000 pl/ha under irrigated conditions (Table 1).

Table 1. Physiological parameters and P, a field superiority index (PFSI), computed after Lin and Binns (1988) for 16 maize inbred lines

Inbred lines	CT drought		TOTDM optimal		TOTDM drought		PFSI	
	g/g dm/h	rank	g/pl	rank	g/pl	rank	st.[1]	rank
A 632Ht[2]	*0.2516*	*1*	*0.2607*	*7*	*0.2547*	*10*	*4.16*	*7*
F 46/85	*0.6488*	*6*	*0.2527*	*10*	*0.3137*	*15*	*5.11*	*10*
F 1023	*0.9968*	*14*	*0.2217*	*14*	*0.2237*	*7*	*9.74*	*16*
F 1040/83	*1.3532*	*16*	*0.2143*	*15*	*0.2230*	*6*	*6.59*	*12*
F 911/83	0.8852	12	0.3033	2	0.3163	16	9.22	15
F 644/83	*1.3108*	*15*	*0.2243*	*12*	*0.1620*	*1*	*3.20*	*6*
F 213/85	*0.4164*	*2*	*0.2583*	*8*	*0.2060*	*3*	*3.07*	*4*
F 20128/85	*0.5736*	*4*	*0.2060*	*16*	*0.2200*	*5*	*1.93*	*2*
F 945/83	0.4684	3	0.2823	3	0.2690	12	3.09	5
F 727/86	0.7820	9	0.3800	1	0.2677	11	0.04	1
F 823/83	*0.7592*	*8*	*0.2550*	*9*	*0.2503*	*9*	*5.05*	*9*
F 20318/85	*0.8828*	*11*	*0.2280*	*11*	*0.2017*	*2*	*4.71*	*8*
B 73	0.9104	13	0.2223	13	0.2090	4	8.00	14
Mo 17Ht	0.8188	10	0.2790	4	0.2940	14	7.99	13
F 1267E	0.5928	5	0.2743	5	0.2493	8	6.03	11
F 593/83	*0.7108*	*7*	*0.2717*	*6*	*0.2693*	*13*	*2.72*	*3*
F values	4.41**		4.41**		3.77**			

1) Computed with standardized values
2)Italics indicate the inbred lines crossed in a p(p-1) diallel
** - Significant for P<0.01

Laboratory experiments

Seeds of the same sixteen maize inbred lines were germinated on moistened filter paper at the room temperature (22° to 26°C). After 3-4 days, the germinated seeds were planted individually 5 cm deep in pots containing 1.5 kg soil-sand mixture (5:1) and maintained in controlled environment chamber at 27/20±1°C day/night temperature, 14 h day length and normal soil humidity (70% of soil water capacity, S.W.C.).

After three weeks from sowing, for half of pots, water stress was applied by water withholding until the soil humidity reached 40% S.W.C., and this situation was maintained for one week. The other half of pots was watered at 70% S.W.C. (control plants).

A randomized complet-blok design with five replicates was used in each variant.

Residual transpiration (CT) (Clarke, 1992), cell membrane stability (DI) (Saadalla et al., 1990), biomass accumulation of the roots and shoots (TOTDM) were evaluated in 4-5 leaf stage, both in control and droughted seedlings.

The meteorological conditions during the field experiments are presented in figure 1. Moisture regimes of the three locations were markedly different. At Fundulea, more quantities of rainfalls were registered especially in April, as compared with Valu lui Traian and Caracal.

Total seasonal precipitations were 260 mm at Fundulea, 240 mm at Caracal and 208 mm at Valu lui Traian.

P field superiority indexes (PFSI) for grain yield, proposed by Lin and Binns (1988), were computed using the following formula:

$$P_i = \left(\sum_{j=1}^{n} (x_{ij} - M_j)^2 \right) / (2n)$$

were:

n = number of locations;
x_{ij} = yield for genotype i in location j;
M_j = yield of genotype with the largest yield in location j.

Selection for drought tolerant genotypes based on this criterion do not exclude genotypes with good efficiency under optimal conditions.

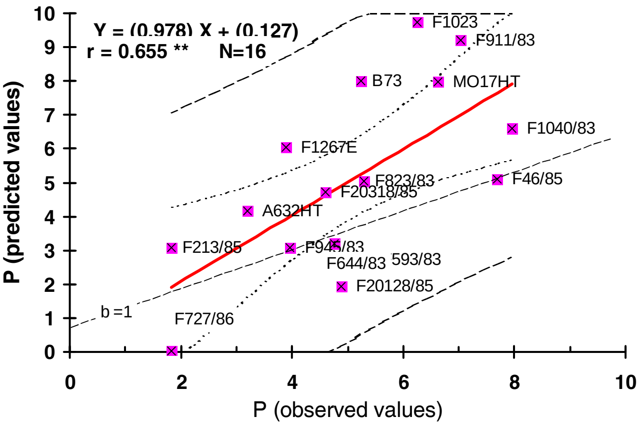
Searching for a relationship between P field superiority index and physiological traits studied in laboratory was carried out with multiple regression procedure of Execustat vers. 2.1 (Strategy Plus Inc., 1991).

Estimation of the inheritance of the physiological traits was based on the statistical model proposed by Căbulea in 1983 for a p(p-1) diallel. The model is a modification of the models of Hayman (1954) for computation of the genetic variances, and Griffing for computation of the general and specific combining ability, as well as the estimation of nuclear-cytoplasmatic interaction. The improved model allows the reciprocal separation of the maternal and paternal actions.

RESULTS AND DISCUSSIONS

According to F values, sufficient variability for some physiological parameters (PP) was detected among the 16 maize inbred lines (Table 1). Ranking of the lines was different for each PP and for PFSI, suggesting that simple regression might not be useful for setting up a relationship between each PP and PFSI. A multiple regression seemed to be more appropiate to predict a cumulative superiority index, better correlated to PFSI.

Equation of this multiple regression was estimated after a reduced model in which the coefficients with F values less than 1 were eliminated. Data presented in annex 1 and figure 1 show an acceptable model fitness and correlation between predicted P superiority indexes and those obtained on the basis of field experiments (Lin and Binns, 1988).



P predicted = 4.133 CTdrought - 34.51 TOTDMoptimal + 43.769 TOTDMdrought

Figure 1. The relationship between the P values predicted on the basis of physiological parameters and observed P values (computed with standardized data according to Lin and Binns, 1988)

Generally, all analyzed types of genic effects and interactions are implied in the determination of PP (Table 2).

Table 2. F values resulted from the analysis of genetic variances for physiological parameters in a diallel p(p-1) with p = 10

Source of variation	CT optimal	CT drought	DI	TOTDM optimal	TOTDM drought
Additive effects	12.02**	19.53**	6.47**	268.33**	316.60**
Non-additive interactions	3.87**	2.81**	4.49**	14.64**	39.94**
Cytoplasmic (maternal) effects	3.62**	3.95**	3.24**	10.37**	11.68**
Nuclear-cytoplsmic interactions	2.34**	0.55	1.93**	10.47**	9.52

** - significant for P<0.01

Annex 1. Analysis of multiple regression between P field superiority index (Lin and Binns, 1988) and physiological parameters determined at seedlings (4 leaves) grown under controlled laboratory conditions

Variances F values and probability of multiple regression coefficients

Source of variation	Variance	F value	Probability
CT drought	407.69	82.55	0.0000
TOTDM optimal	6.01	1.22	0.2900
TOTDM drought	41.08	8.32	0.0128

Variances analysis for the reduced model used to compute the multiple regression coefficients

Source of variation	Variance	F value	Probability
Model	151.59	3.69	0.0000
Error	4.94		

Standard error at values and probability for multiple regression coefficients

Source of variation	Standard error	F value	Probability
CT drought	1.63	2.53	0.0252
TOTDM optimal	18.84	-2.33	0.0369
TOTDM drought	15.18	2.88	0.0128

Additive effects have the largest weight, but significant non-additive, cytoplasmic and nuclear-cytoplasmic effects were estimated, suggesting a complex inheritance of the PP.

F 20318/18, A 632Ht, F 823/83, F 20128/85, F 1023, due to their significant negative *Gi* values for the cumulative index, are supposed to transmit uniformly more favourable PP for drought resistance to their hybrid combinations, while F 1040/83 and F644/83 have significant positive *Gi* values for the same cumulative index and it would be expected to transmit less favourable PP to all their hybrid combinations (Table 3).

Table 3. Additive genic effects for physiological parameters and a cumulative index in 10 maize inbred lines

Inbred lines	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F 1040/83	1.75***	1.02***	0.72***	1.45***
F 644/83	0.48*	0.39***	0.63***	0.71***
F 593/83	-0.23	-0.07*	-0.01	-0.17
F 20318/85	-0.35	-0.14***	-0.02	-0.24**
A 632Ht	-0.37	-0.07*	-0.12***	-0.42***
F 823/83	-0.60**	-0.18***	-0.18**	-0.59***
F 20128/85	-0.39	-0.20***	-0.30***	-0.49***
F 210/85	0.02	-0.19***	-0.09**	0.11
F 1023	-0.30	-0.25***	-0.31***	-0.36***
F 46/85	-0.01	-0.32***	-0.32***	-0.01

*, **, *** - significant for $P<0.05$, $P<0.01$ and $P<0.001$, respectively

A 632Ht and F 823/83, used as females, are supposed to determine uniformly more favourable PP. Conversely, F 1040/83 will influence negatively PP in all its combinations when used as female (Table 4).

Table 4. Cytoplasmic genic effects for physiological parameters and a cumulative index in 10 maize inbred lines

Inbred lines	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F 1040/83	0.67**	-0.09**	-0.16***	0.61***
F 644/83	0.16	0.12	0.08**	0.12
F 593/83	0.06	-0.02	-0.02	0.05
F 20318/85	-0.20	-0.04	0.00	-0.16
A 632Ht	-0.29	0.09**	0.06*	-0.32***
F 823/83	-0.30	-0.10**	-0.06*	-0.26**
F 20128/85	-0.15	-0.05	0.03	-0.07
F 210/85	-0.13	-0.01	0.00	-0.11
F 1023	0.12	0.08*	0.01	0.05
F 46/85	0.07	0.02	0.04	0.10

*, **, *** - significant for $P<0.05$, $P<0.01$ and $P<0.001$, respectively

Certain specific combinations may have a superior drought resistance due to their significant favourable non-additive interactions (Table 5) and/or nuclear-cytoplasmic effects (Table 6).

Such favourable interactions were registered in two commercial hybrids, popular for their better behavior under drought conditions: Fundulea 322 (F 1040/83 x F 644/83) with a total (non-additive + nuclear-cytoplasmic) cumulative index -1.46 and Fundulea 320 (A 632Ht x F 1023) with -0.49. It seemed that F 322 might be a superior combination under drought conditions and this supposition is confirmed by data presented in figure 2.

Table 5. Significant non-additive genic effects for physiological parameters and a cumulative index in specific combinations among 10 maize inbred lines

Inbred lines	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F1040/83 x F644/83	-0.76	-0.30**	-0.74***	-1.20***
F1040/83 x F20318/85	0.46	-0.16	-0.07	0.55*
F1040/83 x A632Ht	1.67**	-0.02	0.20**	1.89**
F1040/83 x F823/83	0.83	-0.19*	0.13	1.15***
F1040/83 x F20128/85	-0.36	0.47***	0.12	-0.71**
F1040/83 x F1023	-0.55	0.44***	0.25**	-0.74**
F1040/83 x F46/85	-1.26*	-0.11	-0.01	-1.17***
F644/83 x F593/83	0.94	0.29**	0.44***	1.09***
F644/83 x F20318/85	0.93	0.49***	1.04***	1.49***
F644/83 x A632Ht	0.79	0.71***	0.44***	0.52*
F644/83 x F1023	-0.68	-0.42***	-0.61***	-0.87***
F644/83 x F46/85	-0.44	-0.37***	-0.56***	-0.63*
F593/83 x F210/85	-0.64	0.08	-0.06	-0.78**
F593/83 x F46/85	-0.84	0.31***	0.24**	-0.92***
F20318/85 x A632Ht	-0.45	0.11	-0.02	-0.58*
F20318/85 x F210/85	-0.32	-0.17	-0.35***	-0.49*
A632Ht x F20128/85	-0.59	-0.17	-0.08	-0.49*
A632Ht x F210/85	-0.71	-0.14	-0.21**	-0.77**
A632Ht x F1023	-0.53	-0.07	-0.02	-0.49*
A632Ht x F46/85	-0.64	-0.10	-0.02	-0.55*
F823/83 x F20128/85	-0.33	0.21*	0.01	-0.52*
F823/83 x F210/85	-0.65	-0.01	-0.15*	-0.79**
F20128/85 x F210/85	1.05	-0.10	-0.02	1.13***
F20128/85 x F1023	0.43	0.05	0.23**	0.61*
F20128/85 x F46/85	1.04	0.06	0.19*	1.17***
F210/85 x F1023	1.07	-0.04	0.01	1.13***
F1023 x F46/85	0.75	0.09	0.22**	0.87***

*, **, *** - significant for $P<0.05$, $P<0.01$ and $P<0.001$, respectively

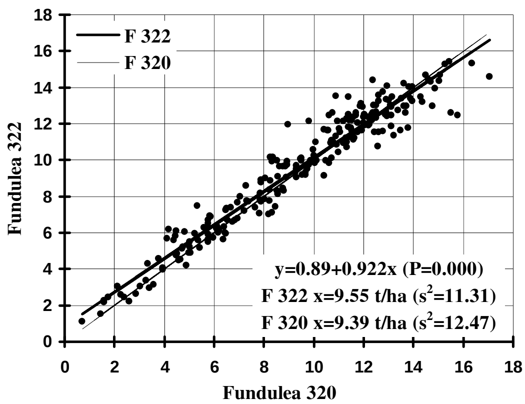


Figure 2. Linear regression between grain yields (t ha^{-1}) of maize hybrid F 322 (Reg. 1990) and the check F 320 (Reg. 1985) obtained in 234 trials performed under both irrigated and dryland conditions (1987 - 1995)

Table 6. Significant nuclear-cytoplasmatic effects for physiological parameters in specific combinations among 10 maize inbred lines

Combinations	*TOTDM optimal*	*TOTDM drought*	*Cumulative index*
F644/83 x F1040/83	0.45***	0.20*	-0.26***
F823/83 x F1040/83	0.83***	0.16*	-0.67***
F20128/85 x F1040/83	1.33***	0.33***	-1.00***
F1023 x F1040/83	-0.16*	0.55***	0.71***
F46/85 x F1040/83	0.61***	0.21**	-0.40***
F20318/85 x F644/83	0.71***	0.21**	-0.50***
A632Ht x F644/83	0.02	0.24**	0.22**
F823/83 x F644/83	0.65***	1.35***	0.69***
F210/85 x F644/83	0.46***	0.24**	-0.23**
F20128/85 x F823/83	-0.24***	0.09	0.33***

*, **, *** - significant for P<0.05, P<0.01 and P<0.001, respectively

Table 7. Predicted relative gain for drought resistance in three way hybrid combinations among maize inbred lines used in the study

Combination	Predicted relative gain for drought resistance
(A632Ht x F 823/83)xF 1023	-2.39
(A632Ht x F 823/83)xF 20318/85	-2.35
(F 823/83 x F 20128/85) x F 20318/85	-2.33
(A632Ht x F 20128/85) x F 20318/85	-2.30
(F20318/85 x F 1023) x A632Ht	-1.79
(F20318/85 x F 1023) x F 823/83	-1.75
(A632Ht x F 20128/85) x F 1023	-1.42
(F 823/83 x F 20128/85) x F 1023	-1.22
(F20318/85 x F 1023) x F 20128/85	-1.02

Fundulea 322 (FAO maturity group = 400-500) overyielded on the average the check Fundulea 320 with 0.16 t ha^{-1}, but with 0.89 t ha^{-1} under very dry conditions.

Under favourable conditions (8 - 14 t ha^{-1}) the two hybrids gave similar grain yields.

The superior drought tolerance of Fundulea 322 is suggested, also, by the b value of the linear regression and a lower variance of yield.

CONCLUSIONS

Sufficient genetic variability among the maize inbred lines for physiological traits was revealed.

Genic actions and interactions implied in the determinations of the investigated physiological traits are significant and complex:

- some of the genotypes could be used as favourable gene sources for improving the physiological traits (directly in hybrid combinations, as shown in table 7 or for releasing of starting material);
- application an of adequate selection method for maximum genetic gain should be done.

Multilinear relation between PFSI, estimated on the basis of field experiments (Lin and Binns, 1988) and some physiological traits determined on seedlings under laboratory controlled conditions has to be additionally verified regarding the response of the selection on the basis of laboratory physiological traits in drought resistance determined under field conditions.

Necessity appears to improve and to complex this relation with some other laboratory and field physiological traits, known as having significant and important implications in maize drought resistance such as:

- canopy infrared thermometry under stress conditions;
- rate of root growth under stress conditions (phytotoxic herbicide method);
- stress/optimal growing ratio in a determined time period (1 week);
- maize seedling growth in simulated water stress (media with constant water potential - PEG or manitol solutions).

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Nuclear-cytoplsmic interactions	2.34**	0.55	1.93**	10.47**	9.52

Table 3. Additive genic effects for physiological parameters and a cumulative index in 10 maize inbred lines

Inbred line	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F1040/83	1.75***	1.02***	0.72****	1.45***
F644/83	0.48*	0..39****	0.63***	0.71***
F593/83	-0.23	-0.07*	-0.01	-0.17
F20318/85	-0.35	-0.14***	-0.02	-0.24**
A632Ht	-0.37	-0.07*	-0.12***	-0.42***
F823/83	-0.60**	-0.18***	-0.18**	-0.59***
F20128/85	-0.39	-0.20***	-0.30***	-0.49***
F210/85	0.02	-0.19***	-0.09**	0.11
F1023	-0.30	-0.25***	-0.31***	-0.36***
F46/85	-0.01	-0.32***	-0.32***	-0.01

*, **, *** - significant for P<0.05, P<0.01 and P<0.001, respectively

Table 4. Cytoplasmic genic effects for physiological parameters and a cumulative index in 10 maize inbred lines

Inbred line	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F1040/83	0.67**	-0.09**	-0.16***	0.61***
F644/83	0.16	0.12	0.08**	0.12
F593/83	0.06	-0.02	-0.02	0.05
F20318/85	-0.20	-0.04	0.00	-0.16
A632Ht	-0.29	0.09**	0.06*	-0.32***
F823/83	-0.30	-0.10**	-0.06*	-0.26**
F20128/85	-0.15	-0.05	0.03	-0.07
F210/85	-0.13	-0.01	0.00	-0.11
F1023	0.12	0.08*	0.01	0.05
F46/85	0.07	0.02	0.04	0.10

*, **, *** - significant for P<0.05, P<0.01 and P<0.001, respectively

Table 5. Significant non-additive genic effects for physiological parameters and a cumulative index in specific combinations among 10 maize inbred lines

Inbred line	CT drought	TOTDM optimal	TOTDM drought	Cumulative index
F1040/83 x F644/83	-0.76	-0.30**	-0.74***	-1.20***
F1040/83 x F20318/85	0.46	-0.16	-0.07	0.55*
F1040/83 x A632Ht	1.67**	-0.02	0.20**	1.89**
F1040/83 x F823/83	0.83	-0.19*	0.13	1.15***
F1040/83 x F20128/85	-0.36	0.47***	0.12	-0.71**
F1040/83 x F1023	-0.55	0.44***	0.25**	-0.74**
F1040/83 x F46/85	-1.26*	-0.11	-0.01	-1.17***
F644/83 x F593/83	0.94	0.29**	0.44***	1.09***
F644/83 x F20318/85	0.93	0.49***	1.04***	1.49***
F644/83 x A632Ht	0.79	0.71***	0.44***	0.52*
F644/83 x F1023	-0.68	-0.42***	-0.61***	-0.87***
F644/83 x F46/85	-0.44	-0.37***	-0.56***	-0.63*
F593/83 x F210/85	-0.64	0.08	-0.06	-0.78**
F593/83 x F46/85	-0.84	0.31***	0.24**	-0.92***
F20318/85 x A632Ht	-0.45	0.11	-0.02	-0.58*
F20318/85 x F210/85	-0.32	-0.17	-0.35***	-0.49*
A632Ht x F20128/85	-0.59	-0.17	-0.08	-0.49*
A632Ht x F210/85	-0.71	-0.14	-0.21**	-0.77**
A632Ht x F1023	-0.53	-0.07	-0.02	-0.49*
A632Ht x F46/85	-0.64	-0.10	-0.02	-0.55*
F823/83 x F20128/85	-0.33	0.21*	0.01	-0.52*
F823/83 x F210/85	-0.65	-0.01	-0.15*	-0.79**
F20128/85 x F210/85	1.05	-0.10	-0.02	1.13***

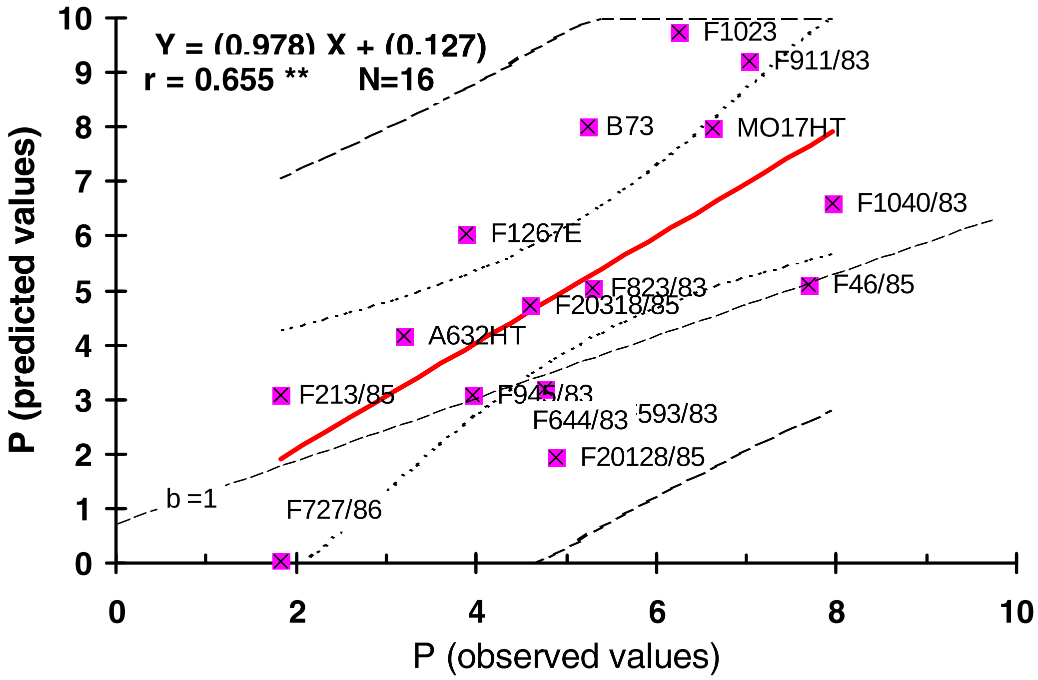
F20128/85 x F1023	0.43	0.05	0.23**	0.61*
F20128/85 x F46/85	1.04	0.06	0.19*	1.17***
F210/85 x F1023	1.07	-0.04	0.01	1.13***
F1023 x F46/85	0.75	0.09	0.22**	0.87***

***, **, *** - significant for P<0.05, P<0.01 and P<0.001, respectively**

Table 6. Significant nuclear-cytoplasmatic effects for physiological parameters in specific combinations among 10 maize inbred lines

Combination	*TOTDM optimal*	*TOTDM drought*	*Cumula-tive index*
F644/83 x F1040/83	0.45***	0.20*	-0.26***
F823/83 x F1040/83	0.83***	0.16*	-0.67***
F20128/85 x F1040/83	1.33***	0.33***	-1.00***
F1023 x F1040/83	-0.16*	0.55***	0.71***
F46/85 x F1040/83	0.61***	0.21**	-0.40***
F20318/85 x F644/83	0.71***	0.21**	-0.50***
A632Ht x F644/83	0.02	0.24**	0.22**
F823/83 x F644/83	0.65***	1.35***	0.69***
F210/85 x F644/83	0.46***	0.24**	-0.23**
F20128/85 x F823/83	-0.24***	0.09	0.33***

1) Non-significant values after general significance



P predicted = 4.133 CTdrought - 34.51 TOTDMoptimal + 43.769 TOTDMdrought

Figure 1. The relationship between the P values predicted on the basis of physiological parameters and observed P values (computed with standardized data according to Lin and Binns, 1988).

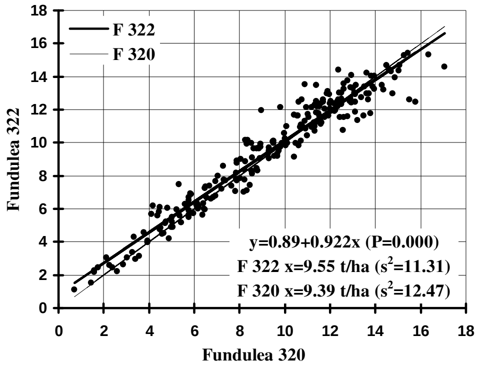


Figure 2. Linear regression between grain yields (t ha-1) of maize hybrid F 322 (Reg. 1990) and the check F 320 (Reg. 1985) obtained in 234 trials performed under both irrigated and dryland conditions (1987 - 1995).

Table 7. Predicted relative gain for drought resistance in three way hybrid combinations among maize inbred lines used in the study.

Combination	Predicted relative gain for drought resistance
(A632Ht x F 823/83)xF 1023	-2.39
(A632Ht x F 823/83)xF 20318/85	-2.35
(F 823/83 x F 20128/85) x F 20318/85	-2.33
(A632Ht x F 20128/85) x F 20318/85	-2.30
(F20318/85 x F 1023) x A632Ht	-1.79
(F20318/85 x F 1023) x F 823/83	-1.75
(A632Ht x F 20128/85) x F 1023	-1.42
(F 823/83 x F 20128/85) x F 1023	-1.22
(F20318/85 x F 1023) x F 20128/85	-1.02