Genetic Variability in Inbred Lines from a Tropical Maize Germplasm under Selection for Phosphorus Efficiency Uptake.

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Introduction

The problem of phosphorus in the soils is that its absence or limited availability results in a reduction of the plants development, increasing the cycle, reducing the foliar area and the volume of the roots, bringing about a reduction in the final grain yield (Gaume, 2000).

The best alternative to reduce this problem would be to use the maximum potential of adaptation of the plants and the soils adverse conditions, and to get improved cultivars with bigger relative capacity to the efficiency in the absorption and use of the P.

The existing genetic variability in the Brazilian maize germplasm has been reported for researchers from field experimentation results for P contents, production of substances of dry aerial part of plants and roots and grain yield (Alves, 1994; Machado, 1995).

The general combining ability is interpreted as being the mean results of a line in hybrid combinations, and the specific combining ability is used to assign cases where certain hybrid combinations are better or worse of what could be wait of the mean response of the hybrid combinations of the lines (Sprague & Tatum, 1942).

The knowledge of the genetic aspects of the content of the essential minerals for the plants and the efficiency in the use of them is relatively limited. Much of the research results found in the literatures show that the procedures to be used in breeding works, must be based in the genetic inheritance of the quantitative characteristics of the plants and that they are estimated by the use of diallel crossings.

Thus, the diallel analysis has been a tool of much use for the maize breeders for the evaluations of its experimental materials (Hallauer e Sears, 1968; Hallauer, 1972).

Some researchers as Gorsline et al. (1964), have pointed out that great part of the genetic variability related to the minerals contents of the maize plants is controlled by additive gene action, but the non-additive gene actions are also present.

The objectives of the present work had been to study the general and specific combining ability, type of gene action involved in the inheritance of the content and efficiency in the use of P, in the diallel crossing using 12 lines o different sources of maize germplasm from a breeding program for efficiency in the use of P.

Material e Methods

The maize inbred lines used in this study were selected previously from a research work conducted for selecting lines for drought tolerance in soil with low P content. Two of them (L11 and L12) were selected from previous studies in both nutrient solution and in soil

Cerrado condition, as efficient and non-efficient for P uptake, and has been used in the Embrapa maize breeding program.

Sixty six single crosses among twelve inbred lines were obtained by the diallel mating scheme, in 2004, at Embrapa Maize and Sorghum Research Center, in Sete Lagoas, MG.

In 2005, the 80 entries were evaluated (66 single crosses, the 12 parental and 2 testers), at the experimental station of Janaúba, Northern region of Minas Gerais state, altitude 516 m, latitude 15º 47'S and longitude 43º 18'W, annual mean rainfall of 873, 5 mm, mean temperature of 24,7°, and mean relative humidity of 65%. The soil was classified as latosol yellow, dystrophic and of clay texture. The material was evaluated using a randomized complete block design with two replications, in 5 m long single row plot, with 55 thousands plant ha^{-1}. Fertilizers were applied in accordance with the soil analyses results, in order to establish two levels of P. Two areas were properly fertilized with P stress (<3 ppm) and with P non-stress (>20 ppm). Data were collected for the following traits: days to anthesis (DA), plant height (PH), ear height (EH), stalk and ear lodging (R+S) , rotten ear (ER), prolificacy (PROL) and grain yield GY (kg $plot^{-1}$).

The variance analysis and the diallel analysis to calculated the general combining ability (GCA) and the specific combining ability (SCA) effects by using the method 4, model I (Griffing, 1956) for all studied traits, were computed using the Genes program (Cruz, 1997). The quadratic component estimates were calculated by the formulas presented by Cruz & Regazzi (1994): $\hat{o}_g$ = QMG (general mean square) – QMR (error mean square)/ 2p (number of parental) and $\hat{o}_s$ = QMS (specific mean square) – QMR.

Results and Discussion

In the combined analysis of variance (Table 1) highly significant (P<0,01) differences among treatments means were found for all the five traits DA, PH, EH, R+S, ER, PROL, and GY, suggesting genetic variability among the maize inbred lines and their hybrids for P uptake efficiency. The highly significant differences for GCA and SCA (P<0,01) found for the all traits studied, showed the heterogeneity of the general and specific combining ability in relation to these traits studied. Looking at the genetic side, the highly significant differences found for GCA and SCA means squares indicates that both additive and non-additive gene effects are of importance in this set of lines for all the five traits. Therefore, in relation to the most important type of gene effect, due the quadratic component associated to SCA being greater than the GCA, has suggested the predominance of non-additive gene effects. Similar results were found by Cruz & Regazzi (1994) where they worked with previous selected maize genotypes. The interaction between GCA x Environment, significant (P<0,01) differences were found for DA, ER, PROL and GY and (P<0,05) for PH and R+S; while for SCA x E significant differences (P<0,01) were found for the traits DA, R+S, ER and PROL but not significant for PH, EH and GY. The CVe values obtained for the traits studied were within the limits reported in most literature indicating good precision for the estimates.

The GCA estimates for the five traits are shown in Table 2. The higher g_i estimates for the trait GY were found for the inbreds L 79 and L 20. Inbreds L11 and L 12 have been identified in the Embrapa maize breeding program as the most and the least efficient lines for P utilization. For the trait DA inbreds L 12 and L 43 presented the higher and the lower estimates values. For PH and EH the major positively contributions came from the lines L 33 and L 12, respectively, and negatively for line L11 for both traits. The inbred L 48 presented the lower estimate values for R+S trait and the higher values for ER trait. Lines L 79 and L 20 with the highest GCA estimates for GY showed to be the most important in contributing positively in their single crosses hybrids.

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TABLE 2 : Estimates of general combining ability (g_i) mean effects for days to anthesis (DA), plant height (PH), ear height (EH), root and stalk lodging (R + S), ear rot (ER), prolificacy (PROL)) and grain yield (GY), according to Method 4 of Griffing (1956) for the 12 inbred lines, grown in two environments without and with P.

	GCA						
INBRED LINES	**DA**	**PH (cm)**	**EH (cm)**	**R + S**	**ER**	**PROL**	**GY (Kg ha^{-1})**
L67	-0.095	1.190	2.589	5.886	12.185	-0.108	-0.474
L73	-0.595	6.190	-1.875	-4.598	1,518	-0.047	0.140
L27	-0.131	6.160	3.482	-5.545	-9.652	0.035	0.237
L79	-0.274	-6.488	-7.232	-2.566	0.227	-0.087	0.421
L43	-0.988	-1.667	1.696	10.425	-4.030	-0.045	-0.061
L48	0.655	2.828	2.589	-10.276	14.584	-0.018	-0.372
L17	-0.560	-1.667	2.232	-2.332	4.860	0.045	-0.278
L84	-0.381	-1.845	-3.125	2.217	-2.044	0.139	0.373
L20	-0.131	5.298	0.448	2.301	-4.862	0.043	0.567
L33	0.048	6.369	1.339	-2.256	-10.374	0.137	0.289
L11	0.976	-12.917	-7.589	-9.779	2.084	-0.221	0.212
L12	1.476	-3.452	5.446	16.524	-4.496	0.127	-1.055

TABLE 1 : Combined analysis of variance mean squares and the estimates of the quadratic components associate with the general combining ability (GCA) and specific combining ability (SCA) for days to anthesis (DA), plant height (PH), ear height (EH), root and stalk lodging (R+S), ear rot (ER), prolificacy (PROL)) and grain yield (GY), for 12 inbred lines e 66 diallel single crosses, grown in two environments with and without P.

		Mean Squares						
Source	d.f.	**DA**	**PH**	**EH**	**R+S**	**ER**	**PROL**	**GY**
Treatments	77	21.373**	1402.107**	470.026**	794.575**	1145.406**	0.1935**	7.524**
GCA	11	39.933**	1311.242**	53.826**	2491.297**	4928.172**	0.3709**	8.474**
SCA	66	18.279**	1417.251**	462.726**	511.788**	512.612**	0.1639**	7.366**
Environments	1	8308.013**	152817.4**	192315.7**	7577.8**	411.26**	0.3857**	143.93**
T x E	77	2.9803	336.381	105.478	281.224**	298.482**	0.0878**	0.846*
GCA x E	11	5.6017**	355.506*	139.799	479.230*	623.453**	0.1545**	1.504**
SCA x E	66	2.5434**	333.194	99.757	248.223**	244.319**	0.0767**	0.737
Error	160	3.7809	303.735	126.304	220.755	177.175	0.0546	0.788
G. Mean		51.68	162.35	90.25	18.55	23.68	1.48	3.759
ϕg		2.582	71.964	27.680	162.181	339.356	0.0226	0.549
ϕs		14.498	1113.516	102189.4	291.033	335.437	0.1093	6.578
CV%		3.67	10.73	12.45	80.04	56.21	23.51	15.73

* , ** significant at the 0.05 and 0.01 probability levels, respectively.