Combining Ability for Nitrogen Use in a Selected Set of Imbred Lines from a Tropical Maize Population.

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Introduction

Nitrogen deficiency is one of the most important stresses affecting maize production in tropical areas (Lafitte and Bänziger, 1995). The great majority of tropical soils present low levels of fertility, consequently higher levels of yields require higher inputs of chemical fertilizers, mainly of Nitrogen. Thus, a maize cultivar with genetic potential to utilize N efficiently could produce economically in poor soils with low levels of fertilizer applications or high yields with better inputs of fertilizers due its capacity to utilize N efficiently. Moll *et al* . (1987) and Pollmer *et al*. (1979) pointed out that variation in the capacity of maize genotypes to take up N from the soil and to utilize plant nitrogen for grain production has been widely reported. Genetic variation in response to N supply of inbred line (Balko and Russel, 1980), has been observed and it appears to be possible to develop hybrids with tolerance to low N in soils. In most breeding programs one of the main objectives is to identify inbred lines with productive potential "per se" and high combining ability for hybrid production that express high heterotic levels for grain yield. Maize cultivars present different behavior when grown in low levels of N and show different N partition and biomes inside the plant, especially in terms of N removed from the vegetative tissues (Ta and Wieland, 1992). With respect to genetics parameters related to N use efficiency, dominance effects had the great contribution to the observed genetic variance (Clark and Duncan, 1991). The genetic variation due to the general combining ability was greater related to N plant structure (productivity and dry matter), indicating that differences among crosses could be attributed to additive gene effects(Rizzi *et al*., 1993). The objectives of this work were to evaluate the N use efficiency of inbred lines and determine de relative importance of general and specific combining ability for N efficiency by using a diallel crosses.

Material and Methods

A selected group of ten tropical inbred lines of maize derived from a tropical yellow dent tuxpeño synthetic population (CMS 61) was crossed in a diallel system through controlled hand pollinations. The resulting 45 single crosses, the 10 parental lines and a control - N use efficient line, were grown in the experimental area of Embrapa Milho e Sorgo/Embrapa, in Sete Lagoas, MG, in 2000. For both trials was used a lattice design 7 x 8 with two replications, and plot size was a single 5 m row spacing 0,90x 0,20m between and within rows, respectively. Each of the two nitrogen levels was considered a separate field trial plant adjacent to each other in a Latosoil dark-red, dystrophic and of clay texture, typical of the savannas Brazil Center areas, with low levels of N. The first area, with N stress (N0 =10 kg ha_{-1} of N), was planted using 250 kg ha_{-1} of the formula 4:14:8 plus Zn and 20 kg of FTE BR 12 (micronutrient source). The second area, with no N stress (N1=120 kg ha_{-1} of N) was used 250 kg ha_{-1} of the formula 4:14:8 plus Zn, 20 kg ha_{-1} of FTE BR 12 (micronutrient source) and 30 kg ha_{-1} of N. At the latter, five weeks after sowing, 90 kg ha_{-1} of N (Urea) was side dressed applied. Data were collected for ear yield (EY), plant height (PH), ear height (EH), number of root and stalk lodge (NRSL), and prolificacy (Prol). Each experiment was analysed separately as a lattice design. Analysis of genotypes distribution was performed based on N stress index (NSI) on EY under N stress condition to classify the most tolerant materials to the N stress imposed in the trials. Also date for YE were analyzed using Griffing(1956) Model I, Method 2 to calculate general and specific combining ability.

Results and Discussion

Nitrogen treatment had a significant effect on ear yield (EY), plant height (PH), ear height (EH), and prolificacy (Prol) traits. Yield reduction under low nitrogen level (N0) in comparison to higher level (N1) treatments, in terms of average EY, ranged from 1206 kg ha_{-1} to 2080 kg ha_{-1} for lines and from 4346 kg ha_{-1} to 6730 kg ha_{-1} for the crosses. Yield under N0 level was lowest for line L 3 and highest for line L 2, and yield under N1 level line L 4 was lowest and highest for line L 8. Differences among inbred lines and single crosses were observed for PH, EH and Prol traits. Inbred L3 presented the lowest values under low N level, and there were consisting differences for the results under high level of N, for these three traits. For the trait Prol, means of single crosses were greater under N0 level than for N1 level, but happened the opposite for the inbred lines maybe due to the reduction in PH and EH. Nitrogen treatments had an important effect on the means of inbred lines under N1 in comparison with N0 resulting in a reduction of 18,9% (PH), 27,5% (EH) and 27,6% (Prol). Similarly, the reduction for single crosses means were 12,9%, 22,9% and 22,5% for PH, EH and Prol, respectively. Thus, as was expected reductions in terms of average performance were lower for single crosses than for the lines. Similar results were found by Laffite *et al*., 1995, Kling *et al*., 1997; and Arellano *et al*. 1997. The analysis of variance for ear yield showed significant ($P<0,01$) for genotypes under N1 and N0 levels (Table 1).

Table 1. Summaries of the analysis of variance for ear yield (kg ha_{-1}) for maize inbred lines and a diallel set of 45 crosses among these lines in experiments with two levels of N. EMS/Embrapa, SL(MG), 2002.

SV	DF	MS	F
		High N (N1)	
Genotype	54	8485648.7706	**
G.C.A.	9	3445309.3416	**
S.C.A.	45	9493716.6564	**
Error	40	1065602.0055	
		Low N (N0)	
Genotype	54	4262932.9923	**
G.C.A.	9	1578508.1132	ns
S.C.A.	45	4799817.9681	**
Error	40	1133352.0108	

** significant at the 1% level of probability F test;
ns= Non significant

Significant (P<0,01) was detected for SCA under both N treatments, but GCA was only significant (P<0,001) under N1. Arellano, *et al*. 1997, found significant differences for GCA and SCA effects in a study involving a diallel of 14 inbred lines, and because SCA effects for yield were larger under low N level, they consider that these effects were more important under low than under high N availability. On the other hand, Below *et al*. (1997) working with six temperate lines found that additive effects were more important than dominance effects. Estimates of the SCA and GCA effects for both N levels, for EY of the 10 inbred lines are presented in Table 2.

Table 2. Estimates of specific (above diagonal - N1 and below diagonal - N0) combining abilities (SCA) and general combining abilities (GCA N1 and GCA N0) for ear yield, for a diallel set of crosses among ten inbred lines, in experiments with two levels of Nitrogen. EMS/Embrapa,SL,(MG),2000.

	L1	L2	L3	L4	L5	L6	L7	L8
L1	-	2554,301	127,002	1928,117	-306,119	886,708	1802,193	546,318
L2	2351,437		450,116	997,091	346,269	47,202	336,836	1155,072
L3	652,778	-197,331		813,711	1523,609	1120,633	-445,050	773,259
L4	914,417	638,376	381,588		-407,789	1768,601	-372,923	510,718
L5	-131,146	-174,184	1188,874	-222,703		419,096	1415,743	514,492
L6	512,152	165,498	1088,997	1465,201	507,496		1259,740	1211,127
L7	512,486	148,410	2390,709	-885,954	228,197	814,094		1812,230
L8	304,818	476,618	474,420	978,399	113,925	761,342	920,656	
L9	78,600	-493,651	915,934	919,537	1249,541	1077,890	282,703	-730,465
L10	938,639	642,384	427,381	362,144	1158,083	-1117,870	2112,135	658,302

	L9	L10	GCA N1	GCA N0
L1	993,923	1055,549	536,412	88,238
L2	676,392	1941,605	456,274	404,223
L3	1738,403	1097,365	-335,476	68,829
L4	1433,840	1717,435	-258,490	-397,229
L5	290,616	1764,533	-491,653	-94,007
L6	1005,436	428,725	91,370	161,017
L7	574,891	805,806	162,504	160,335
L8	-1833,006	1846,097	90,108	-205,793
L9		578,392	-513,208	-355,658
L10	776,210		262,154	170,044

DP (Gi) =199,991 e DP (Gi - Gj) = 297,997-- N1= 120kg/N ha^{-1} ; N0= 10 kg/N ha^{-1}
DP (Gi) =206,160 e DP (Gi - Gj) = 307,322 (N0)
DP (Sij) =672,363 e DP (Sij - Six) =988,332 (N1)
DP (Sij) = 693,415 e DP (Sij - Six) =1019,24 (N0)

GCA and SCA effects differed according to the level of available nitrogen. Although the additive effects have been detected, the SCA effects predominated over the GCA. The GCA estimated effects were positive for the lines L1, L2, L3, L6, L7 and L10, under N0 level. Under N1 level, lines L1, L2, L6, L7, L8 and L10 also presented favorable GCA effects.

Therefore, five out of the ten lines present high GCA effects in both N0 and N1 levels. Lines L4, L5 and L9 had negative GCA effects at both levels of N. This led to a conclusion that the involvement of additive gene action should facilitate selection efforts for better line identification under non-stress environments. Normally, breeders is interested in hybrid combinations, with SCA more favorable and where there is at least one of the lines with GCA effect more favorable. Therefore, crosses like L1 x L2 should be highly desirable.

Trials conducted at low yielding environments have a higher frequency of producing statistically non-significant differences, or having a larger coefficient of error variation than trials conducted under high yielding environments. This is because the error variance usually does not decrease as much as the genetic variance when going from high to low yielding environments (Bänziger *et al.*, 1997). Even though the environmental and economical limitations related to N fertilizer utilization, traditionally the greater majority of the maize breeding programs in the tropics are under optimum fertilization conditions where heritability and potential selection genetic gains are usually much greater.

Therefore, our results agree with earlier results found (Laffite and Edmeades, 1995) that show yield of inbred lines related to N use are under genetic control. As shown by the results of the others traits, the identification of traits related to EY at high and low N levels could allow the development or identification of hybrids with high performance to stress environments.

A further part of this study was the examination of the most promising lines to N efficiency. As seen in Fig 1, quadrant 1 characterized by low NSI (N Stress Index) and yield was composed of all the lines and the inbred tester, and was classified as low yieldings and non-responsive to N stress. In quadrant 3, characterized by high NSI and yield, was composed of 17 single crosses, and were classified as high yieldings and responsive to N stress.

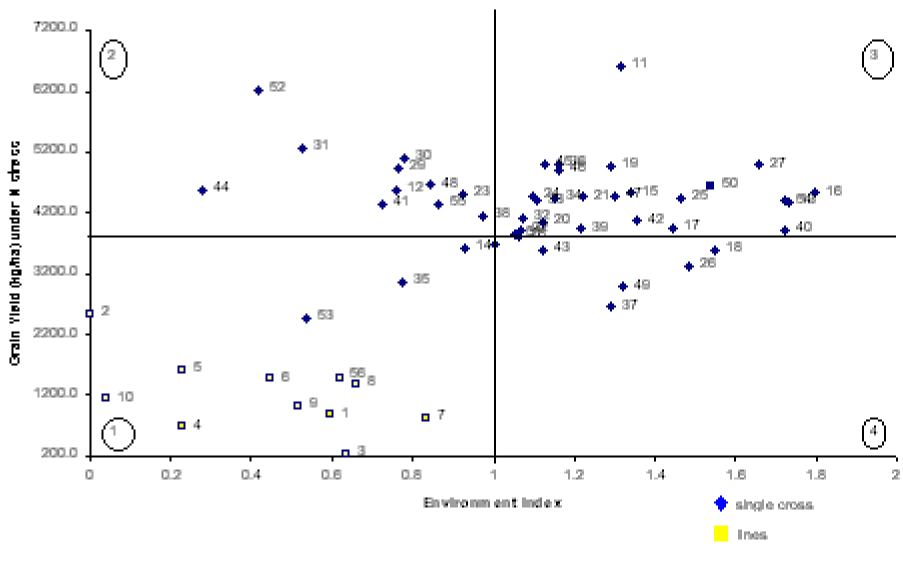

Fig1 - Ear yield as or function of environment index (EI) for10 lines, 45 single crosse, and 1 line tester trials under two N levels. SL (MG), 2000.

NSI= $(Y_{N1} - Y_{N0}) / (Y^{\overline{N1}} - Y^{\overline{N0}})$

Y_{N1} =production under N1; $Y^{\overline{N0}}$ = mean production under N0

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