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YIELD POTENTIAL OF TROPICAL MAIZE HYBRIDS IN ACID SOILS

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INTRODUCTION

Maize is one of the three major cereal crops grown in the world. In Malaysia, it is an important commodity as most of the grain maize used to support the local livestock feed industry is imported in the past three decades (USDA/FAS, 2009). Meanwhile, most of the arable soils in the country are weathered and acidic in nature, comprising 72% or 23.7 million ha of land area in Malaysia (IBSRAM, 1985; FAO, 2006). The soils have low cation exchange capacities (CEC), low basic cations, especially Ca and/or Mg, and high aluminum (Al) concentration in the soil solution (Shamshuddin et al., 1991). Among these constraints, Al toxicity is the major factor limiting plant growth and yield potential in acid soils, including maize (Shamshuddin et al., 1991). Even though the application of lime has proven to overcome the soil acidity problems, a number of limitations in use have been reported (Kamprath, 1971; Shamshuddin et al., 1998; Hede et al., 2002). Hence, planting high yielding varieties, in particular, maize hybrids tolerant to acid soils along with the use of sustainable agronomic practices offers an effective strategy for improving maize productivity in acid soils in the country. The objective of this study was to select maize hybrids for high yield potential in acid soils.

METHODOLOGY

The 36 maize hybrids obtained from a 9x9 diallel cross and the two check varieties, the composite variety *Sukmaraga* as acid soil tolerant check variety and the hybrid *Putra J-58* were evaluated in 2007 in Puchong and Serdang, in Split Plots arranged in a RCB design, with three replications. Two soil conditions (unlimed and limed) and genotypes were assigned to the main-plots and the sub-plots, respectively. The unlimed treatment was the naturally acid soil, while the limed treatment was the soil treated with ground magnesium limestone (GML) at the rate of 2 t ha^{-1}. The data were subjected to the analysis of variance (ANOVA) using the General Linear Models (Proc GLM) of the Statistical Analysis System (SAS) version 9.1 (SAS Institute Inc., 2003).

RESULTS AND DISCUSSION

Application of GML at 2 t ha^{-1} in Serdang series soil in Puchong decreased exchangeable Al on the topsoil from 3.05 to 0.9 $cmol_c kg^{-1}$, while that on mixed-tin tailings soil in Serdang decreased exchangeable Al from 1.58 to 0.52 $cmol_c kg^{-1}$. Application of GML also increased the basic cations and the soil pH. The relative grain yields of the hybrids in this study decreased exponentially with the increasing amount of exchangeable Al (Fig.1). Critical value for exchangeable Al was 0.60

$cmol_c kg^{-1}$, indicating that application of lime at the rate of 2 t ha^{-1} was enough to alleviate exchangeable Al in Serdang; however, it was not enough in Puchong. For a better growth of maize in acid soils, the exchangeable Ca and Mg have to be increased to about 1.22 and 0.42 $cmol_c kg^{-1}$, respectively, while the soil pH has to be raised to about 5.1.

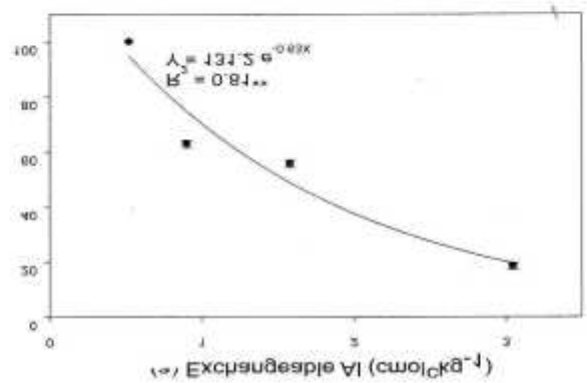

Fig.1. Effects of exchangeable Al on relative grain yield of 36 maize hybrids

The reduction of grain yields in acid soil in Puchong was high, ranging from 49 to 91%, while in Serdang, it ranged from 24 to 64%. Grain yields of the hybrids varied greatly within acid soil conditions and locations, in which different hybrids were found to have high yield performance in the different acid soil conditions and locations. The top ten high yielding hybrids in each acid soil condition and across environments (the combined data of both soil conditions and locations) out-yielded both the check varieties (Table 1). With regards to heterosis, the hybrids exhibited significant and high heterosis estimates for grain yield, indicating that the hybrids performed higher grain yield over their parents. Only H29 was consistently high yielding in each soil condition at the two locations. The hybrid also showed relatively high critical level of Al (0.62 $cmol_c kg^{-1}$). This hybrid was progeny of a cross between acid soil tolerant inbred line (IPB-12) and an elite inbred line introduced from CIMMYT (CML-2). Furthermore, its parental inbred lines had the highest genetic distance (0.72) based on the SSR markers (data were not shown), indicating that high diverse genetic background was possessed by the hybrid. Thus, high heterosis was expected from the hybrid.

Table 1. The top ten high yielding maize hybrids and the two check varieties evaluated on each soil condition from the combined data of two locations, heterosis estimates and critical level of Al

Hybrid	Yield ($kgha^{-1}$)	MPH (%)	Hybrid	Yield ($kgha^{-1}$)	MPH (%)	Hybrid	Yield ($kgha^{-1}$)	MPH (%)	Critical level of Al ($cmol_c kg^{-1}$)
Acid soils			Limed soils			Across environments			
H18	2662	252.7	H36	6001	582.4	H21	4275	153.8	0.64
H24	2875	328.3	H21	6164	325.6	H29	4117	133.3	0.62
H29	2871	395.5	H25	5665	156.3	H36	4007	420.1	0.60
H17	2816	204.7	H26	5633	210.7	H25	3980	103.1	0.60
H9	2772	263.5	H8	5594	394.7	H30	3914	121.8	0.64
H23	2668	300.7	H34	5576	290.5	H26	3873	97.6	0.56
H30	2660	449.5	H14	5461	206.5	H17	3827	127.3	0.63
H4	2587	327.0	H10	5404	99.0	H8	3814	278.2	0.55
H7	2533	771.1	H33	5401	280.2	H4	3805	115.6	0.74
H28	2450	235.4	H29	5364	174.2	H9	3766	123.6	0.44
Putra J-58	2179	n.a.	*Putra J-58*	5310	n.a.	*Putra J-58*	3744	n.a.	0.64
Sukmaraga	2563	n.a.	*Sukmaraga*	5088	n.a.	*Sukmaraga*	3826	n.a.	0.64
Hybrid mea	2210	-	Hybrid mea	4925	-	Hybrid mea	3576	-	-

n.a=not available

Regarding to tolerance to acid soils, hybrids generally showed a lower relative yield (63%) than Sukmaraga as acid soil tolerant check variety (66.9%); however, they had higher relative yield than Putra-J58 (56%). This indicates that the hybrids revealed in the study had high tolerance to acid soils than commercial maize hybrid variety established in the country. The highest relative yield in Puchong was shown by H29 (72.8%), while in Serdang was shown by H24 (86.2%). To distinguish hybrids corresponding to their tolerance to acid soils, a quadrant model was developed according to Sangalang and Bouwkamp (1988) and Howeler (1991). Five hybrids, H29, H24, H17, H18 and H9 were found to be tolerant to acid soil and had high yielding potential in acid soil conditions (Quadrant III) (Fig.2).

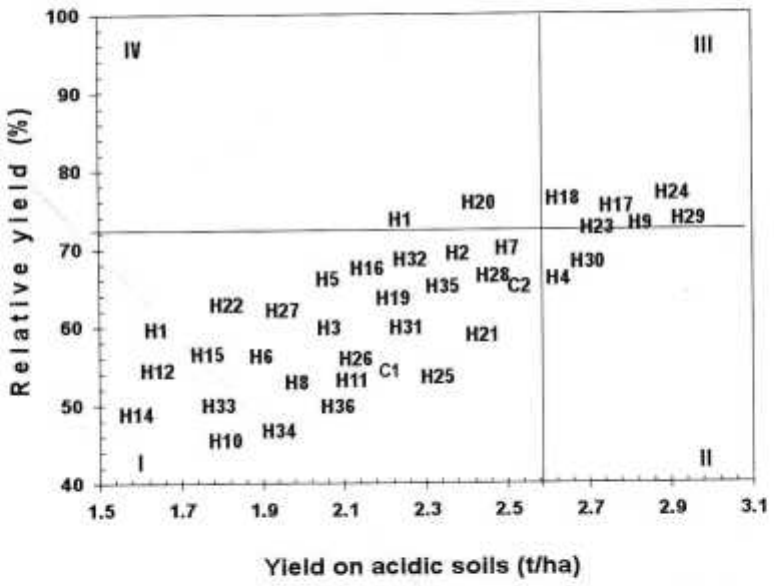

Fig.2. Relationship between relative yield and yields of hybrids in acid soils of 36 maize hybrids and two check varieties

CONCLUSION

This study has revealed hybrids that have high genetic potential for tolerance to acid soils. Among the hybrids, H29 was identified to be tolerant to acid soils and high potential on both acid and limed soils. Hybrid H29 should be given the opportunity for further evaluation before it is released as a hybrid maize variety for commercial production.

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