Breeding maize for Al tolerance, P use efficiency and acid soil adaptation for the cerrado areas of Brasil: the EMBRAPA´s experience.

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The soils of the tropical savannas, an area of approximately 850 million hectares, are characterized by its low fertility, low pH, low P availability, high P sorption capacity and toxic levels of aluminum (Foy, 1992). The main strategy to cope with soil fertility problems has been to correct the soil and also the use of large amounts of fertilizer. A more reasonable approach is to associate small levels of soil improvement with more adapted genotypes. Therefore, tailoring the crop to fit acid/less fertile soils may be more effective economical, and environmentally friendly, than changing the soil to fit the crops. This has been the key concept of a number of EMBRAPA´s breeding programs for the "Brazilian cerrado" along the time.

A maize breeding program for acid soil adaptation started in the seventies at EMBRAPA-Maize and Sorghum (Bahia Filho et al., 1977). This research has been focus in three major components: aluminum tolerance, phosphorus efficiency and yield under acid and fertile soil conditions. A large number of open pollinated varieties, hybrids and inbred lines have been developed and evaluated both "per se" and in crosses in these conditions. Some of the major results obtained from many studies of each of these stresses in the scope of EMBRAPA´s maize breeding program are summarized below.

In the case of Al tolerance, the screening has been conducted in nutrient solution with 222 μM of Al and a control solution with 0 Al (Magnavaca et al., 1987). The selection criteria used can be Relative Seminal Root Length (RSRL) or Net Seminal Root Length (NSRL).The main conclusions of a number of studies on the inheritance of Al tolerance in maize measured in nutrient solution, conducted by our research group are: a) Al tolerance is a highly inheritable trait, specially at the family mean level; b) in maize, it is a quantitative trait controlled by a few genes; c) the simultaneous evaluation of maize lines "per se" and in diallel crosses using solution with and without Al (control), increases the ratio of additive versus non additive effects from a factor close to 5, when compared with the situation were the genotypes are evaluated only in Al solution. The simultaneous use of Al and control solution makes the correlation between inbred line per se evaluation and general combining ability of this line quite high (Parentoni et al., 2001); d) in terms of germplasm, the frequency of Al tolerant maize genotypes in Brazilian materials has been higher in maize race "Cateto" and lower in maize races Tuxpeno and Pool 25; e) good sources of Al tolerance has also been found in maize genotypes from Cameroon and Kenya; f) one Al tolerant synthetic was obtained by recombining the four major Al tolerant sources from our breeding program. The synthetic has shown a higher NSRL than all of the parents. This synthetic is now in the third cycle of divergent recurrent selection for Al tolerance; g) F2 and F3 populations from the F1 between maize lines Cateto and L 53 (Al tolerant and Al susceptible) were used to map Al tolerance. Five QTLs which explained 60% of the phenotypic variance were detected (Nimango Cardenas et al., 2003); h) a set of 150 F9 recombinant inbred lines from this cross were developed and will be used for fine mapping of Al tolerance in maize.

Baligar & Fageria (2001) compared the efficiency of the use of nitrogen, phosphorus and potassiun in different crops. They reported that for N values in general were lower than 50%, for K they are close to 40% and for P they were lower than 10%. These results show the importance of

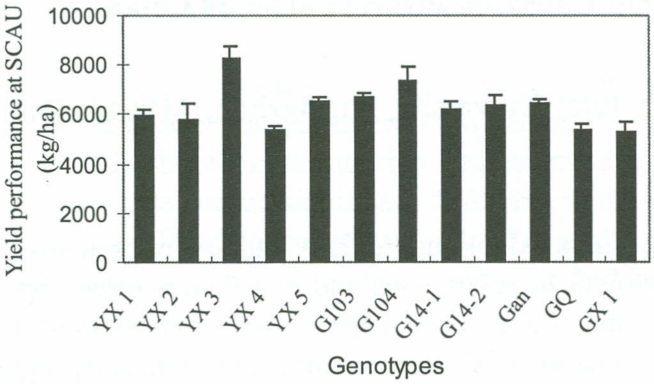

Figure 1. The 10 new-bred genotypes were planted with control genotypes GX1 and GQ in P-sufficient soil at the farm of SCAU.

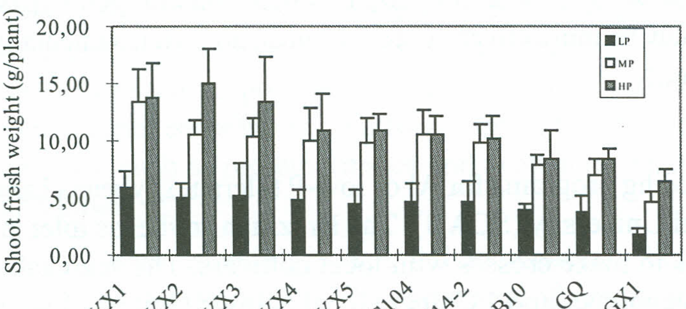

Figure 2. Soybeans were planted in the pot containing soils with addition of 0, 0.44 and 0.88 g KH_2PO_4 per kg soil. After 45 day treatment, the plants were harvested, and then shoot fresh weight were measured. The shoot fresh weight per plant.

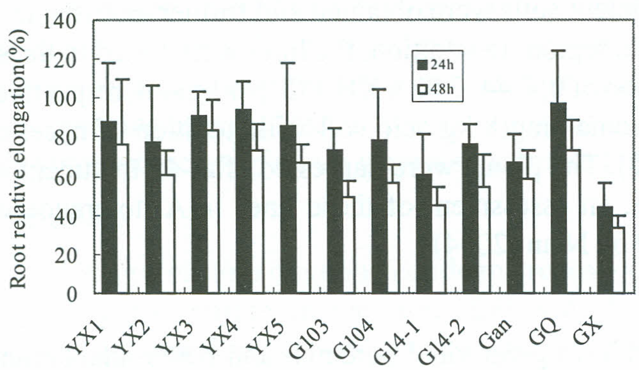

Figure 3. The genotypes were exposed to 0, and 50 μM $AlCl_3$ for 24 and 48 h, respectively, then the root relative elongation [(no Al/ Al) ×100%] were measured.

Conclusions

The performance of these new-bred genotypes confirms our successful breeding programs of associating high yield potential and stability to acid soils with Al toxicity and low P availability.

References

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