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# Three years performance of a tolerant and a susceptible maize cultivar on non-amended and amended acid soil

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**Abstract**

A long term agronomic experiment was conducted from 1996 to 2000 at Ebolowa, Cameroon. On the acid soil with high Al supply maize grain yield of the soil acidity-tolerant cultivar ATR-SR-Y was 61 % higher compared to the sensitive cultivar Tuxpeno sequia. The annual application of 60 kg P $ha^{-1}$ for three consecutive years did not significantly increase the grain yield of the soil acidity-tolerant cultivar. Except in the first year lime addition resulted in a significant increase of grain yield of the tolerant (82%) and particularly the susceptible cultivar (208%). This corresponded to a significant decrease in exchangeable Al and to a significant increase in pH and exchangeable Ca and Mg contents of the soil. The application of chicken manure or green manure (*Cassia septabilis* leaves) significantly increased maize grain yield. These increases in yield were partly attributed to an increase of exchangeable Ca and available P of the soil with chicken manure and to a decrease of exchangeable Al with the application of *Cassia septabilis* leaves.

## Introduction

Maize (*Zea mays* L.) is grown on approximately eight million hectares of acidic soils (Brewbaker, 1985; Pandey and Gardner, 1992). On these soils maize yield is reduced due to Al or Mn toxicities, and because of Ca, Mg, P and Mo deficiencies (Aldrich et al; 1975, Granados et al; 1993).

In tropical Africa, acid soils cover 29% of the continent (Eswaran *et al.*, 1997). To meet Sub Saharan African food security by the year 2050, Jacques du Guerny (1997) estimated that food production should be increased seven-fold as compared to the 1995 level. This implies the development of strategies for advanced, resource-friendly, sustainable, and economic production systems on acid soils including the introduction of improved acid soil-tolerant germplasm, the amelioration of soil acidity using phosphorus, lime and/or organic amendments.

A long term agronomic experiment was conducted from 1996 to 2000 both in Ebolowa, Cameroon and in the Eastern Acid plains of Colombia with the objective of assessing the relative advantages of the use of acid soil-tolerant maize cultivars compared to the use of fertilisers and organic manure to correct soil acidity.

## Material and methods

The ATR-SR-Y maize cultivar, acid soil-tolerant and developed by maize breeders of Cameroon, and the sensitive cultivar Tuxpeno sequia from Mexico were used.

Soil amendments per year were as follows: phosphorus at O and 60 kg $ha^{-1}$, lime at 0 and 2 t $ha^{-1}$, chicken manure at 0 and 4 t $ha^{-1}$ and green manure (*Cassia septabilis* leaves) at 0 and 4 ton $ha^{-1}$. Treatments were arranged as a randomised complete block design with six replications and a plot size of 6 x 6 m, consisting of eight rows $plot^{-1}$, each 6 m long. Plant density was 5,3333 plants $ha^{-1}$. In all plots additional fertiliser application occurred as follows: 100 kg $ha^{-1}$ N, 24 kg $ha^{-1}$ $P_2O_5$ and 14 kg $ha^{-1}$ $K_2O$ according to local recommendations.

Soil data were collected at the beginning of the experiment and after three consecutive years of soil amendments. Soil samples were analysed at CIRAD, Montpellier, France.

## Results and discussion

At the beginning of the experiment, soil chemical analysis revealed that the pH ($H_2O$) ranged from 4.43-4.65 and exchangeable Al ranged from 1.57 µmol $kg^{-1}$ to 2.47 µmol $kg^{-1}$. The Mg content varied from 0.09 µmol $kg^{-1}$ to 0.38 µmol $kg^{-1}$.

After three consecutive years of soil amendments and maize cultivation, none of the soil characteristics had changed significantly as compared to the control plots.

On acid soil (control plots) the acid soil-tolerant cultivar exhibited a 61% higher grain yield than the susceptible cultivar. Soil amendments generally significantly increased maize grain yields by 5% and 42% for the tolerant and the susceptible cultivar, respectively.

Phosphorus application did not change pH or Mg. However, exchangeable Al and $H^+$ tended to increase, and the available (Olsen) P content of the soil increased in plots planted with the Al-sensitive but P-efficient cultivar Tuxpeno sequia.

Except for the first year of application (1997), the lime effect was highly significant and increased with the duration of the experiment. Lime application alone led to a 82% and 208% yield increased compared to the unlimed control for the tolerant cv ATP-SR-Y and the susceptible cv Tuxpeno sequia, respectively. The combination of chicken manure with lime gave an additional 50% and

40% more grain yield compared to the lime application alone for the tolerant and the susceptible maize cultivar, respectively. These results were partially explained by the decrease in Al exchangeable in the soil and the increase in Ca, Mg and pH.

Chicken manure application alone produced 73% and 15% more grain yield than the control for both the tolerant and susceptible cultivar, respectively. These yield increases were attributed to the increased availability of soil Ca and P as the pH of the soil was not affected.

The effect of green manure on grain yields was positive and significant except for the 1997 cropping season and the tolerant cultivar. *Cassia septabilis* leaf application was more beneficial to the susceptible cultivar (86% increase in grain yield compared to a 27% yield increase for the tolerant cultivar). The positive effect of green manure application could be related primarily to a decrease in exchangeable Al.

Lime application resulted in a reduction of exchangeable Al allowing a more efficient uptake of N and P absorption particularly for the sensitive cultivar. This observation is in agreement with the findings of Raij and Quaggio (1997). Plots planted with the susceptible cultivar had higher levels of available P than control plots. This is in agreement with results by EMBRAPA, Brasil (personal communication) stating that Tuxpeno sequia is Al-sensitive but P-efficient. Application of chicken manure resulted in a decrease in exchangeable Al which confirms the findings of Keltjens (1997). The lack of a significant corresponding pH increase was also observed by Zekeng (1992). The slow rate of pH change compared to lime suggested that acid soil correction with manure might take a longer time than the three years investigated in this study.

The results clearly show that for soil acidity-sensitive maize cultivars organic amendments readily available to small farmers can at least partly substitute for lime application. However, at this site in Cameroon, lime application was necessary and highest yields were only achieved when lime and chicken manure were combined. The use of soil acidity-tolerant cultivars can greatly reduce the need for lime application and thus contribute to the overall sustainability of cropping systems.

**Acknowledgement**

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*Table 1.* Grain yield of two maize cultivars in the third year and soil characteristics after three consecutive years of soil amendment

| Treatments | Soil acidity-tolerant cv ATR-SR-Y | | | | | | | Soil acidity-sensitive cultivar Tuxpeno sequia | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain yield kgha$^{-1}$ | pH $H_2O$ | Exchangeable cations Al | H | Ca | Mg | Avail. P | Grain yield kg ha$^{-1}$ | pH $H_2O$ | Exchangeable cations Al exch. | $H^+$ | Ca | Mg | Avail. P |
| Control | 2918 | 4.54 | 2.32 | 0.16 | 0.42 | 0.13 | 22.00 | 1282 | 4.51 | 2.25 | 0.17 | 0.64 | 0.14 | 17.66 |
| Phosphorus | 2895 | 4.45 | 2.47 | 0.19 | 0.43 | 0.14 | 21.20 | 2420 | 4.47 | 2.45 | 0.19 | 0.54 | 0.12 | 27.16 |
| Lime | 4720 | 4.77 | 1.30 | 0.11 | 1.21 | 0.73 | 18.52 | 5410 | 5.38 | 0.70 | 0.05 | 1.49 | 0.84 | 21.25 |
| Chicken manure | 5245 | 4.61 | 1.61 | 0.18 | 0.78 | 0.21 | 31.39 | 5080 | 4.54 | 2.20 | 0.20 | 0.72 | 0.16 | 29.45 |
| *Cassia sept.* | 3164 | 4.75 | 1.96 | 0.24 | 0.57 | 0.18 | 22.15 | 3333 | 4.90 | 1.76 | 0.19 | 0.61 | 0.18 | 22.50 |

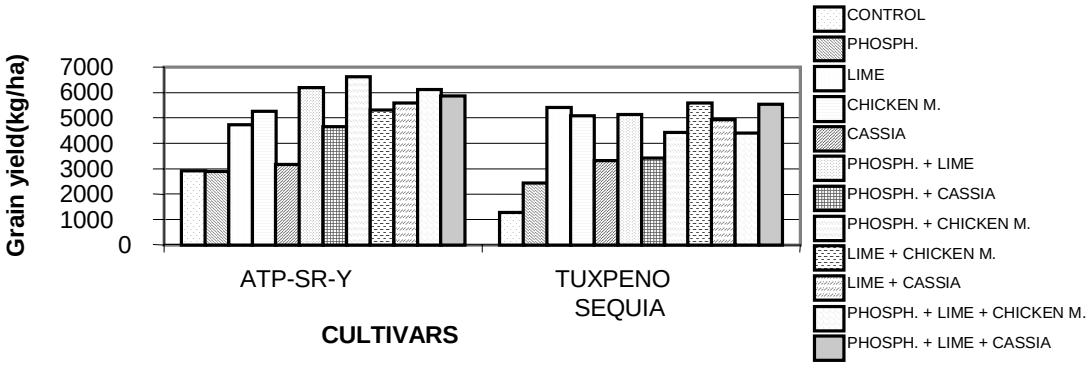


*Figure 1.* Grain yield of two maize cultivars as affected by phosphorus, lime, chicken manure, *Cassia septabilis* leaves application after 3 consecutive years of soil amendments