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Effects of fertilizing with potassium and magnesium in maize growing on an oxisol of the Federal District of Cerrados, Brazil

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9. ABSTRACT

A field experiment on maize was carried out on the land of the Agricultural Research Centre of Cerrados (Centro de Pesquisa Agropecuaria dos Cerrados), Brazil. The soil is a dark dystrophic latosol of clayey texture, with 36 ppm of K. Five levels of potassium and four levels of magnesium were used, producing in the first year a significant response to the application of 75 kg of K_2O per ha. The maximum yield of 4890 kg of grain per ha was obtained with 300 kg of K_2O per ha, applied broadcast. The yield corresponding to 75 kg/ha K_2O was 4076 kg/ha, equal to 175% of the yield with no potassium. The financial value of the yield increment was 9.3 times the cost of the potassium chloride used. No significant difference (5% level) was recorded between 150 kg of K_2O per hectare applied broadcast, and the same placed in the planting furrows.

The magnesium level was varied by applying calcareous limestone and dolomitic limestone in different proportions. No significant response to magnesium was obtained in the first year.

After the first maize crop the soil was found to contain 17 ppm of K.

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Effects of fertilizing with potassium and magnesium in maize growing on an oxisol of the Federal District of Cerrados, Brazil[1]

(Efeito da adubação com potásio e magnésio na cultura do milho num oxisol do Distrito Federal Cerrados)[1]

Preliminary report – Nota prévia

K. Dale Ritchey[2] and Edson Lobato[3]

Summary

A field experiment on maize was carried out on the land of the Agricultural Research Centre of Cerrados (Centro de Pesquisa Agropecuária dos Cerrados), Brazil. The soil is a dark dystrophic latosol of clayey texture, with 36 ppm of K. Five levels of potassium and four levels of magnesium were used, producing in the first year a significant response to the application of 75 kg of K_2O per ha. The maximum yield of 4830 kg of grain per ha was obtained with 300 kg of K_2O per ha, applied broadcast. The yield corresponding to 75 kg/ha K_2O was 4076 kg/ha, equal to 175% of the yield with no potassium. The financial value of the yield increment was 9,3 times the cost of the potassium chloride used. No significant difference (5% level) was recorded between 150 kg of K_2O per hectare applied broadcast, and the same placed in the planting furrows.

The magnesium level was varied by applying calcareous limestone and dolomitic limestone in different proportions. No significant response to magnesium was obtained in the first year.

After the first maize crop the soil was found to contain 17 ppm of K.

Introduction

Collecting soils from an area of 600 000 km² of Cerrados in central Brazil, *Lopes* (1975) showed that in 85% of 518 samples analysed, the exchangeable potassium content was lower than 0,15 meq K+ per 100 cc of soil, a level that can be considered critical. The magnesium content was below the critical level of 0,5 meq/100 cc of soil in 90% of the samples.

Preliminary observations by *W.V. Soares* (personal communication) regarding experiments in the Federal District indicated that a rewardingly significant response to potassium on maize was to be expected.

Magnesium levels in maize leaves, in other experiments by the CPAC in which calcitic limestone was used to correct soil acidity, stood at about 0,08% after cultivation of maize for two years. This level is well below the figure generally accepted as critical (*Jones* and *Eck*, 1973).

A field experiment to test various levels and methods of application of K and Mg was conducted at the Centre for Agricultural Research of Cerrados, 40 km from Brasilia.

Materials and methods

The soil used for this study was a dark red latosol, dystrophic, clayey in texture (Pedology and Soil Fertility Team, 1976). Soil analysis showed a pH of 4,6 (soil:water=1:2,5), exchangeable aluminium ca. 1,1 meq/100 cc of soil, and exchangeable calcium plus magnesium 0,34 meq/100 cc of soil (extraction with KCl, 1 N), that is to say an effective cation exchange capacity with about 72% aluminium saturation. The level of exchangeable potassium was 0,0092 meq/100 cc of soil (36 ppm).

The experimental design adopted comprised randomised blocks, with fourfold replication. Each plot measured 7,20×14,00 m, with a useful area of 4,00×10,0 m. The distance between rows was 0,80 m.

Table 1 Properties of the limestones used in field experiment on maize

Limestone	Content of Ca	Content of Mg	CCE	Fraction of the total retained by sieve of mesh: 9	20	60	100	Fraction of the total passing 100-mesh sieve
	%	%	%	%	%	%	%	%
Calcitic	32,1	0,2	79,9	2	8	45	19	26
Dolomitic	22,1	11,6	100	1	30	41	10	18

The original vegetation of the experimental area was a closed forest. The trees had been felled several years before, and the land used as pasturage for cattle. During the dry season of 1975 the ground was cleared, ploughed and fenced. After levelling a lime dressing was given, equivalent to three tonnes of calcium carbonate per hectare. For the treatments in which potassium was a variable (table 2), the limestone used was dolomitic; its characteristics are given in table 1. To provide the different magnesium levels required in treatments 8, 9 and 10, calcitic limestone and dolomitic limestone were blended.

Two weeks after the lime had been tilled in with a rotary hoe, a base dressing was applied broadcast. This consisted of 320 kg/ha of P_2O_5 as ordinary superphosphate, 9 kg/ha of Z as zinc sulphate, 1,1 kg/ha of B as borax, and 0,2 kg/ha of Mo as ammonium molybdate. Graded quantities of potassium chloride, corresponding to the potassium treatments to be given broadcast, were applied at the same time. A rotary hoe was used to mix these fertilizers with the soil. The depth to which the fertilizers and lime were incorporated, dependent on the natural compaction due to rain, was estimated at 15 cm.

On 15 november 1975 the experimental area was planted with hybrid maize, variety Cargill 111, and at the same time 20 kg/ha of N as urea and 80 kg/ha of P_2O_5 as ordinary superphosphate was applied in the bottoms of the planting furrows. The

[1] Contribution to the programme of research on soil fertility carried out by the Universities of North Carolina and Cornell, in collaboration with CPAC/EMBRAPA and USAID-Brazil, under contracts numbers AID/Csd 2806 and AID/Csd-2490. This work received additional financial support from the Potash Institute (Atlanta) and the International Potash Institute (Berne).

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treatment 6 also received 150 kg/ha of K_2O in the form of KCl in the bottoms of the furrows. The band of fertilizer was covered with about 5 cm of soil before the seed was sown.

Three applications of urea, each supplying 80 kg/ha of nitrogen, were given as top dressings on the 24th, 44th and 62nd days after sowing.

The plants germinated in plots that received KCl in the furrows were counted nine days after sowing, to find whether they had suffered a reduction of stand. At 21 days after sowing the plants were thinned out to a density of 50000 per hectare. Weeds were controlled by hoeing. Attacks by the Lagarta rosca *(Agrotis ipsilon)* were controlled by applying insecticide. The use of a spreader for the fertilizer in conjunction with the insecticide turned out to be harmful, leading to damage and even death of some plants, and so to a reduction of stand on some plots.

The figures for rainfall during the experiment are given in table 3, along with the dates of important stages in the development of the plants.

Results and discussion

The yields of grain at 15,5% moisture content are given in table 2. These results are also shown graphically in figure 1, in which the effect of the dose 75 kg/ha of K_2O as compared with the dose zero is shown to be outstanding. Plants having the treatment containing no potassium showed classical symptoms of deficiency of the element, and their height was much less than that of their neighbours on other plots. Their stems remained thinner and weaker so that by harvest time about 50% of the plants were lodged or had broken stems.

Table 2 Yields of maize grain, Cargill III, corrected to 15,5% moisture, as a function of potassium and magnesium doses in fertilizing treatments

Treatment number	Potassium applied (K_2O) kg/ha	Magnesium applied (Mg) kg/ha	Grain yield kg/ha	Significance[1]
1	0	345	2328	a
2	75	345	4076	b
3	150	345	4372	b c
4	300	345	4890	c
5	600	345	4712	c
6	150[2]	345	4453	b c
8	150	7,5	4362	b c
9	150	27	4301	b c
10	150	97	4017	b

[1] Yields with different letters are significantly different (Duncan test, 5% level).
[2] Potassium chloride applied in planting furrow.

It may be seen from table 2 that in the first year of the experiment the use of calcitic limestone (as compared with dolomitic) had no significant deleterious effect, although symptoms of magnesium deficiency were to be seen on young plants during the second dry period. Likewise there was no harmful effect due to the placement of 150 kg/ha of K_2O in the bottom of the furrow, as compared with broadcast application. Probably, the separation of the fertilizer from the seed by five centimetres of soil reduced the potentially damaging effect of a high salt concentration.

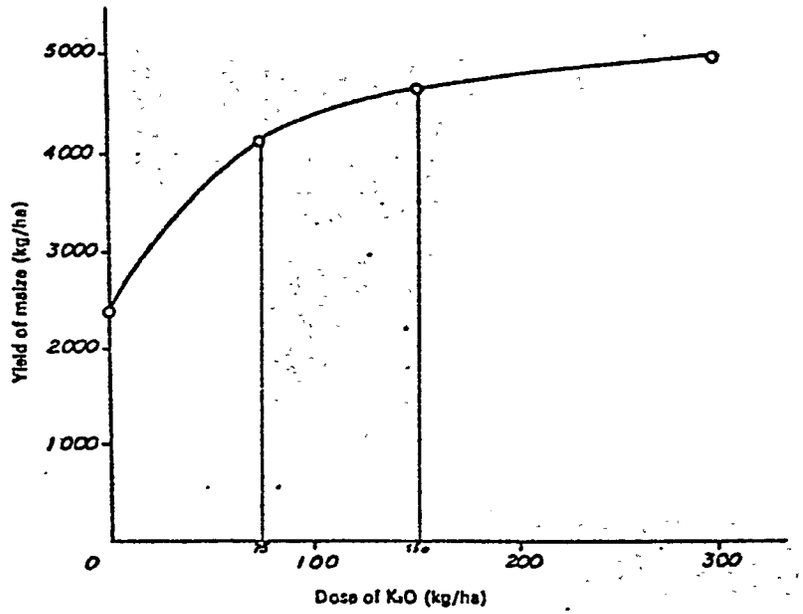

Fig. 1. Maize grain yield as a function of potassium manuring.

Table 3 Distribution of rainfall and the physiological stages of maize, variety Cargill III, in the experiment CPAC, D.F., 1975–1976

Dates	Rainfall mm	Notes
1975		
30 oct.		Limestone applied
30 oct. to 11 nov.	161	
12 nov. to 21 nov.	9	Drought, 10 days
15 nov.		Planting
22 nov. to 29 nov.	85	
30 nov. to 14 dec.	11	Drought, 15 days
15 dec. to 22 jan.	283	
1976		
23 jan. to 3 feb.	12	Drought, 14 days
29 jan.		Panicle formation (50% of plants)
4 feb. to 7 apr.	484	
7 apr.		Physiological ripeness (formation of dark coat)

Although the maximum yield obtained in the experiment was above the national average it was lower than that recorded in other experiments by the CPAC in which similar doses of nitrogen, phosphorus and potassium were given. Various factors probably contributed to reduce the maximum yield here. The effect of spreader for applying fertilizers with insecticide was to reduce yield by some 300 kg/ha. During the formation of the panicles the maize suffered a drought of 14 days (table 3), and

in this period of stress it was observed that about four leaves died at the base of each plant. The yield of maize grain is quite sensitive to shortage of moisture at this stage of growth.

A simple economic analysis of the use of potassium shows that for the level of investment in fertilizers used in this experiment, it is highly profitable to use enough potassium to obviate a deficiency of the element. The data in table 4 show that the return, per cruzeiro invested in potassium fertilizer, was Cr$ 9.30 at the fertilizing rate 75 kg/ha of K_2O.

Table 4 Financial analysis of use of potassium fertilizer in field experiment, CPAC, 1975–1976

Potassium dose K_2O kg/ha	Yield kg/ha	Increment kg/ha	Value of increment (a) Cr$/ha	Cost of K fertilizer (b) Cr$/ha	Return (a/b)
0	2328	—	—	—	—
75	4076	1748	1713,04	183,75	9,3
150	4594	2266	2220,68	367,50	6,0
300	4890	2562	2510,76	735,00	3,4

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