GUIDELINES FOR FERTILIZATION OF MAIZE ON SOIL SERIES OF THE AVALON AND HUTTON FORMS: III POTASSIUM

(Met opsomming in Afrikaans)

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Abstract

From correlation studies on the results of 143 NPK field experiments on maize, the K/Mg ratio was found to be the only factor to correlate significantly with K reaction, although the results indicated that K analysis may play a part if it is considered in combination with the K/Mg ratio. Using a technique whereby 'positive' and 'negative' K reactions at different combinations of K analysis and K/Mg ratios on a soil form basis were graphically plotted, it was possible to calculate the chances of a K reaction under various conditions. From these calculations, it was shown that the chances of a K reaction are much higher on the red Hutton than on the yellow Avalon soils, but that the chances decrease with increasing soil K and K/Mg ratio. On the basis of these results, K guidelines were compiled which can be used to predict the chances of a K reaction at increasing K analyses and K/Mg ratios on Avalon and Hutton soils.

Introduction

Guidelines for nitrogen and phosphorus fertilization of maize have been presented in previous publications (Möhr, 1973, a&b). The present paper, which is the last in this series, reports on the reaction patterns and guidelines for K fertilization on Hutton and Avalon soils. The K guideline was also evaluated, using the experimental results of the 1971/72 season (Möhr, 1972b).

Material and Methods

The results of the same 143 NPK experiments, previously reported on (Möhr, 1973, a&b) served as material for this investigation. Distribution of the experiments has been presented in the first paper (Möhr, 1973a). Full particulars on the experiments regarding such aspects as designs, procedures, methods of fertilizer application, soil analyses, soil identification and so forth have been reported on in detail by Möhr (1970, 1972a and b). Soil series were identified according to the classification norms established by Loxton, Hunting & Associated (1970, 1971). As was the case with nitrogen and phosphorus (Möhr, 1973, a&b), simple and multiple correlation and regression analysis on grouped data formed the basis of the investigation. The motivation for using various factors, grouping indices and methods applied has been fully discussed (Möhr, 1970; 1972a).

Results and Discussion

In the majority of experiments referred to potassium had no significant effect. In fact in only 20 per cent of the experiments was a significant positive effect to K found whilst in a further 12 per cent, there seemed to be a positive trend. The K carrier used for the experiments contained chloride. According to Botha (1972), this may have had a detrimental effect and should be kept in mind — especially where K was bandplaced at relatively high rates.

By simply considering whether a significant K reaction or not was found in the various experiments on a soil series basis, it is clear that relatively more experiments on the red Hutton soils showed K reactions than on the yellow Avalon soils as shown in the summary in Table 1.

Furthermore the S/100g clay ratio also seems to play a part — that is more experiments show a response to K the lower the S/100g ratio is (more highly leached). This had been indicated by Möhr (1970) in a preliminary investigation of the results of 66 of the 143 experiments. In this particular study where a large number of factors were included in a multiple correlation and regression analyses, Möhr (1970) found that only the K/Mg ratio showed any relationship to K reaction, provided the data were grouped on a soil form basis. This study was followed up by adding the results of later experiments. Again it was only the K/Mg ratio which correlated with K reaction, but only in the case of the Hutton form. The r-value was 0,44 (significant at $p = 0,05$) and the regression equation $\log (X + 2) = 2,14 - 0,93 \log (Y + 10)$. Although the K analyses as such showed no significant relationship, it was nevertheless obvious that soil K did play some part, provided it was considered in combination with the K/Mg ratio. Modifying a technique by Cate & Nelson (1971) whereby two factors — that is soil K and K/Mg ratio — were considered simultaneously in regard to qualitative reactions ('positive' and 'negative'), the data was merely plotted on a two-dimensional graph as presented for Avalon and Hutton soils in Figures 1 and 2.

'Positive' refers to those experiments where the K reaction was significant or the trend strongly positive (just failing to attain significance at $p = 0,05$), and 'negative' to those experiments where no K reaction was found. At this stage the factor S/100g clay ratio (degree of weathering or leaching) was not considered. Subsequently, however, in the evaluation of the K guideline referred to, Möhr (1972b) came to the conclusion that the S/100g clay ratio, especially for the Hutton soils, cannot be ignored. In fact the evaluation, which will be discussed later, clearly showed that the poorly leached Hutton soils (S/100g clay >15) should fall within the Avalon group. Therefore, Figure 1 refers to medium and highly leached Hutton soils (S/100g clay 5—15 and < 5 respectively), and Figure 2 to Avalon soils plus poorly leached Hutton soils (S/100g clay > 15).

TABLE 1 *Summary of experimental results (1961/62–1970/71) with regard to K reaction on different soil series*

Soil form	Soil series	Number of experiments per serie	K reaction (number of experiments)		
			Reaction	Trend	No reaction
Avalon	Bleeksand	11	–	1	10
	Soetmelk	14	1	1	12
	Bezuidenhout	1	–	1	–
	Leksand	3	1	1	1
	Avalon	10	1	–	9
	Bergville	2	–	1	1
	Kanhym	1	1	–	–
Hutton	Mangano	2	–	1	1
	Shorrocks	10	–	3	7
	Makatini	4	–	1	3
	Bontberg	3	–	1	2
	Msinga	13	4	5	4
	Vimy	1	1	–	–
	Middelburg	1	1	–	–
	Hutton	10	9	–	1
TOTAL		86	19	16	51

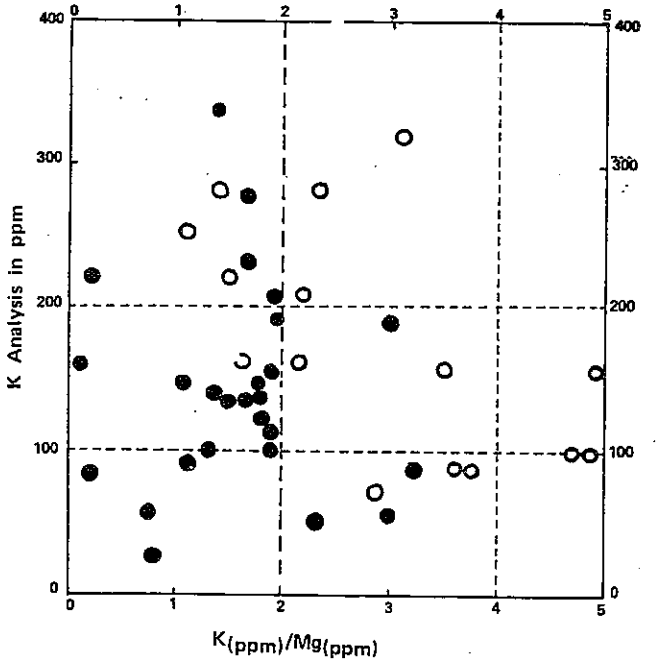

Fig 1 *Potassium reaction in terms of K analyses and K/Mg ratio for soil series with S/100g clay < 15 for the Hutton form.*

- ● *Experiment showing a significant K reaction or strong positive trend*
- o *Experiment where K had no effect*

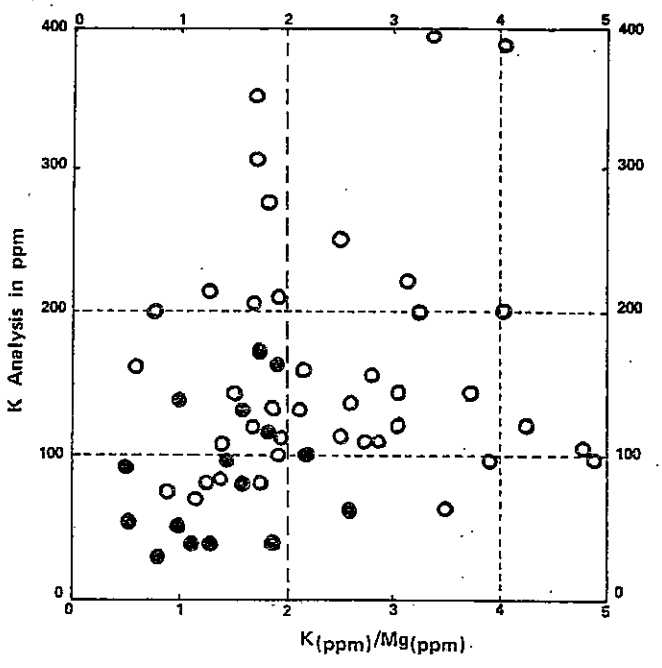

Fig 2 *Potassium reaction in terms of K analyses and K/Mg ratio for soil series with S/100g clay > 15 for the Hutton form and all S/100 g clay classes for the Avalon form*

- ● *Experiment showing a significant K reaction or strong positive trend*
- o *Experiment where K had no effect*

TABLE 2 Chances for expected K reactions at seven combinations of K analyses and K/Mg ratios for the Avalon and Hutton forms

Soil form	Chances for K reaction at –						
	K< 100 K/Mg< 2	K< 100 K/Mg 2–4	K< 100 K/Mg> 4	K100–200 K/Mg< 2	K100–200 K/Mg> 2	K> 200 K/Mg< 2	K> 200 K/Mg> 2
Hutton*	$^{6}/_{6}=100\%$	$^{3}/_{6}-50\%$	$^{0}/_{2}=0\%$	$^{11}/_{12}=93\%$	$^{1}/_{4}=25\%$	$^{5}/_{8}=63\%$	$^{0}/_{3}=0\%$
Avalon plus Hutton **	$^{9}/_{14}=57\%$	$^{1}/_{3}=33\%$	$^{0}/_{1}=0\%$	$^{5}/_{13}=39\%$	$^{0}/_{14}=0\%$	$^{0}/_{6}=0\%$	$^{0}/_{4}=0\%$

* Series with S/100g clay ratio < 15

** Series with S/100g clay ratio > 15

Subdividing each graph on the basis of largest number of 'positive reactions', the chances of K reactions within each subgroup demarcated by a specific K analysis figure and K/Mg ratio, were calculated. These results are presented in Table 2.

When interpreting the results in Table 2, the following possible restrictions should be kept in mind:

(a) The number of experiments per subgroup varies from 14 to as low as 2. It is therefore quite obvious that the 'chance interval' may increase as the number of experiments per group decreases.

(b) 'Chances' is purely a mathematical concept and there is no statistical proof that it is repeatable.

From Table 2 the following may be concluded:

(i) It is quite clear that the chances for a K reaction are much larger on the Hutton than on the Avalon soils.

(ii) Although the chances decrease with increasing soil K and K/Mg ratio it would seem that the K/Mg ratio is the more decisive factor. This is especially noticable in the case of the Hutton soils where the chances of K reaction are between 90–100 per cent at a soil-K of < 100 and < 200 ppm but with K/Mg < 2. Increasing the K/Mg to 2–4, the chances decrease to 50 and 33 per cent respectively.

(iii) At a soil K of > 200 ppm and K/Mg > 4, no experiments showed any K reaction.

The above results may present an explanation as to why soil K on its own usually correlates poorly with K reaction. The reason for the much smaller chance of a K reaction on the Avalon soils may be due to a higher natural K status in the subsoil or soft plinthic layer (little or no vertical movement beyond this point) as pointed out by Farina (1971) and Skeen, Dudding & Clayton (1972a). The fact that the K/Mg ratio is very important or that Mg plays a significant part has been shown by various researchers (e g Scaife, 1968; Bonat, 1969; Eksteen, 1970; Wolf, 1972).

From the foregoing results it was not possible to compile quantitative guidelines similar to those for N and P (Möhr, 1973, a & b) because the basis is qualitative rather than quantitative. Furthermore for each group or soil K and K/Mg combination, there is either a chance of a K reaction (even if the chances given are 0–20 per cent) or no K reaction (even if the chances given are 90–100 per cent). Therefore it was only possible to compile guidelines which indicated the percentage chance of K reactions at various combinations of soil K and K/Mg ratio. These guidelines are presented in Figures 3 and 4.

In order to evaluate the K guidelines against the results of the 1971/72 season as mentioned under 'Introduction' the K guidelines had to be quantified in some way or other. The following approach was decided on. By alotting index values to each of the chance classes (from Figures 3 and 4) and assuming that 1 000 kg grain removes 4 kg K from the soil (Orchard, 1971) and for K applied recovery figures are 80 per cent for sandy, 65 per cent for loamy and 50 per cent for clayey soils, it was possible to quantify the K guideline (Botha, 1971). The index values allotted to the various K reaction chance classes were 1,00 for the 80–100 per cent class, 0,25 for the 20–40 per cent class, 0,50 for the 40–60 per cent class, 0,25 for the 20–40 per cent class and 0,00 for the 0–20 per cent class. For a yield target of say 6 000 kg/ha on a sandy red soil analysing 100 ppm K and K/Mg < 2, the K required was therefore calculated as follows:

K removal (4 kg/1000 kg grain) x recovery compensation (80 per cent recovery for sandy soil) x index value (1,00 for red soil with chance of a K reaction of 80–100 per cent).

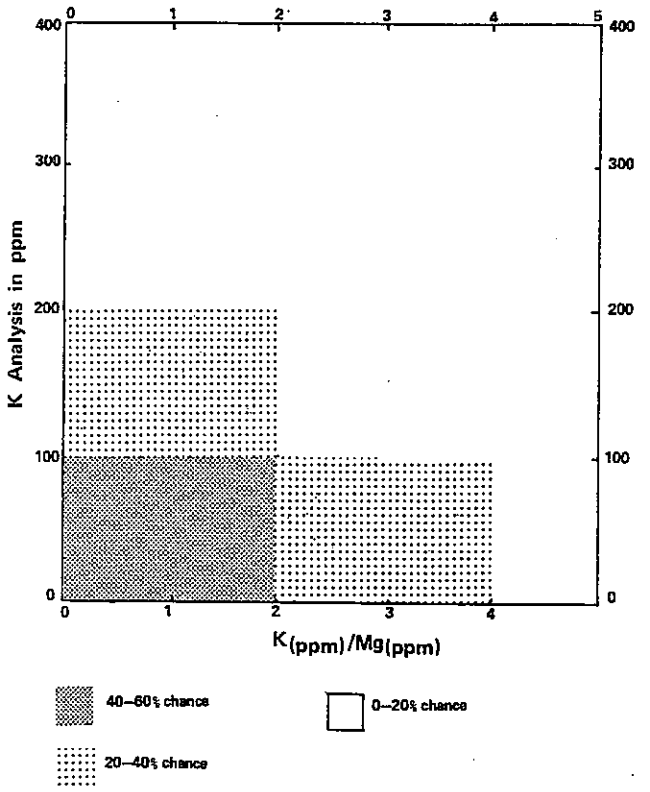

Fig 3 Model (guideline) for the chances of K reactions at increasing K analyses and K/Mg ratios for poorly leached red soils (Hutton form) and yellow soils (Avalon form)

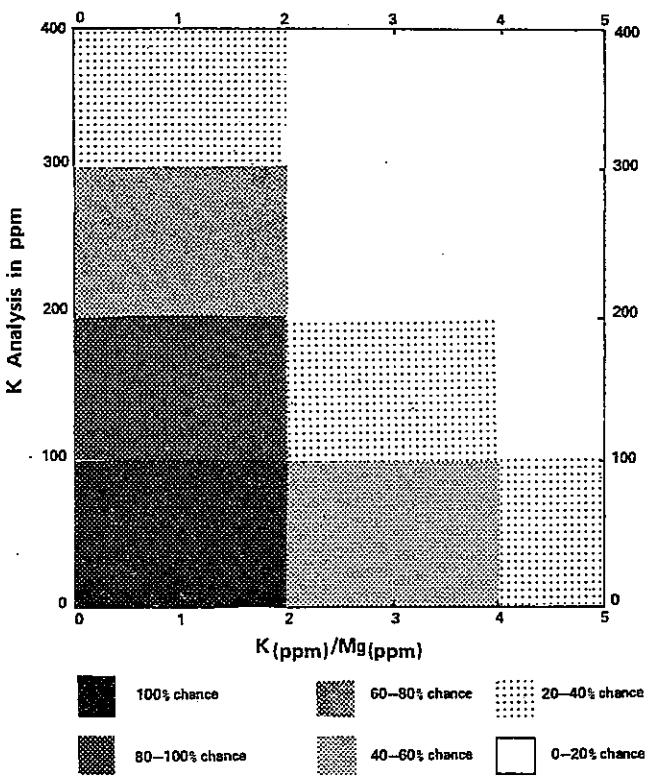

Fig 4 Model (guideline) for the chances of K reaction at increasing K analyses and K/Mg ratios for medium and highly leached red soils (Hutton form)

In terms of actual figures it is:

$$(4 \times \frac{6000}{1000}) \times \frac{100}{80} \times 1{,}00 = 30 \text{ kg K/ha.}$$

In the same way K requirements for various yield targets and combinations of K analyses and K/Mg ratios were calculated (Möhr, 1972b).

In view of the above hypothetical approach and the fact that the K guidelines are based on a chance concept, the evaluation of the K guideline against the 1971/72 results is presented with reservation in Table 3).

A value of 5 kg K/ha was arbitrarily allotted to those experiments where K reactions were not statistically significant but the trend strongly positive.

From Table 3 the following may be concluded:

(i) The deviations are 5 kg K/ha and less in only seven of the 21 experiments although there are no differences in four of the experiments.

(ii) It is, however, significant that the largest deviations occur for the poorly leached series (S/100g clay > 15) of especially the Hutton form — that is, the K guidelines indicate K reaction whilst K had no effect or even a positive tendency in the particular experiments. In the initial calculations of chances of K reactions as previously discussed, no differences regarding degree of leaching was applied. According to the above observation it appears that a further subgrouping on the basis of S/100g clay is justified. If the K results of the experiments on the poorly leached Hutton soils are evaluated against the K guideline for Avalon soils the deviations are decreased considerably as shown in Table 4.

In view of these conclusions, the K guidelines initially presented by Möhr (1972a) were refined on the basis of the results presented in Table 2 (see figures 3 and 4). Even with the refinement of the guidelines, there still appears to be rather large deviations in some cases. However, when evaluating the K guidelines purely on a chance basis, the agreement is fairly good. Still, further refinements and/or confirmation of the existing guideline are necessary. This is especially true in regard to the possible influence of the S/100g clay ratio. Even the type and quality of clay mineral may also have to be considered in future. At this stage, however, it is suggested that the present guidelines

TABLE 3 Evaluation of K guideline against the 1971/72 experimental results

Yield (kgx100/ha)	K analysis (ppm)	K/Mg ratio	Texture	K levels in kg/ha		Deviation kg/ha	Soil series	S/100g clay value
				actual (experiments)	calculated (K guideline)			
67	258	2,5	Sandy	0	10	–10	Mangano	15
49	163	2,1	Loamy	0	26	–26	Msinga	11
45	93	3,2	"	(5)*	13	– 8	"	8
52	150	1,8	"	(5)	26	–21	"	14
50	158	2,0	"	(5)	26	–21	"	9
52	105	2,2	Sandy	(5)	6	– 1	Shorrocks	19
49	105	1,4	"	0	32	–32	"	20
36	142	1,9	Loamy	0	15	–15	"	18
43	163	1,6	"	0	26	–26	Makatini	20
45	142	1,5	"	0	20	–20	"	16
54	330	1,4	Clayey	(5)	10	– 5	Vimy	14
55	72	0,29	Sandy	0	13	–13	Hutton	2
51	88	1,6	Sandy	(5)	13	– 8	Bleeksand	19
46	134	2,6	"	0	0	0	"	48
54	88	1,7	"	0	13	–13	"	28
56	75	0,9	"	0	13	–13	Soetmelk	25
47	112	2,5	"	0	5	– 5	"	28
50	165	2,9	Loamy	20	0	+20	"	18
43	101	5,0	Sandy	0	0	0	Mooiveld	18
46	122	4,2	Loamy	0	0	0	Avalon	14
78	60	3,5	Sandy	10	10	0	Ruston	2

* Positive trend but not significant at p = 0,05

TABLE 4 Comparison between optimum K levels for poorly leached Hutton soils and K guideline values for Avalon soils

Yield (kgx100/ha)	K analysis (ppm)	K/Mg ratio	Texture	K levels in kg/ha		Deviation	Soil series	S/100g clay
				actual (experiments)	calculated (K guidelines)			
67	258	2,5	Sandy	0	0	0 (–10)**	Mangano	15
52	150	1,8	Loamy	(5)	8	–3 (–26)	Msinga*	14
52	105	2,2	Sandy	(5)	9	–4 (–6)	Shorrocks	19
49	105	1,4	"	0	13	–13 (–32)	"	20
36	142	1,9	Loamy	0	5	–5 (–15)	"	18
42	163	1,6	"	0	9	–9 (–26)	Makatini	20
45	142	1,5	"	0	9	–9 (–20)	"	16
54	330	1,4	Clayey	(5)	9	–4 (–5)	Vimy*	14

* Because of relatively high S/100g clay ratio, considered as poorly leached

** Deviations in case of the original K guideline (Table 3)

could be used, but with reservation, until feature research provides more information.

Opsomming

RIGLYNE VIR DIE BEMESTING VAN MIELIES OP GRONDSERIES VAN DIE AVALON- EN HUTTON-VORMS: III KALIUM

Die resultate van 143 NPK-veldproewe met mielies, uitgevoer vanaf 1960/61 tot 1971/72 op die belangrikste grondseries in die mieliegebiede, is ondersoek met die primêre doel om riglyne vir bemestingsaanbevelings daar te stel. Die meerderheid van proewe is egter uitgevoer op series van die Avalon- en Huttonvorms. Enkelvoudige en meervoudige korrelasie- en regressiestudies op die proefdata wat volgens verskillende grond- en ander faktore groepeer is, het die basis van die ondersoek gevorm. In hierdie gedeelte word slegs die tendense en riglyne ten opsigte van kalium op grondseries van die Avalon- en Huttonvorms aangebied.

Volgens die ondersoek was die K/Mg-verhouding op 'n grondvormbasis die enigste faktor wat korrelatief 'n verwantskap met K-reaksies getoon het. Alhoewel geen korrelasie tussen K-ontledings van die proefgronde en K-reaksies verkry is nie, het die gegewens daarop gedui dat die grond-K-gehalte wel moontlik van belang mag wees indien dit in kombinasie met die K/Mg-verhouding op basis van grondvorm en tot 'n mindere mate, S/100g kleiverhoudings beskou word. Deur gebruik te maak van 'n tegniek waardeur 'positiewe' en 'negatiewe" K-reaksies by verskillende kombinasies van K-ontledings en K/Mg-verhoudings grafies geplot is, was dit moontlik om die kanse vir 'n K-reaksie onder verskillende toestande te bereken. Op grond hiervan is gevind dat die verwagting vir 'n K-reaksie aansienlik groter op die Hutton- as op die Avalongronde is, maar dat kanse afneem met verhoogde grond K en K/Mg verhouding. So ook verhoog die kanse vir 'n reaksie binne elke grondvorm met verlaagde S/100g kleiverhouding. Op basis van dié resultate is K-riglyne saamgestel wat die kanse vir K-reaksies op Hutton- en Avalongronde by toenemende K-ontledings en K/Mg-verhoudings, aandui.

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