GUIDELINES FOR FERTILIZATION OF MAIZE: II NITROGEN

(Met opsomming in Afrikaans)

P J MÖHR, Fertilizer Society of South Africa, Research Division

Abstract

From an investigation of the results of 143 NPK field experiments on maize, it was found that nitrogen reaction patterns were primarily determined by the optimum yield or production class. With subgrouping of the data, soil texture was shown to be also related to N requirements. From these results it was concluded that, provided a realistic yield target could be determined, soil series as such was not an important factor to consider in the determination of N requirements. However, it was shown that soil series was a valuable tool when estimating a yield target. Using the various regression lines for soil texture, a guideline for N requirements at varying yield targets was compiled.

Introduction

Guidelines for phosphorus fertilization of maize have been presented by Möhr (1973). This was based on a preliminary investigation of the results of 66 NPK experiments (Möhr, 1970) followed by a further investigation of the results of 77 experiments (Möhr, 1972a and b) conducted during the period 1961/62 to 1971/72). The motivation, objectives, experimental methods and results regarding nitrogen, phosphorus and potassium have been described and fully reported on (Möhr, 1970, 1971, 1972a). From these investigations, NPK fertilization guidelines were compiled (Möhr, 1972a). The present paper is a follow-up of the previous paper mentioned (Möhr, 1973) where the reaction patterns and guideline for N fertilization are discussed and presented. Furthermore, the N guideline was evaluated, using the experimental results of the 1971/72 season (Möhr, 1972b).

Material and Methods

As mentioned, the results of 143 NPK experiments on maize served as material for this investigation. The majority of experiments were conducted on a co-operative basis in the important maize growing areas of the country. Distribution of the experiments has been presented (Möhr, 1973). The experimental procedures, designs, methods of application, nitrogen carriers and so forth have been fully described (Möhr, 1970).

Soil analyses on the experimental sites were carried out (Möhr, 1973). Based on profile descriptions and physical and chemical analyses for the various horizons, soil series were classified according to Loxton, Hunting & Associates (1970; 1971). A summary of the analysis data for the particular series and full particulars on all the experiments have been reported on by Möhr (1970; 1972a and b).

Simple and multiple correlation studies and regression analyses on grouped data formed the basis of the investigation. The methods applied, grouping indices and discussion of and motivation for using particular factors have been presented (Möhr, 1970; 1972a).

Results and Discussion

From the preliminary investigation (Möhr, 1970) using positive stepwise multiple regression analyses, it was found that optimum yield or production class and yield increase on a soil series basis were in some way or other related to expected N reactions. Clear patterns could, however, not be established. This investigation was followed up by adding the results of a further 43 NPK experiments, but, using the same approach, still no clear patterns emerged (Möhr, 1972a). It was, however, quite obvious that N reaction patterns for high yielding experiments differed significantly from those for low yielding experiments. The marked influence of yield therefore most probably confounded or included any possible effect of either soil series or yield increase. Modifying the approach slightly, simple correlation and regression analyses for optimum yield and optimum N were carried out. The data was then subgrouped on the basis of textural class, and the calculations repeated. The results of these calculations are presented in Table 1.

TABLE 1 Simple correlations coefficients (r values) and regression equations for the relationship between optimum yield (X) and optimum N (Y)

Textural class	r values	Regression equation
All classes	0,86**	$X = 19,81 + 0,374Y$
6–15% clay	0,92**	$X = 17,56 + 0,419Y$
15–35% clay	0,90**	$X = 20,01 + 0,375Y$

** Significant at $p = 0,01$

Due to the fact that a too small number of experiments were conducted on soils with a clay content of less than six per cent and of more than 35 per cent, correlation and regression analyses were not carried out for these particular textural classes. From Table 1 it is clear that subgrouping on the basis of texture or clay content increased the r values. Furthermore the difference between the *a* values (17,56 and 20,01) of the two clay classes is rather marked.

Regression lines for light and medium textured soils based on the equations in Table 1 and an estimated line for heavy textured soils are presented in Figure 1. A so-called removal line, based on the assumption that 100 kg maize grain removes or requires 1,5 kg N from the soil, is also presented in Figure 1.

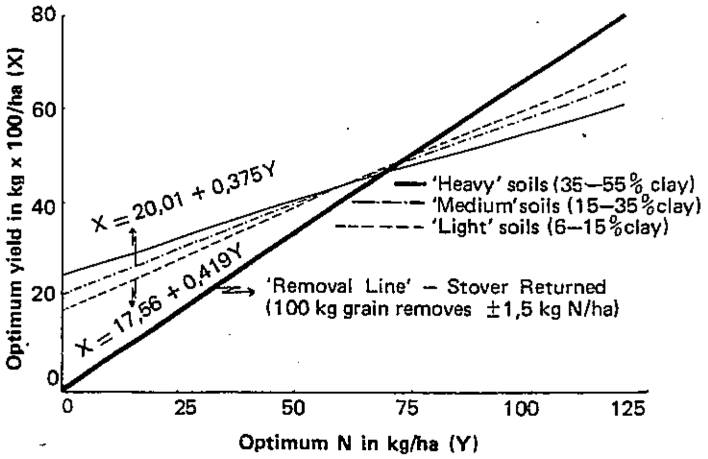

Fig 1 *Relationship between optimum yield and optimum nitrogen requirements*

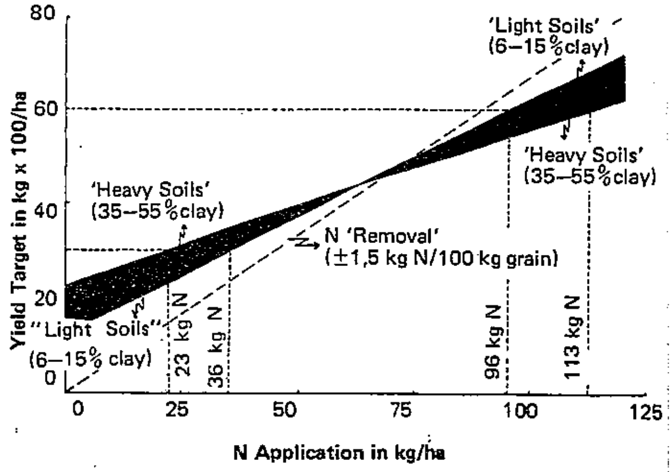

Fig 2 *Guideline for the determination of N-requirements for different yield targets*

Orchard (1971) quotes a removal figure of 1,46 kg N where stover had been ploughed back. In all the experiments, stover had been returned to the particular plots.

From Figure 1 the following may be concluded:

(i) Apart from texture, the N requirement at a certain yield is more or less the same as the N removal (intercept of the removal line and particular regression line). Above this yield, more N is required than is removed, the difference increasing with increasing yield. Below this yield, however, less N than the removal figures is required, with an increase in the difference as yields decrease. A zero N requirement is reached at a yield or production class of 1 500 to 2 500 kg/ha.

(ii) With regard to texture it is apparent that the lower the clay content the more the regression line tends to that of the removal line. Therefore, light-textured soils require more N at a lower production class than heavy-textured soils, whilst at high production classes, it is just the reverse.

An explanation for the above can possibly be found in the different natural N delivery rates of soils. The lighter the soil, the lower the N delivery rate will be, so that the N requirement for a pure sand cultiver will theoretically approximate the N removal line. On the other hand, the heavier the soil, the higher the N delivery rate should be. This is probably related to organic matter content (Farina, 1971). The fact that more N is, however, required for heavier than lighter-textured soils at production classes above a certain point, is difficult to explain, because a large number of factors such as differences in moisture regime, root development, soil temperatures, microbial activity and N adsorption capacity may play a part. Furthermore it should be borne in mind that moisture requirements (rainfall) will be much higher on a heavy than on a light-textured soil at a high production class or yield target.

Using the regression lines in Figure 1, a guideline for N requirements at varying yield targets was compiled and is presented in Figure 2. Optimum yield or production class has here been replaced by the concept of yield target. In using this guideline, the importance of determining or estimating a realistic yield target is emphasized. Factors such as rainfall, effective soil or root depth, texture, plant population cultivar, weed control and management level should all be considered and integrated as far as possible. A sound basis to use for the prediction of yield or determination of a yield target is the so-called production potential. Basic research on the factors determining production potential and the compilation of a guideline in this regard have been carried out by Crafford and Nott (1970). Further refinements and additions have been made by Möhr & Van Niekerk (1972).

According to Skeen, Dudding & Clayton (1972), the N requirements of maize is primarily determined by the expected yield and the differences in N reactions on different soils – most probably texture. Engelstad & Parks (1971) concluded from the results of a number of N experiments on different soil types in Tennessee that optimum N is closely related to optimum yield. The approach used for the present investigation and conclusions drawn are therefore considered to fall within realistic limits as confirmed by the work of other researchers.

As mentioned in the 'Introduction', the accuracy of the N guideline was evaluated against experimental results of the 1971/72 season (Möhr, 1972b). This evaluation is summarized in Table 2. From these results it is obvious that there are a number of marked deviations. Closer inspection of the results, however, showed quite clearly that the greatest number of large deviations occurred in the experiments where the row width was 2,1m (western maize areas) and the smallest number where the row width was 0,9m (eastern maize areas). This aspect was then further investigated by subgrouping within each textural class on the basis of row width, and carrying out correlation and regression analyses for each subgroup. The results are presented in Table 3.

TABLE 2 Comparison between actual optimum N levels and estimated N values from the guideline model

Yield kg/ha x 100	'Texture'	N level in kg/ha		Deviation (kg/ha) %*		Soil series
		actual experiments	estimated N model			
49	Loamy	40	75	(−35)	−47	Msinga
45	"	30	65	(−35)	−54	"
52	"	60	79	(−19)	−25	"
52	"	50	79	(−19)	−35	Shorrocks
49	"	60	75	(−15)	−20	"
36	"	0	42	(−42)	−100	"
42	"	50	55	(− 5)	− 9	Makatini
51	Sandy	60	76	(−16)	−33	Bleeksand
46	"	50	65	(−15)	−23	"
54	"	60	80	(−20)	−25	"
56	Loamy	80	85	(− 5)	− 6	Soetmelk
47	"	70	70	(0)	0	"
50	"	80	77	(+ 3)	+ 4	"
43	Sandy	40	55	(−15)	−27	Mooiveld
50	"	70	75	(− 5)	− 7	Kosi
50	"	80	75	(+ 5)	+ 6	"
54	Clayey	100	95	(+ 5)	+ 5	Vimy
56	"	90	90	(0)	0	Msinga
78	Sandy	125	130	(− 5)	− 3	Ruston
76	"	120	125	(− 5)	− 4	Devon
56	"	70	85	(−15)	−17	Rocklands
38	Clayey	70	50	(+20)	+40	Arcadia
53	"	80	89	(− 9)	−10	Arcadia

* Deviation as a percentage of the estimated values

TABLE 3 Simple correlation coefficients (r values) and regressions equations for the relationship between optimum N (Y) and optimum yield (X)

Subgroups		r values	Regression equation
Textural class	Row width (m)		
6–15% clay	0,9	0,89**	X = 17,88 + 0,395Y
	2,1	0,78**	X = 16,88 + 0,445Y
15–35% clay	0,9	0,88**	X = 18,95 + 0,38Y
	2,1	0,86**	X = 20,75 + 0,423Y

** Significant at p = 0,01

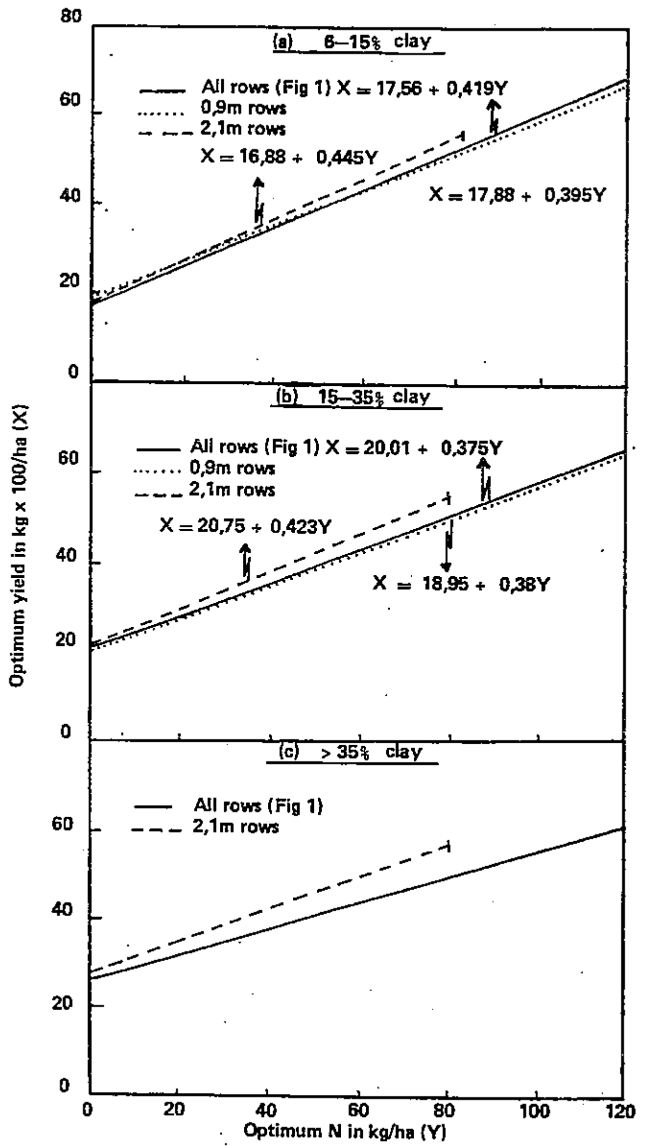

Fig 3 *Relationship between yield and nitrogen requirements on different soil textural classes for 0,9 and 2,1m rows (plantpopulation ± 36 000/ha and ±22 000/ha respectively)*

The most important conclusion from the results in Table 2, is that there are significant differences between the regression lines within each textural class which implies that row width is an additional factor to consider when using the N guideline. Regression lines, based on the equations in Table 2, are presented in Figures 3(a) and (b). Due to insufficient data, correlation and regression analyses for the >35 per cent clay textural class could not be calculated. An estimated line was, however, fitted on the limited results available and presented in Figure 3 (c).

From Figure 3 the following may be concluded:

(i) The regression lines for 0,9m rows do not differ significantly from those presented in Figure 1, although there is a tendency for a difference in the case of light-textured soils (Fig 3a).

(ii) Regarding the 2,1m row width, it is clear that less N is required than predicted from the N guideline in Figure 2 and that the difference increases with increasing clay content. Although the differences within each textural class seems to increase with increasing yield, the per cent increase remains constant.

It should be noted that the regression lines for 2,1m rows stops at a yield of approximately 5 500 kg/ha. The reason is that yields for wide rows usually do not exceed this figure.

From the foregoing evaluation and further investigation a refinement of the existing N guideline in the case of wide rows (approximately 2m) has been presented (Möhr, 1972b) as follows:

10 per cent lower N required for 'sandy' soils
15 per cent lower N required for 'loamy' soils
20 per cent lower N required for 'clayey' soils

Using this refinement, the N guideline was again evaluated and is presented in Table 4. The 'improvement' – that is the decrease in difference between actual and estimated values – varies from 11 to as high as 100 per cent. In two cases, however, the deviation is considerably increased. The soils on which the particular experiments were conducted has a clay content of less than 6 per cent. Referring again to Figure 3, which shows that the difference between narrow and wide rows decreases with decreasing clay content, one can assume that in the case of soils with < 6 per cent clay, there should hardly be any difference between narrow and wide rows. Therefore, where soils are very sandy, it is suggested that row width has no or only a small effect and can most probably be ignored. It is quite obvious that the N guideline presented needs further refinement and/or confirmation. Work should also be done on the natural N delivery rate of different soils under different cropping and cultural practices. Further refinement regarding production potential and the determination of a realistic yield target is also urgently required. Until such information becomes available, the present N guideline can be used provided adjustments are made where necessary.

Opsomming

RIGLYNE VIR DIE BEMESTING VAN MIELIES: II STIKSTOF

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. 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 stikstof aangebied.

TABLE 4 — Improvement as a result of refining the N guideline by including the effect of row width

Deviation (from Table 2)	Deviation (refined guideline)	Improvement
%	%	%
47	38	+ 19
54	39	+ 28
23	9	+ 61
35	24	+ 31
20	4	+ 80
9	10	+ 11
33	6	+ 82
23	0	+100
25	11	+ 56
6	3	+ 50
4	4	0
27	13	52
7	9	−28
6	24	−300

Uit die ondersoek is afgelei dat stikstofvereistes hoofsaaklik bepaal word deur die optimum opbrengs of produksieklas. Onderverdeling van die proefdata volgens tekstuurklas, het egter redelike verskille ten opsigte van N-vereistes getoon. Verder is gevind dat, mits 'n realistiese opbrengsmikpunt bepaal kan word, grondseries as sulks nie van wesentlike belang is in die vasstelling van N-vereistes nie. Daar is egter op gewys dat grondseries wel 'n belangrike hulpmiddel kan wees in die vasstelling van die opbrengsmikpunt. Op basis van die onderskeie regressielyne is 'n riglyn wat die N-vereistes by verskillende opbrengsmikpunte op ligte-, medium- en swaar gronde aandui, opgestel.

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