TROPICULTURA, 1989, 7,3, 98-102

Comparative responses of two maize varieties to fertilizers on a newly cleared ferralitic soil in Southern Benin — Physical analysis.

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Keywords: Maize - Fertilizers - Ferralitic soil — Benin

Summary

In this study, which is the introduction to a long research programme to promote fertilizer use in Benin, the authors compared the physical responses to fertilizers and more especially nitrogen fertilizers on two varieties of maize grown on a fertile Ferralitic soil in Southern Benin.

Physically, the two varieties behaved almost identically over the entire N range, had the same optimal dose for maximum yield, but yields were much higher for "Poza Rika 7843" than for "NH2". Ferralitic soils when generated, fertilized adequately and planted with good variety of maize give very high yields.

The experimental conditions become less frequent in Benin: fallow periods and cycles become shorter and few fertilizers are used. Responses to fertilizers may be totally different on the poor ferralitic soils, which are dominant in Benin, and are presently studied by the project. An extensive economical analysis on this yield data is presently carried out by the project.

Samenvatting

In deze studie, die een aanleiding is tot een langdurend onderzoeksprogramma om het meststoffenverbruik in Benin te intensifiëren hebben de auteurs het effect van minerale meststoffen en in het bijzonder stikstofmeststoffen op twee maisvariëteiten, geteeld op een vruchtbare Ferralitische bodem in Zuid Benin, vergeleken.

Fysisch gezien hadden de twee variëteiten dezelfde reactie op N meststoffen voor alle dosissen, hadden dezelfde optimale dosis voor maximum rendement, maar de rendementen waren hoger voor "Poza Rika 7843" dan voor de variëteit "NH2".

Ferralitische bodems die werden geregenereerd en goed bemest kunnen hoge maisrendementen geven.

De voorwaarden van dit experiment worden minder en minder frequent in Benin: rustperiodes en cycli worden korter en weinig meststoffen worden gebruikt. Arme ferralitische bodems, die overheersen in Benin kunnen een totaal ander beeld geven. Deze worden nu bestudeerd door het projekt.

Introduction

Maize production is important in Benin and amounted to 286.000 tons on 394.000 ha in 1981 (23), but average yields are only about 730 kg/ha. The use of low yielding varieties, the low management level and especially fertilizers are the reasons for this low productivity. In fact fertilizer-use is largely limited to cotton cultivation (30) but increasing efforts are being made to use fertilizers on other crops too.

Fertilizer effectiviness is highly related to the choice of a good variety and fertilizer recommandations as far as they exist must be reassessed when high-yielding varieties are planted (16) and must be based on economical data, specially in view of the fast rising fertilizer price in this country. Moreover, the choice of the correct dose is very important to minimize losses which could pollute the environment (4). Low fertilizer use in Benin minimises these risks.

Varietal effects of the physical response of maize to the environment are described in literature, for example the moisture stress (3, 28), soil acidity (27), tillage methods (14, 33) and many other factors including nutrition (6, 13, 20, 24), but few comparisons have been made taking into account the specific local economical conditions in the efficiency of fertilizer use, specially in Benin.

In this study, agronomical results (which will be used for the economical analysis in future work) related to fertilizer use, in particular nitrogen, on two maize varieties, are discussed.

Material and methods

The data were collected in the 1984 season from April till July (31). The newly cleared soil was a "Terre de barre" or a "sol ferralitique faiblement desaturé" in the French classification system (12). It is characterised by a high sand content, slightly acid

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Received on 31 03.87 and accepted for publication on 11 08.88

reaction and a low P content (10). The exchangeable K content lies in the range of 0.15 to 0.35 meq/100 g of soil where response to K-fertilization on tropical soils can be expected (5). These considerations justified the basal P and K dressings in this study.

This soil is not representative for the poor ferralitic soils in Benin, for example in the Mono region, where much lower values for P and K have been found (7).

Some soil characteristics are given in table 1. In total 20 sub-samples of the 0-30 cm toplayer in the area of 800 m^2 were taken with a dutch auger, well mixed and a composite sample of 1 kg taken for analysis.

The site of the experiment was situated at the experimental farm of the faculty of Agricultural Sciences and used after a fallow of three years. Fertilizer use before that period is not known with certainty, but may be at the origin of the high fertility status.

TABLE 1:
Analysis of the topsoil in the maize variety experiment.

Texture	0— 2 μ	8.30 %	NA_4 acetate extractible pH=7 (1:50)	
	2— 20 μ	2.03 %	Ca^{2+}	3.05 meq/100 g
	20— 50 μ	1.95 %	Mg^{2+}	2.25
	50— 200 μ	23.55 %	K^+	0.20
	200—2000 μ	61.22 %	Na^+	0.42

Field capacity (pF=2.5)	6.0	P-Truog 21 00 ppm P.
Permanent wilting point	3.6	C: 0.86 %
Humidity	2.4 %	N: 0.08 %
pH water (1:25)	6.5	C/N 11 20
pH KCL	6.0	O.M. 1.48 %
Sum of cations: 5.92 meq/100 g.		
CEC: 6.65 meq/100 g.		

The climatic zone is classified as less suitable for maize production (8). Climatic data and mean rainfall data for the period 1950-1980 are given in table 2.

The agro-climatic area has a rainfall around 1000 mm with a bimodal rainfall pattern: 2 rainy and 2 dry seasons. The first wet season is from March till July and the second one during September-October.

TABLE 2
Temperature, rainfall and relative humidity at the experimental site.

	April	May	June	July	August	Sept
Temp. (°C)	28.3	27 3	26.3	25.9	26.0	25.5
Rainfall (mm)	141.1	101.5	175.5	14 7	54.6	288.8
Rel. Hum.	80	83	85	86	86	85

Rainfall 1950-1980 (mm)

Jan	Febr	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec.
12.2	26.5	81.4	120.6	180.1	331.1	134.8	46.4	75.7	126.5	40.1	13.2

In fact the area offers only one humid season (rainfall superior to ETP) and one maize season, agriculture during the second season being a risk.

The soil was freshly tilled at the moment of planting to a depth of 10 cm and pulverised which facilitated banding and covering the fertilizer near the planting line. In fact minimum soil tillage has several advantages (1, 11, 21).

Poza Rika 7843 is a variety with a long cycle (115-120 days) resistant to Helminthosporiosis, streak and lodging. The grain is dent corn with a floury tendency and vitrous, and water requirements are low. However, the latest information has indicated that this variety was less preferred organoleptically than the local varieties by the agricultural community.

The variety NH2 has a cycle of 120-125 days with good resistance to lodging. It tolerated *Puccinia polyspora* and water shortages. The white grain is half vitrous and offers good conservation properties. Yield expectations are lower than for the variety Poza Rika 7843.

The design is a split plot using two varieties, 4 doses of N and 4 replications. The treatments were completely randomized within the replications. Four plots receiving no fertilizer were added. Oxisols and Ultisols require fertilizer N to sustain high yields (15, 18, 26).

In many places in sub-Saharan Africa, a good response to N fertilizer will occur only if sufficient P is applied as well (32). A basal dressing of 80 kg P_2O_5/ha and 60 kg K_2O/ha was applied at the moment of planting as side dressing (5 cm besides the sowing line and 5 cm deep), in the form of triple superphosphate (46 % P_2O_5) an sulphate of potash (50 % K_2O). As recommended (19), urea was choosen as N fertilizer.

Trials in Nigeria pointed out that splitting N doses in two doses improved maize yields in humid zones of Nigeria (17) and may even increase protein N in split dressing treatment (25).

In our experiment, the urea was applied at the rates of 0, 40 and 120 kg N/ha. Half was applied 15 days after planting and half at 40 days after planting at a distance of respectively 8 cm and 10 cm from the sowing line at the other side of the basal P and K application. As no estimations of volatile ammonia losses are known in the area, the banded fertilizer was covered. Long term research (19) in West Africa has shown that nitrogen placement methods are of minor importance in nitrogen efficiency

The crop was planted at a density of 80 cm x 30 cm, a practice which is generally recommended in Southern Benin.

Weeding was done when necessary and an insecticide "Decis" was sprayed after on attack of stalkborers.

two types of response curves (9) were calculated for the yields and will be used in the evaluation of the economic response.

3. Results and discussion

Yields of maize for the two varieties are given in table 3, the analysis of variance in table 4.

TABLE 3

Yields of maize (kg/ha) for the different fertilizer applications (kg/ha). Moisture content of 14 %.

	Dose			
Variety	0	40	80	120
NH2	3370	4350	3490	4030
	3010	4010	5030	4730
	3720	5090	4910	4510
	2860	3930	4490	4630
Poza Rika 7843	3390	4910	5600	5680
	4560	5620	6180	6080
	4860	6050	6230	5740
	4430	6780	6190	6620

Although soil analysis data showed levels of P and K to which response to phosphatic and potassic fertilizers can be expected, average yields on the check plots receiving no fertilizer amounted to 4190 kg/ha and 3120 kg/ha for resp. Poza Rika and NH2 are comparable to resp. 4310 kg/ha and 3240 kg/ha when only P and K are applied.

For potassium, fertilizer trials on maize in Nigeria (29) indicated that yield responses to K were small or rare when exchangeable K is above 0.5 meq/100 g of soil, although values as low as 0.12 meq/100 g of soil in the savannah zone is not an index for deficiency for yields of 3000 kg/ha (dry grain), perhaps due to the fact that maize can extract non-exchangeable K from the minerals found in these soils.

For P, most extraction methods extract only the mineral P from the soil. This stresses again the necessity that soil test procedures require extensive correlation and calibration with crop response in the field.

Ferralitic soils have excellent physical properties and when adequately fertilized show high yields of 4 to 5 tons/ha of maize during several years. If not adequately fertilized, after regeneration by fallow, yields may drop after a few seasons of intensive cropping.

In view of the current pressure on the cleared land in Benin, fallow periods often shorten and are no longer sufficient to regenerate soil fertility. In this case an other fertility management system, including mineral and organic fertilization has to be developed.

For the two varieties, Least Significant Differences (LSD) for yields showed a significant difference at the 5 % level between N O and N 4O, N 8O, N 120.

TABLE 4

Analysis of variance for yields of the two varieties.

Source of variation	Sum of squares	Degrees of freedom	Mean square	F ratio
Tot. variet.	2007.76	7	286.82	2.58*
Blocks	286.37	3	95.46	43.48**
Varieties	1680.28	1	1610.28	
Err. var.	11.11	3	37 04	
Treatments	1243.79	3	414.60	25.15**
Int. VXT	33.00	3	11.00	0.67
Err Treatm.	296.76	18	16.49	
TOTAL	3581.31	31	115.53	

When mean yields of the two varieties are observed, yields for Poza-Rika 7843 are superior to the yields of NH2 at all fertilizer doses. For the two maize varieties, there is an increase in yields with fertilizer doses.

Nine types of response functions were fixed through the data and the two curves with highest determination coefficient were withheld. Results are given in table 5.

TABLE 5

Response equations for yields for the two varieties.

Variety	Response equations	R^2
NH2	$\ln Y = 8.0787 + 0.067077 X^{0.5} - 0.0034137 X$	0.6200
	$\ln Y = 8.4052 - 0.326960 e^{-0.05593 X}$	0.6213
Poza	$\ln Y = 8.3596 + 0.07181 X^{0.5} - 0.0036949 X$	0.6862
	$\ln Y = 8.7136 - 0.35449 e^{-0.04329 X}$	0.6808

These functions are presented in fig. 1. We can observe that the two types of response curves are similar for the two varieties and show a rapid increase at low N dose which decreases at higher N doses.

The forms of the curves are similar to those found in literature (15, 22) in different regions of the world, where an inflexion point is found at 80 kg N/ha (18) but, because no difference is found between the yields for 40 and 80 kg/ha, the former dose should be taken as the recommended dose giving the maximum yield. This optimal dose can be considered as the same for the two varieties because the interaction NXVariety is not significant at the 5 % level. Although these two varieties give the same form of response curve, this is not a general fact and differences may exist between varieties giving quadratic, linear, and no responses on the same soil (2). The two varieties behave almost identically when yield increase (kg grain/kg applied N) is plotted against N rate.

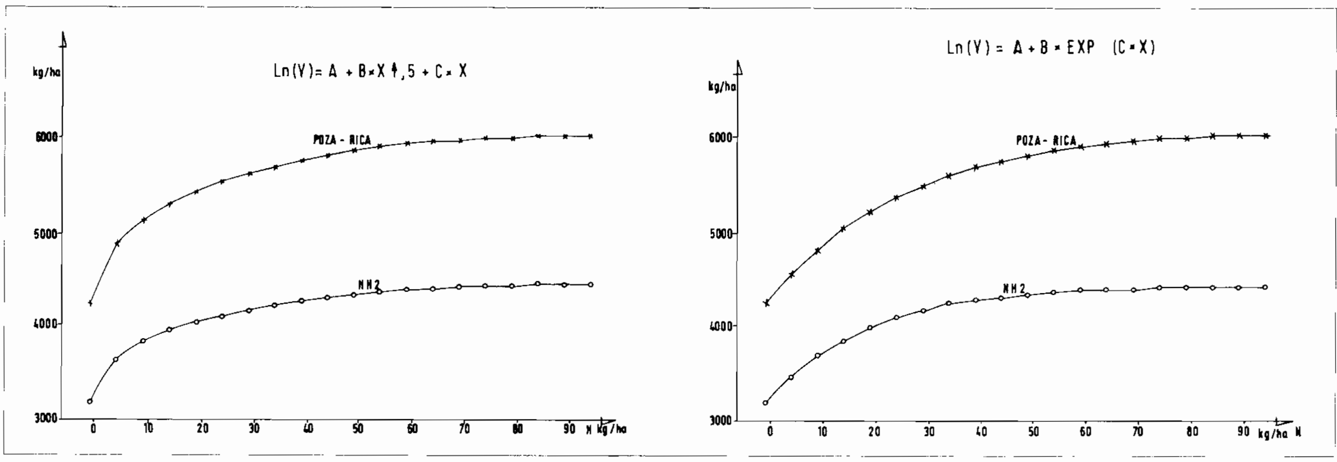

Figure 1. Response curves for maize yields (kg/ha) in function of N doses (kg/ha) for the varieties "Poza Rika 7843" and NH2

Conclusions

The two varieties "Poza Rika" and "NH2" have an almost identical response curve, but "Poza Rika" gives higher yields than "NH2".

The study proves that only by selection of a good variety, the same rate of fertilizer can already provide a significant increase in yield of grain.

Climatological suitability maps existing in Benin should be carefully interpreted as the maize variety is an important factor, the zone being classified as less suitable for maize production.

Acknowledgements

This study was carried out with the financial support and in the frame of the project "Fertilisation et régénération des sols en République Populaire du Bénin", financed by the Belgian Ministry for Cooperation (ABOS/AGCD).

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