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REPUBLIC OF NIGER

MINISTRY OF HIGHER EDUCATION AND RESEARCH

INRAN

NIGER CEREALS PROJECT

Subvention no. 683 – 130 – 201

BETWEEN NIGER AND THE UNITED STATES OF AMERICA

FINAL REPORT

of

C. B. BROWN

RESEARCH AGRONOMIST AND SOIL SPECIALIST

February, 1980

PDAAN 511

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I N R A N

This final report presents:

(1) A summary of the findings in agronomic research in Niger between 1976 and 1979.

(2) The objectives for a program in land-capability studies for Niger.

(3) An example of a method for calculating the amendments necessary for attaining optimum agricultural production in Niger.

Details for each of the subjects mentioned above can be found in reports, previously submitted to INRAN.

C. B. Brown
Research Agronomist
and Soil Specialist

February, 1980

REVIEW BY

SOIL SPECIALIST

The Soil Specialist was Agronomist at CNRA, Maradi from the inception of the NCP in 1976 until July 1979, when he was transferred to the National Soils Laboratory, where he holds the position of Research Soil Scientist. Some of the more important findings of his research are listed below.

I. A nation-wide system for the comparative study of the performance of millet, sorghum and cowpeas has been established. The work began in the growing season 1977 with pilot trials at CNRA; in 1978, experiments were laid out at 33 different locations. In 1979, there were experiments at 85 sites. In any undertaking of this magnitude in a country the size of Niger, there must inevitably be many problems. Nevertheless enough data are available from these nation-wide trials, to allow some statistically sound conclusions.(1)

(1) The variety of millet P_3 Kolo studied in 1977, 1978 and 1979 is not the best selected variety in Niger. CIVT is better than P_3 Kolo; and several other local varieties produced just as good a yield as P_3 Kolo and CIVT at specific locations within the country. However it must be recorded that P_3 Kolo was fist introduced into the field in Niger in 1960 and this researcher has found no evidence that its purity was maintained after 1964. CIVT is now in its third year of field testing. Among the local varieties tested were: Zongo, Zongharwa, Guerguera, Bazomi, Dan Barno, and others simply described as the local variety.

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(1) Detailed procedures and results for each series of experiments are published in the Annual Technical Reports of the CID Agronomist 1977 and 1978.

(2) The four selected varieties of sorghum L 30, ½ MSB, A_2B_2 and A_4 D_4 produced better than the local varieties only at Maradi and Niamey. At all other sites, the local variety of the district gave higher yields of grain. The local varieties tested were Bagoba, El Délé, El Abouda, Jan-Dawa, (Ja-Dawa), Jan-Jaré, Mo-[illegible]a, Itchordi, Thebou, Abdou-Kadri, Gothèye, Fara-Dawa, Biyil, Guéro, Babodia-Fara and N'Gabiri Kéné.

(3) During the period the selected varieties of cowpeas proved better than the local varieties but the trails were only done at 4 sites. Variety T 4-69 is suitable for areas with average annual rainfall greater than 600 mm, and TN 88-63 grew better in areas of lower rainfall.

Some of these findings had been previously noticed and mentioned by careful observers, but there had never been any scientific trials to confirm or deny their observations. These experiments supply statistically tested conclusions.

II. This is the first time that local varieties of millet, sorghum and cowpeas have been tested side by side, with the selected varieties, and also in diffrent parts of Niger, although several villages had shown definite preferences for their own local varieties. Thus, some of the results reported below, are not merely extrapolations which could have been made from studies elsewhere. They represent, the first time that these data have ever been available in Niger.

(1) All local varieties of millet, sorghum and cowpeas respond positively to nitrogen and phosphate fertilizers.

(2) Yields of cowpeas and peanuts are increased when they receive a "starter" nitrogen fertiliser. Legumes are not inoculated in Niger.

(3) Analytical data for soils show an improvement in nutrient status -- N, P and organic matter -- when legumes are used in the rotation

(4) Green manure reduces the yield of all varietes of millet in the first year of spreading.

(5) Pen manure and compost increase yield immediately and in subsequent years.

III. Then, there are certain findings, which resulted from the continuation of experiments which had been initiated by IRAT and INRAN prior to 1976.

It is suggested that with all these findings, it should be possible for INRAN in co-operation with the Department of Agriculture to find at least one package of agricultural practices which will immediately improve peasant output. The Agronomist has shown experimentally that yields have been increased from 300 to 450 kg/ha by the use of different cultural practices, and if fertilizer is also used, one can attain an improvement of from 300 - 750 kg/ha depending on the initial status of the soil.

(1) Spacing 1m × 1m for normal millet, 0.8m × 0.3m for valley sorghum, and 1m × 0,5m for dune sorghum are satisfactory. Dwarf millet (3/4 HK), gives a yield of twice that of the other varieties and it requires a different spacing.

(2) IRAT's recommendations of 75 units P_2O_5 as a base treatment every 6 years, with annual dressing of 20 units, have been substantiated. In spite of IRAT's work, the Agronomist thinks that these levels can be reduced because of the residual effect of phosphatic fertilizers.

(3) Both commercial superphosphate and rock phosphate from Tahoua increase yield of millet, in the same way as expressed in 2 above. However, it takes 2 to 3 times the weight of rock phosphate to get an equivalent increase in yield. (An economic study is recommended).

(4) Phosphatic fertilizers have an immediate effect and also a delayed effect which may last as long as 10 years in a millet-legume rotation. I am willing to experiment with a half of the applications over a 10 year, rather than a 6 year period (See 2 above)

(5) A minimum of 2 weedings is absolutely necessary for millet and sorghum -- the first within the first month after seeding when thinning is done, the second just as the plants begin to flower, which is towards the end of the second month. Other cleanings are recommended as well as the removal of all "striga".

(6) The response curve for millet and sorghum treated with nitrogen continues to increase up to 90 units/ha; but the curve starts to flatten out above 60 units. This leads me to the conclusion the best economic returns for nitrogen are somewhere between 45 and 50 units/ha. Nitrogen is added in 2 applications, one at each of the obligatory weedings. (Once again an economic evaluation of these research findings is suggested).

(7) Legumes in the rotation always cause an increase in the yield of millet. A legume - mil rotation can increase millet grain by approximately 200 kg/ha: a legume-legume-mil may increase the millet by 500 kg/ha; but this must be verified.

(8) Crotolaria Senegalensis, (Gougiya Awahii) has been selected as a local legume which can be introduced during the fallow year in a rotation. Laboratory tests show that this legume increases soil nitrogen, phosphorus and organic matter.

(9) There has been no significant response to K fertilizers on the sandy soils. Experiments in the Soil Laboratory in Niamey show that a sandy micaceous soil of Niger discharges K into the soil.

IV. In the absence of any appropriate economic study, a pilot trial was used to determine profit or loss of two agricultural systems -- traditional and recommended. I would like to pass the figures on to an agro-economist for a critical evaluation of this single experiment.

(1) If a peasant farmer employs the recommended practices on a $4\frac{1}{2}$ ha farm he can make a profit of about 20,000 CFA. If he sticks to the traditional techniques he losses 17,000 CFA per year, but he meets the deficit by supplementary employment.

ADDENDUM: The use of recommended techniques alone will increase yield by 50%, and if we also add fertilizer we can double the yield.

PROGRAM FOR
A
SECTION ON SOIL FERTILITY IN INRAN[1]

INTRODUCTION

It is almost axiomatic that the first priority of any country is to be self sufficient in food. Food is a product of agriculture: agriculture depends on many things, but perhaps the most important is the soil. A section of Soil Fertility in INRAN will have the responsibility of finding out methods which will improve agriculture production in Niger, especially of the 4 important crops--millet, sorghum, cowpeas and peanuts.

SOIL FERTILITY SECTION

The objectives of this section are:

(1) To make land capability studies in Niger.

(2) To locate and describe those soils in Niger which are suitable for one or more of the major crops grown in the country.

(3) To deterimine and recommend the levels of major fertilizers (NPK) which are necessary to obtain maximum yields on these soils.

(4) To predict or determine deficiencies in minor elements, and to recommend corrective measures.

(5) To suggest where possible, the introduction of new crops.

(6) To work with an economist to select the systems which are economically feasible in Niger.

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(1) Details and budget for this work, have been presented to the Director General of INRAN.

FERTILIZER PROGRAM

SEED MULTIPLICATION CENTER AT DOUKOUDOUKOU

by

C. B. Brown
Research Soil Specialist

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SUMMARY OF RECOMMENDATIONS:

Period: 1980 - 1985

Yield Goal: 1500 + kg/ha of millet

Mapping Units: (1) 10B sand, 1-3% slope;

(2) 11A loamy sand in depressions, less than 1% slope

Fertilizer recommendations for both mapping units are similar, except for magnesium. Analyses for magnesium and calcium should be made in 1984. Analyses should be made for minor elements.

As long as the rainfall reaches 400 mm annually, the yield should be no less than 1000 kg/ha, which is nearly $2\frac{1}{2}$ times the national average.(1)

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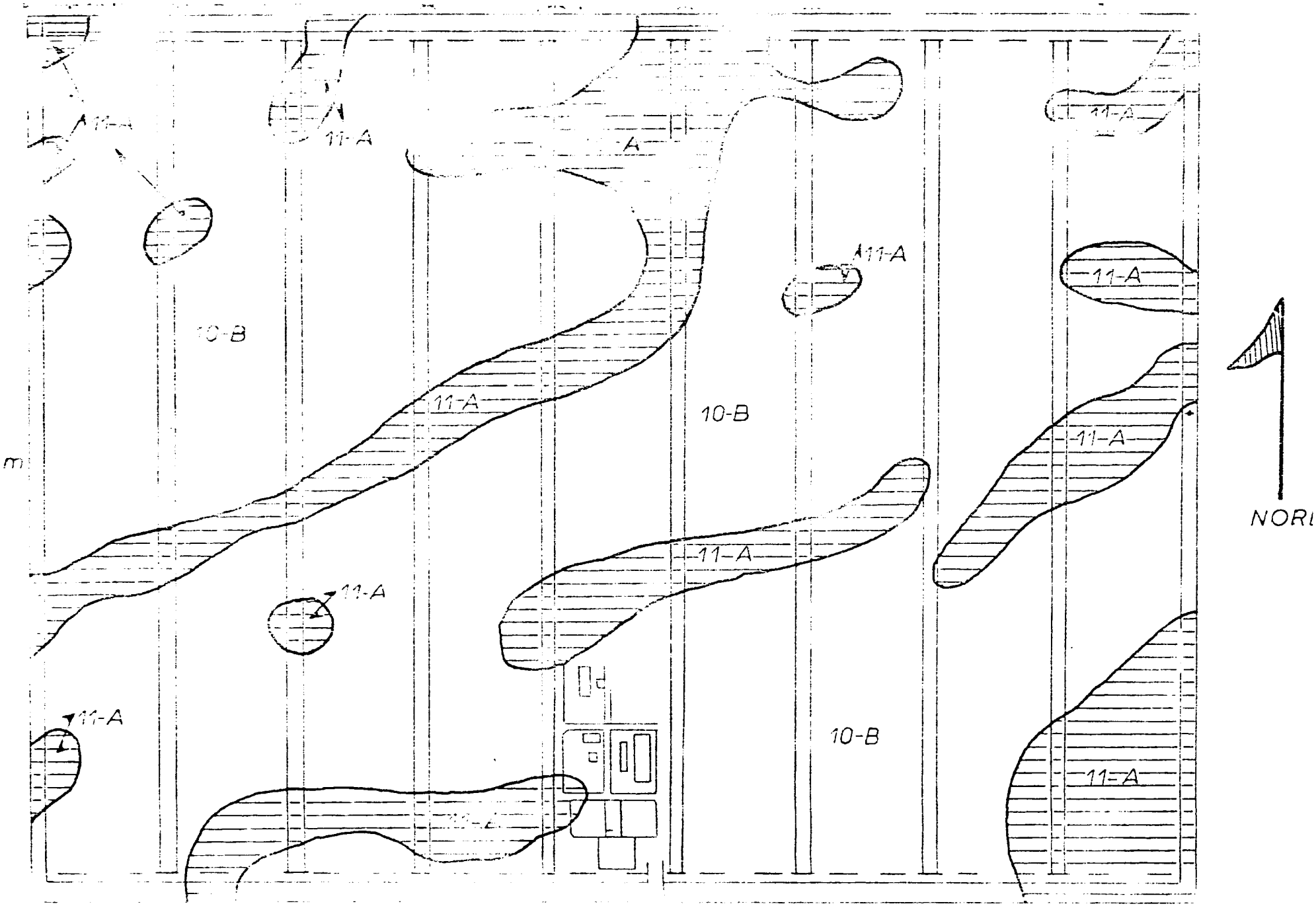
(1) The highest national average yield in the 70's was 421 kg/ha in 1978. Annual Progress Report CTD. NCP (1978).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SUMMARY TABLE OF RECOMMENDATIONS[1]

Soil Amendment	Millet/Sorghum	Cowpeas/Peanuts
LIME	Nil	Nil
NITROGEN	40-50 units N/ha per year, continuing the practice of 2 applications at specified times.	10-20 units N/ha as a starter
PHOSPHORUS	40-50 units P_2O_5/ha before seeding. See the detailed program page, 14.	Same as for millet and sorghum.
POTASSIUM	Nil	Nil
MAGNESIUM	-	-
Soil 10B	300 kg of magnesium salt/ha before seeding.	Same as for millet and sorghum.
Soil 11A	Nil	Nil
OTHER ELEMENTS	Nil	Mg SO_4 to correct the sulphate deficiency, see page 16.
MINOR ELEMENTS	Boron salt less than 2 kg/ha	Same as for millet and sorghum

(1) Profit or loss has not been calculated.

THE CALCULATIONS

The following references have been extensively used in making the calculations.

1. Allen, B. L. (1978). Report on Soils of Tarna, Doukoudoukou, Guéchéme and and Hamdallaye Stations. CID/Texas.

2. Baker, J. M. and Tucker, B. B. Fertilizer Recommendation Guide, O.S.U. Extension facts No. 2225. Oklohoma State University Stillwater Oklohoma.

3. Brown, C. B. (1977): Seed Multiplication Center at Doukoudoukou (Niger). Preliminary soil survey with fertilizer recomendation NCP/Niger.

4. Georgia Cooperative Extension Service, Soil Test Code Book (1974) U.G.A. Athens, Georgia 30601.

5. Tisdale, S.L, and Nelson, W.L. (1975) Soil Fertility and Fertilizers, Macmillan Publishing Co. Inc. N. Y.

The preceeding soil map was prepared by Allen (1978). Allen divided the soils into two mapping units 10B and 11A. Brown (1977) described these same soils as dune and depression soils respectively. Field descriptions are given by both researchers. Brown's predictions, without the use of analytical data, were identical with those of Allen (1978) which were supported by laboratory analyses.

INTERPRETATION OF ANALYTICAL DATA

Although no recommendations are given for irrigation or drainage, particle size analyses resultas appear in the following table, and from these results some general conclusions are drawn

PHYSICAL PROPERTIES

PARTICLE SIZE ANALYSIS

Mapping Unit 1CB

Analytical Data

Depth cm	% Sand	% Silt	% Clay	Texture Class
0- 14	93.4	4.8	1.8	Sand
14- 36	93.4	3.5	3.4	"
36-190	89.4	3.5	7.2	"

These soils are very sandy with high infiltration rates. Irrigation will increase yields.

If rain-fed, an annual rainfall of 300 mm or less will give poor yields of millet, and the yields will be further reduced if nitrogenous fertilizers were added to the soil. Between 300 mm and 400 mm of annual rainfall, the distribution and the actual useful rainfall will decide the yield. An annual rainfall of 400 mm or more, will be satisfactory for millet at Doukoudoukou. These inter-relationships between yield and rainfall were observed as a by-product of a study of varieties of millet X fertilizer throughout Niger by Brown[1], but these trends may be more fundamental when judged in the light of Charoy's work (1974)[2]. He reported that the water requirement for millet during its 114-days growing season was 366 mm, and he also noted that similar sands at Tarna have good water holding capacity.

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(1) Brown C. B. (1978) Rapport Technique Annuel de l'Agronome du CID. L'INRAN, Niger. (English Translation)

(2) Charoy J. (1974) Dynamique de l'eau dans les sols ferrugineux tropicaux d'origine dunaire de Tarna et application au mil à l'arachide et au sol nu. L'Agronomie Tropicale. XXIX, N° 8:821-830.

PARTICLE SIZE ANALYSIS

Mapping Unit 11A

Analytical Data

Depth cm	% Sand	% Silt	% Clay	Texture Class
0- 21	93.8	4.9	1.8	Sand
22- 45	90.8	5.4	3.8	"
45- 78	88.7	4.3	7.0	"
78-115	85.1	-	14.9	Loamy sand
115-137	85.2	0.7	14.1	" "

As far as physical properties are concerned, this mapping unit can be treated like 10B. It has a little better water holding capacity in it rooting zone.

SOIL REACTION: pH

Analytical Data

Soil No	pH of Soil	pH Required	Remarks
		Millet/Sorghum	
10B	5.1-6.1 (rooting zone) 4.7 (below)	5.5-7.0	The rooting zone is well within the required pH range, but in the lower horizons it is below the limit of tolerance which is pH 5.0
		Cowpeas/Peanuts	
11A	6.4-5.2 (rooting zone) 4.9-4.5 (below)	5.5-7.0	Same as for millet and sorghum.

RECOMMENDATIONS: No lime is recommended. The pH should however be monitored especially if applications of nitrate, chloride or sulphate fertilizers are used. If the pH should approach minimum tolerances, lime should be added.

CHEMICAL PROPERTIES

Major Nutrients NPK

Analytical Data

NITROGEN

Soil No	Soil % N	Soil % O.M.	Required N	Remarks
			Millet/Sorghum	
10B	-	0.17	30 units N/ha	Nitrogen results are missing, but on these sandy soils with low organic matter nitrogen will be in short supply.
			Cowpeas/Peanuts	
11A	-	0.18	10-20 units/ha as starter	Same as for millet and sorghum.

RECOMMENDATIONS: In the absence of residual nitrogen, add more than 30 units N/ha, say 40-50 units/ha for millet or sorghum.

For cowpeas or peanuts an application of 10-20 units as starter is satisfactory.

If grain follows legumes the nitrogen can be reduced 1/3 for millet in a legume-grain rotation, and 2/3 in a legume-legume-grain rotation. At present, there is no proven data on intercropping on these particular sandy soils, but recommendations similar to legumes can be reasonably made.

Note: In the U.S.A. (Oklahoma, for example) where grain sorghum yield may approach 10,000 kg/ha, up to 240 units/ha nitrogen may be recommended.

PHOSPHORUS

Analytical Data

Soil No	Soil P_2O_5 kg/ha	Required P_2O_5 kg/ha	Remarks
		Millet/Sorghum	
10B	12(1)	44-55 kg/ha	Phosphate is low. With basic dressing already added, 45 units P_2O_5/ha per year for grain should be enough.
		Cowpeas/Peanuts	
11A	12(1)	44-66 kg/ha	54 units P_2O_5/ha are needed

RECOMMENDATIONS: Over the 5 year period, I would recommend an experimental(2) series of phosphate treatments, since field-trials have shown a delayed effect of P_2O_5: 45 units in year 1, decreasing each year by 10 units and reverting to 45 units in year 5, that is for grain: 45, 35, 25, 15, 45 kg/ha 1980, 1981, 1982, 1983, and 1984 respectively.

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(1) Data from similar soils at Maradi.

(2) Any reduction in yield which can be unquestionably tied to phosphate reduction, should indicate the necessity for going back to the higher level of phosphate.

POTASSIUM

Analytical Data

Soil No	Soil	Required	Remarks
	K me/100 gms		
		Millet/Sorghum	
10B	20 kg/ha	55-66 kg/ha	K is low. These soils need between 35 and 45 kg K/ha but experiments have shown that these micaceous sands have adequate power to supply K for a 2,000 kg yield of grain per year
		Cowpeas/Peanuts	
11A	25 kg/ha	55-66 kg/ha	Same as for millet and sorghum

RECOMMENDATIONS: No potassium.

SULPHUR, MAGNESIUM AND CALCIUM

Analytical Data

Soil No	me/100 gms (units/ha)			Remarks
	Ca	Mg	CEC	
10B	0.7 (314)	0.2 (54)	3.7	Both Ca and Mg are low, and are approaching deficiency. Ca will be supplied as a by-product of phosphate fertilization, and so the data indicate a necessity for Mg, Ca saturation at less than 10% indicates a need for S.
11A	2.2 (980)	1.2 (324)	6.6	Low, but not deficient. Limits of adequacy are 0-220 kg/ha for Ca. 0-144 " " " Mg.

RECOMMENDATIONS: Where magnesium and sulphur, are required, use as gypsum with magnesium, dolomitic limestone with sulphate, or magnesium sulphate at the rate of 300 kg of total fertilizer/ha.