UNITED NATIONS
ECONOMIC AND SOCIAL COUNCIL

49495

Distr.
LIMITED

E/CN.14/INR/70
15 July 1964

Original: ENGLISH

ECONOMIC COMMISSION FOR AFRICA
Conference on Co-ordinated Industrialization
in West Africa
Bamako, 5-15 October 1964

SOIL FERTILITY AND FERTILIZERS IN WEST AFRICA

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(The contents of this paper do not necessarily represent the views of the Food and Agriculture Organization).

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SOIL FERTILITY AND FERTILIZERS IN WEST AFRICA

by

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In this paper an attempt has been made to cover the question of soil fertility and fertilizers from description of the soils to experimental work and fertilizer sales to the farmers. The wideness of the subject makes it necessary to summarize rigidly, giving the main features of each section.

As there is still a considerable lack of precise statistical date about West African agriculture, most of the figures in this paper have had to be collected separately.

I Soils, climate, crops

According to the FAO Africa Survey, the Western and Western equatorial region is divided roughly along lines of latitude into six zones which classify the gradual change from the Sahara Desert in the north to the rain forest in the south.

Saharan and sub-Saharan zones are of minor interest in this paper.

Sahelian zone extends from Senegal to Sudan, covering also the northern parts of Mauritania, Mali, Upper Volta, Niger and Chad. When rainfall is below 400 mm, cropping is possible only in areas flooded during the wet season (sorghum rice). About 400 mm rainfall means that cropping is safer. The Office du Niger in Mali runs 50,000 hectares of irrigated areas growing rice and cotton.

Soils of this zone are mainly: Brown, Reddish-brown, Chestnut and Reddish-chestnut soils with inclusions of Red-yellow Mediterranean-like soils. They are of medium fertility, poor in organic matter, shallow and rich in lime. In the southern part of the zone where crops are grown, red, friable and acid soils are found which are often sandy in texture and highly subject to erosion. Alluvial soils are widespread.

They are suitable for rice production and cattle grazing; black cotton soils occur in the east of the zone.

Sudanian zone includes much of Senegal, the southern parts of Mali, Upper Volta, Niger and Chad and the greater part of Northern Nigeria. This belt already shows increasing humidity towards the south. The rainfall in this zone is between 600 and 1,000 mm. The vegetation is open woodland savannah. Millets and sorghums are the dominant subsistence crops but maize and root crops, particularly cassava, begin in this zone. Rice is widely grown in riverine areas.

The soils are very similar to those found in the southern part of the Sahelian zone, including reddish-brown lateritic soils, red-yellow podzolic soils and areno latosols.

Guinean zone stretches from southern Senegal and Gambia, east to Sudan. In Eastern Ghana it meets the coast. Rainfall in this area is between 1,200 and 1,600 mm. The main subsistence crops are cassava and maize, upland and swamp rice are grown. Small areas of coffee and cocoa, as well as oil-palm and groundnuts are found.

The most important soils are the deep red-yellow friable soils of the tropical forest and savannas which are low to fertility but quite resistant to erosion and under suitable management they can become of medium productivity.

The sandier soils are best suited to forest production. Deep, yellow, friable, well-drained forest soils also occur and although they may be permanently wet and low in nutrients, under good management they are suitable for a variety of crops.

Guinean Equatorial zone which is the southernmost zone, is a discontinuous belt beginning in Sierra Leone, widening in Liberia and the Ivory Coast and disappearing in Ghana, to re-emerge in Western Nigeria and continue to the Congo Basin. The annual rainfall is usually more than 1,800 mm and the dry season less than three months. This zone has the greatest possibility for tree crops such as cocoa, coffee, oil-palm, banana, rubber. The subsistence crops include cassava, maize, upland and swamp rice.

The deep, yellow, friable forest soils mentioned in the Guinean zone are the most important of the present zone. Poorly drained alluvial and mangrove soils also occur, together with water-logged soils and small areas of the well-drained, red, deep, friable soils of the tropical forest uplands.

With the exception of the tropical black and brown earths which are very scarce, all soils mentioned would be classified as latosols. These are the zonal or climatophytic soils of the tropics. They are characterised by reddish colours and stable micro-aggregation which promotes free drainage. The clay fraction is composed mainly of kaolinitic minerals with iron and aluminium oxides. The great majority of latosols are developed over quartoze rocks: prominent among them are the granites and gneisses of the basement complex, acidic schists and phylites, sandstones, shales and unconsolidated deposits. They are also formed over basic rocks, though these frequently give rise to basisols. Most of the soils are old and have been subjected to very intensive leaching except in the valleys.

II. Fertility and productivity of West African soils

The characteristics of the fertility of West African soils have been investigated by the classic means of soil survey, soil analysis, plant analysis and field experimental work. Although the picture is not yet complete, information available allows a general summary of the soil fertility status in West Africa.

1. The organic matter content is generally low and very low for instance in the forest between 2.2 and 2.8% (0 - 15 cm layer) and in the savanna soils between 0.34 - 1.2% (Ofori).

2. The exchange capacity of these soils is in general very low. Highest values for the 0 - 15 cm layer of some of the forest soils in Ghana is 12 me% and of some savanna soils is 2.5 me% (de Endredy).

3. The pH of the top soils from some of the forest and savanna areas lies between 5.5 and 7.2.

4. Nitrogen The organic matter content in the soil affects the low nutrient status. By the burning method of clearing the bush at the end of the fallow, nitrogen and sulphur disappear. The nitrogen content of some forest soils in Ghana is about 0.12%. Values as low as 0.017% are obtained for some savannah soils. About 200 kg N in the forest and 70 kg N in the savanna soils are released per hectare per annum. The rate of mineralisation is 3% for forest and 4% for savanna soils (Stephenson and Djokoto). A large part of N is lost through leaching. It seems that the reason why the crops often do not show acute deficiency symptoms is that the planting seasons coincide with the rise in the nitrate values in the soils (Greenland).

5. Phosphorus As organic matter and the mineral apatite as the main suppliers of P in the soil are low or negligible, the phosphorus status is usually low, particularly in the savannah. In addition, most of the phosphorus is fixed by the high aluminum and iron content of the soils. Values for "available" phosphorus (Bray's method) range from 1.5 ppm to 5 ppm. Generally P is the most deficient nutrient in West Africa.

6. Potassium The importance of this nutrient (relative to N and P) in West Africa is still under discussion. Values of exchangeable K for some soils range from 0.128 me% to 0.437 me%. These values are comparatively high considering the amount taken up by the crops. Recent findings (FAO Fertilizer Program) indicate however, that the role of potash has possibly been under-estimated up to now.

7. <u>Other nutrients</u> In general no calcium deficiency has been found but there was no definite effect of lime applied in field experiments. Magnesium deficiency has been found on light soils, particularly on oil-palm in Nigeria. There is some evidence from experimental work in Northern Nigeria and Northern Ghana about the sulphur deficiency in these soils. Micronutrients have been investigated to a limited extent and it has been found that urgent problems do not yet exist in this field.

8. <u>Level of yields</u> Whatever the differences in the soils and in the requirements of the different crops, from the agronomic point of view and considering the need for improved agricultural productivity, in general, the soils in West Africa should be considered as poor in all three main nutrients. This will be proved by experimental data later on in this paper but another striking demonstration of this fact is the low and very low yields obtained at present under normal farming conditions without fertilizers. As a rough average figure, the following yields without fertilizers can be quoted:

cocoa	350 kg/ha (dried beans)
maize	700
millet	500
sorghum	700
rice	1,000 (paddy)
groundnuts	400
cassava	4,000
yams	5,000

These yields are obtained under normal rainfall conditions under which the low plant nutrient status of the soils is definitely the main limiting factor. The yields in countries where fertilizer is intensively used are at least five times greater.

III The role of fertilizers

Two items should be discussed briefly at the beginning as they are very closely connected with the effect of fertilizers: the problem of (a) organic matter and (b) the interaction of fertilizer with other production factors.

(a) Organic matter In countries with a traditionally intensive fertilizer application, particularly in the temperate climatic zones, the normal practice is the combination of heavy organic manuring (for instance 20 tons per hectare stable manure) with heavy dressings of mineral fertilizer (for instance 120-120-120 kg/ha NPK) with an excellent effect.

Organic matter improves the structure, the water holding capacity, the absorbtion complex of the soil and provides plant nutrients.

In West Africa, experimental findings (Nye, Stephenson, Djokoto and others) show that there is generally a yield-increasing effect by organic manure of different types, especially outside the forest zone. Organic manure plus fertilizer usually gives additional increases in yields. Another experience is: though the manured land gives much higher yields than the un-manured land, the additional yields obtained with fertilizers are as great on the manured as on the un-manured land. This is a very important fact which contradicts a still fairly common thesis that mineral fertilizers would only work in combination with organic manure.

The favourable results by organic manure have mostly been achieved in experimental stations. Unfortunately in practical agriculture, manure is only available in very limited areas, for instance, in areas of compound farming, and it has been almost impossible up to now to convince the farmers to plant green manure. As only heavy dressings of organic matter could improve this situation substantially, from the practical point of view there does not seem to be much hope. Bearing this in mind, it is apparent that inorganic fertilizers are practically the only realistic means of increasing soil fertility.

Fertilizer which increases yields first increases the vegetative development of the plant, including root growth. As these parts of the plant remain in the field, in addition to the fertilizers, a certain additional quantity of organic matter is given to the soil which, on maize for instance, is quite considerable. This additional quantity is certainly not the complete solution of the problem of organic matter but under present conditions it seems to be almost the only possible method of giving the soil some additional organic matter, that is, by applying mineral fertilizers.

(b) Fertilizer and other production factors: Fertilizer alone does not give the maximum yields but the effect of fertilizers is greater if the other practices are also improved: varieties, plant protection, methods of cultivation, water supply. An example from Ghana (Nyankpala) on groundnuts shows what can be achieved by improvement of all production factors including fertilizers.

Normal groundnut yield	:	400 kg/ha
Yield by closer spacing (90-15 cm)	:	800
Close spacing + 100 kg/ha Single Superphosphate ($20\ P_2O_5$)	:	1200
Close spacing + SS + seed dressing (Dieldrex A)	:	1320
Close spacing + SS + seed dressing + improved variety	:	1580

The combination of all factors, of which fertilizer is one, has increased the yield almost four-fold.

It is generally accepted that 50% of the yield increases achieved in the world during the last 100 years are due to the application of fertilizers. The other 50% is shared by the other factors.

Fertilizer experimental and demonstration work

The experimental work with fertilizers started in West Africa about 30 years ago. Much has been done inside experimental stations and in some countries such as Senegal, Ghana and Nigeria, also outside the stations. Typical examples of fertilizer experimantal work follow:

Senegal: A fertilizer field experiment on millet in Senegal was interpreted with the help of foliar diagnosis. In this experiment, comparison was made between the three following four-year rotations:

- burnt fallow - groundnuts - millet - groundnuts
- fallow turned-under - groundnuts - millet - groundnuts
- millet used as green manure - groundnuts - millet - groundnuts

Effects of fertilizers were studied, applied to different crops as follows: N, on millet, 300 kg/ha of ammonium sulphate (21% N); P, on fallow, 500 kg/ha of tricalcium phosphate and K, on groundnuts, 85 kg/ha of muriate of potash (60% K_2O).

The responses of millet to the different treatments were:-

Effects of the different kinds of fallow and the fertilizers applied

	Unfertilized yield kg/grain/ha	Fertilized (NPK) yield kg/grain/ha
Burnt fallow :	912	1565
Fallow turned under:	1244	1809
Millet used as green manure :	1070	1974

Without any fertilizer the differences between the three kinds of rotation were not great. However, fallow turned-under was significantly better than burnt fallow.

The effect of fertilizers was very large and the response varied between 45 and 85%, depending on the rotation. When fertilizers were applied, the rotation that included "millet used as green manure" gave the highest yields, significantly higher than those obtained for burnt fallow.

The Institut de Recherches pour les Huiles et Oléagineux (I.R.H.O.) carried out pre-extension trials in connexion with the following rotation: groundnuts - food crop - groundnuts, followed by two years natural fallow. The following NPK formulas, which differed according to the region, were applied to the groundnuts: 6-20-10 at 120 kg/ha; 14-12-0 at 103 kg/ha; 4-11-32 at 153 kg/ha; and 10-0-30 at 103 kg/ha. The last three formulas also contained 3 kg "Nutramine" (micro-element mixture).

Results: In the Kaolack area the 7-year average of groundnut yields was as follows:

With fertilizer	1,850 kg shell nuts/ha
Without fertilizer	1,310
Increase by fertilizers	540

an average increase of 41%.

Increase due to fertilizer (residual): 190 kg grain/ha, i.e. an average increase of 48%, which alone would justify the use of fertilizers.

M a l i

Groundnuts: The following NPK formulas were compared for five years in six different areas of the country: 6-10-20, 10-14-8, 6-20-10, 16-6-2, 7-24-3.

On an average the best yields were obtained by 6-20-10 kg/ha which gave an increase of + 23% (= 479 kg/ha), + 40% (= 334 kg/ha), + 29% (= 506 kg/ha), + 55% (= 413 kg/ha, + 28% (= 417 kg/ha), + 32% (= 585 kg/ha) in the different regions.

With these yields the value: cost ratio of fertilizer application would be in the range of 1.45 to 2.53 to one.

Sorghum: Among the five formulas which have been compared in four years experiments, 9-21-0 was the most successful, giving 26% (= 336 kg/ha) increase.

Rice: The effect of 40-100 kg/ha N proved very successful in the area of controlled irrigation of the Office du Niger. Minimum N fertilizer proved to be the most efficient. In spite of low analysis results for P, the effect of phosphate was low. There was some indication of maximum deficiency.

Maize: In a series of experiments, N, in doses of 150 kg/ha, sulphate of ammonia (30 kg N) gave a highly significant increase of 126%. The effect of 80 kg/ha is fairly significant. A double dose of this gave very highly significant increases.

L i b e r i a

Four trials were carried out on swamp rice. The source of N was urea, of P_2O_5, rock phosphate and of K_2O, muriate of potash. The increases due to rock phosphate at a rate of 45 kg/ha P_2O_5 were 22% over control, about of the same range as the increases obtained by only 22 kg/ha P_2O_5 from single superphosphate in neighbouring countries. There was no interaction of plant nutrients.

The responses to 45 kg/ha of N (urea) are 17% and, as far as the results are comparable, lower than the responses to 45 kg/ha of N, in the form of sulphate of ammonia, obtained in Senegal: 31 and 61% increases in two cases.

The trials were carried out on swamp rice, using the variety "Senegal". Plant nutrient levels were 45 to 67 kg/ha in contrast to the 22 to 45 levels used in Ghana and Senegal. The increases are also shown clearly in the categories with one, two and three plant nutrients and also at different levels of application of plant nutrients.

Liberia

4 Trials, NPK 45-45-45, $N_2P_2K_2$ 67-67-67

	Yields (kg/ha)	Increase (kg/ha)	Increase (%age)	Value: cost ratio
Control	1,742	-	-	-
N	2,036	294	17	2.2
P	2,129	387	22	4.3
K	1,993	251	14	3.4
NP	2,473	731	42	4.2
NK	2,129	387	22	2.4
PK	2,407	665	38	4.8
NPK	2,702	960	55	4.3
$N_2P_2K_2$	2,899	1,157	66	3.6

Price of rice: $0.20 per kg paid to the farmer.

As shown in the last column of the table, the value: cost ratio all 8 fertilizer treatments pay, the best of them being P with 4.3, NP with 4.2, PK with 4.8 and NPK with 4.3.

Ivory Coast

Banana: In experiments with the NPK formulas 5-12-24, 9-13-18 and 10-15-20, applied in quantities of 400 - 800 - 1200 - 1600 kg/ha, the following results have been obtained: the best increases by 1200 kg/ha of the formula 5-12-24 (= 60 N, 140 P_2O_5 and 280 K_2O), applying this formula already in the second year, a yield of 54 tons per hectare of bananas was obtained compared with 21 tons per hectare on the plot without fertilizers.

Coconut palm: IRHO reports the following experimental results:

	Without fertilizers	1.5 kg per palm MP per year
Number of nuts per palm and year :	22	43
Weight of copra/palm/year (kg):	3.2	7.5

Oil-palm: General treatment is an NK mixture up to about the fourth year. From that time on, 1 - 1.5 kg MP per palm is normally used. No remarkable effect has been found with phosphate but a number of fertilized plots have shown magnesium deficiency. Yield increases from 2 tons per hectare to 10 tons per hectare have been obtained in experimental stations.

Ghana

Cocoa: The Cocoa Research Institute, Tafo, is carrying out trials with fertilizers and different types and grades of shade on cocoa. A fertilizer application of 46 kg/ha N, 70 kg/ha P_2O_5 and 50 kg/ha K_2O gave nearly a ten-fold increase in 5 years on non-shaded plots from 300 kg/ha to 3,000 kg/ha. The effect of fertilizers is about half on the plots with full shade. The best fertilizer effect was achieved from phosphorus. The results available so far show that fertilizers should only be applied and will show their full effect if combined with improved management practices. Although reduction of the shade results in an immediate increase of cocoa yield, the significance of the loss of organic matter has to be considered. Work on 23 cocoa soils, representing the major cocoa regions in Ghana, showed that averages of 50 – 95% of the total phosphorus, 95% of the total nitrogen and over 95% of the total sulphur of these soils were found in organic matter.

Maize: 150 trials were carried out on maize farms in 5 maize growing districts. The responses to 12 kg/ha N were high in three out of the five districts. The double quantity of N gave a further 30% increase, = 700 kg/ha. The response to phosphorus combined with either N or K was in general low. However, in one district a phosphorus rate of 12 kg/ha together with 25 kg/ha N gave a response of more than 80% over control, = 830 kg/ha. Increases due to potassium alone were only obtained in one district. In all districts the application of 40 kg/ha K_2O together with N and P increased the yields considerably.

FAO Fertilizer Programme

The purpose of the FAO Fertilizer Programme is to increase the application of the technically and economically right types of fertilizers in West Africa.

The Fertilizer Programme has to provide the governments with realistic figures for the planning of the development of fertilizer application in the country as a whole and to give advice on this field.

Principles

(a) The Programme is based on previous experimental results available in all the countries taking part. It is considered as a complement to previous research work with a very practical aspect. It can be estimated that about one third of the work is research and about two thirds is demonstration and extension work.

(b) A very wide basis for the Programme has been chosen, including much larger numbers of trials and demonstrations than have been done before. All fields are outside the experimental stations on farmers' fields under practical farming conditions.

(c) The quantities per acre of plant nutrients have been chosen according to the economic minimum which gives still a relatively high yield increase. The results should be immediately practicable.

(d) The crops covered by the Fertilizer Programme so far are mainly annual ones: maize, millet, guinea corn, rice, groundnuts, yams, cassava, beans and vegetables. As far as possible, fields have been selected on which improved varieties are already grown and improved methods of cultivation applied. However, the percentage of these is not more than 5% of the total number of trials and demonstrations.

(e) The extension aspect of the Fertilizer Programme is taken very seriously because the practical demonstration of fertilizer effects on the farmers' own fields are the best means of extension and publicity for fertilizer application.

(f) The execution of the Fertilizer Programme makes it essential that a close co-operation be maintained between research on one hand and agricultural extension on the other.

The following countries are taking part in the Fertilizer Programme in West Africa at present: Ghana, Togo, Nigeria, Senegal and Gambia. We are in contact with some other West African countries concerning planning of experimental work and exchange of experiences.

Five other countries in West Africa are on the waiting list for participation in the Programme.

The total number of trials and demonstrations laid out in West Africa to date is 15,500. The full results are available now up to minor season 1963/64. The harvest of the major season trials 1964 is not yet completed.

The technical and economic results presented below are from the major seasons 1962 and 1963.

Ghana

Maize 87 trials, NPK 22.5 - 22.5 - 22.5 Kg/ha
$N_2P_2K_2$ 45 - 45 - 45 Kg/ha

	Yield increase		Net return	VCR +
	kg/ha	%	$/ha	
Control	1080	-	75.60	-
N	262	24	9	2.0
P	277	25	10	2.1
K	284	26	16.5	5.6
NP	416	38	11	1.6
NK	346	32	11.5	1.9
PK	467	43	20.5	2.6
NPK	676	62	27.5	2.3
$N_2P_2K_2$	857	79	19	1.5

+ VCR = Value: Cost Ratio = Value of the increased yield divided by the cost of the fertilizers.

Rice 16 trials, NPK 22.5 - 22.5 - 22.5 kg/ha
$N_2P_2K_2$ 45 - 45 - 45 kg/ha

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	955	-	95	-
N	563	59	47.10	6.1
P	673	70	57.90	7.2
K	508	53	47.60	15.9
NP	893	94	70.70	4.8
NK	1036	109	91.10	8.3
PK	1382	145	125.60	10.9
NPK	1740	182	152.60	7.5
$N_2P_2K_2$	2158	227	172.20	4.9

Yams 14 Trials, NPK 22.5 - 22.5 - 22.5 kg/ha
$N_2P_2K_2$ 45 - 45 - 45 kg/ha.

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	6057	-	170	-
N	1743	29	40	5.4
P	1690	28	38	5.2
K	350	6	6.5	3.0
NP	1352	22	20	2.6
NK	2415	40	55.5	5.4
PK	1926	32	41.5	4.3
NPK	3062	51	64.5	4.0
$N_2P_2K_2$	3538	58	56	2.3

Groundnuts 46 Demonstrations, P_1 22.5 P_2 45 kg/ha

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	1334	-	165	-
P_1	374	28	36	4.5
P_2	783	59	76	4.7

Best fertilizer treatments (technically and economically).

Maize: NPK 22.5 - 22.5 - 22.5 kg/ha gives a 62% increase over control and a VCR of 2.3.

Rice : NPK 22.5 - 22.5 - 22.5 kg/ha gives a 182% increase over control and a VCR of 7.5.

Yams : NPK 22.5 - 22.5 - 22.5 kg/ha gives a 51% increase over control and a VCR of 4.0

Groundnuts: P 45 kg/ha gives a 59% increase over control and a VCR of 4.7.

Latest results indicate a favourable effect with additional 10 kg/ha N.

N i g e r i a

Maize 49 Trials, NPK 22.5 - 22.5 - 22.5 kg/ha
$N_2P_2K_2$ 45 - 45 - 45 kg/ha

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	1268	-	53.0	-
N	360	28	7.0	1.8
P	397	31	8.6	2.0
K	341	26	10.6	3.4
NP	440	34	2.5	1.1
NK	470	37	8.5	1.7
PK	402	31	5.0	1.4
NPK	426	33	-1.0	0.9
$N_2P_2K_2$	463	36	-16.0	0.5

Rice: 29 Trials, NPK 22.5 - 22.5 - 22.5 kg/ha

$N_2P_2K_2$ 45 - 45 - 45 kg/ha

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	1400	-	140	-
N	312	22	23	3.8
P	313	22	22.6	3.6
K	310	22	27.6	9.1
NP	314	22	14.5	1.8
NK	280	20	16.5	2.4
PK	437	31	32	3.6
NPK	398	28	21	2.1
$N_2P_2K_2$	559	40	18	1.5

Yams : 34 Trials, NPK 22.5 - 22.5 - 22.5 kg/ha

$N_2P_2K_2$ 45 - 45 - 45 kg/ha

	Yield increase kg/ha	Yield increase %	Net return $/ha	VCR
Control	9362	–	262	–
N	2372	25	59	8.4
P	3579	27	63.6	9.5
K	2128	22	56.6	18
NP	3604	38	84.5	6
NK	3013	32	72.5	7.5
PK	2359	25	54	5.5
NPK	3159	33	69	4.5
$N_2P_2K_2$	3455	36	59	2.6

Best fertilizer treatments

Maize The combinations of nutrients have not proved economic on local varieties. They pay however on improved varieties.

N, P and K at 22.5 kg/ha give an average increase of 30% over control and a VCR of between 1.8 and 3.4.

Rice PK at 22.5 kg/ha with an increase of 31% over control and a VCR of 3.6.

NPK at 22.5 kg/ha with an increase of 28% over control and a VCR of 2.1.

Yams NP 22.5 kg/ha with an increase of 38% over control and a VCR of 7.5.

NPK at 22.5 kg/ha with an increase of 33% over control and a VCR of 4.5.

Senegal

Rice 14 Trials, NPK 22.5 – 22.5 – 22.5, kg/ha
$N_2P_2K_2$ 45 – 45 – 45 kg/ha

	Yield increase		Net return $/ha		VCR	
	kg/ha	%	Unsubsidized	Subsidized	Unsubsd.	Subsd.
Control	1436	–	114.90	114.90	–	–
N	500	35	32.30	35.70	5.2	9.3
P	375	26	23.00	26.00	4.2	7.5
K	396	27	27.70	29.70	7.9	15.3
NP	467	32	22.70	28.10	2.6	4.0
NK	553	38	32.50	37.90	3.7	7.0
PK	471	32	26.70	31.70	3.1	6.3
NPK	628	44	31.50	39.40	1.5	4.9
$N_2P_2K_2$	1179	82	56.90	72.70	2.5	4.3
N_2	871	61	54.30	61.10	4.5	8.2
N_2P_2	885	61	4.40	52.20	2.4	3.8

Millet. 19 Trials, NPK 22.5 – 22.5 – 22.5 kg/ha
$N_2P_2K_2$ 45 – 45 – 45 kg/ha

	Yield increase		Net return $/ha		VCR	
	kg/ha	%	Unsubsidized	Subsidized	Unsubsd.	Subsd.
Control	609	–	48	48	–	–
N	395	65	23	27	4.4	7.8
P	316	52	16	20	2.8	5.0
K	314	52	22	23	12.0	24.0
NP	482	79	21	28	2.4	4.2
NK	372	61	20	23	3.2	4.8
PK	339	56	15	20	2.4	4.3
NPK	529	87	23	30	2.3	3.7
$N_2P_2K_2$	629	103	12	27	1.3	2.2
14-7-7 (270kg/ha)	514	84	21	34	2.1	6.7
14-7-7 (540kg/ha)	653	107	12	39	1.3	4.6

Groundnuts 66 Demonstrations, NPK

	Yield increase		Net return		VCR	
	kg/ha	%	Unsub.	Sub.	Unsub.	Sub.
Control	1046	-	94	94	-	-
6-20-10 (135 kg/ha)	287	27	17	19	2.8	4.0
6-20-10 (270 kg/ha	315	30	9	15	1.5	2.1
8.3-8.3-8.3 (135kg/ha)	313	30	19	21	3.0	4.3
8.3-8.3-8.3 (270 kg/ha)	318	30	11	16	1.6	2.2

Best fertilizer treatments

Rice N 22.5 kg/ha gives an increase of 35% over control and a VCR of 5.2 (unsubsidized) and 9.3 (subsidized).

N 45 kg/ha gives an increase of 61% over control and a VCR of 4.5 (unsubsidized) and 8.2 (subsidized).

NPK 45-45-45 kg/ha treatment with 82% increase over control gave the highest increase but it was less economic.

Millet N 22.5 kg/ha gives an increase of 65% over control and a VCR of 4.4 (unsubsidized) and 7.8 (subsidized)

NP 22.5 kg/ha gives an increase of 79% over control and a VCR of 2.4 (unsubsidized) and 4.2 (subsidized)

NPK 22.5 kg/ha gives an increase of 87% over control and a VCR of 2.3 (unsubsidized) and 3.7 (subsidized)

Groundnuts 6-20-10 (135 kg/ha NPK) gives an increase of 27% over control and a VCR of 2.8 (unsubsidized) and 4.0 (subsidized)

8.3-8.3-8.3 (135 kg/ha) gives an increase of 30% over control and a VCR of 3.0 (unsubsidized) and 4.3 (subsidized).

As the Fertilizer Programme is not yet finalized, the following conclusions should be considered as preliminary.

1. The increases per unit of plant nutrient are usually larger than expected under average farming conditions. The total average increase of all experiments carried out within the Fertilizer Programme in West Africa is 65% over non-fertilized plots. For comparison, the average increase in 1962 in the Near East Fertilizer Programme with comparable quantities of fertilizers per hectare, was 42%. In Northern Latin America, the average increase of 83% over control has been achieved by a double dose of fertilizers on an average.

The biggest West African average increase in 1962 was in Ghana (79% over control.) In Senegal the average increase was about 10% less and in Nigeria about 30% less.

2. Trials carried out with increasing does of the three plant nutrients NPK show that under average conditions the biggest increase of yield is achieved by the first 20 kg per hectare of each plant nutrient. There is a further considerable increase between 20 and 40 kg/ha which is usually also economic but the yield curve flattens considerably between 40 and 60 units of plant nutrients and is almost horizontal between 60 and 80 units. As soon as improved varieties are used and the methods of cultivation improved, and of course also in irrigated areas, larger quantities of fertilizers per hectare are justified.

3. The results in all West African countries, with a few exceptions, show that two plant nutrients give a higher increase than one and that three plant nutrients give more than two. In the forest, N gives the main increase but there is a further economic increase with an addition of P. In the savannah, the P effect is the biggest but the addition of N gives a further increase. The

increases by combination of NK and PK were lower. When NP is combined with K, there is a considerable and economic increase in 60% of the trials.

4. There was not much <u>interaction</u> between the different plant nutrients but usually a simple additive effect. Potash however shows in many cases a clear interaction; potash alone has generally no effect or on rice in many cases a depressive one, but potash in combination with NP usually shows a very good effect in the forest but to a fairly large extent also in the savannah.

5. <u>Importance of plant nutrients</u>

<u>N.</u> There is a widespread N deficiency throughout the forest area but also in the savanna N has proved very useful. N is the nutrient which is often used alone on irrigation projects (Office du Niger and Richard Toll). Considering the whole of West Africa, the N requirements seem to be highest in the forest near the sea, becoming less in the savanna and compared with P becoming less in the Sudanian and Sahelian zones.

<u>P.</u> The first importance of P is outside the forest in the savanna and north of it. P is used quite often alone especially in Northern Nigeria on groundnuts and is recommended at a ratio of about 3 parts to 1 part N in countries such as Niger, Upper Volta and Mali. It has been found however that in general P is also very efficient in the forest, and in general in a smaller quantity than N.

<u>K.</u> In contrast to widespread belief, the results of the FAO Fertilizer Programme show effects of potash in many areas. Potash is usually needed in high rainfall areas but its effect is also striking for instance on rice in the savanna. Coconut and oil palm, which are not covered by the Fertilizer Programme, are the only crops to show a proved effect by applications of potash alone.

6. Deficiency symptoms have been observed in large numbers on the plots with unbalanced fertilizer application, for instance N deficiency PK plots and P deficiency on NK plots and so on.

7. There are of course variations in the nutrient requirements of the different crops but mainly between legumes and non-legumes. The experiences of the Fertilizer Programme show for instance that the differences should not be over-estimated for practical purposes. In Ghana for instance it was found that the best fertilizer treatment for such different crops as maize and yams is 22.5 - 22.5-22.5 NPK kg/ha.

8. Under shifting cultivation, fertilizer application showed advantageous effects from the first year after clearance of the land.

9. The general effect obtained up to now indicates that for planning the development of fertilizer application, one should think from the beginning in terms of the three plant nutrients N, P and K. The deficiency symptoms observed already in the first year after unbalanced treatments, demonstrate how poor the available plant nutrient reserves are.

10. Economic aspects: The main factors influencing the profitability of fertilizer application are: price of fertilizer, the increase achieved by a certain quantity of fertilizer and the price for the increased yield achieved by the farmer. In the above tables the term value:cost ratio (VCR) is generally used. This is the value of the yield increase by fertilizers, divided by the cost of the fertilizer, for instance: if the value of the increased rice yield is $100 per hectare and the cost of fertilizers for one hectare rice is $20, the value: cost ratio is $100 ÷ 20 = 5. This means that $1 invested in the purchase of fertilizers gives the farmer

5 back from the increase yield, or a net profit of $4. There is a general understanding that because of the risks a fertilizer application should be considered as economic only if there is a minimum value:cost ratio of 2, which means 100% net profit.

(a) The figures in the tables show that although there are considerable variations from one crop to another and from country to country, most of the crops pay when the right type of fertilizer is applied: in Ghana it is already certain that fertilizer pays on all crops except cassava where it is sometimes doubtful because of the very variable market value.

(b) In Nigeria unfortunately one of the main crops, maize, only pays when improved varieties are used. As most of the maize is by far still the local variety, fertilizer on this crop is recommended only cautiously. Cassava is also doubtful. Fertilizer on other crops normally pays. In Northern Nigeria the heavy fertilizer subsidy makes certain that fertilizer application is an economic proposition to the farmer.

(c) In Senegal, the profitability of fertilizer application is normally assured but also in Senegal fertilizers carry a heavy subsidy which makes their application a good business for all farmers.

(d) An important point is not only the question of whether fertilizer application pays or not but simply the problem of whether the small farmer is able and willing to spend money on fertilizers at all. If he has not got the money for the fertilizer and he cannot get fertilizer on credit, he will not buy fertilizers, regardless whether fertilizer application pays or not. Therefore the Fertilizer Programme is trying to find the technically justifiable minimum quantity of fertilizer per hectare in order to bring the fertilizers purchase within the financial reach of the small farmer. It seems that the 20-20-20 NPK level is the compromise between the technical and financial requirements.

11. Extension aspects: Fertilizers applied on the farmers' own fields are the most efficient way of interesting the farmers. It is estimated that on an average at least ten farmers have seen one of the fertilizer fields, which would mean that up to now about 150,000 farmers have seen the effect of fertilizers through organized field days. In addition, many farmers see the fields on their own. Based on practical experience on the field, additional means of extension have been used to reinforce the effect: meetings at different levels, films, radio broadcasts in vernacular, simple leaflets.

Many farmers although hesitant at the beginning, showed a surprisingly keen interest in buying fertilizers. In fact there is at present disappointment among farmers who want to buy fertilizers but cannot get them.

As the Fertilizer Programme, and in connection with it, the extension activities, are still going on, we are in many areas in the position of someone who makes a good propaganda for goods which are not available. As the effect of propaganda does not usually last very long and is only efficient when used immediately, the lack of fertilizer sales might cause some serious disappointment in the long run among the farmers.

12. Fertilizer recommendations: In Senegal and Ivory Coast there is a list of fertilizer recommendations available for the main crops throughout the country. These recommendations are re-checked from time to time on the basis of new experimental results. In the

other West African countries there have not so far been complete fertilizer recommendation lists. In Ghana a pretty complete one has recently been drawn up by evaluation of fertilizer experimental results available up to now in the country, including FAO Fertilizer Programme results. The recommendations take into consideration the technical and economic points of view and also the difficulties which would arise if the things were made too complicated for practical use.

Fertilizer recommendations are available in Northern Nigeria but in the southern part of the country they are still under consideration.

The availability of clear fertilizer recommendations has proved to be one of the pre-conditions for increasing the fertilizer application.

IV. Development of fertilizer application in West Africa

The application of fertilizers by West African farmers started in 1949/50 in Senegal and Nigeria. The following figures give the development in West Africa from 1956/57 to 1961/62 according to FAO statistics:-

	t. N.	t. P_2O_5	t. K_2O
1956/57	5465	2490	3635
57/58	4627	2301	3518
58/59	3897	3440	3353
59/60	3037	3327	2514
60/61	3505	1357	3736
61/62	3065	3466	3709

Most of the fertilizer is used as mixtures, except in Northern Nigeria where most of it is used as straight single superphosphate and sulphate of ammonia.

The biggest fertilizer consumption in West Africa at present is in Senegal which has developed its fertilizer application as follows:

1949	130 tons fertilizer
53	3371
58	5772
63	37701

In Ivory Coast, the consumption has developed as follows:

1953	1813 tons fertilizer
58	7589
60	13489

Official figures are not available after this date.

The development of fertilizer application in Nigeria is as follows:

1960	8125 tons fertilizer
62	19568

Most of it is used in Northern Nigeria but the fertilizer application in southern Nigeria is increasing considerably.

In Ghana up to 1962, the annual consumption was usually a few hundred tons but the application is increasing now.

1963	4000 tons fertilizer
64	5500

An additional quantity of about 4,000 tons of fertilizer in all per year is used at present in Liberia, Mali, Sierra Leone, Gambia and Togo.

The overall NPK ratio is roughly 1 - 1 - 1 except in Northern Nigeria where it is NP at approximately 1 - 3. The total application in 1964 in West Africa is around 80,000 tons fertilizer. This represents roughly the following quantities in plant nutrients:

6,000 tons N

8,000 tons P_2O_5

6,000 tons K_2O

Of the straight nitrogen fertilizer, about 75% is sulphate of ammonia, the rest urea and ammonium nitrate. Of the phosphate fertilizer, 80% is single superphosphate, the rest triple superphosphate and dicalcium phosphate. Of the potash fertilizer, 95% is muriate of potash, the rest sulphate of potash.

V. Possibilities for increased fertilizer application

Generally speaking and according to our experience, the main difficulties for increasing fertilizer application in West Africa are not so much on the side of research and extension as quite clearly on the items distribution and marketing and related subjects. These points need an active improvement. Besides these there are some factors which are connected with fertilizer application but their improvement is more a long term one:

Land tenure: The fact that many farmers cultivate rented land and contracts are often for a very short term, could prevent many of them from investing something in the soil. However, the generally recommended fertilizer quantity gives an immediate effect in the year of application. Therefore the difficulty with land tenure should not be too serious, in fact we have found in Ghana that farmers apply fertilizers almost regardless of whether they are cultivating their own land or rented land. One should not wait to recommend fertilizers on rented land until conditions have been basically changed because this could last for a long time.

The newly created big farm units such as co-op farms, state farms require fertilizers more urgently than others and in bigger quntities because they have changed to continuous cultivation by using ploughs.

Irrigation: Besides the very big irrigation areas (Office du Niger in Mali and Richard Toll in Senegal), there is so far no irrigation of major importance in West Africa. There are plans under way in connexion with the Volta Lake project in Ghana but the total area of land under controlled irrigation, which is at present not more than 50,000 ha, will not be more than 100,000 ha in the foreseeable future.

Research: Research in the field of fertilizers could do even more by putting the main emphasis on applied research instead of on basic research. There will always be a certain part of the work which is not for immediate practical application but experimental stations should not only concentrate on work inside the station. Some kind of extension work should always be included which also means continuous direct contact with practical agriculture and the possibilities of different types of fertilizers under different conditions and at different levels.

Extension: As indicated in the summary about the FAO Fertilizer Programme there are much larger possibilities for an extension service in contributing to a higher fertilizer application. It should be relatively easy to introduce fertilizer to the big farm units with continuous cultivation but the main work will always be introduction of fertilizers to small farmers. The general belief that small farmers cannot be convinced to use fertilizers should not always be used as an excuse for one's own inefficiency. In each extension service there should be full-time fertilizer officers from the top at least down to the district level. Experience in Ghana shows the excellent effect of a full-time fertilizer staff near the farmer.

Fertilizer campaigns have proved to be quite successful when based on practical field demonstrations and combined in an intensive way with other means of extension and publicity such as field days and rallies at different levels, filmshows, radio broadcasts, simple leaflets and even articles in the press. This seemed to be important because not only the farmer but also people in the ministries have to be convinced and informed about the importance of fertilizers in their country.

Distribution of fertilizers: According to our experience in West Africa, the key problem for an increased fertilizer application is the distribution to the individual farmers. If this can be improved, the problem of increased fertilizer application as a whole will be bascally solved.

Quite a number of attempts have been made on a nationwide basis or in parts of countries or concentrating on certain crops, to introduce fertilizers. Most of them have been more or less frustrated, mainly because the effect of a fertilizer campaign has not been followed up intensively by commercial activities for fertilizers sales to the farmers.

The most striking positive example of what can be done is Senegal. There, the right combination of a fertilizer extension campaign plus distribution facilities has been found. Another example of this kind is Northern Nigeria. In both cases, however, the fertilizer is heavily subsidized and mainly used on the export crop groundnut.

The Pilot Schemes for fertilizer distribution which started in Ghana in 1963 and in Western Nigeria in 1964, are trying very hard to introduce practically unsubsidized fertilizers for all crops of interest, local and export ones. These schemes are being carried out in limited areas and should serve as examples for others. Particularly in Ghana the first scheme gave the initial impulse for an increasing fertilizer application in many parts of the country. The distribution of fertilizers to bigger farm units is usually not difficult but as the large number of small farmers represent still the bulk of the agriculture and will do in the near future, much more emphasis should be placed on them.

As experience shows in other parts of the world with predominantly small farmers, the most logical and efficient way is to organize fertilizer distribution by an intensive system of supply and marketing co-operatives. In Japan for instance the whole agriculture would not function without this. In India the influence of this type of agricultrural co-ops is increasing. Already existing co-ops could be used or reactivated and new ones formed.

Once such an organization is working on the village level, besides fertilizers other aids such as seeds, plant protection materials and tools could be distributed, and credit and marketing of agricultural products orgazized. Material such as fertilizer at fair prices could be supplied, and the farmers should get fair and stable prices for their products. These things cannot be done from one year to the next, but as a certain basis already exists, this system could be extended greatly. Development in this direction seems especially advisable as a number of related problems are solved by it at the same time.

Subsidies: The fertilizer consumption so far is highest in those countries where there is a fertilizer subsidy:

Senegal	50% subsidy.
Northern Nigeria	60% subsidy.

The financing of the subsidy is possible because the crop for which the fertilizer is mainly used, groundnut, is an important export crop in both countries. It might be more difficult, however, to finance a fertilizer subsidy for locally used crops. As far as is known, no subsidy is in sight for these in the near future.

Types of fertilizers: The fertilizers sulphate of ammonia (SA) (20%N), single superphosphate (SS) (18% P_2O_5) and muriate of potash (MP) (60% K_2O) are still the most suitable fertilizers under the many and varied conditions in tropical agriculture from the points of view of their chemical and physical properties. There is, however, the low concentration of plant nutrients of SA and SS. As the transport in these countries is very costly, the low concentration has a strong influence on the profitability of these fertilizers.

Comparing SA with Ammonium Nitrate (AN)

Northern Nigeria

1 t. SA CIF Apapa: $50
Freight from harbour to farmer: $45
Total $95 for 200 kg N = $0.48 per 1 kg N

1 t. AN CIF Apapa $72
Freight from harbour to farmer: $45
Total $117 for 330 Kg N =$0.35 per 1 kg N

Therefore 1 kg N as Ammonium Nitrate in Northern Nigeria only costs 73% of the N in Sulphate of Ammonia.

Northern Ghana

1 t. SA CIF Tema $50
Freight from harbout to farmer: $36
Total $86 for 200 kg N =$0.43 per 1 kg N

1 t. AN CIF Tema: $72
Freight from harbour to farmer $36
Total $108 for 330 kg N =$0.33 per 1 kg N

Therefore 1 kg N as Ammonium Nitrate in Northern Ghana only costs 76% of the N in Sulphate of Ammonia.

Comparing SS with Triple Superphosphate (TS)

(Northern Nigeria)

1 t. SS CIF Apapa $50
Freight from harbour to farmer: $45
Total $95 for 180 kg P_2O_5=$0.53 per 1 kg P_2O_5.

1 t. TS CIF Apapa:	$100	
Freight from harbour to farmer:	$ 45	
Total	$145 for 460 kg P_2O_5 =	$0.32 per 1 kg P_2O_5

Therefore 1 kg P_2O_5 as TS in Northern Nigeria only costs 60% of the P_2O_5 in SS.

Northern Ghana

1 t. SS CIF Tema:	$ 50	
Freight from harbour to farmer	$ 36	
Total	$ 86 for 180 kg P_2O_5 =	$0.47 per 1 kg P_2O_5
1 t. TS CIF Tema:	$100	
Freight from harbour to farmer:	$ 36	
Total	$136 for 460 kg P_2O_5 =	$0.30 per 1 kg P_2O_5

Therefore 1 kg P_2O_5 as TS in Northern Ghana only costs 64% of the P_2O_5 in SS.

In fact there is a general world tendency towards the higher concentrated nitrogen and phosphate fertilizers.

When mixing SA, SS and MP mechanically at the common ratio of 1 - 1 - 1, the highest concentration of 100 kg mixture is about 28 kg plant nutrients. Calculated on the CIF basis Tema, plus mixing and rebagging costs, 100 kg NPK mixture 1 - 1 - 1 fertilizer i.e. with total 28 kg nutrients in 1964, costs \$7 (\$5.6 + 1.4). 100 kg of a ready made compound 15-15-15 (i.e. 45 kg nutrients per 100 kg fertilizer) in 1964 costs \$9 CIF.

The kilo of plant nutrient costs in the mechanically mixed fertilizer $0.25 and in the compound $0.20. Besides this the compound fertilizers are well bagged, well granulated and have therefore usually a better keeping quality. The financial advantage of the higher concentrated compound becomes more striking when adding the costs of transport to the farmer in for instance <u>northern Ghana</u>:

1 t. mechanical mixture 1-1-1 :	$70	
Freight harbour to farmer:	$36	
Total	$106	for 280 kg plant nutrients
		= $0.38 per kg plant nutrient

1 t. compound:	$ 90	
Freight harbour to farmer:	$ 36	
Total	$126	for 450 kg plant nutrients
		= $0.28 per kg plant nutrient

The costs of the compound delivered to the farmer are only 74% of the costs for the mechanical mixture.

As the number of fertilizer recommendations at the present stage has to be very limited for practical reasons and the 1-1-1 ratio covers a large part of the requirements, the concentrated compound fertilizers can be of great advantage.

Experiments, particularly in Northern Nigeria and Northern Ghana, show that the sulphur content of SA and SS has a considerable importance in increasing yields, in fact the superiority of these fertilizers is based on their sulphur content in widespread areas. Higher concentrated fertilizers are usually without sulphur. The new possibilities recently described by Samuel L. Tisdale, might help to get higher concentrations plus sulphur. These include, among others, a urea/sulphur product combining molten sulphur with molten urea and prilling. Ammonium phosphate + sulphate (16-20-0) is already well-known. There is a strong development of the suitable ammonium phosphate-elemental sulphur and triple superphosphate elemental sulphur assemblages. In many cases bulk blended goods containing elemental sulphur are added to complete high analysis granular or pulverized materials. L. Tisdale recommends an average elemental phosphorus to sulphur ratio of 1.3 : 1.0 for fertilizer to be used in sulphur deficient areas.

Packing requirements: The quality of fertilizers and of their packing material has special importance in the tropics where there are usually no adequate storage facilities. As the fertilizer is used by the farmers after the rains have started, the lack of dry storage quite often spoils the quality of the fertilizers, which becomes wet and very hard. The ideal fertilizer would be a granular high concentrated compound in a strong and absolutely waterproof plastic bag, which could even be stored in the open. Some experience in this matter has been collected in 1964 in the pilot scheme for fertilizer distribution in Ghana where strong plastic bags without jute outer bags were used quite successfully.

Summarizing the possibilities for increased fertilizer application in West Africa, it is clear that the whole system does not work without a very active support from the respective governments. More and more economists and politicians see the possibilities which fertilizers offer for the development of their country. They also see that the matter of increased fertilizer application cannot be considered on its own but that the fertilizer application can serve as the motive power behind a series of developments which all go in the direction of general improvement of agriculture.

VI. Estimated fertilizer requirements by 1970

According to FAO statistics, the fertilizer application in West African countries between 1956 and 1961 was nearly static, about

40,000 tons total fertilizer with a plant nutrient content of approximately 3,000 tons each of N, P and K. From 1961 to 1964, the total West African fertilizer application went up to about 80,000 tons total with 6,000 tons N, 8,000 tons P and 6,000 tons K.

The strong tendency for progress in agriculture in all West African countries also shows in the newly increasing fertilizer application. In spite of this encouraging increase, the kg. of plant nutrients per hectare of arable land is still below one, which is a negligible amount, compared for instance with the United Arab Republic, which uses 74 kg plant nutrients per hectare of arable land.

In the whole of Africa, West Africa is the part which still has to catch up most. The tendency of the last few years could be the beginning of such an intensive development.

Increased agricultunal productivity is necessary, not only to meet the full food demand of the present and the rapidly increasing population; increased productivity per person and per hectare is in the interest of the economy of the countries and of the individual farmers.

The following estimated figures are based partly on known development plans in West African countries but it is also assumed that in the years to come, more plans for increased agricultural productivity will be launched which will include higher fertilizer application.

Estimated Fertilizer Requirements for 1970 in West Africa in tons of plant nutrients, N, P_2O_5 and K_2O

Country	t. N	t. P_2O_5	t. K_2O	Total ($N + P_2O_5 + K_2O$)
Nigeria	12000	16000	8000	
Cameroun	5000	2000	5000	
Chad	500	800	500	
Niger	500	1000	500	
Dahomey	500	500	500	
Togo	500	500	500	
Total I	19000	20800	15000	54,800
Ivory Coast	5000	5000	5000	
Ghana	10000	10000	10000	
Upper Volta	500	500	500	
Liberia	1000	1000	1000	
Sierra Leone	200	200	200	
Total II	16700	16700	16700	50,100
Senegal	8000	12000	8000	
Mauretania	100	100	100	
Mali	1000	1000	1000	
Guinea	2000	2000	2000	
Portuguese Guinea	100	100	100	
Gambia	200	200	200	
Total III	11400	15400	11400	38,200
Grand total	47100	52900	43100	143,100
In round figures	47,000	53,000	43,000	

Compared with the consumption in 1964, with a total of 20,000 tons plant nutrients, the estimates for 1970 are about seven-fold.

Summary

1. Most of the West African soils are classified as latosols with the exception of tropical black and brown earths which are very scarce. The latosols are characterized by reddish colours and stable micro-aggregation which permits free drainage. The clay fraction is based mainly on kaolinitic minerals with iron and aluminium oxides. The great majority of latosols are developed over quartoze rocks: prominent among them are the granites and gneisses of the basement complex, acidic schist and phylites, sandstones, shales and unconsolidated deposits.

2. The fertility status of West African soils is in general low. The organic matter content and exchange capacity are low to very low, the pH of the top soils lies usually between 5.5 in the forest and 7.2 in the savanna. The content of nitrogen and phosphorus is usually low, phosphorus particularly in savanna. The potassium content is low, mainly in the high rainfall areas. There is a widespread deficiency of sulphur in the savanna and a magnesium deficiency in the forest. There is normally no calcium deficiency and no urgent micro-nutrient problem caused yet. The level of yields is low, for instance 700 kg/ha maize and 5,000 kg/ha yams.

3. The role of fertilizers in West Africa is becoming more important although fertilizer works best in combination with other improved production factors. It has been estimated that 50% of the yield increase in the last 100 years are due to fertilizer application. Organic manure would be of much use but in practice almost does not exist.

4. The experimental results presented from different countries are mostly from experimental stations and the FFHC Fertilizer Programme. The total average increase in West Africa is 65% over non-fertilized plots. The increases are highest in Ghana (79% over control).

Under West African conditions, the first 20 kg of plant nutrient per hectare give the highest increase. The second 20 kg give a further considerable and economic increase. With quantities of plant nutrients above 40 kg/ha, the increases decline.

Under West African farming conditions, the low level of 20-20-20 kg/ha NPK is recommendable from the technical and economic points of view. This low treatment pays in most cases except on local maize and cassava in Nigeria and cassava in Ghana.

The fertilizer trials and demonstrations are used intensively for extension purposes and the results serve as a basis for fertilizer recommendations.

5. The total <u>fertilizer consumption</u> in 1961 in West Africa was 40,000 tons, containing 3,065 tons N, 3466 tons P_2O_5 and 3709 tons K_2O. The consumption had increased by 1964 to 80,000 tons fertilizers containing 6,000 tons N, 8,000 tons P_2O_5 and 6,000 tons K_2O.

6. The main <u>possibilities for increased fertilizer application</u> consist of applied research and intensive fertilizer extension work, but first of all in an improved distribution system for fertilizers to the individual farmers, including supply, credit and marketing facilities. Subsidies, higher concentrated fertilizers and improved packing could also contribute.

7. Considering the general improvement in West African agriculture, it has been estimated that by 1970 the following quantities of plant nutrients could be used in West Africa: 47,000 tons N; 53,000 tons P_2O_5 and 43,000 tons K_2O.

Literature

1. ECA Report of the West African Industrial Co-ordination Mission. Addis Ababa, 1964.

2. FAO Africa Survey. Rome 1962.

3. FAO. Fertilizers, an annual review of world production, consumption and trade. Rome, 1962.

4. FAO. The Fertilizer Economy of the Asia and Far East Region. Rome, 1960.

5. FAO. Fertilizer Use - Spearhead of Agricultural Development. Rome, 1963.

6. FAO. Report of the First Meeting on Soil Fertility and Fertilizer Use in West Africa. Rome, 1963.

7. FAO, FFHC Fertilizer Programme Review of Trial and Demonstration Results, Rome, 1961/62 and 1962/63.

8. Hauck, F.W. Fertilizers on Rice in some West African countries. L'Agronomie Tropicale, No.8, August 1963.

9. Hauck, F.W. Fertilizers in Progressive Agriculture. Accra, September 1963.

10. Ignatieff V. and Page H.J. Efficient Use of Fertilizers. FAO, Rome, 1962.

11. Nye, P.H. and Greenland D.J. The soil under shifting cultivation. Commonwealth Agricultural Bureau, Farnham Royal, Bucks. England 1960.

12. Ofori, C.S. The role of fertilizers in increasing agricultural productivity in Ghana. Kumasi, 1962.

13. Sulphur Institute News. April 1964.