FEDERAL MINISTRY OF WATER RESOURCES
AND RURAL DEVELOPMENT

UPPER NIGER RIVER BASIN AND RURAL
DEVELOPMENT AUTHORITY
MINNA

REPORT ON FERTILITY SOIL SURVEY OF SWASHI IRRIGATION PROJECT

SUBMITTED BY

SOIL MANAGEMENT UNIT,
DEPARTMENT OF OPERATIONS
UNRB & RDA, MINNA.

DECEMBER, 1995.

TABLE OF CONTENTS

1.0 INTRODUCTION:

1.1 Swashi Irrigation Project is one of the giant and most viable irrigation projects within the jurisdiction area of the Authority. It is located at Swashi, a village in Borgu Local Government Area of Niger State.

1.1.1 Soil fertility survey of the project came up betwe 30th November, 1995 and 3rd December, 1995. It would be remembered that this exercise was not the first of its kind that would be carried out in the area. Fertility soil survey similar to this exercise took place in May, 1993 and since that time the land of the area has not been re-examined to ascertain the fertility and hence this is one of the reasons why the Authority directed that the soil fertility survey be done in November. Besides this directive, in the recommendation made in respect of last fertility and soil conservation assignment it was recommended that after two cropping seasons fertility of the soil of this project should be rechecked in order to keep the land in productive conditions. So, this fertility survey scheduled for Nov., was very timely and quite desirable.

1.2 The objectives of fertility soil survey conducted were:

(a) To examine and collect for analysis representative surface soil samples of the project area from the depth of 0 - 15cm, covering nine sector areas (about 2,800ha.),

(b) To reassess erosion and other soil management problems capable of undermining the productivity of the project vast agricultural land with a view to recommending appropriate management measures to arrest the problems,

(c) To evaluate again soil fertility conditions of the soil of the project area and make appropriate fertilizer recommendations based on soil analytical findings,

(d) To make recommendation for other soil management measures that will ensure a profitable and sustainable crop production in the area and;

(e) To establish a soil fertility data bank for the Authority for future references.

1.2.1 Field activities in respect of the survey involved going round the whole of the project area to acquaint with the entire site conditions (reconnaissance survey). During reconnaissance survey it was discovered that there were eleven (11) sector areas in the entire project site, apart from the areas not suitable for irrigation but suitable for tree crops. Reconnaissance survey was made successful through assistance rendered by the Senior Tractor Operator of the scheme, Mallam Adamu Jibril (Dogo). He took me round the whole site and each sector was satisfactorily examined and sampled accordingly.

1.2.2 Each of the sector areas was taken as a sampling block and from each of them soil samples were collected with a soil auger and a hand trowel to a depth of 0 - 15cm. A randomised system of fertility soil sampling in accordance with FAO/UNESCO guidelines was used and all soil samples collected from each sector were later bulked to obtain a representative sample of the sector. Each of the representative soil samples was labelled before final disengagement from the field. At this juncture my appreciation also goes to Mallam Sanni Shehu, the Security Guard and Alhaji Ladan, the Principal Irrigation Superintendent for their spirited efforts and useful contributions before commencement of field works and for overwhelming technical assistance they rendered during the field survey of the project.

1.2.3 Preliminary soil survey was followed by augering, sampling and collection of soil samples already discussed in the preceeding sections. And before leaving the field site conditions such as slope, drainage, topography, vegetation, present land-use and human influence in respect of each of the sector areas were carefully observed and noted down to form parts of this report.

1.3 PRETREATMENT OF SOIL SAMPLES:

Having collected the samples from the field, they were prepared in the way of pretreatment before sending them to the laboratory for analysis.

The pretreatment involved air-drying them for 3 - 4 days after which they were subjected to grinding with a porcelain mortar and pestle and sieving them with a 2mm-mesh soil sieve.

2.0 LABORATORY ANALYSIS OF SOIL SAMPLES:

Altogether, there were twelve (12) representative soil samples collected for fertility tests from the field (Appendix A-1) and immediately after sample preparation was accomplished (pretreatment), they were sent to the laboratory for physical and chemical analyses. In the laboratory each of the samples was tested for the following physical and chemical parameters. Viz:-

(i) Soil P^H (Soil reaction)
(ii) Particle-size distribution analysis
(iii) Exchangeable cations or bases
(iv) Exchangeable acidity
(v) Cation Exchange Capacity
(vi) Organic Carbon
(vii) Available Phosphorus and;
(viii) Total Nitrogen.

The following standard laboratory methods were used for the analysis.

2.1 SOIL P^H:

The P^h of each of the soil samples was determined in a 1:2½ ratios, i.e. soil: solution suspension ratios of water and 1N Kcl respectively. The P^H was later read with a glass electrode P^H meter.

2.2 PARTICLE-SIZE DISTRIBUTION ANALYSIS:

Particle-size distribution analysis was done by employing hydrometer method which involved the use of neutral sodium hexametaphosphate (calgon) as dispersing agent.

2.3 EXCHANGEABLE CATIONS:

The exchangeable cations in the soil samples were extracted with 1.0N NH_4OAC at P^H 7.0 (neutral ammonium acetate solution) and determined by the use of a flame analyser.

2.4 EXCHANGEABLE ACIDITY:

This was determined by titrating filterates of soil samples treated with 1N Kcl (potassium Chloride) and 0.01N NaOH (Sodium hydroxide).

2.5 ORGANIC CARBON:

Organic carbon was determined by the use of Walkey-black method, a wet combustion method that involves the oxidation of organic matter with $K_2 Cr_2 O_7$ (potassium dichromate) and 10N concentrated H_2SO_4 (sulpharic acid).

2.6 AVAILABLE PHOSPHORUS:

The available P was determined using Bray 1 method that employs a mixture of 1N NH_4F (Ammonium Fluoride) and 0.5N Hcl (Hydrochloric acid). Then the colour absorbance read colorimetrically on the spectronic 20 spectrophotometer.

2.7 TOTAL NITROGEN:

Total Nitrogen was determined using the common micro-kjeldahl procedure of Bremmer Black, 1965.

2.8 PERCENTAGE BASE SATURATION (PBS)

This was derived by taking exchangeable sodium, for instance, as a percentage of the total CEC of each soil sample.

2.9 EXCHANGEABLE SODIUM PERCENTAGE (ESP)

The ESP on the other hand was derived by first dividing the value of Na^+ by CEC value of each respective analysed sample and then multiplying by 100%

$$\text{Thus, ESP} = \frac{Na^+}{CEC} \times \frac{100\%}{1}$$

3.0 RESULTS OF ANALYSIS AND GENERAL FERTILITY STATUS OF THE PROJECT AREA:

3.1 SOIL TEXTURE

The texture of soil of the area is generally light with the percentage of sand averaging about 60%. However, in all, three textural classes were encountered in the field. They are sandy loam (SL), Loam (L), and Sandy clay loam (SCL). Sandy loam is dominated in samples collected from sectors 101, PF 103^A, 103^B, 104, 105, 203^B and 206.

Loam texture is characterised by samples obtained from sectors 102 only while sandy clay loam is dominated in samples from sectors 202, 105^B, 203^A and 204. Based on the three textural classes encountered it could be reasonably described that while soils from sandy loam and loam sector areas are well-drained, porous and have low retentive capacity, soils from sectors with sandy clay loam texture are relatively poorly drained especially during the peak of rainy season and have

moderate to high water retention capacity. In terms of aeration and water circulation within surfacial layer examined for fertility studies the soils are okay.

3.2 SOIL p^H:

The p^H values of the soils are still within desirable limits for crop production ranging from 5.0 - 6.50 in most of the sector areas. Liming of the sectors is therefore not necessary except sector 203^A which is strongly acid in reaction. Raising the p^H of the soil in this sector (203^A) above 4.0 p^H value therefore can increase phosphorus adsorption due to the increase in hydrolysis of Al^{3+}, Fe^{2+} and Mn^{2+} that are likely to be present in large quantities at such a low p^H value and below.

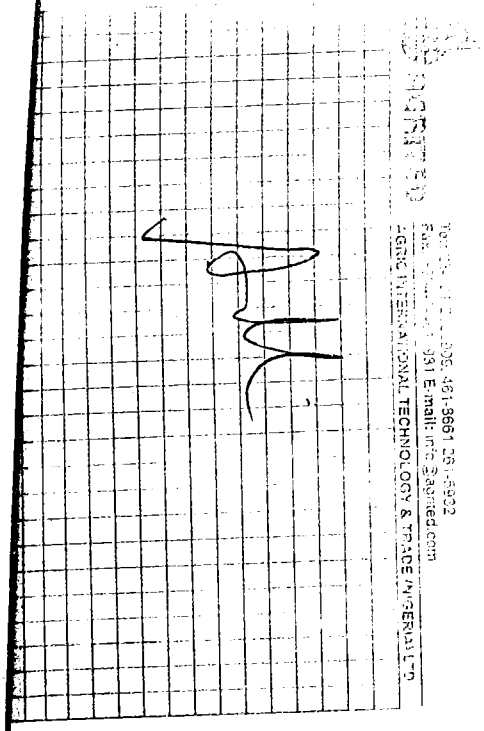
3.3 EXCHANGEABLE CATIONS:

The exchangeable sodium (Na) in meq./100g soil is within the low range which is required of sodium for crop growth. Furthermore, the exchangeable K is high in sector areas 101 and 102 respectively. But it is found to be very low in sectors 103^A, 104, 105^A, 105^B, 202, 203^A, 203^B, and 204 and low in other sectors. So there has to be a supplement for potassium on those plots because lack of K could lead to lodging in grain crops coupled with attendant poor growth.

Calcium on the other hand is very low in all the sector areas and they all need calcium supplements in order to improve crop performance. Magnesium is low in sectors PF 103^A, 103^B, 105^A, 105^B, 204 and 206 but moderate in other sectors, so Mg has to be supplemented in plots where it is inadequate.

3.4 BASE SATURATION:

The average base saturation percentage of all the samples is very high averaging quite above 90%. Base saturation is generally related to the soil p^H and to the level of soil fertility.



OSPHORUS:

lable phosphorus of most of the soil sector areas 102, PF 103^A, 104, 202, 203^A, is moderate. So it is not necessary orus to such plots and so also to sectors which are relatively high in available P 06 and 105^B in which P is very low might nt of phosphorus to raise its level in

:

c matter of most of the sectors is ranging from moderate to high with the exception of few plots like 206, 203^A and 104 where their organic matter is low so the level of organic matter in such plots need to be raised to desirable level.

3.7 TOTAL NITROGEN:

Total Nitrogen in some sector areas like 103^{B} and 104 is low so it needs to be supplemented in these plots. But in sectors 101, 202, 203^{B} and 204 is moderate while other sectors are between medium and high in N level.

3.8 CATION EXCHANGE CARACITY (CEC):

The highest CEC value in all the samples was recorded in sample from sector area 203^{A} which is 6.01 meq./100g soil and this is still regarded as being very low, so CEC is generally very low and is dependent on the P^{H} of the soil. The analytical results of all these parameters are presented in the analysis result table on page 16.

4.0 PHYSICAL ENVIRONMENT AND PRESENT LAND USE:

4.1 The area covered with fertility soil survey is located in the savannah vegetation zone. The area falls within the catchment of Swashi basin and other rivulets draining from the North-South directions into the main river (R.Swashi). The immediate surrounding areas along the river is characterised by rock Boulders and stones. These make it not to be suitable for tractorised farming. However, it has promising potentials for growing tree crops like Cashew, Mango (in some locations) and Guava. Apart from rocky and stony nature of these areas they are also badly gullied and very undulating in topography.

4.1.1 The geology of the area is generally basement complex of granitic and basaltic materials. In terms of topography of the farm plots (sector areas), they are generally gentle sloping and relatively flat terrain. As at the time of fertility survey harvesting of cereal crops such as rice (on sectors 103 and 203) and maize, sorghum, guineacorn, cotton, groundnut and planting of Onion in the upland portions of the field both on the left bank main canal and some part of right bank main canal was in progress. Some of the participating farmers on the scheme were observed to be practising mixed farming, i.e. cultivation of cereals and rearing of livestock within the project area. There were also evidences of bush burning which might hinder the fertility of soil.

5.0 FERTILIZER RECOMMENDATIONS:

5.1 The following fertilizer recommendations are made on the basis of presently available fertilizer formulations in the country and fertility status of individual sector areas. In this case while some recommendations are generalised due to absence of certain plant nutrients attempt is also made to make special fertilizer recommendation for some sector areas observed to be somewhat poor in fertility.

5.1.1 For rice production, 250kg/ha of NPK 20-0-20 (about 5 bags) is still recommended and should be applied at least one week before transplanting.

But it is better worked well into the soil during land preparation. Thereafter, this should be followed by 200kg or 4 bags/ha of CAN in two equal doses, the first dose at about 2 - 3 weeks after transplanting and the second dose at about 6 - 8 weeks after transplanting. Application of CAN would ensure bringing Ca content observed to be generally low in the area to optimum level for good crop performance.

5.1.2 For Maize, Sorghum and Guineacorn, 200kg/ha of NPK 12-12-17 + 2MgO is recommended for application at land preparation followed by 200kg or 4 bags/ha of CAN applied 4 - 6 weeks later. CAN could be replaced by Urea $(NH_2)_2$ CO at the rate of 150kg/ha if available. But then NPK 15-15-15 or NPK 20-0-20 could also replace NPK 12-12-17 +2MgO if available although there is no point in applying P containing fertilizer material to the soil that already has gotten more than enough of available P. However, in sectors 206 and 105^B NPK 15-15-15 would be ideal because of low level of available phosphorus. If NPK 20-0-20 is not available a better alternative is KNO_3 (Potassium Nitrate) applied at the rate of 100kg/ha.

5.1.3 For Groundnut, cowpea, soyabean (leguminous crops) it is recommended that 100kg/ha. of KNO_3 be applied as a starter ration due to adequate available P. But in plots 206 and 105^B application of NPK 12-20-20 +2MgO is recommended to supplement inadequate available phosphorus in the two sectors.

5.1.4 For Onion production, apply 200kg or 4 bags/ha of CAN at nursery. Nitrogen fertilizer should be applied to the field plots in two equal doses at 2 - 3 weeks and 6 - 7 weeks after transplanting. In the field plots if CAN is not available then apply Urea at 150kg/ha together with 100kg/ha. of SSP. If FYM (Farm Yard Manure) is also available, it may be applied at the rate of 5 - 6 t/ha. together with 125kg/ha. of SSP in the alternative.

5.1.5 For Sunflower production, basal dressings of P and K should be applied about 3 days before planting at the rate of 225kg/ha. of SA, 250kg/ha. of SSP and 68kg/ha. of MOP. This should be followed by top-dressing with 50kg/ha. of sulphate of ammonia (SA) 3 - 4 weeks after planting.

5.1.6 For Sugarcane production, 250kg/ha. of Urea or 400kg/ha. of CAN should be broadcast and worked into the soil before laying the sugarcane cuttings. This should be combined with 150kg/ha. of MOP applied by broadcasting before laying of sugarcane cuttings. Sugarcane would thrive well in plots 103 and 203. These fertilizer recommendations are only valid for the next two cropping seasons. After two cropping seasons soils of the area must be subjected to a fresh fertility test to ascertain their nutrient status.

6.0 GENERAL OBSERVATION AND RECOMMENDATIONS:

6.1 Most of the badly eroded plots observed during the 1993 fertility and conservation soil survey were observed in the just concluded fertility survey to

be rapidly stabilizing in the field. But to forestall any problem in the stability processes it is recommended that all eroded surfaces in the field should remain fallow so that grasses would be allowed to grow in them (gullies) naturally.

6.2 It was also observed that bush burning was an increase in the field and since bush burning is not a good soil management and conservation practice it therefore follows that burning of natural vegetation which protects soil surface against erosion agents (run-off and wind) should be controlled within the project area. Some of the water conveyance structures (canals) in the field were also observed to be inefficient in delivering water to the field when irrigating field plots and in this case there is the need for the structures to be rehabilitated as a matter of urgency.

6.3 On plot 101 seepage losses of water under the bunds of field main canal in the left bank and secondary field canal also in the left bank were noticed and as such the observed bunds with defects need to be raised and compacted during rehabilitation works in the field so that seepage losses are checked permanently.

6.4 Also the activities of nomads and their cattle were observed in the project area which if not controlled now could lead to destruction of farm structures as well as crops. To this end, the activities of farm animals (livestock) should be controlled to the barest minimum while peasants

practising mixed farming (crop and animal production) on the scheme should be educated.

6.5 Farm plots 103 and 203 were observed to possess good potentials for sugarcane production and as a result it is recommended that sugarcane should be given a trial on these two plots in the next growing season. Fertilizer recommendation in respect of sugarcane production has been given under section 5.1.6.

RATING FOR SOIL FERTILITY CLASSES

NITROGEN (TOTAL N):

Low	-	Less than 0.15% N.
Medium	-	0.15 - 0.20% N.
High	-	greater than 0.20% N.

PHOSPHORUS (BRAY 1-P)

Low	-	less than 8ppm.
Medium	-	8 - 20 ppm.
High	-	greater than 20ppm.

POTASSIUM (EXCHANGEABLE K):

Low	-	less than 0.20 meq./100g soil
Medium	-	0.20 - 0.40 meq./100g soil
High	-	greater than 0.40 meq/100g soil

ORGANIC MATTER (% O.M.)

Low	-	less than 2.0%
Medium	-	2.0 - 3.0%
High	-	greater than 3.0%

SOURCE: Fertilizer Use and Management practices for crops in Nigeria (1989) series No.2.

REFERENCES:

1. Nelson and Tisdale (1975) Soil Fertility and Fertilizers.
2. Rusell, E. W. (1980) Soil Conditions and Plant Growth.
3. Foth, H. D. (1984) Fundamentals of Soil Science.
4. Young, A. (1980) Tropical soils and soil survey.
5. Cottenie, A. (1980) Soil and Plant testing as a basis for fertilizer recommendation, FAO Bulletin No. 38.
6. Fertilizer Use and Management Practices for Crops in Nigeria, FMAWR & RD Fertilizer Publication, (1989).

SWASHI IRRIGATION PROJECT FERTILITY SOIL SURVEY
LABORATORY SOIL ANALYSIS RESULTS

Soil Sample Collector: J. A. Oladiro
(Soil Conservationist)

1.	SOIL SAMPLE NO:	101	102	103^{A} (PF)	103^{B}	104	105^{A}	105^{B}	202	203^{A}	203^{B}	204	206
2.	Depth of Sampling (Cm)	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15	0-15
3.	MECHANICAL ANALYSIS:												
	Sand (%)	52.0	48.0	58.0	64.0	76.0	68.0	64.0	52.0	50.0	54.0	74.0	73.0
	Silt (%)	31.0	35.0	25.0	21.0	11.0	17.0	11.0	23.0	23.0	30.0	5.0	14.0
	Clay (%)	17.0	17.0	17.0	15.0	13.0	15.0	25.0	25.0	27.0	16.0	21.0	13.0
4.	Textural Classes (USDA)	SL	L	SL	SL	SL	SL	SCL	SCL	SCL	SL	SCL	SL
5.	SOIL REACTION (P^H):												
	$P^H - H_2O$ (Ratio 1:)	6.50	6.00	5.70	5.70	5.70	5.90	5.50	5.60	4.80	5.80	5.80	5.80
	P^H - Kcl (Ratio 1:2½)	4.40	4.20	4.10	4.00	3.90	3.90	4.10	4.40	4.00	5.00	5.00	4.90
6.	Organic Carbon (%)	1.48	0.76	1.10	1.52	0.84	1.68	1.08	1.40	0.84	1.68	1.40	0.52
7.	Organic Matter (%)	2.55	1.31	1.86	2.62	1.42	2.90	1.86	2.42	1.45	2.90	2.42	0.90
8.	Total Nitrogen (%)	0.14	0.18	0.25	0.09	0.07	0.22	0.20	0.13	0.17	0.14	0.11	0.21
9.	EXCHANGEABLE CATIONS (Meq/100g Soil)												
	Ca	2.00	2.20	1.20	1.00	1.80	2.00	2.00	2.60	3.20	2.20	1.00	1.60
	Mg	1.40	1.20	0.60	0.80	1.60	1.00	0.80	2.60	2.00	2.00	0.80	1.00
	K	0.71	0.36	0.23	0.26	0.10	0.15	0.	0.20	0.23	0.20	0.23	0.26
	Na	0.23	0.22	0.26	0.23	0.17	0.22	0.23	0.17	0.22	0.13	0.17	0.13
10.	Exchangeable Acidity (Al &H)Meq/100g Soil	0.16	0.20	0.16	0.16	0.08	0.20	0.12	0.12	0.36	0.20	0.12	0.20
11.	Cation Exchange Capacity (CEC)	4.50	4.18	3.45	2.45	3.75	3.57	3.19	5.69	6.01	4.73	2.32	3.19
12.	Base Saturation (%)	96.4	95.2	94.3	95.5	97.9	94.4	99.0	94.4	94.0	95.9	94.8	93.7
13.	Exchangeable Sodium Percentage (ESP)	15.80	5.30	7.50	9.40	4.53	6.20	7.21	4.00	3.70	3.75	7.32	4.10
14.	Available Phosphorus (BRAY-1)(PPM)	21.00	11.20	8.80	41.00	8.80	5.60	2.80	14.00	9.80	11.20	[illegible]	2.80
15.	Lime Requirement (Tonne/ha.)	-	-	-	-	-	-	-	-	1	-	-	-

*NOTE:

SL - Sandy Loam
L - Loam
SCL - Sandy Clay Loam
PF - Plot Farm.

Annalysed by: Mall. A. Muhammed,
M. Sulaiman,
[illegible],
(Lab. Tech. in Soil/Soil Lab.)