FEDERAL MINISTRY OF WATER RESOURCES

AND RURAL DEVELOPMENT

UPPER NIGER RIVER BASIN AND RURAL

DEVELOPMENT AUTHORITY

MINNA

AGRICULTURAL SOIL SURVEY OF THE LEFT BANK

OF

SWASHI RIVER IRRIGATION PROJECT

SUBMITTED BY

SOIL MANAGEMENT UNIT

DEPARTMENT OF OPERATIONS

UNRB & RDA, MINNA

SEPTEMBER, 1998

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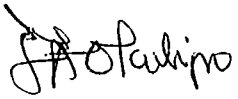

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1.0 INTRODUCTION

1.1 In an attempt to appraise the agricultural soil potentials and limitations of Swashi rive *Irrigation Project, the soil management unit of the Authority moved to the site in the first weel of July, 1998 following the approval and directive received from the Authority that the Agricultural soil survey of the left bank area of the project should be conducted.*

1.1.1 As common with any agricultural soil test and investigation, the primary objective of conducting the survey in the left bank was to examine, appraise and determine the physical and chemical characteristics of agricultural soils from the surface down to the subsoil, i. e.to the depth of between 100cm (1.0m) and 150cm (1.5m). On the other hand, the soil survey was also intended to examine other physical land limitations such as erosion (land degradation) with a view to recommending appropriate soil management measures to curtail such limitations or problems in the field. This was in addition to determining the suitability or otherwise of soils and water for sustainable irrigated agriculture in the project area.

1.2 LOCATION OF PROJECT AREA

1.2.1 Swashi Irrigation Project is located at Swashi, a rural settlement in Borgu Local Government Area of Niger state. The area lies between latitudes 10° 15′ N and 10° 30′ N and between longtitudes 4° E and 4° 12′ E on the map of the Federal Republic of Nigeria.It is about 90km away from New-Bussa (Kainji) and about 60km away from Wawa.

1.2.2 Swashi village is at about the middle-way between Wawa and Rofia. The project area is presently connected with a good motorable road (at present) to other adjoining towns such as Wawa and Kainji.

2.0 METHODOLOGY OF SOIL SURVEY

2.1 Before commencement of fieldwork, existing available record showed that detailed agricultural soil investigation (survey) of the area had not been previously conducted. There were no data or information related to the soils of the area except the soil conservation survey report produced by the soil management unit in 1993 and the subsequent soil fertility survey report submitted by the same unit in 1995. Hence, in our preliminary investigations, these two separate reports together with the literature of some nearby towns and villages were thoroughly reviewed.

2.1.1 Also, the aerial photographs were not available for the area at the time of carrying out the survey except a 1:25,000 scale project general layout map (DRG. No. C-KP/52/02) produced by MALAYSIA INTERNATIONAL CONSULTANTS (NIG.) LIMITED (1982). This 1:25,000 scale map was extensively used in the field as base map and from it, relevant soil and land classification map was produced as part of this report.

2.1.2 Due to the fact that the area has been opened up for farming over the years and land clearing accomplished by the Authority at the beginning of the project the combination of which has given rise to plain farmland, the method of soil survey employed was 'loose' grid system of soil survey. Thus, traversing was done in each clearly defined sector area and along permanent land and irrigation features and structures in order to delineate soil boundaries, locate soil profile pits and collect soils samples.

2.2 AREA COVERED BY SOIL SURVEY AND PARAMETERS COVERED INSOIL TESTING

2.2.1 The agricultural soil survey covered the entire irrigable land in the left bank main canal of the scheme with total hectrage of about 1405.4Ha. In this left bank area covered there are five (5) sectors or plots and the area of each of the prominent five sectors is given as follows:

Sector 101----------336.14 ha.

Sector 102---------- 96.79 ha.

Sector 103----------553.80 ha.

Sector 104---------- 86.94 ha.

Sector 105----------331.73 ha.

2.2.2 Having located each sector area and having completed field reconnaissance, soil investigation began with auger borings. Auger holes were drilled to 100cm-(1.0m) depth using Dutch-eyed hand propelled soil auger. Soil profile pits were excavated to 150cm (1.5m) depth or to impenetrable layer and described in accordance with FAO guidelines (1977), and at each site, slope, vegetation, relief, landuse, topography, cropping pattern, cropping history, etc. were also observed and noted down for the purpose of this report.

2.2.3 Soil samples were collected for physical and chemical analysis (fertility evaluation) in the laboratory. Each soil sample was tested for texture (mechanical analysis or particle-size distribution test), pH (soil reaction), Exchangeable cations (Ca, Mg, K, Na), Exchangeable acidity, Cation Exchange Capacity (CEC), Total nitrogen, Organic matter, Base saturation, ESP, Electrical conductivity (Ec x 10^6 mhos/cm), Available phosphorus, etc. using standard laboratory procedures.

2.2.4 The routine laboratory procedures or methods employed for analysis are as follows:

2.2.5 Particle-size distribution analysis (texture) was determined in the previously air-dried soil samples that had been sieved through a 2mm-test sieve, using the hydrometer method. Sodium hexametaphosphate (Calgon) $Na(HPO_4)_6$ was used as dispersing agent.

Then the textural triangular method of USDA was used to classify the soil data thus obtained into texture groupings.

2.2.6 The pH (soil reaction) was determined using the glass electrode pH meter in soil : water and soil : KCl of soil : solution suspension ratio $1:2^1/_2$.

2.2.7 The Exchangeable cations (Ca, Mg, K, Na) were extracted by using 1N neutral ammonium acetate (NH_4OAC) at pH 7.0 and determined using Gallenkamp Flame photometer for K and Na and Ca and Mg determined by titration.

2.2.8 The Exchangeable acidity (H & Al) was determined by titrating filtrates of soil samples treated with 1N Potassium Chloride (1N KCl) with 0.01N Sodium Hydroxide (NaOH) and phenolphthalein used as indicator.

2.2.9 The cation exchange capacity (CEC) was determined by first saturating the exchange sites of the soil with Mg^{2+} ions provided in a 1N Magnesium acetate solution of pH 7. Then the saturating Mg^{2+} ions were displaced from the exchange sites with a 1N NaCl solution; the Mg^{2+} ion thus displaced was determined by titrating with 0.05N Na-EDTA.

2.3.0 The Total nitrogen was determined using the modified micro-kjedahl method of Bremmer Black (1965).

2.3.1 Organic carbon was determined by acid dichromate digestion in concentrated sulphuric acid. The digest was then titrated with ferrous ammonium sulphate using diphnylamine as indicator. The organic matter was then calculated from the organic carbon data obtained.

2.3.2 The Exchangeable Sodium Percentage (ESP) was derived by taking the value of exchangeable sodium in each sample as a percentage of cation exchange capacity, i.e. ESP = $Na^+/CEC \times 100/1$ %

$$= \frac{\text{Exchangeable sodium} \times 100\%}{\text{Cation Exchange Capacity}}$$

2.3.3 The Electrical conductivity (Ec x 10^6 mhos/cm) was determined in a $1:2^1/_2$ ratio extract, i.e. soil : solution suspension and conductivity read using a conductivity meter.

2.3.4 The Available Phosphorus (P) was determined using Bray 1 method that uses a mixture of 1N NH_4F (Ammonium Fluoride) and 0.5N HCl. Then the colour absorbance was read colorimetrically on the spectronic 20 electro-photometer.

2.3.5 Water sample was also collected from the project to determine its suitability or otherwise for agricultural purpose (irrigation) in the field. The water sample obtained was similarly subjected to tests in the laboratory to determine certain parameters as pH (Acidity or Alkalinity), total dissolved solid, chloride, bi-carbonate, conductivity, sodium adsorption ratio

(SAR), sulphate, etc. The tests were conducted in accordance with existing standard laboratory guidelines.

2.3.6 The results of laboratory analysis of the various selected soil samples and water sample of the irrigation project are presented in sections 5.0 and 5.1.0 of this report

3.0 PHYSICAL ENVIRONMENT

3.1.0 The project area is situated in the Guinea savannah (middle-belt) vegetation zone of Nigeria. The area falls within Kainji Lake Basin. The left bank area where the soil survey took place has a nearly level to gently undulating or rolling topography. The terrain rises from the left bank of River Swashi upward with the slope extending gradually and increasing into the adjoining project sectors. However, the immediate area along the river boundary is associated with rock boulders, stones and gullies. Hence, this part had been marked for tree crop production due to its rocky nature and other topographical defects.

3.1.1 Generally, the left bank area is characterised by relatively flat and low-lying terrain (sectors 101, 102 and 103) and gently undulating to rolling terrains (sectors 104 and 105) respectively.

3.2 CLIMATE

3.2.1 The climate of the project area is based largely on data for Kainji (New-Bussa) meteorological station. It is hot tropical climate with essential features of high temperature (T^{o}) all the year round and a pronounced wet and dry season. Rainfall is generally more than evapo-transpiration beginning from late April and terminating in October in an average year. The average annual rainfall around this area is about 1600mm.Therefore, rainfall, temperature (T^{o}), humidity, solar radiation, amount of sunshine and length of the day are not limiting factors for crops commonly grown in the project area.

3.3 GEOLOGY

3.3.1 Geologically the project area is covered by 1:200,000 scale geological map of Nigeria (Fed. Ministry of Mines and Power, 1974). The area is underlain by undifferentiated basement complex and sandstone of Nupe formation, the Nupe sandstone being positioned on the basement complex.

3.3.2 This has largely contributed to the sandy nature of the soils of the area. The area is drained into River Swashi, the only major river that passes between the Left Bank and Right Bank projects in the area. Rocky soils and gravely soils are prominent along the river boundary and are very shallow in depth.

3.4 PRESENT LANDUSE

3.4.1 Presently, grain crops such as rice, maize, sorghum (Guinea corn), millet, bean (cowpea) and soybean are commonly grown in the left bank project area. The area also supports cultivation of vegetables such as tomato, pepper, onion and okro especially in the dry season (under irrigation farming). Crops like cotton and groundnut have also been introduced to the area and are reported to be performing quite encouragingly. So, essentially in the left bank project area agricultural landuse is intensively increasing.

3.5 SOILS OF THE AREA

3.5.1 The soils of the left bank project area range between coarse textured and medium textured due to their sandy nature. For instance, the average surface soils of the area are between 70% and 80% in sand content. Apart from textural compositions, the soils also occur in the upland (drier part) and in the lowland with relatively flat terrains (wet part) as could be seen in plots 101, 102 and103 (pilot farm, PF). In this case, adequate drainage must be ensured in order not to make these parts of the field vulnerable to waterlogging.

3.5.2 The soils of the area fall under the general grouping of Ultisols (USDA soil order). Ultisols are basically similar to Alfisols but are much more developed, weathered and leached than the Alfisols. Most Ultisols in the Guinea savannah zone are developed on the Nupe sandstone and from Precambrian crystalline Basement complex rocks found mainly in this vegetation zone with rainfall averaging about 1600mm annually. The organic matter content and CEC (cation exchange capacity) are low and reflect the kaolinitic and oxide clay mineralogy.

3.5.3 The surface soil reaction, (pH) generally ranges between very strongly acid and slightly acid, making the soils to be rather acidic and nutrient impoverished. Ultisols are highly weathered soils and could range from well-drained to poorly drained depending on the soil moisture regime and physiographic position of the land. They are moderately deep to well deep soils and highly leached.

3.5.4 At the lowest level of classification, two series were recognised. These are Typic Paleustults and Aquic Haplustults.

3.5.5 Typic Paleustults are well deep and well-drained soils occupying major parts of sectors 104, 105 and little portion of the upper end of sector 101 in the left bank project. They have dark brown to dark reddish brown sandy and loamy sand surfaces over yellowish red to red sandy loam subsoils. The soils have a soil reaction (pH) of very strongly acid (pH 5.0-6.8). The exchangeable bases are low and CEC is correspondingly low.

Available Phosphorus is also low while organic matter and total nitrogen are low. Generally, the base saturation percentage of this soil encountered in the field ranges from moderate to

high. These soils are found in the middle slope of the project area in the left bank. They support maize, sorghum, cotton, onion, tomato, groundnut, cowpea and millet.

3.5.6 Aquic Haplustults, on the other hand, are moderately deep and poorly drained. They are found in the lower slope (low-lying parts of the field) in sectors 101, 102 and 103. They have dark reddish grey loamy sand surfaces over pinkish grey and light grey sandy clay loam subsoils with yellowish red mottles. The soil reaction (pH) is very strongly acid for both surface and subsurface soil materials.

3.5.7 The exchangeable cations are low to moderate for Ca and Mg but low for K and Na. The CEC values are low while the % base saturation is high to very high. Major crops grown in this part of the field are rice, maize and vegetables.

3.6 LAND CAPABILITY CLASSIFICATION

3.6.1 Land capability classification is the grouping of lands into standard classes and subclasses according to their suitability for irrigation and their capability for crop production. The purpose of land classification for irrigation is to provide an assessment of arable land and indicate their present limitations and degradation while assessing their agricultural potentials.

It differs from; land suitability classification in that it has a broader assessment of the land and does not narrow down to a particular use or crop as in the of suitability classification system.

3.6.2 Land capability classification system used for the left bank project is the modified USDA soil conservation system (SCS) of land capability classification for the Northern states of Nigeria in combination with FAO standard system.

3.6.3 In the left bank project, One major land capability class with two land subclasses was observed. The major class is **class II** arable land. The subclasses land are:

3.6.4 **IIsw**, which is the land with, light surface texture, poor internal drainage and light flooding problem at certain periods of the year. This land occupies major parts of sectors 101, 102 and 103 especially around pilot farm. It is occupying about 986.73ha. of the total arable land in the left bank project. It is moderately deep, but will require some land management measures such as drainage facilities and land levelling to keep it in productive condition.

3.6.5 **IIst** are the soils that have coarse, medium to light surface texture. They have deep soil depth but occur on gently sloping terrain with slight micro-relief. They are well-drained but slightly susceptible to erosion hazards due to topographic position of the land and their texture. This land group occupies most parts of sectors 104 and 105 in the left bank. Application of good management measures such as crop rotation and growing of cover crops among others, would help keep the land in profitable and sustainable state.

4.0 FERTILITY STATUS OF THE AREA

4.1 The chemical properties of any soil that could affect its suitability for irrigation are acidity, fertility and salinity. From the results of soil analysis presented in section 5.0 of this report, there are grossly imbalances in the nutrient status of the soils of the project area.

4.1.1 The soil reaction (pH) of most of the soils ranges from very strongly acid to strongly acid. Except in sector 105A where slightly acid (pH 6.8) was recorded. These pH values are giving one a serious concern since most other parameters are pH dependent. The detail of fertility status of the area is presented in section 5.0. The result of surface water quality is also presented in section 5.1.0 of this report.

4.2 FERTILIZER RECOMMENDATIONS

4.2.1 Fertilizer and soil management practices recommended for the left bank project in this report are strictly guided by the soil quality results (i.e. the results of analysis) as presented in section 5.0 and by the existing soil management practices and fertilizer formulations in the country.

4.2.2 As pointed out earlier on, chemical analysis of selected soil samples of left bank project showed that the soils in this part of Swashi Irrigation Project are rapidly tending towards acidity. To curtail this problem, proper soil management practice should be adopted as soon as possible. The only area in the left bank with very low acidity level at present is the north eastern part of sector 105 (i.e. 105A). The pH here is 6.8 that is quite ideal for crop production.

4.2.3 However, at present soils of any sector area in the left bank with pH level less than 5.5 should be limed at the rate of 1tonne/ha using dolomitic limestone. Dolomitic limestone which contains calcium and magnesium (Ca-$MgCO_3$) is recommended.

4.2.4 For the supply of Nitrogen and Calcium that are both generally inadequate in most of the soil samples, calcium ammonium nitrate (CAN) is recommended at the rate of 250kg/ha. Single superphosphate (SSP) is recommended in addition to CAN at the rate of 100kg/ha to supply phosphorus.

4.2.5 If CAN and SSP are not available, NPK 10-20-20 +2MgO is recommended at the rate of 250kg/ha to supply the three major nutrients and magnesium that are lacking. For now application of Urea fertilizer $(NH_2)_2 CO$ should not be encouraged in the field because of its acidic nature. However, nitrogenous fertilizers must not be applied to leguminous crops since they have ability to fix nitrogen by themselves.

4.2.6 For improvement of organic matter observed to be very low in the soil, a deliberate policy of prohibiting bush burning in its entire ramification should be embarked upon. In this case, all weeds and crop residues after each harvest should be incorporated into the soil and

not allowed to be set on fire in the field. In addition, progressive crop rotation policy that involves rotating of cereals and leguminous crops should be adopted forthwith. Leguminous crops could also be rotated with vegetable crops to improve organic matter content of the soil. Improving organic matter would go a long way to improve the CEC of the soil since CEC is organic matter and pH dependent.

4.2.7 For exchangeable cations or bases and CEC that are very low in the soil, fertilizer and management practices recommended in this report should be strictly adhered to in order to improve their levels in the field.

4.2.8 With respect to salinity, none of the soils of the area is saline since Ec and Na^+ index are very low. Therefore, salinity is not a constraint for crop production in the left bank project at present. The soils would be re-checked again after two active growing seasons to determine the pH levels.

4.3 OTHER RELEVANT OBSERVATIONS AND RECOMMENDATIONS

4.3.1 While in the field the following observations were made.

Field analysis showed that sectors or plots 104 and 105 in the left bank are gently rolling in topography. Their subsoils were also observed to be moderately rich in Al^{3+} and Fe^{3+} and as a result they were observed to possess outstanding potentials for tree crop cultivation such as mango, cashew and guava in addition to arable crops (cereals) that could be grown. Therefore, production of tree crops such as mentioned here should be given a trial in the area.

4.3.2 Night storages in form of farm lakes or ponds were similarly observed in plots 104, 105 and some parts of 101. These night storages appeared to have good potentials for fisheries and so we suggest that they (farm ponds) should be converted to fishponds to serve as a source of revenue generation for the Authority.

4.3.3 Left bank farm road was in deplorable condition as at the time of this assignment in the field. The road calls for rehabilitation and upgrading urgently otherwise it might become impassable with time if nothing is done to improve its condition.

4.3.4 Field canals and drainages are not also in good condition. They should be improved to prevent outbreak of drainage and salinity problems especially in the low-lying areas of the field such as plots 101, 102 and 103 where topography could encourage collection of runoff.

To prevent possible outbreak of soil erosion especially in the plots associated with rolling topography, contour farming (i.e. contour cultivation) should be adopted as part of soil management practices. Moreso, overgrazing by farm animals within the vicinity of farm should not be encouraged.

4.3.5 For anyone visiting Swashi Irrigation Project on official assignment for the first time, i.e. for anyone not familiar with the project area, to locate each plot or sector area of the project

would prove difficult. Because the arrangement pattern of farm plots at present does not allow for this but rather make identification of sectors difficult, especially for a stranger or visitor. Therefore, for easy identification and accessibility of field sectors, we recommend that project signboards and field sector or plot demarcation boards should be provided as a matter of urgency. Each sector should have its own demarcation signboard in order to be able to identify it from other sectors in the field. This is very important.

5.0 SOIL QUALITY RESULTS AND SUMMARY OF SOIL ANALYSIS

Soil Sample No.: GPA

Location: Dry season Tomato Farm (sector 101)

Sampling Depth: 0-30cm (plough layer)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	82.0%	Coarse textured soil
	Silt	11.7%	
	Clay	6.3%	
2. (a)	Textural class (USDA)	LS	Loamy sand
(b)	Colour (if any)	N/A	N/A
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio 1:2$^1/_2$)	5.30	Strongly acidic soil
	pH-KCl (Ratio 1:2$^1/_2$)	4.90	
4.	Organic carbon	0.76%	Low organic matter content. Needs improvement.
5.	Organic matter	1.32%	
6.	Total nitrogen	0.084%N	Very low N-level
7.	Electrical conductivity (Ec x10^6 mhos/cm)	0.05mhos/cm	Less risk of salinity. Salt index not significant.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	5.10	Moderate Ca-level
	Mg	0.40	Low Mg-level. Poor.
	K	0.17	Low K-level. Poor.
	Na	0.13	Low Na-level and desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.76	Low EA level. Good.
10.	Cation Exchange Capacity (CEC)	6.56	Low CEC. Poor fertility.
11.	Base saturation (BS)	88.4%	High base saturation
12.	Exchangeable sodium percentage (ESP)	1.98%	Low ESP. Less risk of salinity in the soil.
13.	Available phosphorus	0.42ppm	Extremely low P-level. P-supply needed.
14.	Lime requirement	Apply 1tonne/ha of	Liming required.

		lime	
15.	Permeability/Infiltration rate	1.8-2.5cm/hr	Rapid flow of water in the soil.
16.	Water holding capacity (WHC) range	6-10cm/m	Low-moderate WHC.
17.	Drainage class	Well-drained soil	Good aeration
18.	Micronutrient elements availability and toxicity	Cu^{2+}, Zn^{2+}, Bo, Mn^{2+} and Fe^{3+} slightly available in toxic quantity	pH should be raised in the soil.

Soil Sample No.: GPB

Location: Dry season Tomato Farm (sector 102)

Sampling Depth: 0-30cm (plough layer/furrow slice)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	88.0%	Coarse textured soil
	Silt	5.7%	
	Clay	6.3%	
2. (a)	Textural class (USDA)	S	Sandy soil texture
(b)	Colour (if any)	N/A	N/A
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio 1:2$^1/_2$)	5.50	Moderately acidic soil
	pH-KCl (Ratio 1:2$^1/_2$)	5.30	
4.	Organic carbon	0.73%	Low organic matter content. Improvement required.
5.	Organic matter	1.30%	
6.	Total nitrogen	0.07%N	Very low N-level. Nitrogen supply required.
7.	Electrical conductivity (Ec x10^6 mhos/cm)	0.06mhos/cm	Salt index not significant. No salinity problem in the soil at present.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	4.00	Low Calcium content
	Mg	1.30	Low-moderate Mg-level
	K	0.19	Very low K-level. Poor.
	Na	0.14	Low Na-level and desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	1.16	Moderate EA level.
10.	Cation Exchange Capacity (CEC)	6.79	Low CEC. Soil not fertile
11.	Base saturation (BS)	82.9%	High base saturation
12.	Exchangeable sodium percentage (ESP)	2.10%	Low ESP. No salinity.
13.	Available phosphorus	0.56ppm	Extremely low P-level. P-supply needed.
14.	Lime requirement	Nil	Liming not required.
15.	Permeability/Infiltration rate	2.5cm/hr	High infiltration rate.
16.	Water holding capacity (WHC)	3-7cm/m	Very low WHC.

	range		
17.	Drainage class	Well-drained agricultural soil	Good aeration and root penetration.
18.	Micronutrient elements availability and toxicity	Cu^{2+}, Zn^{2+}, Bo, Mn^{2+} and Fe^{3+} slightly abundant and toxic	Raise pH level of the soil to curtail toxicity.

Soil Sample No.: Sector 104

Location: Near pumping station

Sampling Depth: 0-30cm (plough layer)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	82.0%	Coarse textured soil
	Silt	7.7%	
	Clay	8.3%	
2. (a)	Textural class (USDA)	LS	Loamy sand
(b)	Colour (if any)	N/A	N/A
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio 1:2$^1/_2$)	5.40	Strongly acidic soil
	pH-KCl (Ratio 1:2$^1/_2$)	5.00	
4.	Organic carbon	0.75%	Low organic matter content. Improvement required.
5.	Organic matter	1.30%	
6.	Total nitrogen	0.084%N	Very low N-content. N-supply required.
7.	Electrical conductivity (Ec x10^6 mhos/cm)	0.02mhos/cm	No salinity problem or sodium hazard.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	1.70	Extremely low Ca-level. Poor.
	Mg	1.70	Moderate Mg-level.
	K	0.11	Extremely low K-level. Poor.
	Na	0.14	Low Na-level and desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.40	Low EA. Good.
10.	Cation Exchange Capacity (CEC)	4.05	Extremely low CEC. Poor soil.
11.	Base saturation (BS)	90.1%	Very high base saturation
12.	Exchangeable sodium percentage (ESP)	3.46%	Low ESP. Less risk of salinity in the soil.
13.	Available phosphorus	0.56ppm	Extremely low P-level. P-supply required.
14.	Lime requirement	Apply 1tonne/ha of lime	Liming required.
15.	Permeability/Infiltration rate	1.8-2.5cm/hr	High infiltration rate.
16.	Water holding capacity (WHC)	6-10cm/m	Low-moderate WHC.

	range		
17.	Drainage class	Well-drained soil	Good aeration and percolation.
18.	Micronutrient elements availability and toxicity	Cu^{2+}, Zn^{2+}, Bo, Mn^{2+} and Fe^{3+} slightly abundant	Raise pH level of the soil.

Soil Sample No.: Sector 105B

Location: Open grassland near Swashi Diversion Dam road used for cultivating rice.

Sampling Depth: 0-30cm (plough layer)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	84.0%	Coarse textured soil
	Silt	7.7%	
	Clay	8.3%	
2. (a)	Textural class (USDA)	LS	Loamy sand
(b)	Colour (if any)	N/A	N/A
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio 1:2$^1/_2$)	5.00	Very strongly acidic soil
	pH-KCl (Ratio 1:2$^1/_2$)	4.60	
4.	Organic carbon	1.04%	Moderate organic matter content.
5.	Organic matter	1.80%	
6.	Total nitrogen	0.07%N	Very low N-content. Improvement required.
7.	Electrical conductivity (Ec x10^6 mhos/cm)	0.08mhos/cm	Salinity not a problem; salt index less than 4mhos/cm.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	5.20	Low- moderate Ca-level.
	Mg	0.20	Extremely low Mg-level. Poor.
	K	0.15	Extremely low K-level. Poor.
	Na	0.19	Low Na-level. Good..
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.84	Low EA level. Desirable.
10.	Cation Exchange Capacity (CEC)	6.58	Low CEC. Soil not fertile.
11.	Base saturation (BS)	87.2%	High base saturation
12.	Exchangeable sodium percentage (ESP)	2.9%	Low ESP. No salinity.
13.	Available phosphorus	0.70ppm	Extremely low P-level. Soil requires P-supply.
14.	Lime requirement	Apply 1tonne/ha of liming material	Liming required.
15.	Permeability/Infiltration rate	1.8-2.5cm/hr	High infiltration rate
16.	Water holding capacity (WHC) range	6-10cm/m	Low-moderate WHC.

17.	Drainage class	Well-drained soil	Good aeration and water percolation
18.	Micro-nutrient elements availability and toxicity	Zn^{2+}, Bo, Mn^{2+}, Cu^{2+} and Fe^{3+} slightly abundant and slightly toxic	pH too low and needs upward improvement.

Soil Sample No.: SW1 (0-35cm)

Soil Profile Pit No. SW1 (Located on sector 105A)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	88.0%	Coarse textured soil
	Silt	5.7%	
	Clay	6.3%	
2. (a)	Textural class (USDA)	S	Sandy soil texture
(b)	Colour (if any)	$5YR^3/_3$	Dark reddish brown
3.	**Soil Reaction (pH):**		Neutral soil
	pH-H_2O (Ratio $1:2^1/_2$)	6.80	
	pH-KCl (Ratio $1:2^1/_2$)	5.10	
4.	Organic carbon	0.99%	Low organic matter level. Improvement required.
5.	Organic matter	1.70%	
6.	Total nitrogen	0.07%N	Very low nitrogen level. N-supply required.
7.	Electrical conductivity (Ec $x10^6$ mhos/cm)	0.03mhos/cm	Less than 4mhos/cm in salt index. No salinity problem.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	3.50	Low Ca-level. Poor.
	Mg	1.40	Low-moderate Mg-level.
	K	0.08	Extremely low K-level. Poor.
	Na	0.17	Very low Na-level. Good.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.60	Low EA level and desirable. Less H^+ and Al^{3+} ion toxicity.
10.	Cation Exchange Capacity (CEC)	5.75	Extremely low CEC. Soil not well fertile.
11.	Base saturation (BS)	89.6%	High base saturation
12.	Exchangeable sodium percentage (ESP)	3.0%	Low ESP. Low Na^+ and salinity hazards.
13.	Available phosphorus	1.62ppm	Extremely low P-level. P-supplement necessary.
14.	Lime requirement (tonne/ha)	Nil	Liming not applicable
15.	Permeability/Infiltration rate	2.5cm/hr	High infiltration rate

16.	Water holding capacity (WHC) range	3-7cm/m	Very low WHC
17.	Drainage class	Well-drained surface horizon soil	Allows good aeration
18.	Micro-nutrient elements availability and toxicity	Mo, Cu^{2+} and Zn^{2+} are present in minute quantity	Less risk of toxicity. Favourable pH level.

Soil Sample No.: SW1 (35-53cm)

Soil Profile Pit No. SW1

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	80.0%	Medium textured soil
	Silt	5.7%	
	Clay	14.3%	
2. (a)	Textural class (USDA)	SL	Sandy loam texture
(b)	Colour (if any)	$5YR^3/_4$	Dark reddish brown
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio $1:2^1/_2$)	5.40	Strongly acidic soil
	pH-KCl (Ratio $1:2^1/_2$)	4.90	
4.	Organic carbon	0.41%	Low organic matter content. Improvement necessary.
5.	Organic matter	0.71%	
6.	Total nitrogen	0.13%N	Moderately low N-level. Nitrogen supply required.
7.	Electrical conductivity (Ec $x10^6$ mhos/cm)	0.05mhos/cm	Below 4mhos/cm. Salinity not a problem at present.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	2.00	Very low Ca-level. Poor.
	Mg	1.10	Low Magnesium level. Poor.
	K	0.06	Extremely low K-level. Poor.
	Na	0.12	Low Na-level Desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.36	Low EA level. Desirable.
10.	Cation Exchange Capacity (CEC)	3.64	Extremely low CEC.
11.	Base saturation (BS)	90.10%	Very high base saturation
12.	Exchangeable sodium percentage (ESP)	3.30%	Low ESP. Low salinity and Na^+ hazard level in the soil.
13.	Available phosphorus	0.14ppm	Extremely low P-level. P-supply necessary.
14.	Lime requirement (tonne/ha)	Apply 1tonne/ha of lime	Liming required in this horizon.
15.	Permeability/Infiltration rate	1.2-1.8cm/hr	Moderate infiltration rate

16.	Water holding capacity (WHC) range	9-12cm/m	Moderate WHC.
17.	Drainage class	Well-drained subsoil horizon	Good aeration and water percolation.
18.	Micro-nutrient elements availability and toxicity	Mn^{2+}, Fe^{3+}, Bo, Zn^{2+} and Cu^{2+} abundant in this horizon.	pH should be raised.

Soil Sample No.: SW1 (53-89cm)

Soil Profile Pit No. SW1

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	77.0%	Medium textured soil
	Silt	8.7%	
	Clay	14.3%	
2. (a)	Textural class (USDA)	SL	Sandy loam
(b)	Colour (if any)	$5YR^{5}/_{8}$	Yellowish red
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio $1:2^{1}/_{2}$)	5.30	Strongly acidic soil
	pH-KCl (Ratio $1:2^{1}/_{2}$)	4.30	
4.	Organic carbon	0.35%	Very low organic matter.
5.	Organic matter	0.60%	
6.	Total nitrogen	0.04%N	Very low nitrogen level
7.	Electrical conductivity (Ec $x10^{6}$ mhos/cm)	Nil	Nil
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	2.00	Very low calcium level.
	Mg	1.30	Moderate magnesium level.
	K	0.60	Extremely low K-level.
	Na	0.16	Low (Na) sodium level and desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.40	Low EA level. Desirable.
10.	Cation Exchange Capacity (CEC)	4.72	Extremely low CEC.
11.	Base saturation (BS)	91.5%	Very high base saturation
12.	Exchangeable sodium percentage (ESP)	3.40%	Low ESP. Less salinity hazard.
13.	Available phosphorus	Nil	Subsoil horizon; lacks phosphorus.
14.	Lime requirement (tonne/ha)	N/A	N/A (Subsoil)
15.	Permeability/Infiltration rate	1.2-1.8cm/hr	Moderate infiltration rate.
16.	Water holding capacity (WHC) range	9-12cm/m	Moderate WHC in the subsoil.
17.	Drainage class	Well-drained	Sub-surface soil well

		subsoil	drained and aerated.
18.	Micro-nutrient elements availability and toxicity	Mn2+, Bo, Zn2+, Fe3+ and Cu2+ moderately available in the subsoil	Toxicity likely due to low pH level at this soil depth. pH should be improved upon.

Soil Sample No.: SW1 (89-150cm)

Soil Profile Pit No. SW1

S/No.	*Soil Parameters/Constituents*	*Obtained Value*	*Interpretation/Remark*
1.	**Particle Size Analysis:**		
	Sand	70.4%	Medium textured soil
	Silt	21.3%	
	Clay	8.3%	
2. (a)	Textural class (USDA)	SL	Sandy loam
(b)	Colour (if any)	$2.5YR^4/_8$	Red
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio 1:$2^1/_2$)	5.00	Very strongly acidic soil
	pH-KCl (Ratio 1:$2^1/_2$)	4.30	
4.	Organic carbon	0.30%	Extremely low organic matter content.
5.	Organic matter	0.52%	
6.	Total nitrogen	0.07%N	Very low nitrogen content
7.	Electrical conductivity (Ec x10^6 mhos/cm)	0.01mhos/cm	No salinity hazard
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	6.50	Moderate Ca-level
	Mg	2.00	Moderate Mg-level.
	K	0.08	Extremely low K-level.
	Na	0.12	Low Na-level. Good.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.32	Low EA level.
10.	Cation Exchange Capacity (CEC)	9.08	Low CEC. Subsoil not well fertile.
11.	Base saturation (BS)	95.8%	Very high base saturation
12.	Exchangeable sodium percentage (ESP)	1.32%	Low ESP. No salinity problem.
13.	Available phosphorus	Nil	C-horizon. Soil lacks phosphorus
14.	Lime requirement (tonne/ha)	N/A	N/A to C-horizon
15.	Permeability/Infiltration rate	1.2-1.8cm/hr	Moderately permeable
16.	Water holding capacity (WHC) range	9-12cm/m	Moderate in WHC.
17.	Drainage class	Well-drained I	Allows good aeration

18.	Micro-nutrient elements availability and toxicity	Bo, Zn^{2+}, Cu^{2+}, Mn^{2+}, Fe^{3+} largely available and likely to be toxic due to low pH.	pH should be raised in the C-horizon if deep rooted crops are to be grown in the field.

Soil Sample No.: SW2 (0-24cm)

Location: Inside Rice Farm, LHS of Left Bank Main Canal

Soil Profile Pit No. SW2 (Located in sector 103A – Pilot Farm)

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	84.0%	Coarse textured soil
	Silt	10.7%	
	Clay	5.3%	
2. (a)	Textural class (USDA)	LS	Loamy sand
(b)	Colour (if any)	$5YR^4/_2$	Dark reddish grey
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio $1:2^1/_2$)	5.0	Very strongly acidic soil
	pH-KCl (Ratio $1:2^1/_2$)	4.3	
4.	Organic carbon	0.79%	Low organic matter content. Improvement required.
5.	Organic matter	1.37%	
6.	Total nitrogen	0.12%N	Moderately low nitrogen content
7.	Electrical conductivity (Ec $x10^6$ mhos/cm)	0.09mhos/cm	Less than 4mhos/cm in salt index. Salinity not a problem in the soil.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	2.0	Very low Ca-level. Poor.
	Mg	1.0	Low Mg-level. Poor.
	K	0.15	Very low K-level. Poor.
	Na	0.21	Low Na-level. Good.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.64	Al^{3+} and H^+ level moderate
10.	Cation Exchange Capacity (CEC)	4.0	Extremely low CEC. Soil not fertile enough.
11.	Base saturation (BS)	84.0%	High base saturation
12.	Exchangeable sodium percentage (ESP)	5.25%	Less than 15%. Low ESP. No salinity effect.
13.	Available phosphorus (ppm)	Nil	Absent. Soil requires adequate P-supply.
14.	Lime requirement	Apply 1tonne/ha of Ca-$MgCO_3$	Liming required.
15.	Permeability/Infiltration rate	1.8-2.5cm/hr	Highly permeable soil

16.	Water holding capacity (WHC) range	6-10cm/m	Low-moderate in water retention
17.	Drainage class	Moderately well-drained soil	Moderate aeration in Ap horizon
18.	Micronutrient elements availability and toxicity	Fe^{3+}, Mn^{2+}, Cu^{2+}, Zn^{2+} and Bo present in moderate quantity but could cause mild toxicity if pH is not improved.	pH level of the soil should be raised.

Soil Sample No.: SW2(24-50cm)

Soil Profile Pit No. SW2

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	***Particle Size Analysis:***		
	Sand	80.0%	Medium textured soil
	Silt	8.7%	
	Clay	11.3%	
2. (a)	Textural class (USDA)	SL	Sandy loam
(b)	Colour (if any)	$5YR^{6}/_{2}$	Pinkish grey
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio $1:2^{1}/_{2}$)	5 0	Very strongly acidic soil
	pH-KCl (Ratio $1:2^{1}/_{2}$)	4 0	
4.	Organic carbon	0.43%	Very low organic matter content.
5.	Organic matter	0.75%	
6.	Total nitrogen	0.07%N	Very low nitrogen content.
7.	Electrical conductivity (Ec $x10^{6}$ mhos/cm)	1.02mhos/cm	Low salt index. Extremely low risk of salinity.
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	1.10	Extremely low Ca-level. Poor
	Mg	1.90	Moderate Mg-level. Fair.
	K	0.14	Very low K-level. Poor.
	Na	0.16	Low Na-level. Satisfactory.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.40	EA level moderate
10.	Cation Exchange Capacity (CEC)	3.70	Extremely low CEC
11.	Base saturation (BS)	89.2%	High base saturation
12.	Exchangeable sodium percentage (ESP)	4.3%	Low ESP. Less salinity and sodium hazards.
13.	Available phosphorus	0.28ppm	Extremely low P-level. P-supplement necessary.
14.	Lime requirement	Apply 1tonne/ha of Ca-$MgCO_3$	Liming required.
15.	Permeability/Infiltration rate	1.2-1.8cm/hr	Moderately permeable soil
16.	Water holding capacity (WHC) range	9-12cm/m	Moderately high water holding capacity

17.	Drainage class	Poorly drained soil	Wetness and mottling characteristics prominent. Poor aeration.
18.	Micronutrient elements availability and toxicity	Mn^{2+}, Cu^{2+}, Zn^{2+}, Bo and Fe^{3+} present as in Ap horizon SW2 (0-24cm) due to low pH of the soil.	Raise pH level of the soil.

Soil Sample No.: SW2 (50-90cm)

Soil Profile Pit No. SW2

S/No.	Soil Parameters/Constituents	Obtained Value	Interpretation/Remark
1.	**Particle Size Analysis:**		
	Sand	72.0%	Moderately heavy textured soil
	Silt	3.7%	
	Clay	24.3%	
2. (a)	Textural class (USDA)	SCL	Sandy clay loam
(b)	Colour (if any)	$5YR^{7}/_{1}$	Light grey
3.	**Soil Reaction (pH):**		
	pH-H_2O (Ratio $1:2^{1}/_{2}$)	4.9	Very strongly acidic soil
	pH-KCl (Ratio $1:2^{1}/_{2}$)	4 0	
4.	Organic carbon	0.3%	Extremely low organic matter content
5.	Organic matter	0.51%	
6.	Total nitrogen	0.06%N	Very low nitrogen content
7.	Electrical conductivity (Ec $x10^{6}$ mhos/cm)	0.08mhos/cm	Salt index level not significant to cause salinity problem
8.	**Exchangeable cations:** **(meq./100g soil)**		
	Ca	7.70	Moderate calcium level.
	Mg	0.30	Very low Mg-level.
	K	0.06	Extremely low potassium level.
	Na	0.17	Low sodium level and desirable.
9.	**Exchangeable acidity:** H & Al (meq./100g soil)	0.20	EA level low. Al^{3+} and H^{+} activity less.
10.	Cation Exchange Capacity (CEC)	8.43	Low CEC. Subsoil not fertile enough.
11.	Base saturation (BS)	97.6%	Very high base saturation
12.	Exchangeable sodium percentage (ESP)	2.01%	<15%. Very low ESP. Non-saline soil.
13.	Available phosphorus	Nil	Absent. Subsoil completely lacks phosphorus.
14.	Lime requirement (tonne/ha)	N/A	Liming not required in this horizon.
15.	Permeability/Infiltration rate	0.9-1.2cm/hr	Low-moderate infiltration rate

16.	Water holding capacity (WHC) range	12-15cm/m	High water retention.
17.	Drainage class	Very poorly drained soil	Strong brown ($5YR^4/_6$) mottles. Poor aeration.
18.	Micronutrient elements availability and toxicity	Fe^{3+} extremely present in this horizon due to very low pH.	pH too low and should be improved in the subsoil horizons.

5.1.0 WATER QUALITY RESULTS AND SUMMARY OF WATER ANALYSIS FOR THE LEFT BANK IRRIGATION PROJECT

S/No.	Constituents	Values	Remark
1	pH at 25°C	6.5	Slightly acidic-neutral irrigation water. Satisfactory
2	Total Dissolved solids	58.3ppm	<400ppm. Good
3	Hardness/Alkalinity	45.0ppm	Very low and desirable
4	Bi-carbonate, HCO_3^-	52.1mg/litre	Low. Low hardness level
5	Sodium, Na^+	0.3mg/litre	Very low Na^+ level. Sodium hazards not a problem.
6	Potassium, K^+	2.0mg/litre	Moderate. Good for agricultural purpose
7	Calcium, Ca^{++}	14.5mg/litre	<50mg/litre. Less precipitation problem
8	Magnesium, Mg^{++}	6.3mg/litre	<50mg/litre. Precipitation very mild at pH 6.5
9	Sodium Adsorption Ratio, SAR	0.09	Very low SAR. Water not saline
10	Chloride, Cl	1.8mg/litre	<25mg/litre. Very low and satisfactory
11	Sulphate, SO_4	11.2mg/litre	<200mg/litre. Very low
12	Nitrate, NO_3^-	5.0mg/litre	Below 10mg/litre. Desirable for irrigation.
13	Phosphate	0.06ppm	Very low
14	Electrical conductivity (Ec x 10^6mhos/cm) at 25°C	68.3mhos/cm	Below 100mhos/cm. Very low salinity class. Excellent.
15	Iron, Fe^{3+}	Nil	Nil
16	Manganese,Mn^{2+}	Nil	Nil
17	Zinc, Zn^{2+}	0.02mg/litre	Low Zn content and desirable
18	Boron, Bo	0.01mg/litre	Quite negligible
19	Copper, Cu^{2+}	Nil	Nil
20	Colour	23.0Hu	>5Hu (units). Water safe for irrigation but not safe for direct

			human consumption.
21	Aluminium	Nil	Nil
22	Fecal coliforms at 44.5°C	Nil	Nil
23	Algae	Not significant in the sample	Negligible

SWASHI IRRIGATION PROJECT, SWASHI

SOIL PROFILE DESCRIPTIONS OF LEFT BANK PROJECT
SOIL PROFILE I

I **Site and General Soil Information:**

i. Soil Profile Pit No. : SW1

ii. Soil Classification: Typic Paleustults (USDA)

iii. Location of profile pit: Left Bank Main Canal area; Near first turnout (about 40m away); Right hand side of farm road from Swashi village. About 200m to Kwala village.

iv. Geology/Parent material: Basement complex, Sandstone

v. Topography/Slope: Gentle slope (0-2%)

vi. Microtopography (if any): Nil

vii. Vegetation/Landuse: Open savannah grassland (fallowland)

viii. Soil depth: Deep

ix. Depth to watertable: Below profile depth

x. Drainage : Excessively well drained

xi. Moisture condition in the soil profile: Moist at the time of observation.

xii. Presence of surface stones and rock outcrops: Nil

xiii. Presence of erosion: Nil

xiv. Presence of salt and alkali: Nil

xv. Human influence: Progressively strong farming activities.

xvi. Described by: Oladipo J.A.

xvii. Date of description: 2/7/98

II **Profile Description:**

A 0-35cm: Dark reddish brown (5YR$^{3}/_{3}$; moist) sand; moderate fine Crumb; friable, non-sticky and non-plastic; moderately firm (dry), moderately weak (moist); common fine roots; few fine quartz grains; clear smooth boundary; neutral reaction, pH 6.8.

Bt1 35-53cm: Dark reddish brown (5YR$^{3}/_{4}$; moist) sandy loam; moderate fine subangular blocky; firm; non-sticky, non-plastic; few fibrous Roots, few fine quartz grains; gradual smooth boundary; strong strongly acid reaction, pH 5.4.

Bt2 53-89cm: Yellowish red (5YR$^{5}/_{8}$; moist) sandy loam; medium subangular blocky, friable; slightly sticky and plastic; few fine roots; few iron concretions; clear smooth boundary; strongly acid reaction, pH 5.3.

Bt3 89-150cm: Red (2.5YR$^{4}/_{8}$; moist) sandy loam; medium angular blocky; firm, moderately sticky, moderately plastic; clear smooth boundary; very strongly acid reaction, pH 5.0.

BC 150cm +: Gravely clay and iron concretionary materials (plinthites). Iron-enriched horizon.

SOIL PROFILE II

I **Site and General Soil Information:**

i. Soil Profile Pit No.: SW2
ii. Soil Classification: Aquic Haplustults
iii. Location of profile pit: On pilot farm (PF103A), inside rice farm.
iv. Geology/Parent material: Basement complex
v. Topography/slope: Nearly level (about 1% slope)
vi. Microtopography (if any): Low-lying terrain with shallow troughs or depressions.
vii. Vegetation/Landuse: Rice farm (plain open grassland)
viii. Soil depth: Moderately deep
ix. Depth to watertable: 90cm
x. Drainage: Poorly drained
xi. Moisture condition in the soil profile: Extremely moist at the time of observation.
xii. Presence of surface stones and rock outcrops: Nil
xiii. Presence of erosion: Nil
xiv. Presence of salt and alkali: Nil
xv. Human influence: Very strong
xvi. Described by: Oladipo J.A.
xvii. Date of description: 2/7/98

II **Profile Description:**

Ag 0-24cm: Dark reddish grey ($5YR^4/_2$; moist) loamy sand; moderate crumb to fine medium subangular blocky; few faint mottles; friable; slightly firm; non-sticky, non-plastic; many fibrous roots; abrupt smooth boundary; very strongly acid reaction, pH 5.0.

B1g 24-50cm: Pinkish grey ($5YR^6/_2$; moist) sandy loam; fine blocky to medium subangular blocky; many very faint mottles; friable; slightly firm; non-sticky, non-plastic; very few fibrous roots; clear smooth boundary; very strongly acid reaction, pH 5.0.

B2g 50-90cm: Light grey ($5YR^7/_1$; moist) sandy clay loam; common medium yellowish red ($5YR^4/_6$) mottles; medium angular blocky structure; firm; moderately sticky, moderately plastic; few fine roots; clear smooth boundary; very strongly acid reaction, pH 4.9.

C 90cm +: Water with increased clay and mottles.

REFERENCES

1. Hodgson, J.M. (1976), Soil Survey Field Handbook. Technical Monograph No. 5.
2. Revised Standard Munsell Soil Colour Charts (1975).
3. Soil Survey Staff (1975), USDA Soil Taxonomy and Classification.
4. Nelson and Tisdale (1975), Soil Fertility and Fertilizer.
5. Cottenie, A. (1980), Soil and Plant Testing as a basis for fertilizer recommendation, FAO Bull. No. 36.
6. Hudson, N W. (1975), Field Engineering for Agricultural Development.
7. Soils Handbook, A practical Guide for the Study of Soil Survey Methods, FDA Bull. (1980).
8. National Atlas of the Federal Republic of Nigeria (1978).
9. Mc. Rae, S.G. & Burnham, C.P. (1981), Land Evaluation.
10. Fertilizer Use and Management Practices for crops in Nigeria, FMAWR&RD Fertilizer Publication, (1989).
11. Gupta, R.L. et. al. (1979), Suitability of Water for Irrigation.
12. Foth, H.D. (1984), Fundamentals of Soil Science, 7th Ed.
13. Israelsen, O.W. and Hansen, V.E. (1962), Irrigation Principles and Practices.
14. Western, S. (1978), Soil Survey contracts and Quality control.