FEDERAL MINISTRY OF WATER RESOURCES
AND RURAL DEVELOPMENT

UPPER NIGER RIVER BASIN AND RURAL
DEVELOPMENT AUTHORITY
MINNA

REPORT ON FERTILITY SOIL SURVEY OF TUNGA-KAWO IRRIGATION PROJECT

SUBMITTED BY

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

DECEMBER, 1995.

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1.0 INTRODUCTION:

1.1 Tunga-Kawo Irrigation Project, one of the prominent Irrigation schemes in Upper Niger River Basin and Rural Development Authority, is located near Wushishi town in Wushishi Local Government Area of Niger State.

1.2 Field works in respect of soil fertility survey of the scheme commenced on 23rd November, 1995 and were completed on 27th November, 1995. It would be recalled that this exercise was not the first that would be done on the project site. The first exercise christened "Detailed Soil Survey of Tunga-Kawo Irrigation Project" came up in as far back as 1991 and since then the fertility level of agricultural land of the scheme had not been re-examined and hence this formed one of the basic reasons for carrying out the fertility survey at this particular time, taking into consideration the time interval between the last soil survey and the present time (1995).

1.2.1 Thus, the objectives of the survey were among others:

(a) To collect for analysis composite surface (0-15cm) soil samples of the area (about 900 hectares) including both commanded and immediate uncommanded area.

(b) To evaluate soil fertility status of the soils of the project area and proffer appropriate fertilizer recommendations.

(c) To assess erosion and other soil management problems in the field and recommend appropriate measures to check the problems and;

(d) To recommend other such measures as to ensure sustainable and profitable crop production in respect of soil management practices.

(e) To supplement soil fertility data bank of the Authority.

1.2.2 In the field after reconnaissance survey was completed, soil sample collection began in ernest. The sampling was guided by pre-determined irrigation structures and lay-out which more or less served as prominent traverse lines along which samples were taken between the sampling depth of 0 - 15cm at each sampling point (Appendix A-1). In doing this, soil samples were collected at random points within each sampling block and later bulked together to obtain representative soil samples.

1.2.3 In each sampling block (area) slope, vegetation, present land use and topography were also observed and noted. And as soon as samples were obtained in the field they were taken to the office for pre-treatment. The pretreatment involved air-drying them for 2-3 days after which they were ground with a porcelain mortar and pestle and sieved using a 2mm-mesh soil sieve.

2.0 LABORATORY ANALYSIS OF SOIL SAMPLES:

In all, fifteen (15) representative soil samples were collected for fertility tests and as soon as pre-treatment was accomplished they were forwarded to the soil laboratory for various physical and chemical

analyses. On reaching laboratory, each representative soil sample was analysed for soil reaction (P^H), particle-size distribution (mechanical analysis), cation exchange capacity (CEC), exchangeable bases or cations, exchangeable acidity, total Nitrogen, available phosphorus, organic carbon and organic matter. The following laboratory testing methodologies were employed for the analysis.

2.1 SOIL P^H:

The P^H (soil reaction) of the soil 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 using the glass electrode P^H meter.

2.2 SOIL PARTICLE-SIZE DISTRIBUTION AND TEXTURE:

Particle-size analysis was carried out on previously air-dried soil samples that had been sieved through a 2mm-mesh sieve. Hydrometer method as described by Bouyoucos (1954) was used and Neutral Sodium Hexametaphosphate (calgon) used as dispersing agent.

2.3 CATION EXCHANGE CAPACITY (CEC):

This was determined by first saturating the exchange sites of the soil with Mg^{2+} provided in a 1N Magnesium acetate solution at P^H 7.0. The saturating Mg^{2+} ions were then displaced from the exchange sites with 1N Nacl solution; the Mg^{2+} thus displaced was determined by titration with 0.05N Na-EDTA.

2.4 EXCHANGEABLE BASES:

The exchangeable bases or cations in the soil were extracted with 1N NH_4OAC at P^H 7.0 and determined using Gallenkamp flame analyser.

2.5 EXCHANGEABLE ACIDITY:

This was determined by titrating filterate of soil samples treated with 1N Kcl (Potassium Chloride) with 0.01N sodium hydroxide (NaOH).

2.6 TOTAL NITROGEN:

Total nitrogen was done using micro-Kjeldahl method of Bremmer Black, 1965.

2.7 AVAILABLE PHOSPHORUS:

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

2.8 PERCENTAGE BASE SATURATION (PBS):

This was derived by taking exchangeable sodium, for instance, as a percentage of cation Exchange Capacity (CEC).

2.9 EXCHANGEABLE SODIUM PERCENTAGE (ESP):

The Exchangeable Sodium Percentage (ESP) on the other hand was derived by dividing the value of Na^+ by CEC value of each respective analysed sample and multiplying by 100%.

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

2.10 ORGANIC CARBON:

Organic carbon was determined using 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 $H_2 SO_4$ (sulphuric acid).

3.0 ANALYSIS RESULTS AND FERTILITY STATUS OF THE PROJECT AREA:

3.1 SOIL TEXTURE

According to grain-size analysis soils may be classified as sand, silt and clay. Thus, in most of the soil samples the relative proportions of silt and clay are more appreciable than that of sand. So, it could be seen that textural classes of majority of the samples are predominently sandy clay loam (SCL), Clay loam (CL), Sandy clay (SC), Sandy loam (SL) and clay (C).

For instance, samples No. TK1, TK7, TK8 and TK9 are sandy clay loam; samples No. TK2, and TK6 are clay loam; samples No. TK3, TK4 and TK10 are entirely clayey in texture; sample No. TK5 is sandy clay while samples TK11 - TK15 are sandy loam as would be seen on soil fertility map (Appendix A - I).

Agricultural soil classes encountered in the project area are summarised below:

Clay (C) - Fine textured soils

Sandy Loam (SL) - Medium textured soils

Sandy Clay (SC) - Fine textured soils

Sand Clay Loam (SCL) - Moderately Heavy textured soils.

Clay Loam (CL) - Moderately heavy textured soils.

The texture of a soil has a very important effect on the flow of soil water, air circulation and the rate of chemical transformation which are of importance to plant growth. Also, land use planning and capability and methods of soil management are largely controlled by Texture of soil. Generally, the best agricultural soils are those that contain 10 - 20% clay, 5 - 10% organic matter and the rest divided about equally between sand and silt. The clay contents in most soil samples are quite appreciable (about 11 - 65%) and hence they are of satisfactory agricultural soils based on clay levels. Organic matter is generally moderate in the field as it lies between 2 - 3% OM on average basis.

3.2 SOIL STRUCTURE:

This refers to the pattern in which the soil particles are arranged. Soil structure practically influences all the plant growth factors e.g. water supply, aeration, plant nutrients availability, microbial activity, root penetration, etc. Generally good soil structure should permit plant growth and favourable soil structure is the key to fertility of a soil. Soil structures encountered in the field are typically coarse angular blocky and medium angular blocky associated with the soils in the lowlands and granular structure in the upland area.

3.3 ORGANIC MATTER:

As was said before the organic matter contents of most of the soil samples range from very low to very high. For example soil samples No. TK1, TK11, TK13, TK14 and TK15 are very low in organic matter while other samples are observed to be quite moderate in organic matter content; sample No. TK9 is particularly observed to be very high in organic matter and this is quite remarkable.

3.4 EXCHANGEABLE BASES:

The exchangeable bases include basic cations like Ca, Mg, K and Na. From the result of chemical analysis carried out calcium contents in the soils of the area are within the range of 1.20 and 8.20 meq./100g soil, i.e. ranging from very low to moderate. It is found to be very low in samples TK13 - TK15; it is low in samples TK11, TK1, TK4, TK5 and TK8. In the remaining samples as located in the fertility map (Appendix A-1) calcium levels are found to be moderate.

On the other hand, Magnesium levels are low in samples TK5, TK13, TK14, TK15 and TK5 but in other areas it is moderate and moderately high in range. Potassium levels are generally low in the field except in areas like TK2, Tk3, Tk4, Tk8 and Tk9 where it is moderate in level.

Sodium (Na) levels are generally low and desirable as such except in Tk6, Tk7 and Tk9 where it is slightly moderate, but the lower it is the better as increase in sodium level may hinder structural stability of the soil and make the soil saline. However, for now there is no cause for alarm.

3.5 CATION EXCHANGE CAPACITY (CEC):

The CEC of most of the samples are generally low except in areas like Tk6 and Tk9 with moderate level of cation exchange capacity. Cation exchange capacity is a function of the soil P^H.

3.6 BASE SATURATION:

The base saturation percentage of all the sampled areas in the field are generally very high and this is a reasonable development in terms of fertility status of the scheme.

3.7 TOTAL NITROGEN:

Most soil samples are moderately low and moderately high in nitrogen contents except at two places (Tk11 and Tk12) where nitrogen is observed to be relatively low.

3.8 AVAILABLE PHOSPHORUS:

The available phosphorus contents in the soils of the area are quite appreciable. With the exception of Tk4 with 4.20ppm of P observed to be low the rest areas in the field are moderate in phosphorus level. Samples Tk14 and Tk15 are even exceedingly high in phosphorus.

3.9 SOIL P^H:

Soil reaction of the most of the soils in the area is within the borderline of very strongly acid, i.e. 4.5 - 5.0 P^H. In this case, soil management practices in the area needs to be improved in order to forestall likely problem of acidity in the future. And for now there is the need for liming

the field in order to check upward trend of acidity problem observed to be gradually on the increase.

4.0 FERTILIZER RECOMMENDATIONS:

4.1 From the results of chemical analysis carried on the soil samples collected from the field as could be seen on the analysis results table on page 15 and based on the current fertilizer formulations available in the country and general nutrients inbalance observed in the entire area of the project, the following fertilizer recommendations which are applicable to all parts of the farm are hereby made.

4.1.1 For rice production in both lowland (fadama) and upland areas, it is recommended that 250kg or 5 bags of NPK 15-15-15 should be applied per hectare during land preparation. And 200kg or 4 bags of CAN together with 50kg or 1 bag of MOP (Muriate of Potash) per hectare as basal application or top dressing should be applied at least 4 weeks after transplanting of rice seedlings to the field. This is the first dose. The second dose should be applied about 8 weeks after transplanting in equal rates of application. Calcium Ammonium Nitrate (CAN) fertilizer would help raise the level of calcium observed to be generally low while MOP would also raise potassium (K) level observed to be generally very low in the entire project area.

4.1.2 For maize, 200kg or 4 bags of NPK 15-15-15 should be applied 1 - 2 weeks after planting per hectare as first dose. The second dose should involve application of 100kg or 2 bags/hectare of MOP applied 4 - 6 weeks after planting.

4.1.3 For Guineacorn, apply 200kg or 4 bags of NPK 15-15-15 at least 2 - 4 weeks after planting or 1½ weeks after transplanting to the field per hectare followed by 100kg or 2 bags of SSP. and 50kg or 1 bag of MOP applied in equal rates about 6 - 8 weeks after planting, per hectare.

4.1.4 For Sugarcane production, 220kg or 4½ bags of Urea $(NH_2)_2$ CO or 385kg (about 8 bags) of CAN or 600kg (12 bags) of NPK 15-15-15/hectare is recommended for broadcasting and worked well into the soil before planting of sugarcane cuttings. There after 278kg (6 bags) of SSP and 150kg (3 bags) of MOP should be applied when sugarcane must have become fully established in the field.

4.1.5 These fertilizer recommendations are only valid for the next two cropping seasons and as a result the soil should be re-examined thereafter to check the levels of plant nutrients, and in particular the P^h of the soil in the field which is rapidly tending toward acidic conditions. And finally for now the whole part of the field should be limed

at the rate of 1 metric tonne of Dolomitic limestone/ ha. i.e. $Ca\text{-}Mg(CO_3)_2$.

5.0 GENERAL OBSERVATION AND RECOMMENDATIONS:

5.1 In the field the following observations were made and appropriate recommendations in favour of each of the observations are given below for consideration. Viz:

5.1.1 *It was observed that the upland area of the scheme are very fragile in texture and gradually depreciating in fertility and in this circumstance crop rotation system combined with other soil management practices should be introduced to the area in order to improve fertility as well as structural well-being of this particular area. Crop rotation should involve rotating cover crops such as legumes (e.g. groundnut, soyabean) with cereals such as maize and guineacorn.

5.1.2 *In the lowland areas (fadama) it was also observed that there are pockets of depression scattered all over the field. These depressions require land grading (levelling) approach so as to make the whole field to be very effective for the flow of irrigation water during irrigation season as well as to ease land preparation for farm machinery and implements.

5.1.3 *The poorly drained areas in the field were observed to be highly vulnerable to excessive flooding at peaks of rainfall. To this end, there

should be adequate provision for drainage facilities to improve the workability, air-circulation or aeration and general drainagibility of the soil in the field.

5.1.4 "Over 80% of the project area was observed to fall in fadama portions of the site and so has high potentials for sugarcane production apart from rice which is presently cultivated in the field. In the light of this, it is recommended that sugarcane be introduced to the project area as a relative cash crop with reasonable economic returns under the present dispensation of irrigated agriculture posture of the Authority. The fadama was observed to be highly suitable for sugarcane.

5.1.5 "The interference of nomads and their cattle with irrigation structures was observed. While recommending that cattle farmers grazing their herds within the field should be flushed out of the premises of the project to forestall further destruction of structures, all irrigation structures most especially canals, flood embankments, field drains and so on with defects in the field should be rehabilitated and made efficiently functional.

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 20 ppm.

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 (series No. 2), 1989.

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TUNGA-KAWO IRRIGATION PROJECT FERTILITY SOIL SURVEY

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

LABORATORY SOIL ANALYSIS RESULTS

SOIL SAMPLE NO.	TK1	TK2	TK3	TK4	TK5	TK6	TK7	TK8	TK9	TK10	TK11	TK12	TK13	TK14	TK15
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	0-15	0-15	0-15
MECHANICAL ANALYSIS:															
Sand (%)	54.0	38.0	8.0	20.0	52.0	22.0	12.0	6.0	6.0	18.0	68.0	64.0	72.0	74.0	77.0
Silt (%)	15.0	33.0	31.0	33.0	9.0	45.0	59.0	57.0	55.0	17.0	19.0	21.0	13.0	15.0	12.0
Clay (%)	31.0	29.0	61.0	47.0	39.0	33.0	29.0	37.0	39.0	65.0	13.0	15.0	15.0	11.0	11.0
Textural Classes (USDA)	SCL	CL	C	C	SC	CL	SCL	SCL	SCL	C	SL	SL	SL	SL	SL
SOIL REACTION (P^H):															
P^H-H_2O (Ratio 1:2½)	4.80	5.40	4.40	4.70	5.00	4.80	4.80	4.60	5.30	5.30	5.20	6.50	5.20	5.80	5.00
P^H-Kcl (Ratio 1:2½)	3.50	3.20	3.00	3.50	4.20	3.20	3.00	3.10	3.50	3.30	3.90	5.10	3.90	4.10	4.70
Organic Carbon (%)	0.32	1.48	1.48	1.60	1.40	1.40	1.72	1.20	2.27	1.91	0.80	1.80	0.68	0.80	0.56
Organic Matter (%)	0.55	2.55	2.76	2.42	2.42	2.97	2.14	2.07	3.93	3.31	1.38	3.11	1.17	1.33	0.97
Total Nitrogen (%)	0.11	0.15	0.21	0.44	0.13	0.17	0.14	0.24	0.22	0.31	0.07	0.06	0.11	0.14	0.17
EXCHANGEABLE CATIONS (Meq./100g soil Ca	3.80	5.60	8.20	4.20	3.60	7.60	5.80	4.40	7.60	6.20	3.00	5.80	1.20	1.60	1.40
Mg	2.20	2.40	6.20	2.40	1.00	3.80	3.40	2.40	4.00	2.40	2.20	5.00	0.60	0.60	0.80
K	0.26	0.54	0.61	0.46	0.13	0.26	0.23	0.86	0.54	0.36	0.26	0.13	0.13	0.10	0.08
Na	0.22	0.20	0.26	0.26	0.22	0.30	0.30	0.26	0.30	0.26	0.22	0.22	0.22	0.23	0.24
Exchangeable Acidity (Al & H) Meq/100g soil	0.12	0.12	0.76	0.16	0.08	0.16	0.08	0.16	0.08	0.12	0.16	0.12	0.12	0.16	0.08
Cation Exchange Capacity (CEC)	6.60	8.86	8.03	7.48	5.04	12.12	9.89	7.78	12.57	9.34	5.80	11.27	1.68	2.69	2.56
Base Saturation (%)	98.4	98.6	90.5	97.9	98.4	98.7	99.1	97.9	99.4	98.7	97.9	98.9	92.6	94.5	96.9
Exchangeable Sodium Percentage (ESP)	3.33	2.26	3.23	3.50	4.37	2.50	3.10	3.34	2.40	2.80	3.80	1.95	1.31	8.55	9.40
Available Phosphorus (BRAY-1) (PPM)	8.40	12.70	11.20	4.20	7.00	11.20	9.80	9.80	11.20	12.70	7.00	9.80	14.00	42.00	56.00
Lime Requirement (tonne/ha)	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1

NOTE:

SL - Sandy Loam
SCL - Sandy Clay Loam
CL - Clay Loam
SC - Sandy Clay
C - Clay.

Analysed by: Mall. A. Mohammed,
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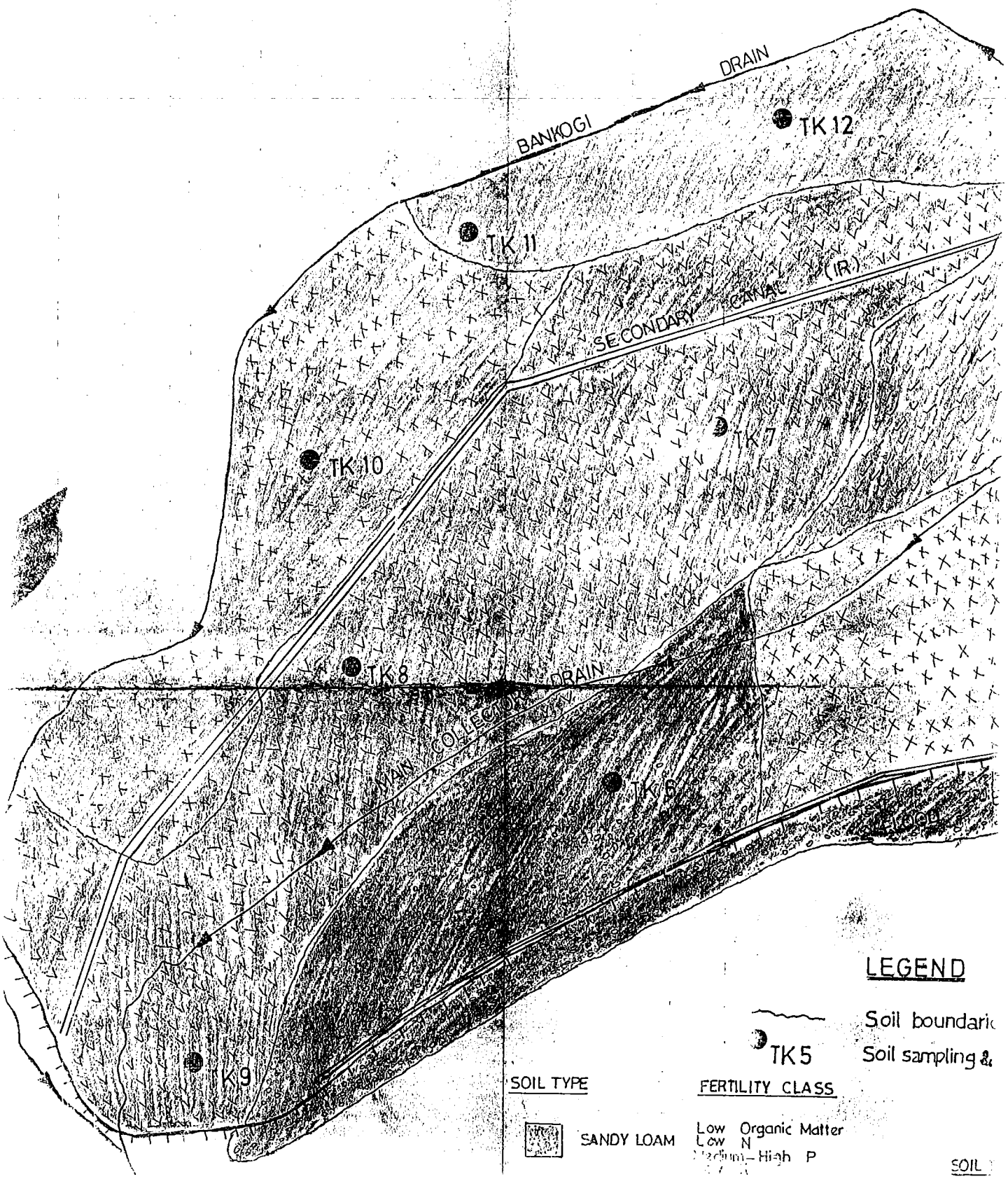
SOIL FERTILITY



SOIL

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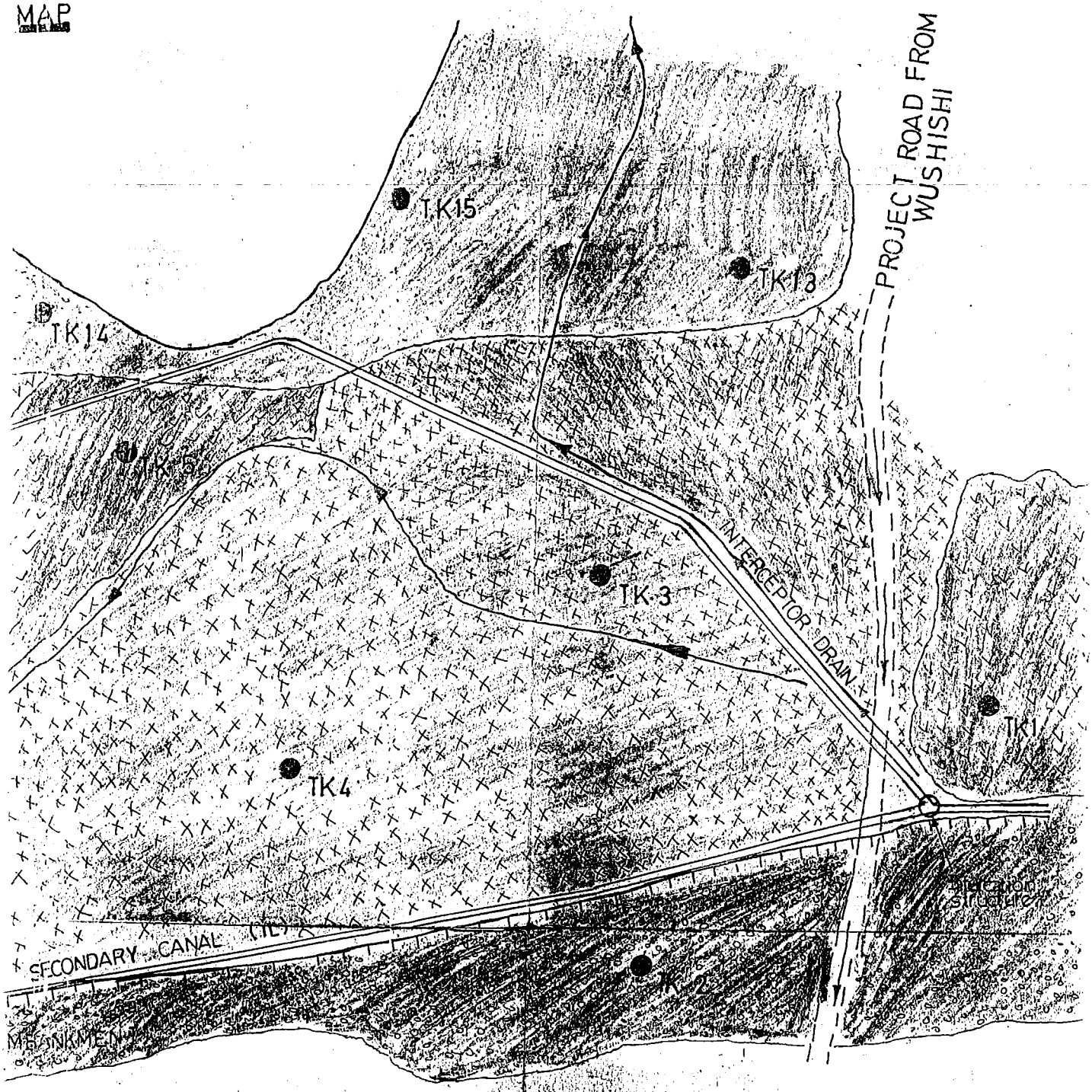
TUNGA-KAWO IRRIGATION PROJECT

MAP



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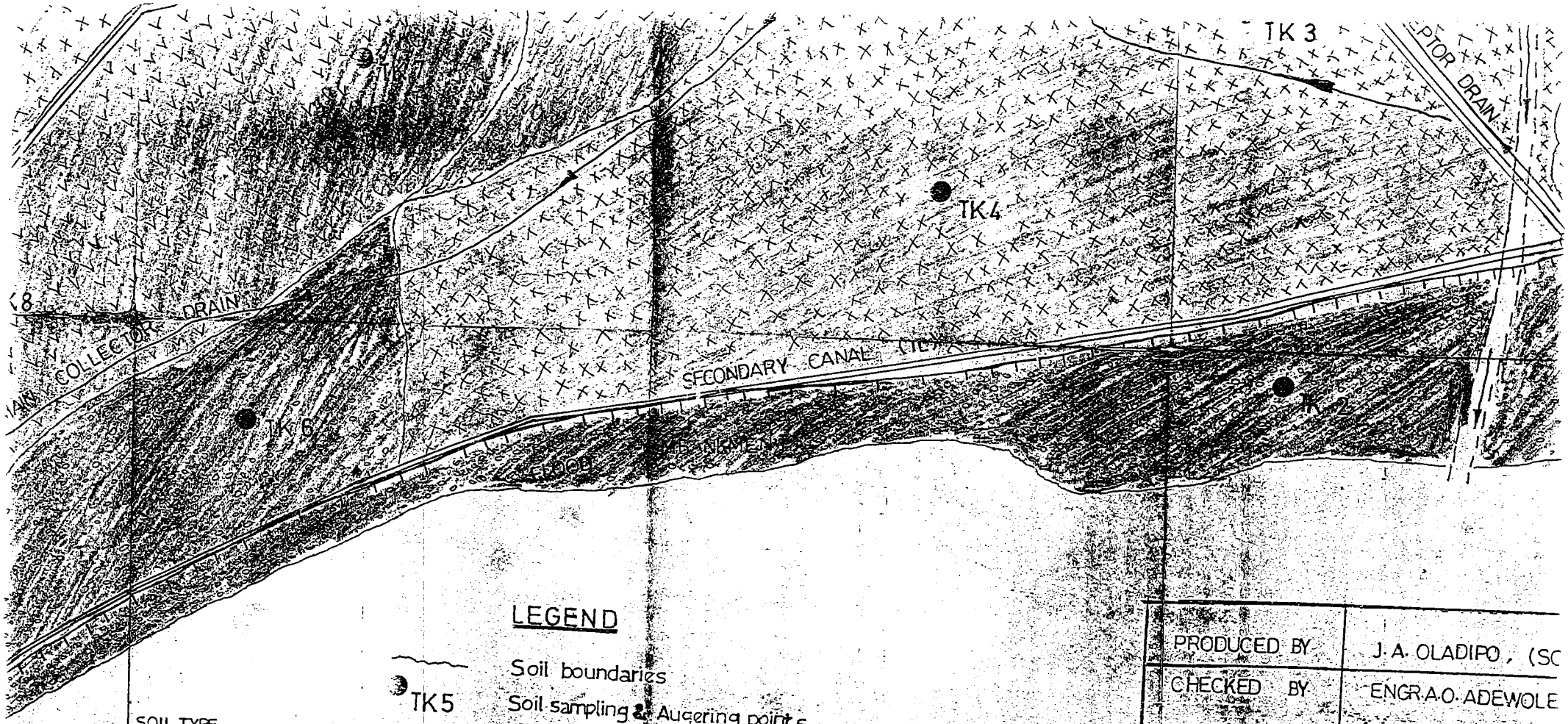

LEGEND

Soil boundaries

TK5 Soil sampling & Augering points

SOIL TYPE	FERTILITY CLASS
SANDY LOAM	Low Organic Matter Low N Medium–High P K
SANDY CLAY	Medium Organic Matter Low N Low P Low K
SANDY CLAY LOAM	Low–Medium Organic Matter Low–Medium N Medium P Medium–High K

SOIL TYPE	FERTILITY CLASS
CLAY LOAM	Medium Organic Matter Low–Medium N Medium P Medium–High K
CLAY	Medium–High Organic Matter Low – Medium N Low – Medium P Medium–High K

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DATE	DECEMBER
SCALE	1 : 1