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A century of soils research and development in Uganda

Henry Ssali
Soils and Soil Fertility Management Programme
Kawanda Agricultural Research Institute
P.O. Box 7065, Kampala, Uganda.

Abstract

In the early stages, Uganda's soils were considered fertile and little was done to improve productivity in a systematic way. However it was soon realized that crop yields in Uganda declined under continuous cultivation due to soil degradation like anywhere else. Initial studies on liming and fertilizers indicated little crop response. Efforts then turned to understanding processes associated with land rests which revealed the importance of both soil chemical and physical properties. The result were recommendations to nse a combination of organic materials, crop rotations, grass rests and soil and water conservation practices to improve and sustain soil productivity. Studies were also conducted to understand the causes of infertile patches in the country like 'lunyu' soils in central Uganda and sterile acid swamps. Research on fertilizer use was intensified after the second world war and focused on the annual cropping systems. Interim fertilizer recommendations for the major crops of that time were released in 1973. Soil resource inventories started in 1933 [Provisional soil map of East Africa] followed by a reconnaissance soil resources inventory between 1955 to 1960. There have been also more detailed soil surveys for specific clients. More recent soils research has focused on integrating soil productivity management through use of organic and inorganic fertilizers, biological nitrogen fixation, rotations, agroforestry and proper soil and water practices.

Key words: Soils research, development, Uganda

Introduction

Soils are cross cutting and many soils research and development activities are collaborative with various commodity programmes under the National Agricultural Research Organization (NARO) and other institutions.
In this paper focus will be on major processes/ developments that have influenced soil productivity management over the century we are celebrating—1898 to 1998.

Soil Productivity Management before 1898

Farmers in different areas have classified soils based on colour, texture and toposequence position and these classifications are used to indicate productivity and suitability for various crops. This started well over 100 years ago and in many cases indigenous classification is still being used.

Soil productivity management practices were part of traditions in many areas of Uganda and these helped to sustain agricultural production. There is evidence that trashlines were traditionally used on sloping lands in South West Uganda to improve soil fertility, water retention and crop productivity. Recent studies (Briggs. *et al*., 1998) have confirmed that trashlines improve soil productivity. Other practices that have been used include stonelines across a field for soil and water conservation, use of livestock manures and household refuse and shifting cultivation where the overused piece of land was rested to improve soil productivity. Many of these practices are still being used by farmers except shifting cultivation which has virtually disappeared partly due to land pressure and high labour costs.

What was done over the first twenty years after 1898. Around 1898 much of Uganda was found verdant and this was interpreted to mean that soils in Uganda were 'fertile'! As a result early research in Uganda concentrated on introducing exportable crops. However, it was soon realized that crop yields and soil productivity declined rapidly during continuous cultivation. Quick fix measures included use of lime (since soils were generally acidic) and use of fertilizers. But these measures on already degraded soils failed to adequately improve productivity. It was then realized that proper soils research was essential to understand how tropical soils behave under continuous cultivation.

Organisation of soils research in Uganda

Soil productivity research in Uganda effectively started in 1924 when a soil chemist was employed by the Department of Agriculture. The chemist was based at Kampala where laboratories [now the Government Chemist] were completed in 1928. The agricultural chemist moved to Kawanda Agricultural Research station in 1937 when laboratories at Kawanda were ready. Since then, national soils research in Uganda has been directed from Kawanda and the soils laboratory at Kawanda has serviced soil productivity research, soil survey and farmer advisory soil/plant analyses (Chenery, 1960b).

Others that have been involved in soils research and development in the country over the years have included:Farmers; Soils Department (Formerly Department of Agricultural Chemistry), Makerere University; East African community (1948-1977); under the East African Agricultural and Forestry Research Organization – EAAFRO that was based at Muguga in Kenya; Regional and international agricultural research centres that started coming in after the mid-1970's; Non-governmental organizations (NGOs) which have increased in number and scope after 1986.

Following the reorganisation of agricultural research in Uganda that culminated in the formation of the National Agricultural Research Organisations [NARO] in 1993, a Soils and Soil Fertility Management Programme was formed. The Programme with an establishment of 12 soil scientists is based at the Kawanda Agricultural Research Institute with a mandate to conduct research on soils, service other NARO institutes/programmes on soils related matters, and provide soil and plant tissue analytical facilities to stakeholders. The other institution with a concentration of soil scientists is Makerere University, with nine soil scientists in the Department of Soil Science [formerly Department of Agricultural Chemistry], Faculty of Agriculture. The Makerere staff teach soil science and together with graduate students, conduct research. The Department also provides soil and plant tissue analytical facilities to stakeholders. In addition to work done by institutions in Uganda, the East African Community (1948-1978), particularly the East African Agricultural and Forestry Research Organization —EAAFRO) that was based at Muguga, Kenya, conducted extensive soils research in collaboration with national institutions in the region.

More recently [beginning in the mid-1980s], International Agricultural Research Centres [IARCs], regional Agricultural Research Centres [ARCs] and non-governmental organisations [NGOs] have initiated collaborative research and development projects relevant to soil productivity.

Early soils research—1924 to 1944

Early soil productivity research in Uganda was linked to introduction of cash crops [cotton, tobacco, coffee or tea] into the indigenous farming systems. Initial [1910-1924] agricultural trials in Uganda suggested that climate was the main factor controlling yield of cotton. However it was soon realised that cotton yields, on-farm and on research stations dropped after a few years of continuous cropping. This demonstrated that European-type farming could not be applied indiscriminately in the tropics and led to systematic investigations into maintenance of soil productivity.

Rotations were evaluated and studies also sought to understand processes and how manure and grass leys, especially elephant grass leys, improve soil productivity. Since smallholder farmers dominated the agricultural sector the guiding principle was to concentrate on low input agriculture hence concentrated on rotations and using materials that were likely to be available to the majority of farmers—mainly organic materials.

Without laboratories initial soil productivity research concentrated on field trials involving, liming, green manuring for both cotton and coffee, application of cotton seed and mulching coffee. Limited laboratory facilities were eventually opened in Kampala (currently Government Chemist laboratories near Wandegeya) in 1928 and these allowed preliminary soil properties investigations. The two long-term field trials were established at Serere in the early 1930's; one "The permanent manurial trial" set up to test repeated application of manure on continuously cultivated land; the other "The Fertility Experiment" was set up to test rotations in conjunction with small manure dressings and in later years fertilizers (Chenery, 1960b).

The early results indicated that physical and chemical properties of soils were equally important and demonstrated the soundness of limited shifting cultivation that had evolved (Martin and Biggs, 1937; Martin, 1944a and 1944b). Other findings included:

- soils were generally acid;
- organic matter was relatively low;
- nutrients decreased during cropping;
- substantial erosion during the cropping phase;
- physical properties deteriorated rapidly during cropping;
- soil productivity improved under grass rest or grass fallow (traditional shifting/rotational cropping was, after all, a sound SP management practice);
- farm yard manure (FYM) improved soil productivity during the cropping phase;
- FYM facilitated establishment of grass leys (fallow) at the beginning of the rest phase;
- green manuring did not always work very well.

Soils laboratories at Kawanda opened 1937 and the new facilities enabled more detailed research to understand soil degradation causes/processes:

- how did the resting period restore soil productivity?
- Why was liming generally ineffective?
- causes and magnitude of nitrate fluctuation in a season and implications for nitrogen management;
- causes of unproductive soil patches locally called-'lunyu';
- causes of strongly acid conditions following drainage of some swamps;

etc.

Findings from these more detailed studies were major contributions to the understanding and management of soils in Uganda and tropical soils in general.

Major recommendations from the above studies included (Stephens, 1970):

- cropping system that included a grass rest period [fallow]; three years cropping followed by a three year grass fallow (Data in Table 1, indicates the

Table 1. Some fertilizer trials in Uganda

Period	Trials	Crops	Crops/areas/reference
1945-54	100	finger millet cotton sorghum groundnut sugar or sweet potato	tested N,P, K, phosphate rarephosphate rate, kraal manure, grass rest at over 30 sites mainly on agricultural stations or government land; Eastern Uganda ans south Mengo (manning and ap Griffith, 1949; Mills, 1953; 1954
1964-1964	290	cotton	N and P on small farmers' fields in Jinja, Kamuli, Iganga, Bugiri, Palisa, Tororo, Busia, Katakwi, Kumi, Soroti, and Lango [Stephens, 1968]
	78	groundnut	N and P on small farmers' fields in Jinja, Kamuli, Iganga, Bugiri, Palisa, Tororo, Busia, Katakwi, Kumi, Soroti, and Lango [Stephens, 1968]
	51	fingermillet	N and P on small farmers' fields in Jinja, Kamuli, Iganga, Bugiri, Palisa, Tororo, Busia, Katakwi, Kumi, Soroti, and Lango [Stephens, 1968]
1959-1973 N, P, K, MgO, FYM, Zn, Fe, Cu, B, Mo,	26	maize	agricultural stations, central and western Uganda [Stephens, 1969]
	27	cotton	agricultural stations, central and western Uganda [Stephens, 1969]
	39	beans	agricultural stations, central and western Uganda [Stephens, 1969]
	36	sweet potato	agricultural stations, central and western Uganda [Stephens, 1969]
	16	groundnut	agricultural stations, central and western Uganda [Stephens, 1969]
	18	fingermillet	agricultural stations, central and western Uganda [Stephens, 1969]
1963-1973	3000	cotton	N and P on farmers' fields, central, eastern and northern Uganda [Foster, 1978]
	1300	groundnut	N and P on farmers' fields, central, eastern and northern Uganda [Foster,1980a]
	900	finger millet	N and P on farmers' fields, eastern and northern Uganda [Foster, 1980b]
		maize	N and P on farmers' fields, western Uganda, Mt Elgon area [Foster, 1980b]
1967-1971	457	groundnut	tested SSP versus TSP on farmers' fields all over Uganda [Foster, 1973a]
1965-1969	85		wheat N and P on farmers' fields on soils derived from volcanic ash in the Mt Elgon area [Foster,1973b]
	132	maize	N and P on farmers' fields on soils derived from volcanic ash in the Mt Elgon area [Foster,1973b]
Total	6355		

benefits of resting the land);
- rotating crops during the cropping phase [cereals/legume, shallow/deeper rooted];
- application of manure during the cropping phase;
- improving the value of manure through better collection and storage;
- soil and water management measures to reduce erosion for various cropping systems and Topography.

Soils Research and Development After 1944 to the mid-1970s

Research to understand chemical and physical soil processes in tropical soils continued but after the second world war there were other developments as well. Prior to 1946 researchers and policy makers did not expect the majority of farmers in Uganda to use inorganic fertilisers mainly due to lack of fertilisers and associated costs. After the second world war urbanization started to increase necessitating a change in soil productivity management strategies. Other contributing factors included:
- increase in land area cultivated thus reducing fallow periods;
- desire for higher yields;
- increased nutrient exports from farms;
- reduced labour coupled with increased costs for opening new fields;
- opening of phosphate mine near Tororo;
- prospects of cheaper nitrogen on the world market.

Table 2. The change in organic carbon [kg/ha], nutrient content [kg/ha] and pH of the 0-45 cm depth of soil following a rest phase and an arable phase on the same area of land at Namulonge

Soil parameter	Measured after resting phase, 1966-69	Measured after arable 1963-66 phase,
organic carbon	+15,950	-19,700
total nitrogen	+ 769	- 968
Total phosphorus	+ 85	- 88
total sulphur	+ 45	- 86
pH [$CaCl_2$]	+ 0.26	- 0.31
exchangeable K	+ 471	- 461
exchangeable Ca	+ 971	- 1,897
exchangeable Mg	+ 420	- 420

N.B. All vegetation was incorporated into the soil with Rototiller after the rest period.
Source: Jones (1972)

The above factors combined to change thinking towards use of fertilizers and there was a need to conduct research to obtain information on using fertilizers to increase/sustain crop yields in Uganda (Manning and ap Griffith, 1949). Numerous trials were conducted on experimental stations and on farmers' fields throughout the country using the major crops of the 1950's and 1960's (Table 2). Result from these trials were the basis for the fertilizer recommendations that were released by the Ministry of Agriculture in 1973.

Inventory of soil resources

It was realized early that an inventory of soil resources was essential before an appraisal of the country's agricultural potential could be made. However, this was a major undertaking requiring a variety of resources—manpower, laboratory facilities, vehicles and funds (Chenery, 1960b). Such resources were difficult to harness in the midst of world wars and years immediately after the war.

The reconnaissance soil survey was eventually conducted in the late 1950's and Uganda became the first country in Africa to have a complete map of its soils at a scale of 1:250,000. The information is on 17 sheets and other details are presented in six memoirs (Chenery, 1960a). The mapping exercise was not cheap, by 1960 the exercise had cost £stg. 80,000—equivalent to £243,983 in 1998 assuming an annual inflation rate of 3%.

Soils resource inventory indicated (Chenery, 1960a):
- many [138] soil mapping units;
- soil reaction covered the entire spectrum pH 1.4 - 9.0; although some soils were very acid yet rich in bases;
- most soils were highly weathered with little nutrient reserves;
- organic matter was generally low compared to temperate soils;
- soil fertility [nutrients] mainly in top 30 cm of the soil hence susceptible to loss through erosion;

- some soils were highly susceptible to erosion particularly those in Karamoja;
- medium to high productivity soils covered less than 5% of the country;

While summarizing the results Chenery (1960a) commented that "compared to other places in the tropics the soils of Uganda are, on the whole, very fertile". Extracts from this statement have been used widely over the years—often out of context, resulting in poor attention to soil productivity problems in Uganda. As a result post independence farmers were not properly sensitized on soil productivity management. Deterioration of soil conservation after independence demonstrates the effects distorting the 'fertile soils' comments. However there seems to be a change and policy makers have realized the important role of soil productivity in agricultural production and development and have started sensitizing farmers.

Soils Research and Development After the mid-1970's

From the mid-1970's to the mid-1980's there was very little soils research in addition, data/information was lost from the research stations during the civil srife years. When soils research activities resumed, the early years, mid-1980's to the early 1990's, efforts focused on rehabilitation and there were several diagnostic surveys. Some of these culminated into collaborative projects with IARCs, ARCs and NGOs.

More recent efforts are concentrating on:

- assessing the impact of earlier research and working with farmers to increase uptake of developed technologies;
- revising recommendations to accommodate new high yielding varieties and changing cropping systems;
- looking at the interactions between soil productivity and crop pests/diseases ;
- integrating inputs (organic and inorganic), soil and water management, rotations and agroforestry for sustainable soil productivity management.
- focusing on using materials available to farmers;
- addressing needs of farmers with different capacities

Development aspects

Proper land husbandry was encouraged right from the 1930's. Up to the late 1960s, protection of arable land in Uganda was often good and soil conservation featured heavily in annual agricultural shield competitions held for many years (Stephens, 1970). Soil conservation was widely practised, and it was taught in schools and enforced by the administration throughout the country. Unfortunately soils in the communal grazing lands are more susceptible to erosion and as stocking rates have increased soil erosion has also increased. These areas include the upper slopes of the hills in Mbarara and Ntungamo districts and the cattle corridor—a wind band stretching from south western Uganda through central Uganda to the north east.

Fertiliser use in Uganda was on the increase even before the interim recommendations were released in 1973. However, fertilizer use in Uganda has generally been low and mainly used by large estates growing sugar and tea. Smallholders have used fertilizers mainly on tobacco, cotton and in a few cases on coffee. Fertilizer use in Uganda peaked in 1971/72 before dropping to virtually zero up to 1990 when rehabilitation of the estate crops started. A survey by the Agricultural Secretariat (Tukacungurwa,1994) indicated that total fertilizer consumption had built up to 27,000 metric tonnes (MT) before declining to 4,205 MT by 1978. The survey indicated that reliable records were not available between 1976 and 1989. The Secretariat kept data from 1990 to 1994 and indicated an average total fertilizer consumption of 5000 MT, a gradual increase from 3,870 MT in 1990 to 6,518 MT

Table 3. Total fertilizer [N + P_2O_5 + K_2O] consumption trends in some African countries ['000 metric tonnes]

Country	1969/70	1971/72	1979/80	1985/86	199/091	1995/96
Uganda	5	8	-	-	-	3
Kenya	42	47	51	109	116	75
Tanzania	11	17	30	39	51	22
Zimbabwe	94	133	120	170	177	164
Malawi	7	15	21	34	48	34
Ghana	1	3	19	13	13	12
Cote d'Ivore	14	24	52	42	36	65
Egypt	348	372	604	864	965	1134
South Africa	509	617	941	879	792	748

\- no data available
Source: FAO Fertilizer Yearbook

in 1994. Projections indicated that consumption will reach 30,000 MT by the year 2000.

Fertilizer use in Uganda is still very low compared to the other countries in the region and Africa [Table 3]. The amounts in the table are lower than those reported by the Secretariat mainly due to the way the data is reported. The Secretariat data is based on total nutrient carriers [urea, ammonium sulphate, single super phosphate etc.] whereas the data in Table 1. Are based on total nutrient [N + P_2O_5 + K_2O] consumption.

Generally fertilizer availability in Uganda is increasing and larger dealers are increasing in number. Initially dealers targeted estates and flower growers however, many are beginning to stock excess fertilizer to sell to smallholder farmers. As a result fertilizer prices are coming down. While fertilizer availability in the country was poor, there was little justification for further research involving fertilizers. However, as fertilizer availability increases, more research will be required to update interim recommendations and focus more on the socio-economic aspects of fertilizer use.

There are now increased efforts by policy makers and other stakeholders working through various technology transfer pathways to sensitise farmers on soil productivity management to increase agricultural production and protect the environment. The Namulonge experience (Jones 1972 and 1976) clearly demonstrated that it was possible to increase productivity of degraded soils and maintain acceptable agricultural production in a sustainable way.

Future work on soils

Future work on soils research and development is expected to include:

- increasing adoption rate of soil pruductivity management technologies;
- address soils needs of the changing and wide spectrum of farmers including developing a viable fertiliser industry;
- developing more cost effective technologies;
- address nutrient requirements of new major crops/ varieties address requirements of modern agriculture;
- update resource inventories and grouping available soils information into classification system

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