PROCEEDINGS

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Crop Improvement in Eastern and Southern Africa

Research Objectives and On-Farm Testing

A regional workshop held in Nairobi, Kenya, 20-22 July 1983

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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa, Canada

Kirkby, R.A.

IDRC. East Africa Regional Office, Nairobi KE

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Crop Improvement in Eastern and Southern Africa:

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Editor: Roger A. Kirkby

RÉSUMÉ

Un atelier a réuni un petit groupe représentatif de scientifiques travaillant à des programmes d'amélioration des cultures alimentaires en Afrique orientale et australe, pour discuter de la planification, de la conduite et de l'élaboration de ces programmes. Le débat a porté surtout sur les aspects méthodologiques, communs à la majorité des cultures réalisées par les petits fermiers et les plus susceptibles de permettre l'utilisation des résultats de la recherche.

On s'intéresse donc ici aux cultures locales et aux pratiques culturales, à l'organisation de l'aide institutionnelle pour améliorer les cultures, aux objectifs particuliers des programmes et au mode d'établissement de ces objectifs, enfin aux méthodes d'évaluation employées pour formuler une nouvelle recommandation sur les travaux de vulgarisation. On résume aussi la séance de discussion qui a porté sur l'organisation des programmes d'amélioration des cultures, l'établissement des objectifs techniques, l'application des critères de sélection, la méthodologie pour les essais tous terrains et sur les fermes et, enfin, l'orientation de la recherche.

RESUMEN

Este seminario reunió un pequeño grupo representativo de científicos que trabajan en programas de mejoramiento de cultivos alimenticios en Africa oriental y meridional con el ánimo de discutir la planificación, la ejecución y el desarrollo de tales programas. El énfasis de la discusión recayó en aquellos aspectos metodológicos, comunes a la mayoría de los cultivos sembrados por los pequeños agricultores, que tienen la probabilidad de influir más en que los resultados de la investigación sean utilizados por el agricultor.

Entre estos trabajos se encuentran breves recuentos de las variedades locales y las prácticas de cultivo empleadas actualmente, la organización institucional para el fitomejoramiento, los objetivos específicos de los programas y su sistema de establecimiento, así como los procedimientos de evaluación empleados para llegar a las nuevas recomendaciones para los trabajos de extensión. También se incluye en este volumen un resumen de la sesión de discusión sobre la organización de los programas de fitomejoramiento, la fijación de los objetivos técnicos y la aplicación de los criterios de selección y la metodología para las pruebas tanto en fincas como en localización múltiple. Varios temas de política fueron identificados.

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STRATEGIES FOR ROOT-CROP IMPROVEMENT IN UGANDA

G.W. Otim-Nape

National Root Crops Improvement Programme,
Serere Research Station, P.O. Soroti, Uganda

Root crops, particularly cassava (Manihot esculenta Crantz.) and sweet potatoes (Ipomea batatas), play a significant role in the economy of Uganda. Other crops, such as yam (Dioscorea spp.) and cocoyam (Xanthosoma spp. and Colocasia spp.) are also grown, especially in Buganda and Western regions, but their importance is relatively minor. Irish potatoes (Solanum tuberosum) are important only in the highland areas of Kigezi and Sebei.

Although the presence of cassava in East Africa was recorded as early as 1779 in Zanzibar (Grant 1875), cassava did not reach Uganda until the end of the 19th century. The Speke and Grant expedition of 1862 did not report the presence of the crop further north than latitude 4°18'N but Stanley found it growing in 1870 (Grant 1875). Morgan, speaking in 1912, states that cassava was widely cultivated in Uganda and that its value as a reserve against the risk of famine was quickly appreciated (Simpson 1918, 1926). The crop is gradually replacing sorghum and finger millet as a staple food crop (IDRC 1982).

Cassava is grown throughout the country but the greatest production comes from the Northern and Eastern regions. Of the 2.35 million metric tonnes of cassava produced in Uganda in 1974, 0.92, 0.68, 0.42, and 0.35 million metric tonnes were produced in Northern, Eastern, Western, and Buganda regions respectively (Planning Unit 1975). Much of the cassava is cropped with maize, beans, and groundnuts, which are harvested at maturity, usually 3-4 months after planting, thus leaving pure stands of cassava. Cassava is grown by peasant farmers in small plots of not more than 1 ha each, although large fields of cassava are beginning to emerge. The area under cassava, by region, is shown in Fig. 1.

Cassava is used mainly for human consumption; however, in some parts of the country, especially in Lango, Acholi, and Teso, enguli, an important local alcoholic drink, is distilled from dry cassava tubers. This has indicated that pure alcohol can be distilled from cassava relatively cheaply. Starch is also manufactured from cassava tubers by the Lira Starch Factory in Northern Uganda.

Research on root crops, especially cassava and sweet potatoes, is being conducted at Serere Agricultural Research Station under the Ministry of Agriculture and Forestry. The station is situated at latitude 1°31'N, longitude 33°27'E and at an altitude of 1140 m above

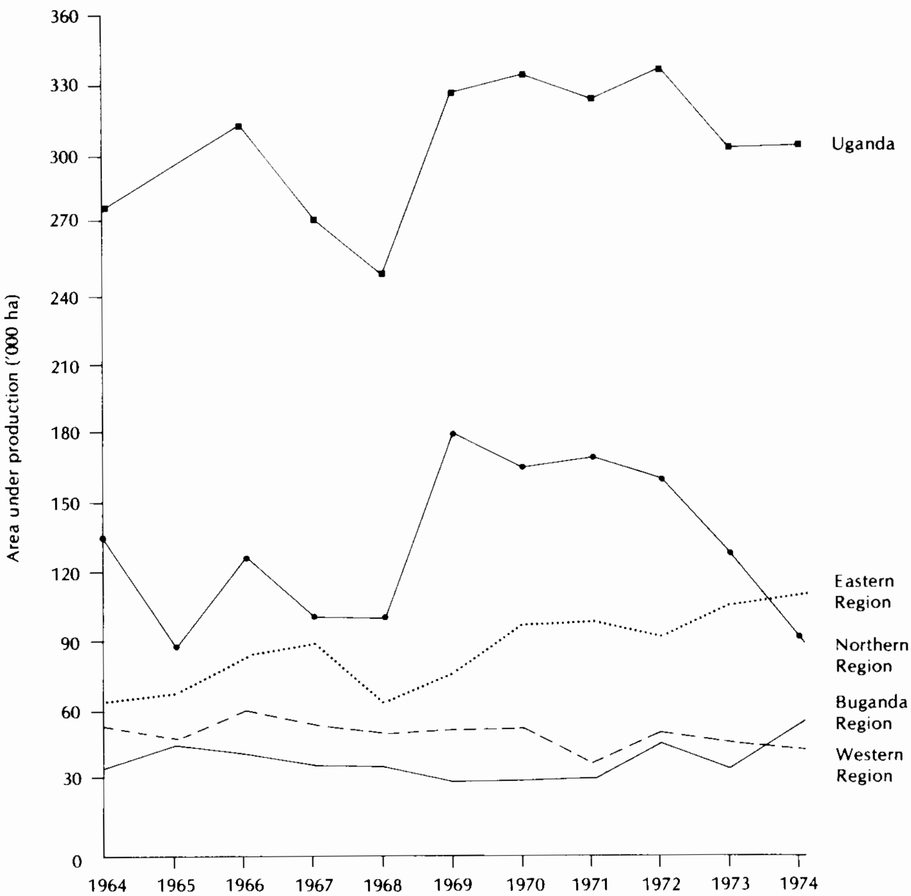

Fig. 1. Area under cassava, 1964-1974.

sea level. In these areas, farmers require cassava and sweet potato varieties that give high and reliable yields. The station is located in an important cassava and sweet potato growing area and is served by a network of government variety trial centres (VTCs) (experimental substations) scattered throughout all ecological zones of the country. At the VTCs, research materials are tested without charge to the crop improvement programs that make use of this service.

Research on sweet potatoes was conducted at Kawanda and Serere Research Stations and Makerere's university farm, Kabanyolo, during pre-Independence and shortly after Independence. The work was mainly concerned with evaluating common local and a few introduced varieties for their yield and for resistance to and cultural control of the sweet potato weevil (Cylo spp.). This work was abandoned shortly after Independence after significant progress had been made.

The history of research on cassava in Uganda dates as far back as 1935. This work was based mainly at the then East African Agricultural Institute, Amani, Tanzania, where breeding of cassava for resistance to African cassava mosaic disease was being carried out. Materials developed at the institute were evaluated further at Serere Research Station and at other places in Uganda for resistance, adaptability, and good agronomic attributes. As a result, a number of varieties (Serere and Bukalasa lines) were released to farmers for growing and the work was abandoned in the late 1950s.

With the outbreak of the cassava green spider mite *Mononychellus tanajoa* at Kampala in 1971, cassava research in Uganda was revived. This was based on entomological investigations of the distribution in Uganda, biology, ecology, and control of the green spider mite. The work was based at Kawanda Research Station, Kampala, and was later abandoned in the late 1970s after significant progress had been made.

At the discovery of the presence of cassava bacterial blight in Uganda, cassava research elsewhere in Uganda was transferred to Serere Research Station and the program was expanded to include plant pathological investigations, with emphasis being placed on cassava bacterial blight and African cassava mosaic disease. In 1980, the program was upgraded to the National Root Crops Improvement Programme (UNRCIP) and assigned the responsibility of improving production and utilization of root crops, especially cassava and sweet potatoes, in Uganda. A plant breeder, an agronomist, and a food technologist were then posted to the core program at Serere. The program is headquartered at Serere Research Station and involves all disciplines: a plant pathologist, breeder, crop entomologist, agronomist, and food technologist are all present. All of these disciplines are responsible to the program leader, who coordinates all of their activities and, in consultation with the Director of Research and the Commissioner for Agriculture, directs research efforts to areas that need urgent attention. Research experiments conducted the previous year are reviewed and new proposals for the coming year are discussed for approval or rejection at the annual national experiment committee meeting (ECM), which is attended by all research officers, directors of research stations; the Commissioner for Agriculture; the Dean of the Faculty of Agriculture and Forestry, Makerere University; and a representative from the National Research Council, farmers, Lint and Coffee Marketing Boards, and regional agricultural officers. Projects approved at the ECM are further discussed at the annual agricultural advisory committee meetings, the main policymaking body of the Research Division.

The National Root Crops Improvement Programme enjoys close working relationships and exchanges research experiences, results, and inputs with the rest of the research programs at Serere Research Station; with the Ministry of Regional Co-operation's Sorghum and Millets Unit at Serere; and with the other research programs at Kawanda and Namulonge Research Stations and at the Faculty of Agriculture and Forestry, Makerere University, Kampala. Close cooperation in the form of the exchange of improved materials, technologies, and information and visits and training also exist with the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria; Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia; and the Asian Vegetable Research and Development Center (AVRDC), Taiwan.

PROGRAM OBJECTIVES

Broad Objectives

The immediate overall objectives of the Uganda National Root Crops Improvement Programme are to evaluate the existing root crop varieties and husbandry practices in Uganda in terms of their benefits to the farmer and to develop improved high-yielding varieties and husbandry practices that will increase those benefits to the farmer. These objectives were established based on the fact that improved crop technologies could only be successful if they were developed based on knowledge of the performance and limitations of existing local varieties, husbandry practices being followed by farmers, farmers' circumstances under which crops are being grown, and how these can be improved.

Specific Objectives and Methods of Achieving Them

The specific objectives of the program are:

(1) To survey a sample of cultivators who grow a substantial amount of root crops, especially cassava and sweet potatoes, in selected areas of Uganda: Initially, the program was to concentrate on the Eastern, Northern, and Nile regions of the country. These are the areas of greatest root-crop production. Approximately 10% of the villages in the project area are chosen, area by area, to provide good coverage of the total target zone. Ten households are chosen from each village, selecting those that regularly grow a substantial amount of crops. Exploratory surveys are conducted by the research scientists through questionnaires. The questionnaire includes the following information: (a) number of cultivars grown with approximate area of each, soil types, names of varieties grown, maturation period and sweetness or bitterness of varieties, scores for individual pests and diseases, yield estimates, and uses of varieties; (b) planting times and methods, previous crops and manure/fertilizer treatment on current crops, land preparation, ridge or flat seedbed, whether intercropped and with what, weeding frequency, and harvesting method and whether part or the whole field is harvested at once; and (c) proportion of the crop used for domestic consumption or for sale and how sold. Collections were made of all cultivars grown by the farmers surveyed.

(2) To evaluate the materials collected from farmers: A nursery was planted with cuttings from all of the farmers' cultivars collected during the survey. The cultivars were interplanted with pest and disease susceptible materials previously inoculated/infected or infested with the appropriate organism(s). The cultivars were later evaluated for pests, disease resistance, and good agronomic qualities. The best entries were multiplied and planted in yield trials at several locations, grouped by duration and soil types. The best entries were again multiplied for further testing and as a source material for multiplication and distribution plots. They also form the elite of local clones as a reference base.

(3) To improve root-crop cultivars: The surveys identified pests and diseases, i.e., cassava bacterial blight, <u>Xanthomonas campestris</u> pv. <u>manihotis</u>; African cassava mosaic disease; cassava anthracnose, <u>Colletotrichum</u> spp.; cercospora leaf spots, <u>Cercospora</u> spp.; and the cassava green spider mite, <u>Mononychellus tanajoa</u>. Appropriate resistant materials have been obtained from IITA and used as parents in crosses with the elite, adapted local lines identified during the evaluation. Segregating generations were screened for resistance to appropriate diseases/pests and for bitterness. Yield trials were conducted using farmers' cultivars as controls and under good husbandry practices; dry matter yield, starch content of tubers, and yield potential are important at this stage. These were repeated

across locations and the best entries identified for yield, resistance, and tuber quality were subjected to farmers' trials.

(4) To broaden the germ-plasm base: A collection of cassava and sweet potato germ plasm from various parts of Uganda has been established. To this collection will be added introductions from IITA and elsewhere. The most promising selections from segregating progenies will be added to the collection.

Husbandry Practices

The practices of the best cassava and sweet potato farmers, as established during exploratory surveys, were taken as the baseline and modified. Those that seemed to produce superior results in field trials were incorporated into farmers' trials and evaluated by them.

Plant Pathology

To identify diseases affecting cassava and sweet potatoes in Uganda, surveys were carried out throughout the country and experiments were conducted at selected VTCs in different ecological regions. Diseased plant samples are sent to the Commonwealth Institute of Mycology (CMI) for identification.

To screen cassava varieties for resistance to African cassava mosaic disease, cassava bacterial blight, cassava anthracnose, cassava stem rust, bacterial stem gall, and cercospora leaf spot, screening methods developed at IITA will be adopted.

To study pathogenic variations among cassava bacterial blight pathogen *Xanthomonas campestris* pv. *manihotis* and adopt appropriate strategies for screening varieties for resistance to the disease, samples of infected cassava leaves and stems will be collected from various regions of Uganda. The bacteria will be isolated from each sample and standard doses of the isolates made. These will then be used to inoculate cassava seedlings in the greenhouse. The ability of each isolate to induce disease and to what degree of severity will be established.

To screen sweet potatoes for resistance to the sweet potato virus complex, the tissue-implantation method commonly used at IITA will be adopted.

Crop Entomology

To identify important cassava and sweet potato pests and screen varieties/lines for resistance to them, pest surveys will be carried out throughout Uganda and field experiments conducted at VTCs located in the various ecological regions. The population buildup of the major pests will be followed and the economic status of the pests assessed.

To screen for resistance of cassava varieties to the green spider mite, the method based on scoring for mite infestation on a scale of 0-5 (as described later) is used. As well, the applicability in Uganda of any IITA-developed cultural or biological methods of controlling the green spider mite will be tested at Serere Research Station and in selected farmers' fields.

To screen for resistance to the sweet potato weevil, sweet potato tubers will be assessed on a scale of 0-5 for weevil infestation.

Evaluation Methods

The methods for evaluating germ plasm for resistance to pests and diseases and for plant and root characteristics are presented in Tables 1 and 2. Each method, using a score of 0-5, is based on a visual estimation of the severity of disease infection or pest infestation and on the degree of intenseness of plant and root characteristics. This method has the advantage of being simple, quick, easy to use, and does not require a lot of skill.

Multilocational Tests

Promising germ plasm of cassava and sweet potatoes is evaluated at selected VTCs that represent the different ecological regions of the country. A network of over 40 VTCs was established during the colonial period to provide areas for testing the technologies developed at research stations for their suitability in the areas concerned. Each VTC is headed by a varietal trial observer (VTO) who usually has a diploma in agriculture. The VTO is supported by agricultural and field assistants. The VTOs are supervised by the officer in charge of the VTCs, who reports to the coordinator of the VTCs, usually a research agronomist appointed by the Commissioner for Agriculture.

On-Farm or Village Tests

The Research Division of the Department of Agriculture has not embarked upon on-farm or village tests; however, plans are under way to incorporate them into the research system.

Quality Tests

Testing the quality of cassava and sweet potato tubers involves counting the number of marketable and unmarketable tubers and estimating the percentage dry matter, starch content, and bitterness of the tubers. The dry matter content of the tubers is determined by taking 2-kg samples of fresh tubers and drying them to a constant weight at 105°C for 4 days. The starch content of the tubers is estimated using the specific-gravity method. This involves determining specific gravities of samples of tubers and reading their percentage starch contents from a standard graph. Bitterness of the tubers is based on organoleptic tests scored on a scale of 1-5, as described in Table 2.

SUMMARY OF METHODOLOGICAL ISSUES

The current objectives of the program have changed considerably. In the past, it had been assumed that technologies developed at research stations would be directly and immediately adopted by farmers. Experience has shown, however, that this assumption has been incorrect and that most of the technologies have not been easily adopted by farmers. As a result, there has been a reexamination of the strategy and it has been realized that development of easily adoptable crop technologies can only be achieved based on a sound understanding of the limitations of existing crop varieties and husbandry practices followed by farmers and on an understanding of farmers' circumstances.

It has also been realized that for a technology to be easily adoptable, the people who will eventually use it should be allowed to

Table 1. Methods of evaluating cassava and sweet

Disease or pest score	CBB	CMD	CA	LS
0	No leaf spot, leaf blight wilt, or die-back on stems	Apparent field resistance, no symptoms seen	No lesions on stems, petioles, or leaves	No symptoms of leaf spot
1	Very few angular water-soaked leaf spots with occasional leaf blights	Mild chlorotic pattern over entire leaflets or very mild distortions only at the base of leaflets, with the remainder of the leaf appearing green and healthy	Few small lesions can be seen on stems and petioles	Few leaf spots on leaves. Approximately 2% of leaf infected and destroyed
2	Angular leaf spots and leaf blights are predominant. No defoliations or gum exudations on leaf lamina, petioles, or stems	Mild chlorotic pattern over entire leaflets or mild distortions only at base of leaflets, with the remainder of the leaf appearing green and healthy	Few yellowish cankers on woody stems late in the season	Many leaf spots on leaves and approximately 4% of leaf infected and destroyed
3	Abundant angular leaf spots and blights; yellow gum exudation on lamina petioles and stems; moderate leaf and twig wilt; and defoliations but no tip dieback	Strong mosaic pattern all over the leaf; narrowing and distortion on lower one-third of leaflets	Large numbers of deep cankers on woody stems followed by distortion	Very abundant leaf spots and approximately 8% of leaf infected and destroyed
4	Very abundant angular leaf spots and blights; yellow gum exudations on stems, petioles, and lamina; very severe leaf and stem wilting; and defoliations together with tip dieback and wilting of lateral branches	Severe mosaic pattern; severe distortion of two-thirds of leaflets; and general reduction of leaf size	Large number of oval lesions on green stems	Severe leaf spotting; leaf spots coalesce together in some cases; and approximately 13% of leaf lamina infected and destroyed
5	Very severe and extensive dieback and drying of most of the green parts of the stems leading to occasional death of the plant	Severe mosaic; severe distortion of four-fifths or more of leaflets; twisted and deformed leaves; and severe reduction of leaf size	Large numbers of lesions; severe necrosis of leaf axils; followed by wilting and severe defoliation	Very severe leaf spotting; leaf spots coalesce in most cases; and approximately 31% of the lamina infected and destroyed

Note: CBB = cassava bacterial blight; CMD = African cassava mosaic disease;
CSR = cassava stem rust; RR = cassava root rot; SPVC = sweet potato

potato germ plasm for resistance to pests and diseases.

CSR	RR	SPVC	GCM	SPW
No rust pustules on mature stem	No tubers rotted	No symptoms of virus on leaves	Apparent field resistance. No spots on terminal buds and leaves are free from mites	Tuber free from weevil infestation
Very few rust pustules on mature stems	Very few tubers rotted	Mild chlorotic patterns or vein clearing on leaf	Mites present and few white spots on terminal buds and on young leaves	Localized swellings on stems and holes on root neck. Less than 10% of tubers weeviled
Rust pustules are abundant on mature stems	Few tubers rotted	Vein clearing, mottling, and distortion of leaves	Few whitish spots on young unfolded and first expanded leaves	Localized swellings on stems; holes on root neck; and 20-40% of tuber weeviled
Rust pustules overcrowded and very abundant on stems	Half the number of tubers rotted	Pronounced vein clearing, mottling, distortion, strapping, and chlorosis of the leaves	Shoot leaves not fully expanded, older expanded leaves with distinct chlorotic spots, and leaf size reduced by about 25%	Localized swellings with severe rotting of stem; 40-50% of tuber weeviled
Overcrowding and excessive abundance of pustules; stems start becoming very rugose	Severe rotting of tubers	Very pronounced vein clearing, mottling, distortion, strapping, and chlorosis of the leaves. Some stunting of plants can also be observed	Apical leaves not expanded; reduction of leaf size to more than 50%; severe chlorosis on older leaves; and possibly infestation of oldest leaves	Localized swellings and severe rotting of stems; 60-80% of tubers weeviled and rotted
Overlapping of most of the pustules that are already excessively abundant on matured stems. Stems completely rugose; withering and death of some lateral buds	All tubers rotted	Very pronounced vein clearing, mottling, distortion, strapping, and chlorosis of leaves; very severe stunting of plants	Shoot dead or unproductive; older leaves infested; little or no infestation of lower expanded leaves	Severe rotting of stems and over 80% of the tuber is weeviled and rotted

CA = cassava anthracnose; LS = cercospora leaf spots of cassava;
virus complex; GCM = cassava green spider mite; SPW = sweet potato weevil.

Table 2. Methods of evaluating cassava and sweet potato germ plasm for plant and root characteristics.

Plant or root score	CS	BH	PC	LH	TNL	TSC	TSZ	TGA	TS	TB
1	Very poor	Very poor (0.1-0.25 m)	Brown	No hair	Short/no neck	Brown	0.5 kg	Very poor	Round	Very sweet
2	Poor	Poor (0.25-0.5 m)	Dark brown	Trace	About 5-7 cm	Dark brown	0.5-1 kg	Poor	Oval	Sweet
3	Average	Average (0.5-1.0 m)	Purple	Average	About 7-10 cm	Purple	1-2 kg	Medium	Medium long (desirable)	Average
4	Good	Good (1-1.5 m)	Red	Abundant and long	About 10-15 cm	Red	2-5 kg	Good	Very long and fat (desirable)	Bitter
5	Very good	Very good (above 1.5 m)	White	Very abundant and long	>15 cm	White	$\geq$5 kg	Very good	Very long and thin (undesirable)	Very bitter

Note: CS = plant's canopy/structure; BH = plant's branching habit; PC = petiole colour; LH = leaf hairiness; TNL = tuber neck length; TSC = tuber skin colour; TSZ = tuber size; TGA = tuber general appearance; TS = tuber shape; TB = bitterness of tubers.

evaluate it before it is released to them. Consequently, the current program places more emphasis on on-farm testing of research station generated technologies. Plans are under way to establish village or on-farm testing networks to fulfill this need. Past evaluation of research station generated technologies was mainly restricted to VTCs. The new networks will be the most innovative and interesting feature of the program.

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Grant, J.A. 1875. The botany of the Speke and Grant expedition. Transactions of the Linnean Society of London, 29, 148.

International Development Research Centre (IDRC). 1982. Agricultural research in Uganda: A program for rehabilitation. Ottawa, Ontario, Canada, IDRC-MR60, 15.

Planning Unit, Ministry of Agriculture and Forestry. 1975. Crop production statistics. Entebbe, Uganda, unpublished data, 32-35.

Simpson, S. 1918. Annual report part II. Department of Agriculture, Government Printer, Entebbe, Uganda, 14.

1926. Annual report part II. Department of Agriculture, Government Printer, Entebbe, Uganda, 13.