IDRC-218e

PROCEEDINGS

Crop Improvement in Eastern and Southern Africa

Research Objectives and On-Farm Testing

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

CANADA

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

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

IDRC-218e

Crop Improvement in Eastern and Southern Africa : Research Objectives and On-Farm Research; a regional workshop held in Nairobi, Kenya, 20-22 July 1983. Ottawa, Ont., IDRC, 1984. 122 p. : ill.

/Plant breeding/, /food crops/, /cultivation systems/, /agricultural research/, /research programmes/, /testing/, /farms/, /East Africa/, /West Africa/ -- /on-farm research/, /agricultural extension/, /methodology/, /sorghum/, /maize/, /groundnut/, /pigeon peas/, /root crops/, /bananas/, /conference report/, /list of participants/, references.

UDC: 63.001.5(676:68) ISBN: 0-88936-396-X

Microfiche edition available

IDRC-218e

Crop Improvement in Eastern and Southern Africa:

Research Objectives and On-Farm Testing

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

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.

CONTENTS

SWEET POTATO CULTIVATION AND RESEARCH IN RWANDA

G. Ndamage

Institut des sciences agronomiques du Rwanda (ISAR),
Station de Rubona, B.P. 138, Butare, Rwanda

Recently, a great deal of effort has been placed on increasing food-crop production in Rwanda (Bazihizina 1983). The sweet potato, a widely cultivated crop, is one of the agricultural products under investigation. It grows at elevations up to 2300 m above sea level. The highest production, however, is obtained at elevations up to 1900 m, above which the crop suffers from low temperatures.

The sweet potato performs very well in all 12 agricultural regions of the country (Fig. 1; Table 1), except in the northern region where there are volcanic soils (Delepierre 1974). It occupies 94 000 ha of land and has a total production of about 782 400 t (Ministry of Planning 1975-1980), representing 20% of the country's food production. It is, therefore, the second most important crop after banana. Table 2 shows the production of sweet potatoes in nine districts of Rwanda.

PRODUCTION SYSTEMS

In rural areas, the sweet potato is cultivated on fallowed land. It is either cultivated alone or in a mixture with beans, sorghum, or cassava. From September to April, it is cultivated on the slopes of hills, whereas from May to July it is cultivated in valleys, which have usually been flooded during the rainy season. Thus, sweet potatoes are available year-round.

In the flooded valleys, large ridges are made so that good drainage is achieved. On the slopes of hills, sweet potatoes are planted either on ridges or bunds.

RESEARCH ORGANIZATION

The Institut des sciences agronomiques du Rwanda (ISAR), whose headquarters are located in Rubona, with the help of the Ministry of Agriculture and Livestock, has conducted research aimed at finding solutions to the various problems that agriculture is facing.

The departments carrying out these studies include the Plant Production Department, Animal Production Department, and Land Management Department, with the help of the Laboratories Department

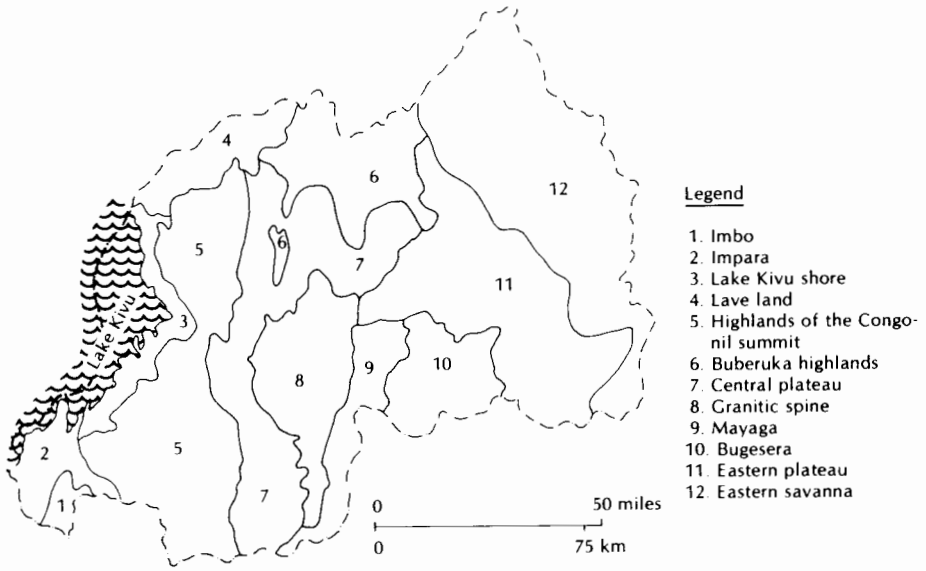

Fig. 1. Agricultural regions of Rwanda.

(chemistry, technology, plant protection) and the Farming System Service, which is concerned with diffusion of research results to local farmers.

The Plant Production Department is made up of five divisions. The Food Crops Division conducts its research in five areas of the country (Rubona, Rwerere, Karama, Ruhengeri, and Tamira) on the selection, improvement, and agricultural techniques of cereals, grain legumes, and root and tuber crops in an attempt to find the most suitable varieties for each ecological zone.

The root and tuber crops research program is organized and stationed according to different ecological conditions: for the sweet potato, yam, and cocoyam at Rubona; cassava at Karama; and Irish potatoes at Ruhengeri. The Irish potato program is well staffed, whereas the sweet potato and cassava programs are not yet self-sufficient with respect to research staff, each program having at present one agronomist/breeder.

PROGRAM OBJECTIVES

Main Factors Limiting Production

During the past 10 years, there has been an increase in total cultivated area but the output remains stagnant or, in some cases, is decreasing. This is due to various factors.

Pests and Diseases

Virus diseases -- These constitute viral complexes that are not yet identified. They are transmitted mainly by aphids (Myzodes persicae) and white flies (Bemisia tabaci). Virus diseases can reduce total production by 50% or more.

Table 1. Summary of agricultural regions.

Region	Altitude (m asl)	Rainfall (mm)	Soils	Main products	Agricultural value
Imbo	970-1400	1050-1600	Alluvial soils	PLANTAIN, CASSAVA, beans, peanuts, sweet potatoes, COTTON, RICE, sugarcane, citrus fruits	Excellent
Impara	1400-1900	1300-2000	Heavy red soils derived from basalts	Plantain, beans, maize, sorghum, sweet potatoes, cassava, peanuts, COFFEE, TEA, Peruvian bark	Good
Shore of Lake Kivu	1460-1900	1150-1300	Clay loam surface soils	Plantain, beans, maize, sorghum, sweet potatoes, cassava, peanuts, COFFEE	Bugoyi and Kanage, excellent; the others, good
Lave land	1600-2500	1300-1600	Volcanic soils	Plantain, beans, maize, sweet potatoes, sorghum, peas, potatoes, WALLWORT, TOBACCO	Excellent
Summit	1900-2500	1300-2000	Humic, acidic soils	PEAS, maize, potatoes, Eleusine sp., buckwheat, SUMMER WHEAT, TEA, SUNFLOWER, LUMBER	Fair
Buberuka	1900-2300	1100-1300	Lateritic soils	Plantain, beans, sorghum, sweet potatoes, maize, potatoes, PEAS, SUMMER WHEAT, barley	Good

Central plateau	1500-1900	1100-1300	Different humic soils	BEANS, sorghum, maize, SWEET POTATOES, plantain, taro, yams, coffee, soybeans	Good
Granitic spine	1400-1700	1050-1200	Light, gravelly soils	Plantain, BEANS, sorghum, maize, SWEET POTATOES, yams, taro, peanuts, cassava, coffee, livestock	Fair
Mayaga	1350-1500	1000-1200	Clay soils derived from slates	COFFEE, BEANS, SORGHUM, maize, plantain, sweet potatoes, cassava, peanuts, soybeans, rice	Very good
Bugesera	1300-1500	850-1000	Clay, highly altered soils	Beans, sorghum, maize, plantain, sweet potatoes, CASSAVA, peanuts, livestock	Poor
Eastern plateau	1400-1800	900-1000	Lateritic soils	Beans, sorghum, maize, PLANTAIN, sweet potatoes, cassava, PEANUTS, livestock	Fair in the north, good in the south
Eastern savanna	1250-1600	800-900	Old soils of variable texture	Cassava, peanuts, beans, sorghum, maize, sweet potatoes, livestock	Very poor

Table 2. Sweet potato production in different districts of Rwanda, 1975-1979.

District	Production (%)	Yield (t/ha)
Butare	17.6	10.6
Gitarama	11.8	8.3
Kigali	11.8	7.9
Byumba	10.6	7.0
Gikongoro	10.4	7.7
Gisenyi	9.8	8.1
Kibungo	7.5	8.9
Cyangugu	7.0	8.9
Ruhengeri	6.6	6.6

Fungal diseases -- Among the most important fungal diseases that attack sweet potatoes in Rwanda is anthracnose leaf spot, which is caused by Alternaria solant. Attack by this fungi can easily result in the total destruction of the crop. Anthracnose is more dangerous in high-altitude regions.

Virus and fungus diseases are spread vegetatively, especially during the period when cuttings are obtained. Hence, it has become a problem because these diseases are present even before planting.

Weevils -- The black weevil (Cylas spp.) attacks almost every part of the plant, but the roots in particular. The weevils bore through the roots or stems and at the same time leave their feces behind. The weevils cause the tubers to rot in the fields during the dry seasons; hence, they become unfit for consumption.

Early-maturing varieties are more susceptible to attack by weevils. Damage by weevils is a problem in almost all regions where this crop serves as a main food source for the population.

Leaf caterpillars -- During the dry season, the larva of the moth Acraea acerata completely eat the sweet potato leaves. The speed of their attack is exceptionally rapid during this period. Damage due to the leaf caterpillar, in 1983, was exceptionally high throughout the country.

Institutional Constraints

Results obtained at research centres do not reach farmers easily. Therefore, farmers concentrate more on using local varieties and traditional techniques.

Production increases are difficult to achieve using traditional agricultural practices that do not involve weeding. Extension personnel have not yet reached farmers in sufficient numbers to encourage them to change from their traditional agricultural practices to the modern intensified techniques that have been developed.

Low Temperatures and Drought

Even though sweet potato varieties are adaptable, they are very much affected by cold in high-altitude regions. Droughts, on the other hand, reduce production in the low-altitude eastern parts of the country.

Planting Date

Farmers tend to plant sweet potatoes late, after they have completed the sowing of grain legumes and cereals, e.g., from April to mid-September the weather is not suitable for planting sweet potatoes on hills or hillslopes; in the flooded valleys planting is carried out from May to July.

Diffusion of Material

Attempts to diffuse materials are facing difficulties of a low production rate of the planting materials. The coefficient of production is about 5, whereas the coefficient of production in a well-managed nursery reaches 15 at a single harvest, which can be conducted three times a year.

Soil Fertility

The level of soil fertility is usually poor. Hillslope soil that is poor in organic matter is another of the many factors that all combine to reduce sweet potato production.

Research Objectives

The main objective of the research program on the sweet potato is to increase production. This can be achieved by the selection of local and exotic material and by the breeding and selection of new varieties having the highest yield of dry matter and high resistance to diseases and pests that reduce yields.

We are attempting to find those varieties that will be tolerant to drought, humidity in the deep valleys, and low temperatures at high altitudes. Particular attention is being placed on adaptability to different types of environments and improvement of quality (nutritive value and taste). The affect of agricultural techniques on fertility, mixed cropping, tuberization, productivity, planting patterns, and preextension are being studied in pilot projects in the hills near ISAR stations.

Selection and improvement in the research program comprises four components: (1) selection of local and exotic varieties -- this involves yield trials (carried out over two seasons) and replicated multilocational trials (carried out over four seasons) using the best varieties obtained from the yield trials; (2) plant breeding -- this is carried out through a selection cycle that goes from seeds to nursery (August) to selection fields (one season) to clonal evaluation (one season) to preliminary yield trials (two seasons) to yield trials (two seasons) and, finally, replicated multilocational trials (four seasons) of the 15 best varieties; (3) agronomic practices -- these are developed for the best varieties; and (4) preextension of recommended agronomic techniques and the best varieties -- the varieties used are chosen from the varietal comparative trials (one or two seasons in the farmer's field).

Selection and Breeding

The first varietal introduction dates back to 1930, when research on the sweet potato was based at the Institut national des études agronomiques au Congo (INEAC), Mulungu, in Zaire. It was only

interested in the introduction of these varieties for adaptation in Rwanda and conducted some yield trials on local and exotic materials.

A well-structured research program on the sweet potato started in 1978 and the first attempts to cross varieties began in 1979. Actually, the first selections were made at the yield and multilocational comparative trial levels.

METHODOLOGY

Breeding Base Populations

Initially, we concentrated more on gathering local germ plasm, particularly that which will adapt best to the varied ecological conditions of this mountainous country. In addition, we looked at exotic materials in the form of seeds or clones. In looking at varieties from neighbouring countries, there is a chance of discovering those types that are adaptable, particularly varieties originating from regions with ecological conditions similar to those of Rwanda.

To obtain a good base population at the time of intervarietal hybridization, it is necessary to choose good parent material. The choice of parent material, therefore, is the key to selection studies. The base population is made up of local materials, exotic materials, and improved families and populations. To constantly improve the base populations, we produce cyclical combinations, which help to obtain a high frequency of genes as well as conserve high genetic variability.

SELECTION CRITERIA

The main objective of the selection program and plant breeding is to produce sweet potato varieties with high yields of dry matter per unit of time and area in a monocultural system, and with high resistance to diseases and pests.

Productivity and resistance to virus disease, therefore, are the first criteria of selection. Rwandan farmers, however, appreciate tubers of good quality, rich in starch, and having good taste. With regard to the vegetative cycle, early-maturing varieties (4 months) are preferred in the first season to enable additional crops to be grown in coming seasons. They allow, therefore, two crops per year. Also, the fast-growing varieties are particularly suited to low-altitude regions with irregular and low rainfall.

Nevertheless, the early-maturing clones are very sensitive to weevils during the dry season. This is the reason why the relatively late-maturing clones, which are vigorous and hardy, are preferred for the second crop, which is planted at the end of the dry season.

The qualities of taste, nutritive value, and rapid growth are considered as the second, third, and fourth criteria of selection. Results over the last 5 years (1978-1983) have shown that the productive clones are adapted to specific ecological areas. Few varieties are widely adapted to all three of the main ecological zones of the country. As mentioned earlier, even though the sweet potato is

an adaptable crop it suffers from cold at high altitudes, hydromorphy in swampy areas, and drought in the low-altitude regions. The adaptability of the sweet potato, therefore, to different types of environment is the last criterion for selection but by no means the least. Table 3 outlines the selection procedure followed.

RESULTS

Selection

The program of selection and identification has identified, from the varietal comparative yield trials conducted in the three main ecological zones of Rwanda, some varieties that are adapted to low-, mid-, and high-altitude regions of the country. Table 4 shows the yields and other important characteristics of the best varieties.

Currently, trials are being conducted in such a way that all of the best materials are put in one trial to help judge production stability over a number of seasons. Some of the best clones have shown a correlation between yield of fresh tubers and dry weight of tubers (r=0.66) and between the weight of the cuttings and the percentage of dry matter in the tubers (r=0.50). The growth of aerial parts contributed to the formation of dry matter. The varieties with big tubers tend to have the highest yield of dry matter (r=0.55).

Agronomic Techniques

Planting Method and Density

The practice of planting trial cuttings on ridges, bunds, and level areas was compared in 1977, 1978, and 1979 without showing any significant differences. However, the experiment conducted on spacing and population density, repeated for two seasons in 1979, showed that the interaction between varieties and population density is not significant and that small ridges of 50 cm height have a slight advantage over those 80 cm high.

Results also showed that population density based on three cuttings per hole did not differ from that resulting from a single cutting per hole. Also, the planting of pregerminated cuttings did not reveal any advantage over the planting of nonpregerminated cuttings.

Fertilizer

The trials on organic and inorganic fertilizers conducted in 1982 at 15 localities from 10 agricultural regions and involving various types of soils involved five clones of sweet potatoes (Rusenya, Caroline Lee, and three of the best adapted clones). Although moderate doses of inorganic nitrogen and potassium gave high yields in all localities, the application of manure as a mulch treatment in drier lowland areas at the rate of 35 t/ha gave yield increases up to 285%.

On-Farm Experimentation

Preextension testing and experimentation in farmers' fields is only being carried out close to the research stations of ISAR. This will change, however, in the future and different ecological conditions and soil types will be taken into consideration in various localities.

Table 3. Sweet potato selection procedure in Rwanda.

Timing	Selection stage	Population density	Experimental procedure	Selection criteria	Selection intensity
1st year					
August	Germination	10000 seeds	Incubation at 30°C	Germination	
August	Nursery	10000 seedlings	Nursery beds, 30 m x 1.2 m; spacing, 10 cm x 10 cm	Virus diseases, fungus diseases	
November	Selection field	10000 clones	Families divided into four replications; square pattern of 100 clones; two cuttings per hole/clone	Virus and fungus diseases, weevils	5% from each 100 clones
May	Clonal evaluation in swampy (dry season) area	500 clones	Test involves four clones and one replication; plot, 1.8 m x 0.8 m	Virus and fungus diseases, weevils	50%
2nd year					
October	Preliminary yield trials (1^{st} season)	250 clones	Test involves four clones and one replication; plot, 5.1 m x 0.80 m	Yield, virus diseases, fungus diseases, weevil pests	40%

March	Preliminary yield trials (2^{nd} season)	100 clones	Test involves four clones and one replication; plot, 5.1 m x 0.80 m	Yield, virus diseases, fungus diseases, weevil pests	
3rd year	Sorting trials at three stations (two seasons)	100 clones	Test involves four clones and one replication; plot, 5.1 m x 0.8 m	Yield, virus and fungus diseases, weevil pests, drought, cold, adaptability to environment	15%
4th and 5th years	Multilocal varietal comparative trials (four seasons)	15 clones	Randomized blocks with four replications; plot, 5.1 m x 0.80 m	Yield, virus and fungus diseases, weevil pests, drought, cold, adaptability to environment	30%
5th year	Preextension	4 clones	Simple repetition across peasant farms	Yield, taste, plus criteria established by farmers	

Table 4. Performance (t/ha) of the best varieties from multilocational varietal trials, 1980-1982.

Ecology	Varieties	Origin	Mean annual yield 1980	1981	1982	Mean yield (1980-1982)	Susceptibility to diseases and pests	Other characteristics
Low altitude (800 - 1200 m)								
	Nyiramujuna[a]	Local	10.0	13	11	12		
	Nsenyakaniga	Local	12.7	-	-	12.7		
	Nyirakayenzi	Local	9.3	-	-	9.3		
	Caroline Lee[a]	Zaire	-	15.5	9.8	12.7		Carotene, very fast maturing
	Gahungezi[a]	Local	9.6	-	-	9.6		
	Caroline Lee 1666	ISAR	-	21.8	7.7	14.8		
	TIS 2544	IITA	-	18.3	7.1	12.7	Weevils	Early maturing
	TIS 2498/16	ISAR	-	-	10.3	10.3		Carotene, early maturing
	Rusenya	Local	-	13.3	3.2	8.3	Very resistant to virus diseases	Well adapted
Mid-altitude (1200 - 1900 m)								
	Rusenya[a]	Local	26.5	23.5	16.2	22	Very resistant to virus diseases	

Nsasagatebo[a]	Local	17.9	-	-	17.9		Early maturing but requiring good soil
Anne-Marie	Local	-	23.5	14.5	19	Virus diseases	
6634 Cordes Rouges	Zaire	26.1	18.5	5.9	16.8	Mites	Bad shooting in early stage
Cordes Vertes	Zaire	-	20	-	20		
TIS 2544	IITA	-	19.3	8.4	13.9	Weevil pests	Very fast maturing (3 months)
Nsulira 1026	ISAR	-	18.0	13.0	15.5		
Caroline Lee[a]	Zaire	-	16.8	9.5	13.2	Weevils semi-vigorous	Very fast maturing
Di. Virosky 16/820	ISAR	-	-	12.8	12.8		Carotene, early maturing
Red Jersey 1220	ISAR	-	-	13.6	13.6		Early maturing
Bukarasa 812	ISAR	-	-	14.1	14.1		
Bukarasa	Local	20	18.5	-	19.3		
Nyiramujuna	Local	23.5	-	-	23.5	Anthracnose	

continued

Table 4. Performance (t/ha) of the best varieties from multilocational varietal trials, 1980-1982 (cont'd).

Ecology	Varieties	Origin	Mean annual yield 1980	1981	1982	Mean yield (1980-1982)	Susceptibility to diseases and pests	Other characteristics
High altitude (1900 - 2300 m)								
	Nsasagatebo[a]	Local	17.7	-	-	17.7		Early maturing, requiring good soils
	Di. Virosky 16	Zaire	14.8	-	-	14.8	Weevils	Early maturing
	Rusenya	Local	14.2	12.0	10.7	12.3		Adaptable, late-maturing variety
	Anne-Marie	Local	-	14.8	13.6	14.2	Virus diseases	Fibrous cortex
	TIS 2498/16	ISAR	-	-	17.3	17.3		Early maturing
	TIS 2544	IITA	-	10.2	16.6	13.4		Early maturing
	Di. Virosky 16/820	ISAR	-	-	15.0	15.0		
	Red Jersey 1220	ISAR	-	-	14.2	14.2		Early maturing
	Caroline Lee[a]	Zaire	13.0	9.3	12.5	12.6	Weevils	Fast growing
	Rutambira[a]	Local	-	-	12.6	12.6	Resistant to virus diseases	Late maturing
	Bukarasa	Local	16.4	-	-	16.4		

[a] Released varieties.

Three or four of the best varieties from varietal yield trials and one or two of the most promising agronomic techniques are combined for on-farm trials. Each variety consists of a single replication on a ridge and on a bund, which enables the comparison to be made with varieties and methods utilized by the farmers. The area per plot is about 16 m^2.

Land preparation is carried out by the farmer, whereas other activities are carried out by both the farmer and researcher. At the farm level, fertilizer is not used. Weeding operations are normally carried out after a period of 1 month. Observations are made by the researcher along with the farmer and harvesting takes place after 5 months. The results obtained indicate that planting on ridges is more advantageous than planting on bunds, the yields being 16 and 13.7 t/ha respectively.

The five best clones for regions of low altitude were tested in 1980 at six farms within the area. The early-maturing Caroline Lee (23 t/ha), Rusenya (14 t/ha), and Cordes Rouges (12.5 t/ha) proved to be very well suited to the conditions on the farms. Each of the tested varieties was chosen for a specific characteristic: Cordes Rouges for its consistency; Rusenya for its taste; and Rusenya and Caroline Lee for their colour (high content of carotene). Similar results obtained in 1982 from all over the country confirmed that Rusenya and Caroline Lee varieties are very adaptable. Nyiramujuna and Nyiranjonjyo, on the other hand, gave good results only in regions of low altitude and Rutambira in regions of high altitude.

Bazihizina, C. 1983. Diffusion des innovations en milieu paysan. Ministry of Agriculture, Kigali, Rwanda.

Delepierre, G. 1974. Les régions agricoles du Rwanda. Note technique no. 13. Institut des sciences agronomique du Rwanda (ISAR), Rubona, Rwanda.

Ministry of Planning. 1975. Miniplan: Annual report. Kigali, Rwanda.

1976. Miniplan: Annual report. Kigali, Rwanda.

1977. Miniplan: Annual report. Kigali, Rwanda.

1978. Miniplan: Annual report. Kigali, Rwanda.

1979. Miniplan: Annual report. Kigali, Rwanda.

1980. Miniplan: Annual report. Kigali, Rwanda.