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BUILDING AN EFFECTIVE POTATO COUNTRY PROGRAM: THE CASE OF RWANDA

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Abstract

This paper describes and analyzes the successful efforts for establishing a viable potato improvement program in Rwanda. Before the creation of the National Potato Program (PNAP) in 1978, effectiveness of research and seed potato production was limited because of lack of trained personnel and scarcity of physical facilities. Partial technical and economic indicators show that PNAP has been able to release four new local varieties, resistant to late blight (the main problem limiting potato production in Rwanda) and, through seed multiplication projects, is supplying healthy seed to 18% of the total potato area. As of 1985, the seed program's internal rate of return is projected to be 40% -more than twice the return offered by most development projects in the country. PNAP's success has been possible, among other reasons, for the strong support from the Ministry of Agriculture, the early incorporation of farmers' needs and points of view into research planning, implementation and technology transfer, and PNAP's emphasis on a few priority lines of action.

Résumé

Cet article décrit et analyse les différentes et fructueuses tentatives faites au Rwanda pour établir un programme viable d'amélioration de pomme de terre. Avant la création du Programme National de Pomme de Terre (PNAP) en 1978, les activités de recherche et de production de semence de pomme de terre étaient limitées à cause du manque de personnel qualifié et de l'insuffisance de locaux et d'équipements. Des indicateurs techniques et économiques partiels montrent que le PNAP a réusi a créer quatre nouvelles varietés locales résistantes au mildiou (le principal problème limitant la production de pomme de terre au Rwanda) et qu'il couvre actuellement les besoins en semence de bonne qualité de 18% de la zone de production à travers des projets de multiplication rapide de semence. En 1985 les projections indiquent un taux de rendement interne du programme de semence de l'ordre de 40%, soit plus du double du rendement atteint par la plupart des projets de développement dans le pays. Le succès du PNAP a été rendu possible, entre autres, grâce au ferme soutien du Ministère de l'Agriculture, la prise en compte très tôt des besoins des paysans et de leur point de vue dans la planification de la recherche, la réalisation et le transfert de technologies et l'accent mis par le PNAP sur un nombre restreint de lignes d'action prioritaires.

Resumen

En este documento de trabajo se describen y analizan los esfuerzos exitosos realizados en Ruanda para establecer un programa viable de mejoramiento de la papa. Antes de la creación del Programa Nacional de Papa (PNAP) en 1978, la falta de personal entrenado y la escasez de infraestructura física limitaron la investigación y la producción de semilla de papa. Indicadores técnicos y económicos muestran que PNAP ha podido lanzar cuatro nuevas variedades locales, resistentes al tizón tardío (el principal problema que afecta la producción de papa en Ruanda) y, ha abastecido de semilla sana al 18% de la superficie cultivada con papa a través de proyectos de multiplicación de semilla. La tasa interna de retornos del programa de semilla, proyectada hasta 1985 es del 40% -más del doble que la tasa de la mayoría de los programas de desarrollo realizados en el país. El éxito de PNAP ha sido posible, entre otras, por las siguientes razones: el decidido apoyo del Ministerio de Agricultura, la temprana incorporación de las necesidades y puntos de vista de los agricultores en la planificación, implementación y transferencia de tecnologías, y el énfasis puesto por PNAP en unas pocas líneas prioritarias de acción.

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BUILDING AN EFFECTIVE POTATO COUNTRY PROGRAM: THE CASE OF RWANDA*

Anibal Monares

I. Introduction

This paper aims to describe and explain the development and performance of Rwanda's potato improvement program (PNAP). Acknowledged by many Rwandan authorities and foreign observers as one of the country's most successful agricultural programs, PNAP is being used as model in Rwanda and neighboring countries. The keys to PNAP's success have been the strong support of the Ministry of Agriculture, the early incorporation of farmers' needs and perspectives into research and technology transfer process and PNAP's focus on a few priority lines of action. The growing demand for potatoes has provided an adequate economic stimulus for the expansion of the area in potato production, and for the rapid adoption of new technologies by farmers.

Background information on Rwanda's economy will be presented briefly to show the socioeconomic and institutional constraints on development, and to provide some prospectives options for increasing food supply in the near future. Next, the role of potatoes, as a food crop of growing importance, will be examined. Finally, following a description of the institutional organization of PNAP, we will focus on the institution's strategy for improving potato production and will present partial indicators of its technical and socioeconomic performance.

* I especially appreciate the numerous useful contributions given by Anton Haverkort and André Devaux, my colleagues from CIP based in Rwanda. I am also indebted to Martin Bicamumpaka, head of Rwanda's National Potato Program (PNAP) for his valuable comments and suggestions.

II. Background Information on Rwanda's Economy

Situated in south central Africa, Rwanda is small and densely populated. Its land is hilly with high average altitude. The country is landlocked, has scarce natural resources, and has underdeveloped physical and institutional infrastructure. Foremost among Rwanda's problems is its rapidly growing population, currently estimated at 5.5 million, or 390 persons per square kilometer of agricultural land --among the highest in continental Africa. The rate of population growth, 3.6% per year, is one of the highest in the world (World Bank, 1983).

Despite these structural characteristics and constraints, the overall economic performance of Rwanda was remarkably good in the last decade. Between 1969 and 1981 Rwanda's GDP (gross domestic product) increased at an average annual rate about 4%, compared to a rate of less than 2% per year in sub-Saharan Africa as a whole (excluding Nigeria) between 1970 and 1979. Rwanda's accelerated growth was caused mainly by external factors: favorable weather conditions, improved terms of trade and high levels of foreign aid inflows.

For a number of reasons, however, it will be difficult to sustain recent performance in the next decades. The terms of trade seem likely to deteriorate, and a slowdown in the rate of disbursement of foreign aid is predicted. Moreover, a lower rate of growth of agricultural output is predicted in the coming years.

Agriculture is the main economic activity of Rwanda. More than 90% of the population is currently engaged in activities related to production and/or distribution of agricultural and livestock products and related services. Over the past decade, food crop production has outpaced the rate of population growth. However, the growth can be attributed primarily to a 40% expansion in the area under cultivation, as the yields of most crops have either been constant or declining. The potential for further expansion of the cultivated land is extremely limited, and future growth will have to come largely from intensification within the farm system and the introduction of measures to stop soil deterioration (Musema-Uwimana, 1983). Two additional negative factors should also be considered in this analysis. First, the fragmentation of land holding is progressively undermining the potential for subsistence agriculture (Bazihizima, 1983).* Second, the prospects for the prices of Rwanda's major export crops --coffee, tea, cinchona and pyrethrum-- are unfavorable, which threatens the government's ability to support agricultural development programs (World Bank, 1983).

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* In 1980 the average acreage for a family holding in Rwanda was 1.15 ha.

III. The Role of Potatoes

The potato is one of the most important and fastest growing food crops of Rwanda (Table 1). Over the past 20 years, the area under potatoes has grown from 18,000 to about 40,000 ha (Table 2). According to FAO statistics, the performance of potatoes in Rwanda has been remarkable, well above of most African countries (Table 3). The annual growth rate of potato production has been twice of the country's population growth. Improved yields and the expansion of the harvested area have contributed about equally to this increase.

Potatoes are an increasingly important component of the Rwandan diet. Per capita potato consumption is now about 40 kg yearly. Consumption trends indicate that the contribution of potatoes in the average food intake will increase significantly.

During the last decade use of potatoes, cassava, wheat, and peanuts has become widespread due to demand and favorable growing conditions. Moreover, because of reduced soil fertility and poor adaptation of food crops grown in traditionally settled central plateau region to the more eastern savannahs and parts of the western mountainous region, yields of bananas and the traditional legumes, beans and peas, have declined. The area under pyrethrum has also decreased due to low world market prices.

In searching for new food supplies and better economic opportunities, highland farmers have shifted toward potatoes in an attempt to maximize the volume of food production and reduce risks when faced with growing land constraints and uncertain weather conditions. The expansion of potatoes would probably have been even more rapid if varieties with adequate resistance to local diseases and pests had been available (Iyamuremye, 1983). The introduction and propagation of new crops such potatoes (and peanuts, soybeans, wheat) allow farmers to diversify in order to protect their families against the risks of famine which have afflicted Rwanda from time to time.

Nearly two-thirds of national food crop production in 1979 was consumed on the farm. Nevertheless, growing demand in urban centers has stimulated significant increases in farm gate prices, particularly for bananas and potatoes, of which 55 and 50%, respectively, are sold (World Bank, 1982). As the net economic returns per hectare from potato production are relatively high, this tuber is displacing cash crops such as pyrethrum from lands where the agroclimatic conditions are suitable (Table 4).

Potatoes are mainly grown between 2,000 and 2,400 meters above sea level on the Zaire-Nile divide, most densely on the slopes of the volcanoes in northern Rwanda. Temperatures vary little from the 17°C daily average, and rainfall averages about 1,500 mm per annum.

Table 1. Food crop production in Rwanda from 1976 to 1981

Product	Quantity in tons		Economic value at farm level ('000 RwF*)	
	1976	1981	1976	1981
Bananas	1,818,000	2,000,000	9,050,000	10,000,000
Beans	240,000	278,000	4,800,000	5,560,000
Peas	75,000	87,000	1,500,000	1,740,000
Groundnuts (unshelled)	14,000	19,800	560,000	792,000
Soybeans	4,500	22,000	81,000	396,000
Other oily plants	--	4,000	--	160,000
Sorghum	180,000	209,000	1,800,000	2,090,000
Maize	78,650	91,000	786,500	910,000
Wheat-finger millet	5,500	10,000	93,500	170,000
Barley	--	4,570	--	77,690
Paddy rice	2,500	7,200	45,000	129,600
Sweet potatoes	810,000	940,000	3,240,000	3,760,000
Potatoes	210,000	300,000	1,680,000	2,400,000
Cassava-taro-yams	360,000	460,000	2,520,000	3,220,000
Trad. fruit-vegetables	53,000	65,000	795,000	975,000
Leafy plants	43,500	50,000	348,000	400,000
New vegetables	600	3,000	9,000	45,000
Passion fruit	--	100	--	1,000
Hot pepper	34	210	3,400	2,100
Traditional tobacco	1,200	1,500	120,000	150,000
Total food crops			27,431,400	32,998,390

Source: Ntezilyayo, A. 1983.

* Rwanda's national currency.

Table 2. Area, production and yield of potatoes in Rwanda since 1961 to 1982

	Area (ha)	Production (t)	Yield (t/ha)
1961/65	18,189	61,980	3.4
1966	9,500	57,300	6
1967	16,500	107,250	6.5
1968	17,500	78,750	4.5
1969	17,200	129,000	7.5
1970	18,000	126,000	7
1971	21,170	148,190	7
1972	18,776	131,430	7
1973	19,286	140,120	7.3
1974	20,011	109,620	5.5
1975	22,676	149,750	6.6
1976	25,708	169,770	6.6
1977	28,806	177,250	6.2
1978	32,169	218,700	6.8
1979	32,000	214,920	6.7
1980	34,000	220,000	6.5
1981	35,000	225,000	6.4
1982	36,000	230,000	6.4

Source: CIP, 1984. Data Bank. Lima, Peru.

Table 3. Growth rate of area, production and yield of potato in Rwanda and Africa between the periods 1961/65 and 1980/82 (annual percent of growth)

	Area	Production	Yield
Africa*	3.97	4.67	0.68
Rwanda	3.50	7.02	3.40

Source: Horton, D. and H. Fano. 1984.

* Average of 33 countries.

Table 4. Comparative returns on cash and food crops in Rwanda (1977)

Crop	Number of working days per ha and per year	Gross earnings per ha (RwF)
Coffee	502	68,400
Banana	110	82,810
Pyrethrum	479	24,660
Potatoes	320	75,580
Tea	All the year	16,200
Beans	150	15,953
Sorghum	170	12,248
Maize	100	10,615

Source: World Bank, 1982.

Potatoes are grown nearly all year with relative shortages in July-August and December-January. During these periods potato prices may double. Consumer prices are influenced by the distance from potato-producing centers.

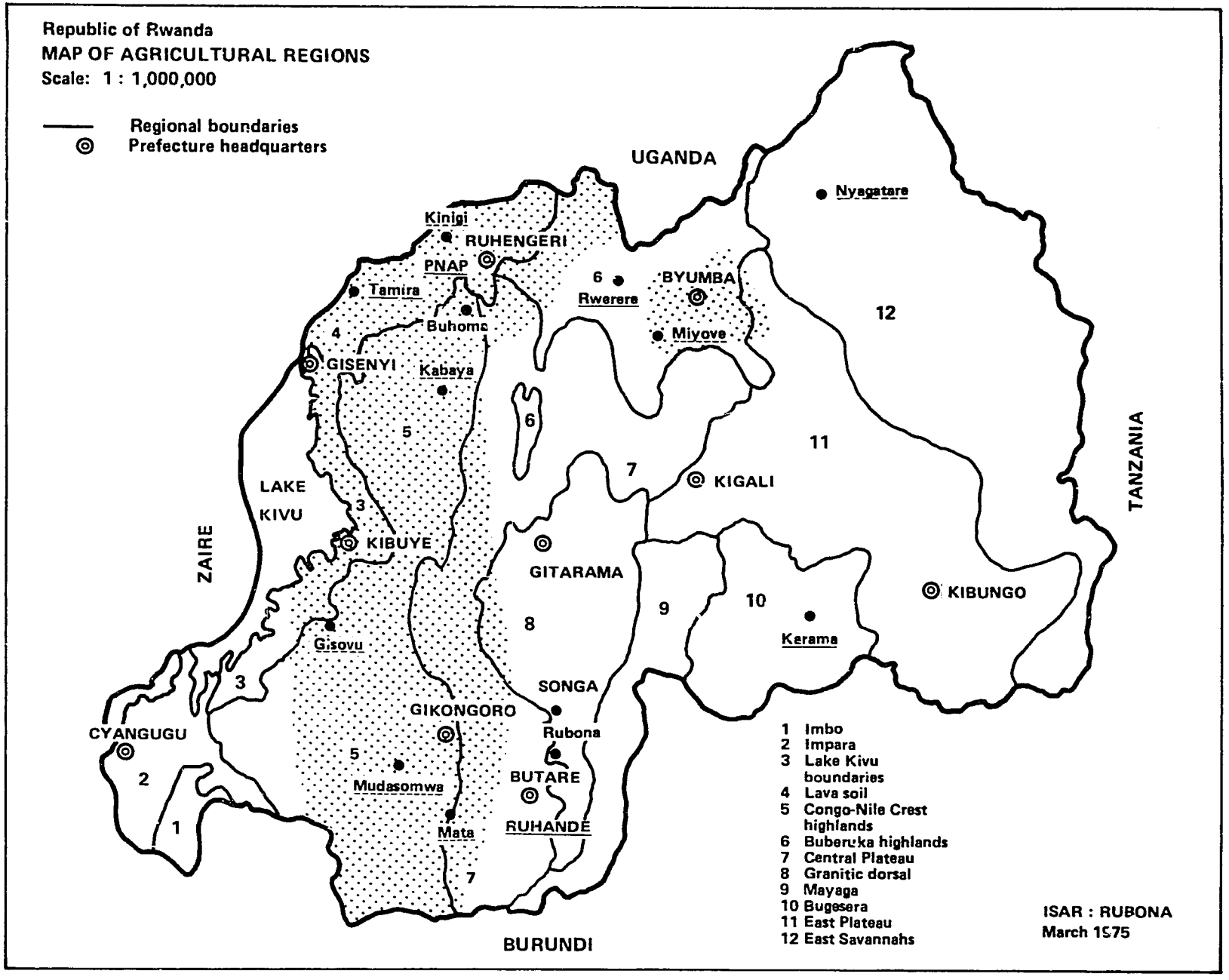
High potato density does not always coincide with high population density. Five prefectures produce about 90% of national production, while the remaining prefectures are net importers of potatoes (Table 5, Map). In these latter areas, potato prices are about twice as high as in potato-producing regions.

Table 5. Potato production by Prefecture in Rwanda (1979)

	Production		Area		Yield
	(000 t)	%	(000 ha)	%	(t/ha)
Butare	1.6	0.7	0.3	0.9	5.3
Byumba	8.3	11.8	4.4	12.6	6.4
Cyangugu	4.0	1.7	0.5	1.4	8.0
Gikongoro	31.0	13.0	5.4	15.5	5.7
Gisenyi	62.2	26.1	7.6	21.6	8.2
Gitamara	3.1	1.3	0.5	1.4	6.2
Kibungo	5.3	2.2	1.2	3.5	4.4
Kibuye	25.8	10.8	2.9	8.4	8.9
Kigali	10.8	4.5	1.9	5.4	5.7
Ruhengeri	66.6	27.9	10.1	29.2	6.6
Rwanda	238.7	100.0	34.8	100.0	6.8

Source: MINAGRI, 1980.

Map of Agricultural Regions and Main Potato Production Zones of Rwanda.



Potato Production Zones

Two main problems limit potato production in Rwanda: late blight (Phytopthora infestans) and bacterial wilt (Pseudomonas solanacearum). Additional constraints include a shortage of fungicides and fertilizers, seed degeneration by viruses and micoplasms, inadequately sprouted seed tubers at planting, lack of knowledge about good cultural practices, losses during storage, inadequate extension programs, and lack of sufficient marketing infrastructure (Bicamumpaka and Haverkort, 1983).

Before the creation of the Rwanda National Potato Program (PNAP) in 1979, about 19 potato varieties were cultivated in Rwanda. The most popular varieties, their origin (if known), and year of introduction, are: Sangema (Mexico, 1972), Montsama (Mexico, 1972), Muhabura, Gashara (1942), Bufumbira (Uganda, 1976), and Condea (Germany, 1970). These six varieties were cultivated by more than 80% of the 100,000 farmers that grew potatoes in Rwanda. They were preferred over the older varieties (such as Kruger, Karabaharaye) for their resistance to late blight (Sangema and Montsama) and better market price.

Degeneration rate for seed potatoes is low in most of Rwanda's potato producing areas, permitting farmers to replant tubers harvested from their own fields for 3 to 10 years before virus infection substantially reduces yields (Haverkort, 1983). This explains why only 30 to 40 % of the farmers buy seed each season and why some old varieties (Kruger, Gashara, Magayane) introduced in the country about 40 years ago are still cultivated.

Approximately 60% of the total potato crop is destined for home consumption on small farms with an average size of 0.5 ha. In most areas, potatoes are intercropped with maize, sorghum, beans, and peas. Mixed cropping is practiced to utilize scarce land and to provide diversified sources of food to farm families. Nevertheless, potato monocropping is becoming more common as new varieties with higher yields and strong market demand are introduced.

The main inputs in traditional potato production in Rwanda are seed tubers and labor. Use of purchased inputs, such as chemical fertilizers, pesticides and machinery, is extremely limited. Average production cost using traditional technology is less than $ 500 per ha; seed tubers account for 33% and labor for 67% (Durr, 1980).

IV. PNAP Institutional Organization

During the colonial period agricultural research in Rwanda was conducted through INEAC, the national institute for agronomic studies in Belgian Congo. In 1962, after Rwanda became independent, INEAC was replaced by the Rwandan Institute for Agricultural Sciences (ISAR). ISAR is a paraestatal agency within the portfolio of the Ministry of Agriculture and Livestock, with its own Board of Directors. By 1982, when Belgium withdrew its technical assistance staff, ISAR's resident staff comprised (ISNAR, 1983):

- 17 Rwandan scientists (1 Ph.D. in agricultural science, 13 agronomy engineers, 1 bachelor of science-level chemist., 1 bachelor science-level biologist, and 1 veterinarian).

- 4 foreign experts (2 assigned to PNAP/CIP and 2 to the Swiss Support Project for the Forestry Division).

- 3 senior technicians (Ingenieurs techniciens) responsible for research program.

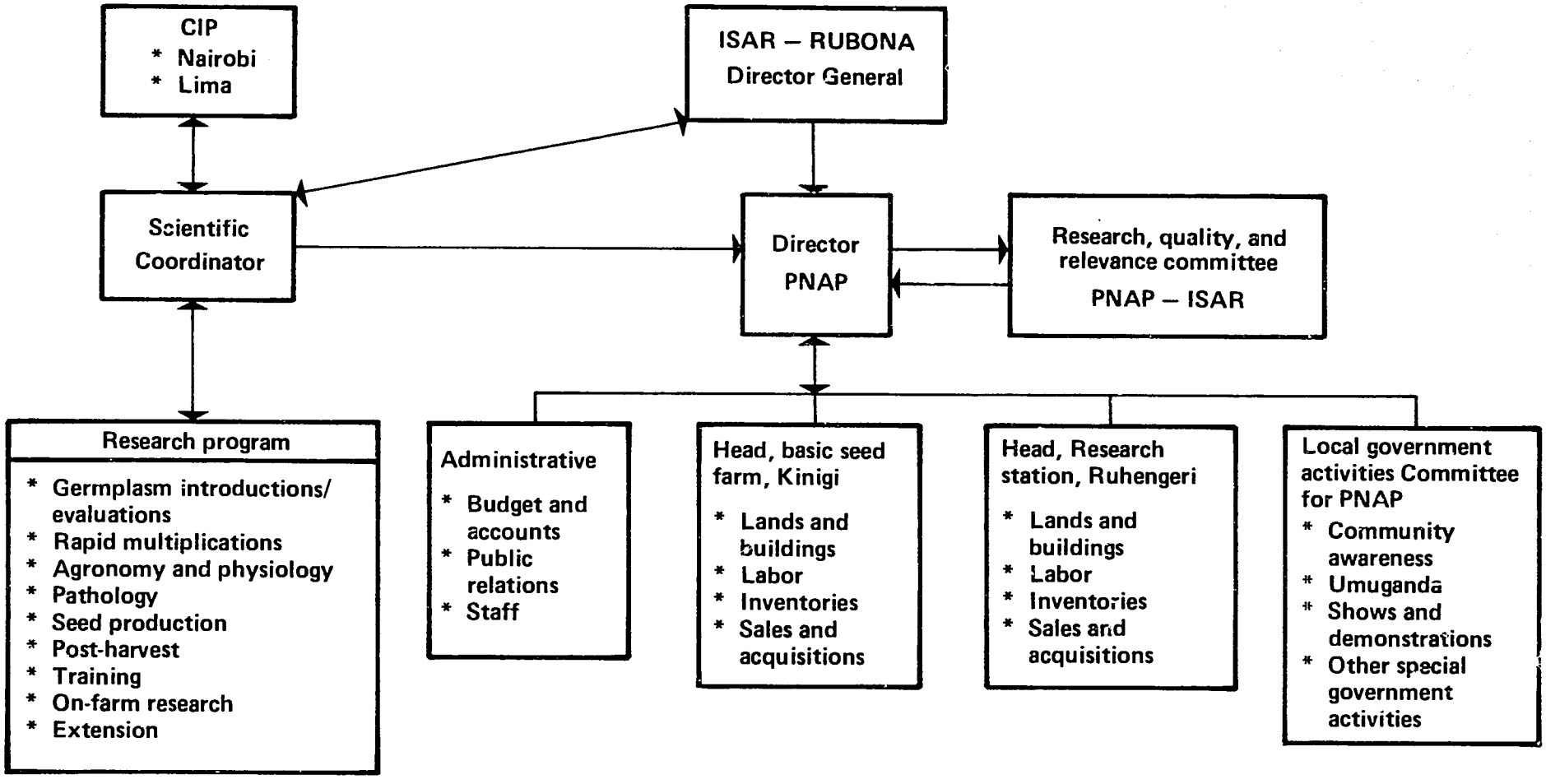
In addition, several Rwandan scientists were completing their studies abroad. ISAR is organized in four departments and manages five research stations: Rubona-Songa, Ruhande, Karama, Rwerere and Tamati.

The National Program for Potato Improvement, a section of ISAR, was established in cooperation with the International Potato Center (CIP) in 1979. It was financed by the Belgian Technical Cooperation Agency, the Rwandan government, CIP, and PNAP itself, from its own seed potato sales. PNAP has a 4 ha research station at Ruhengeri (at 1,850 m) and a 45 ha seed farm in Kinigi (2,300 m). It employs five Rwandan scientists and two expatriate CIP scientists, financed with Belgian funds, some 10 technical and clerical staff, and about 80 field hands (Bicamumpaka, 1982).

Today PNAP is headed by a Rwandan director who makes all program decisions. CIP personnel share responsibility for technical development with Rwandan colleagues in the program (Figure 1). The position of research coordinator is held by a CIP scientist (Haverkort, 1983b).

The Rwanda government's aim, as stated in its national development plan, is the promotion of potatoes as a basic food. PNAP's working philosophy takes into account the need for problem-oriented research for small-scale farming, demonstrations of improved crop production techniques in farmers' fields, and the training of a cadre of research and extension personnel (Nganga, 1983).

Figure 1. PNAP Organization Chart.



Source: Nganga, S. 1983.

To overcome problems limiting potato production, the national potato program focusses on four main objectives:

1. Select and multiply varieties resistant to late blight and bacterial wilt.

2. Establish a system to produce and diffuse healthy seed of improved varieties.

3. Develop a strategy for transferring improved production techniques to potato producers.

4. Enhance research and extension capacity through training activities at different technical levels.

PNAP is organized in six research divisions to fulfill these objectives (Table 6).

Table 6. PNAP research organization

Research division	Main objective	Approximate percent of total budget allocated
Germplasm evaluation	Selection and multiplication of promising genetic material	20
Agronomy	Testing and evaluation of improved cultural practices	8
Storage and seed physiology	Research on improved seed storage techniques and physiological aging processes	8
Seed production	Multiplication and diffusion of seed of improved varieties	40
Pathology	Research on pest and disease epidemiology and control	8
Training and extension	Training of a cadre of research and extension personnel	16
		100

Source: PNAP technical reports and interviews to PNAP leaders, 1982.

V. Evaluation of PNAP Performance

Complexities arise in evaluation partly because a national or a regional crop program generates, screens, adapts, and diffuses many improved technologies and provides several technical services which through interaction mutually reinforce their effects. Partial indicators used here will illustrate PNAP's technical and socioeconomic performance from a multidisciplinary perspective. Research is cumulative, so inevitably some benefits will be "inherited" from potato programs and activities realized before 1979. The following points outline what has been accomplished during a short five-year program.

1. Germplasm Evaluation

From its inception, PNAP breeding research focused on the one most limiting factor: the lack of varieties resistance to late blight and bacterial wilt. Since 1979, PNAP has introduced and tested more than 18,000 different genotypes. Most came from CIP, some were brought from Belgium and Uganda (Bicamumpaka and Devaux, 1984) .

In 1982, PNAP selected and named four new varieties resistant to late blight: Gahinga, Kinigi, Nseko and Gasore (Table 7). Both Gahinga and Kinigi are presently being multiplied by PNAP, Selected Seed Service (SSS) , special projects and selected farmers. Gasore is early, and can be cultivated two seasons each year, and is adapted to lower and dryer areas. Nseko is susceptible to bacterial wilt and probably will be dropped from the multiplication program.

Key factors which have permitted PNAP's rapid selection of varieties have been:

- weather conditions in the volcanic region which permit two crops for selection each year,
- the use of rapid multiplication techniques (mainly sprout cuttings) to increase basic seed stocks,
- the screening and evaluation of advanced clones under farmer conditions on on-farm trials, and
- the fact that Rwandese farmers and urban consumers do not have rigid tuber quality preferences.

2. Seed Production and Distribution

Prior to the establishment of PNAP, potato research was concentrated at the Rwerere Station, and some variety trials and seed multiplication projects were carried out in cooperation with farmers at the Rubona Experiment Station. The effectiveness of research and seed potato production was limited, however, by the lack of trained personnel and the scarcity of physical facilities (Mendoza, 1977).

PNAP does not aim to establish a sophisticated seed certification program (CIP, 1981). The central objective is to supply farmers with improved quality seed. The rationale of this strategy is based on three main facts: (1) potatoes are grown in Rwanda above 1,800 meters elevation where virus diseases are secondary in importance and where farmers' seed degeneration rate is slow, (2) most Rwandan farmers do not use pesticides and chemical fertilizers required for certified seed, and (3) the country cannot afford sophisticated research facilities such as a virology laboratory for post-harvest virus testing. Rwanda's program considers improved seed to be healthy seed of a variecy resistant to late blight and bacterial wilt, of acceptable size, and in good presprouted condition.

Rwanda's seed production system is based on mass selection (Haverkort, 1983). Without available post-harvest virus testing facilities, most important component is visual field observation of three types of plants: the most vigorous, the healthy, and the diseased. Based on this division positive and negative selection is used.

PNAP's seed program has produced and on-farm-tested three kinds of seed (Haverkort et al., 1984) :

- improved local seed of regenerated local varieties originating in Uganda,

- improved varieties introduced from Mexico in 1972 (mainly Sangema and Montsama), and

- newly selected and named varieties by the national potato program in 1982.

The seed program produces about 250 tons of seed per year of which about 200 tons are distributed to seed multiplication projects throughout the country. PNAP does not multiply older local varieties. About 50 % of the seed produced and distributed is from new Rwandese varieties originating from CIP germplasm (Haverkort et al., 1984).

The result is an increasing number of Rwandan farmers with access to and interest in acquiring improved seed to replace old, degenerated varieties. Production of improved seed is still significantly lower than current farmer demand. Yet, reports from seed projects and preliminary surveys indicate that about 7,000 hectares, representing 18% of the total potato area, are now planted with seed originating from the national seed program. The average yield increase on farms is estimated to be about 3 tons per hectare --a 40% increase over traditional seed. Newly selected varieties often yield twice as much as common farmer seed in on-farm trials (Table 8).

3. Economic Evaluation of the Seed Program

Among developing countries Rwanda offers exceptionally favorable ecological and socioeconomic conditions for successful operation of a

Table 7. Potato clones released and named as varieties by PNAP in in 1982 in Rwanda

Name	Clone n.r.	For	Yield t/ha
Gahinga	Uganda-11 Rukoko Petero Murca	Late blight, high yield	15-25
Kinigi	378699-2	Late blight, high yield	20-25
Nseko	65 ZA 5	Late blight	20
Gasore	Grasso-28	Earliness (75 days)	10-12

Source: PNAP technical reports, 1984.

Table 8. Yield increase of three sources of improved potato seed multiplied by PNAP over farmer seed

	No. of on-farm trials	Yield	
		(t/ha)	% increment
Farmer seed	7	12.5	--
Improved local varieties (Muhabura, Bufumbira)	8	15.3	23
Improved introduced varieties (Montsama, Sangema)	72	17.5	40
Locally selected and named varieties (Gahinga, Kinigi)	64	25.8	100

Source: PNAP Technical Reports, 1984.

potato seed program. First, the slow degeneration rate (or yield losses) and long-term use of seed in most of the potato producing areas mean that the multiplier effect of an small stock of basic seed is great. Hence, a seed program producing a small amount of high quality seed every year can satisfy a significant proportion of total requirements.

Second, the demand for seed potatoes in Rwanda is not for healthy seed of old varieties but for new, late blight resistant varieties. PNAP's on-farm research has shown clearly that in most Rwandan potato growing areas the varietal effect is far more important than the level of virus diseases in the seed.

Third, the current volume of improved seed production, distributed through SSS and development projects, is still significantly lower than current farmer demand for seed. The force behind the demand for improved seed is the growing demand for potato in urban markets, which makes potatoes more profitable than most food crops cultivated in the country.

Although PNAP's seed program only started operating in the second half of 1978, a preliminary economic evaluation is worthwhile to compare its overall performance with regard to alternative agricultural development projects. The main assumptions made for the simple computations that follows are:

(a) The economic evaluation is focused on the impact of the improved varieties Sangema and Montsama, both of Mexican origin. The impact of varieties selected by PNAP from CIP germplasm in 1982 can only be estimated for 1984.

(b) All program costs are included (financed by the Belgian Technical Cooperation Agency, the Rwandan Government, CIP, Selected Seed Service (SSS) and various development projects).

(c) Only benefits derived from farmers' use of improved seed produced by PNAP are included.

In view of the assumption above indicated, the internal rate of return presented in the following paragraphs should be considered as minima.

Economic evaluation of the seed program shows that beginning in 1983, the annual benefits exceeded annual costs (Table 9). The internal rate of return is 40% which means that money invested in production and distribution of improved seed yields more than twice the return offered in typical investment projects in the country (15%). In 1984, after six years of operation, the investment in the seed program started producing net benefits (Figure 2).

Since the program is expected to continue operating at the same scale, the future rate of return is expected to be much higher than the 40% estimate presented here. This is because costs will remain at

about the same level but benefits will increase significantly due to the rapid diffusion of the new varieties.

Table 9. Benefits and costs of PNAP seed program (000 US$) and internal rate of return

	Current values		Discounted values*		
Year	Benefits	Costs	Benefits	Costs	Net benefits
1978	0	27	--	27	- 27
1979	0	188	--	164	-164
1980	0	310	--	234	-234
1981	23	362	15	238	-223
1982	173	352	99	201	-102
1983	706	360	351	179	172
1984**	1,526	358	659	155	504
1985**	3,207	358	1,206	135	1,071
Total			2,330	1,333	997

Net present worth = US$ 997,000

Internal rate of return = 40%

* Discount factor: 15%

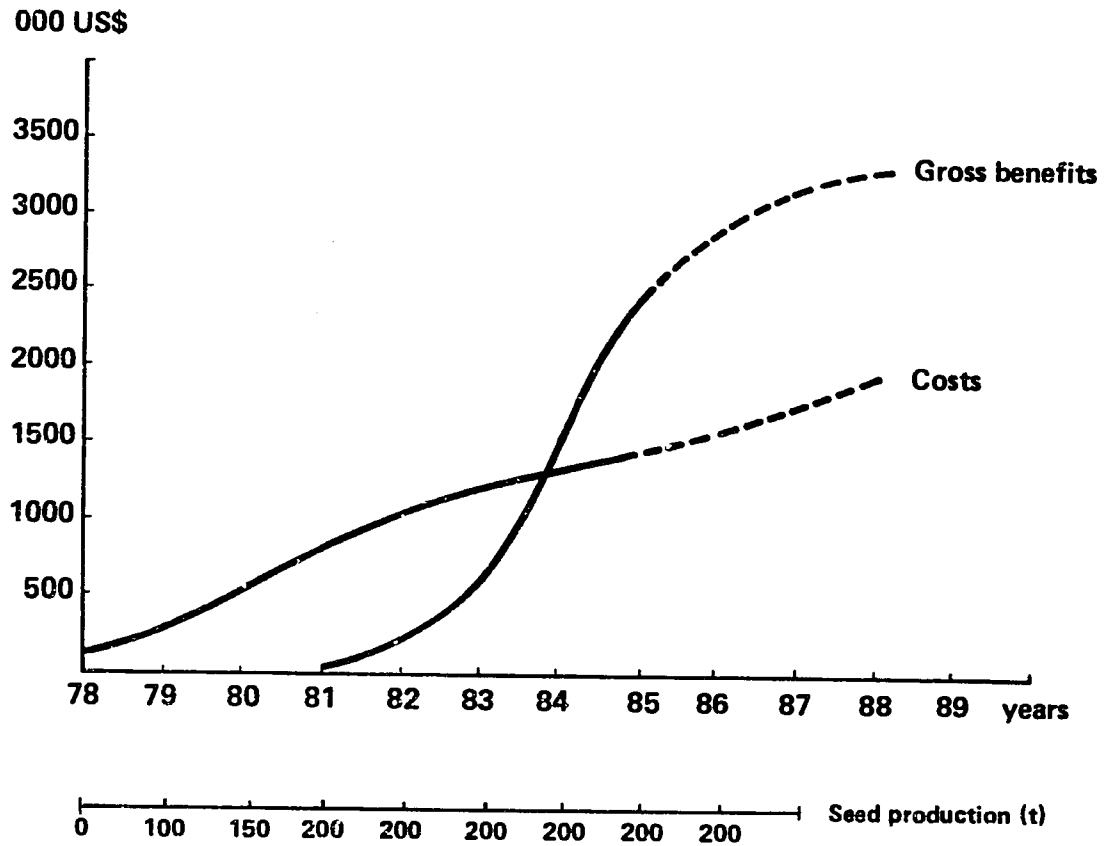
** Benefits and costs for 1984 and 1985 are estimates.

4. On-Farm Research

PNAP has been striving for simplicity and practical application in the transfer of technology and in the use of research information. A key element of PNAP's philosophy is the belief that research programs should respond to farmers' needs and work to deliver improved technology which is appropriate for the conditions in which they live and work. On-farm research has played a central role in implementing this approach and is a main reason for PNAP's success in rapidly identifying production problems and providing farmers with appropriate solutions (Devaux and Tegera, 1981).

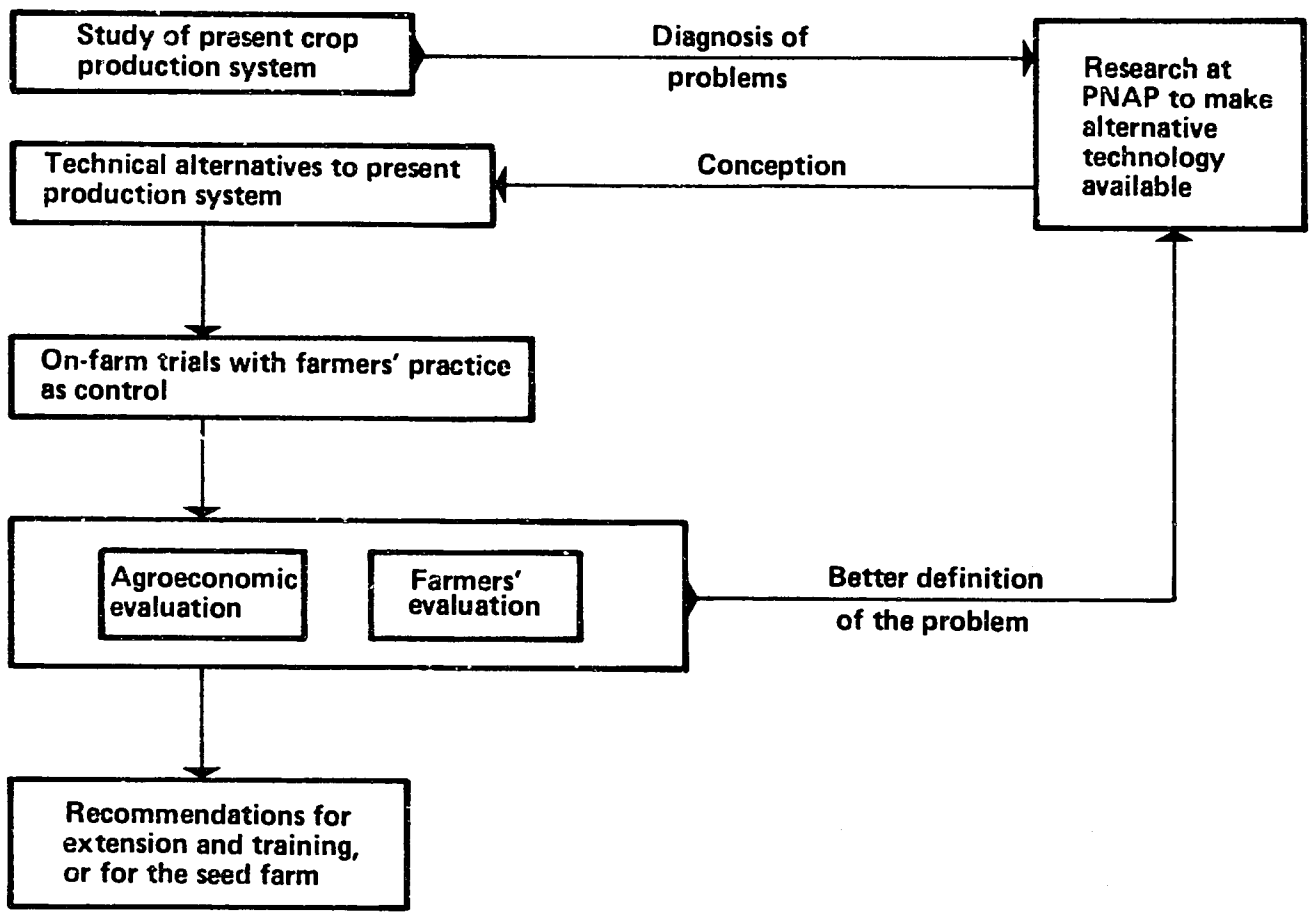
PNAP's institutional strategy combines technology transfer and experimentation in on-farm trials. Their main purpose is to test the validity of a research station's findings in farmers' fields or stores (Figure 3). Every PNAP scientist conducts on-farm trials in two

Figure 2. Cumulative Discounted Gross Benefits and Costs of Rwanda's Seed Program*.



*Discount factor: 15%

Figure 3. PNAP's On-farm Research Methodology.



Source: Devaux, A. and P. Tegera 1981.

communes in one of the two prefectures, Ruhengeri and Gisenyi. One scientist devotes full time to the follow-up of these trials, and makes the arrangements with farmers for planting and harvesting. Staff members conduct more than 80 on-farm trials each year.

During the first years of PNAP's operation, on-farm trials determined the main constraints to potato production in the country and later evaluated at the farmer level all technologies generated through research. This direct contact with farmers makes research more relevant and provides means to evaluate the potential of new technologies before their diffusion.

On-farm trials use two adjacent plots: one for the farmers' common practice and the other for the proposed alternative technology. Evaluations consider both yield and economic returns and results are discussed with farmers. If considered successful in a large number of cases, the new technology is then demonstrated in field days and recommended to farmers.

During 1982-83 PNAP conducted on-farm trials to evaluate four new technologies: late blight control with either fungicides or resistant varieties, use of compost, and diffused light stores. Resulting yields and benefit-cost ratios are shown in Table 10 (Devaux, 1983).

Late blight control, with either fungicides or by using resistant varieties, increased yields considerably and was profitable. Fungicides are not available in large quantities and are expensive, so resistant varieties are the most appropriate and less expensive technology for farmers to control late blight. However, the high profitability of fungicides and interest of farmers in acquiring them may mean that the Ministry of Agriculture and/or development programs facilitate importation and local distribution in the near future.

Results of the use of compost varied because of several factors including the quality of the compost and fertility of the soil. As use of this technology requires substantial changes in farmer practices and the results are variable, farmers are not yet adopting it.

Diffused light stores were evaluated with the idea of reducing losses and improving seed quality. Seed needed more time to sprout under this system than in traditional stores. Rwandan farmers plant twice a year and need sprouted seed as soon as possible after harvesting. Therefore, diffused light technology does not seem suitable.

An informal follow-up survey of farmers led to three conclusions (Table 11):

- The greatest impact has been the introduction of new varieties, which confirms previous observations that susceptibility to late blight resistance varieties has been a major limiting factor.

- Adoption was most effective among farmers living near the place where the trial was conducted.

- The adoption of technologies needing more inputs and/or significant technical changes was less effective.

Table 10. Agroeconomic evaluation of some selected potato production technologies in Rwanda

Technologies	No. of on-farm trials	No. of cases with		B/C
		$\Delta y > 50\%$*	B/C > 1.5**	
Late blight control with fungicides	19	14	15	9.0
Improved introduced varieties	52	31	27	1.3
Locally selected varieties	40	35	31	2.3
Locally selected varieties + compost	14	12	11	3.8
Diffused light seed stores	10	1	1	--
Use of compost	31	13	21	2.8

Source: Devaux, A., 1983

* Number of trials where the improved technology yielded at least 50% more than farmer common practice or variety.

** Number of trials where benefits exceeded costs by at least 50%.

5. Training and Technical Assistance

The success of any potato program in a developing country depends heavily upon the availability of trained people as leaders, advisers, inspectors, and research and extension workers. A CIP mission that visited Rwanda in 1977 to study the problems and potential for potato production concluded that too few personnel were available to conduct research and extension. Hence, ever since PNAP's foundation, CIP has provided Rwanda with significant financial and technical support in training activities as well as in a number of collaborative research projects (Table 12). CIP cooperation has centered on strengthening PNAP's institutional organization, including the creation of viable breeding and seed multiplication programs and the development of an

effective on-farm research strategy adapted to Rwandan needs and resources.

Table 11. Farmer adoption of technologies tested in on-farm trials in Rwanda

Technology	Adoption by farmers (%)	Adoption by neighbours (%)	Neighbours interested (%)
Fungicides (n = 13)	84	30	60
Compost (n = 7)	40	18	20
New (locally selected) varieties (n = 10)	100	90	100
Diffuse light seed stores (n = 4)	0	0	50

Source: Devaux, A., 1983.

Forty seven Rwandan scientists and technicians have participated in specialized courses and workshops from 1977 to 1983 (Table 13). Two scientists obtained higher degrees abroad. CIP also partially financed the training of four technicians in the Netherlands. PNAP has averaged two in-country courses per year, as well as a number of individualized and pre-professional programs which have trained more than 200 local extensionists, students from agricultural schools and farm managers. These training activities were carried out in French and in Rwanda's local language.

With CIP's help and with other external funding, intensive training has included:

- national scientists working together with CIP scientists;
- potato scientists in short courses in other countries, including: Tunisia, Kenya, Peru,and the Netherlands;
- national staff in higher degree programs overseas;
- technical personnel in courses within Rwanda.

Table 12. CIP's collaborative research projects with PNAP

Research Topic
- Constraints to potato production.
- Evaluation of potato germplasm for cool and warm dry tropics. Resistance to late blight and bacterial wilt.
- TPS agronomic research.
- Evaluation, selection and production of TPS progenies.
- Agronomic research to control *P. solanacearum*.
- Breaking dormancy of seed potatoes.
- The potential of low cost diffuse light stores.
- Survey and control of tuber moth (*P. operculella*).
- Survey of diseases and pest affecting the potato in Central Africa.
- Interaction between earliness and susceptibility to late blight.
- Seed production for small farmers in Rwanda. Rapid multiplication technique.
- Optimizing potato productivity.
- Intercropping of potatoes.

Source: CIP files, 1984. Lima, Peru.

Table 13. Rwandese personnel trained through CIP collaborative courses and workshops (1977-83)

Year	Subject	Course/ workshop	Country	Duration	No. of participants
1977	Potato production	Course	Tunisia	1 month	2
1978	Potato production	Course	Tunisia	1 month	2
1979	Seed production	Course	Kenya	1 month	1
	Potato production	Course	Tunisia	1 month	1
1980	Seed storage	Course	Kenya	2 weeks	1
	Potato production	Course	Tunisia	1 month	1
1981	Germplasm management	Course	Peru	1 month	1
	Tissue culture	Course	Nigeria	3 weeks	1
	Potato production	Course	Tunisia	1 month	2
	Optimizing Potato Prod.	Course	Peru	1 month	1
1982	Potato development	Workshop	Ethiopia/ Kenya	1 week	1
	Seed production	Course	Rwanda	1 week	13
1983	Potato production	Course	Rwanda	1 week	17
	Potato production	Course	Netherlands	2 weeks	1
	On-farm research	Course	Tunisia	3 weeks	1
	Potato production	Course	Tunisia	1 month	1
				Total	47

Source: CIP files, 1984. Lima, Peru.

6. Institutional Aspects and Final Remarks.

PNAP is considered to be the most successful agricultural development program in Rwanda and it is being used as a model for other programs both in Rwanda and in other developing countries (Zaire, Uganda, Burundi). A 1983 ISNAR report on the Rwanda national agricultural research system acknowledges that "the remarkable popularity of potatoes in Rwanda was in great measure due to work by PNAP, which proves the importance of studying all angles of problems linked to the development of a given crop."

There are five keys to success of PNAP. First, since its initial planning stages, PNAP has enjoyed strong support from the senior staff at the Rwandan Ministry of Agriculture and Animal Husbandry. This local commitment is illustrated by the willingness of the government to increase financial support for PNAP, thereby reducing dependence on external bilateral aid for PNAP's operations. The current status of financial inputs shows that Rwanda itself contributes more than 75% of PNAP's local operating budget. Belgium continues to provide significant financial support.

Second, PNAP has developed an integrated research-extension approach based on a simple and highly centralized institutional model. Previously agricultural research and extension were separated in Rwanda.

Third, PNAP has focused on a few priority lines of action which respond to farmers' most pressing needs and do not demand sophisticated research resources or a complex institutional scheme. Priority efforts have been devoted to the control of late blight, the main limiting factor for potato development in Rwanda, through selection of resistant varieties.

Fourth, the dissemination of improved varieties on a large scale has been rapid because PNAP's seed program is well established and a national seed service (SSS and development projects) distributes seed throughout the country.

Fifth, since its inception PNAP has incorporated farmers' needs and points of view into the process of research planning and implementation. Through its on-farm research approach, PNAP has kept the focus on the farmer and his or her production problems. The result: PNAP's potato research has remained relevant and efficient, making a valuable contribution to Rwanda agricultural development.

Finally, there is an interesting "spillover" effect of PNAP. Currently, PNAP institutional model is being applied in Burundi and Zaire through the regional networking PRAPAC (Programme Régional D'Amélioration de la Pomme de Terre en Afrique Centrale) based in Rwanda. The rapid expansion of the area planted with potatoes in both Burundi and Zaire faces limiting factors similar to those in Rwanda and the flexible approach developed in collaboration between CIP and PNAP shows great promise.

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