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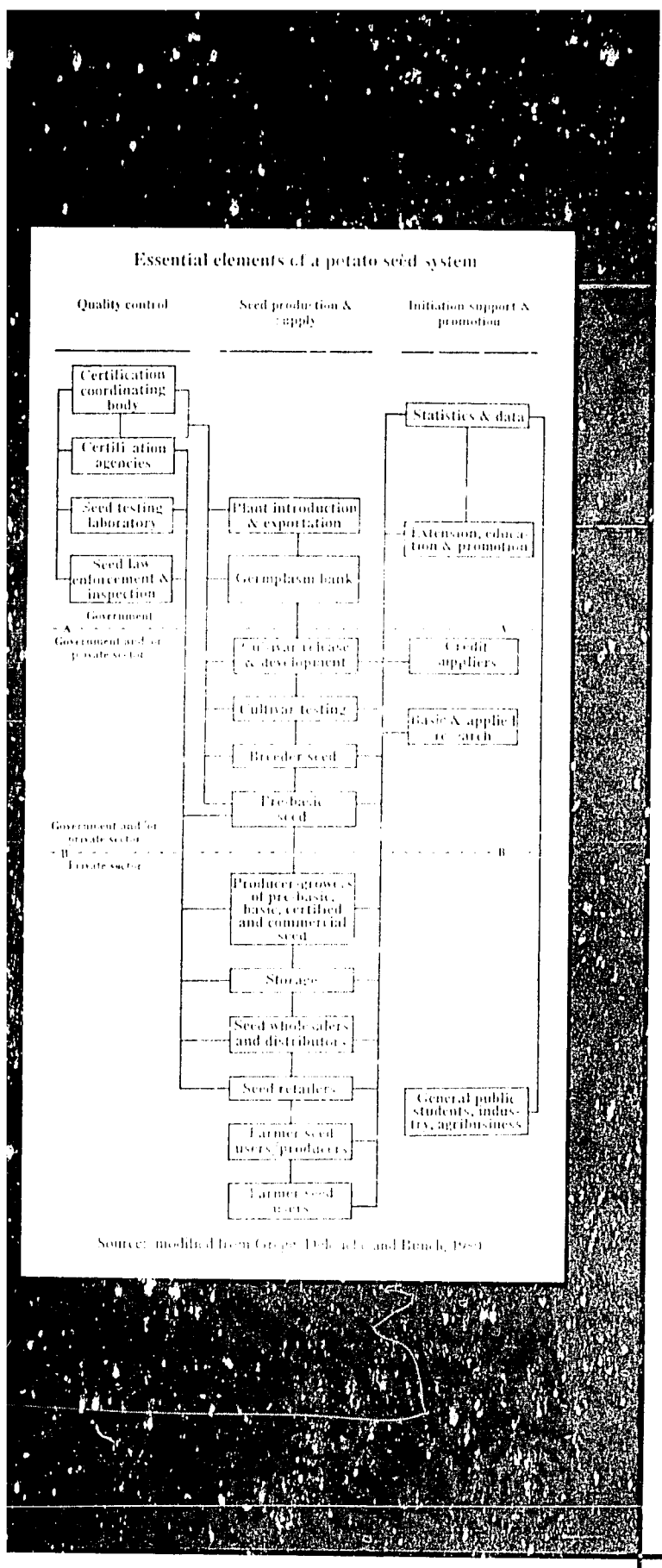

Seed Potato Systems in Ecuador: A Case Study

by

Charles C. Crissman

Jorge E. Uquillas

INTERNATIONAL POTATO CENTER (CIP)

Fundación para el Desarrollo Agropecuario

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Fundación para el Desarrollo Agropecuario (FUNDAGRO)

in collaboration with

International Potato Center (CIP)

1989

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Foreword

Agencies supporting potato improvement in developing countries generally place the highest priority on potato seed programs. The results of these efforts have been mixed due to the differing philosophies guiding the technologies being introduced and the many physical and socioeconomic variables which may affect the performance and achievements of a seed program.

Few comprehensive studies are available which document the structure and functions of seed potato programs. Given the complexity and the key role seed programs have in any country's potato improvement, CIP has initiated a series of case studies of seed programs. This is one of a series of studies; others will examine the seed potato systems in Canada, The Netherlands, and Great Britain, Kenya, and The Philippines. These case studies offer a comprehensive look at the important informal seed sector, the official seed programs, and the interaction among the various elements of the informal system, the official program and farmers.

We expect the conclusions from these studies will help guide CIP activities and that they will also be useful to the national institutions concerned with the successful functioning of this vital component to the potato system.

Richard Sawyer
Director General
International Potato Center
Lima, Peru

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The cooperation of MAG and INIAP are gratefully acknowledged: by making available records and publications these institutions materially assisted the preparation of this report. Farm-level field work for this report also benefited from the cooperation of these institutions and of INTERPAKS of the University of Illinois and CANA of the University of Kentucky. Particular thanks are extended to Hernán Naranjo and Iván Reinoso of INIAP, Jaime Borja of MAG, Francisco Muñoz and Bolívar Navas of FUNDAGRO, and Douglas Horton of CIP for their comments and guidance in the preparation of the report. Special thanks are due to Lilia Salinas who typed, designed, and produced the original copy of this report. Any remaining errors are the responsibility of the authors.

Acronyms

AGDP	Agriculture gross domestic product
BNF	National Development Bank (Banco Nacional de Fomento)
CANA	Collaborative Accord on Nutrition in Agriculture (Acuerdo de Colaboración sobre la Nutrición en la Agricultura)
CESA	Ecuadorian Agriculture Services Center (Centro Ecuatoriano de Servicios Agrícolas)
CIAT	International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical)
CIMMYT	International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maíz y Trigo)
CIP	International Potato Center (Centro Internacional de la Papa)
CNS	National Seed Council (Consejo Nacional de Semillas)
CREA	Economic Recovery Center of Azuay, Cañar and Morona Santiago (Centro de Reconversión Económica del Azuay, Cañar y Morona Santiago)
FODERUMA	Development Fund of Marginal Rural Areas (Fondo de Desarrollo Rural Marginal)
FUNDAGRO	Agricultural Development Foundation (Fundación para el Desarrollo Agropecuario)
ICA	Colombian Agriculture Livestock Institute (Instituto Colombiano Agropecuario)
IICA	Interamerican Institute for Cooperation in Agriculture (Instituto Interamericano de Cooperación para la Agricultura)
INIAP	National Agricultural Research Institute (Instituto Nacional de Investigaciones Agropecuarias)
INEC	National Statistics and Census Institute.
INTERPAKS	International Program for Agricultural Knowledge Systems (Programa Internacional para Sistemas de Tecnología Agrícola)
IBPGR	International Board for Plant Genetic Resources (Consejo Internacional Recursos Fitogenéticos)
MAG	Ministry of Agriculture (Ministerio de Agricultura y Ganadería)
PIP	Production Research Program (Programa de Investigación en Producción)
PNS	National Seed Program (Programa Nacional de Semilla)
PRACIPA	Andean Program for Cooperative Potato Research (Programa Andino Cooperativo de Investigación en Papa)
PRONAREG	National Agricultural Regionalization Program (Programa Nacional para la Regionalización Agrícola)
PROTECA	Program for Agricultural Technology Transfer (Programa de Desarrollo Tecnológico Agropecuario)

Abbreviations

ha	Hectare
q	Quintal
t	Metric ton

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Abstract

Seeds and seed systems, provide a vital link between cropping seasons. While systems of botanical seed reproduction have been extensively studied, the seed systems of vegetatively reproduced crops are relatively undocumented although vegetatively reproduced crops are a major food source in many countries.

This research report, one of a series of case studies of seed potato programs, examines the seed potato system in Ecuador. This system is dominated by a farmer-based informal seed system. There is a single organized seed production program of which the major components are split between three Ministry of Agriculture agencies. Recent technical advances in the production of pre-basic seed by rapid multiplication techniques have made major improvements in the health quality of certified seed. However, local research has shown that seed health is less important than variety or location in explaining yield differences in the Ecuadorian *sierra*. Among the major technical changes in the potato sector -- chemical inputs, improved varieties, and modern seed production -- modern seed production appears to offer less chance for significant impact on the productivity of the sector than the other changes.

In Ecuador the official seed program may have the most impact on the productivity of the potato sector by emphasizing the development and release of new varieties. Production areas that should be high priority are those still without widespread improved varieties. Since the informal seed system has not developed any mechanism to deal with genetic erosion, the official program should act to preserve the availability of small amounts of traditional varieties.

Lack of resources, poor communication and coordination among the agencies with responsibility in the seed system, and a poorly developed distribution scheme are significant limitations in the smooth functioning of the official system. The agencies are generally oriented to serving the seed needs of the large commercial farmer. Except for the development of new varieties which are diffused through the farmer-based informal seed system, the small farmer is largely untouched by any official activities related to potato.

If a distribution system can be devised that guarantees that the amount of seed currently produced is actually used as seed and is made available to the 90% of potato producers who are small farmers, then the current volume of certified seed production could have a significant impact by hastening the dispersal of new varieties.

Summary

In Ecuador potato production is primarily an activity of the small highlands farmer. The government has been officially involved in potato research and extension for 25 years, and potato seed production and promotion for 15 years. Yet seed production from the official program remains at a low level and most is utilized by a few large farmers within a small radius of the government seed production farm.

Since potato is a main staple in the Ecuadorian diet and potato production is the central market activity of tens of thousands of farm families, various elements of the potato system have received the attention of numerous researchers. While many of the problems have been accurately described and reasonable suggestions made for their resolution, potato production remains essentially undisturbed by direct government efforts. Potato is not the only crop that has lacked support: over the last two decades the government has consistently reduced its expenditures of both agricultural research and extension to levels below where effective progress is more a matter of luck than planned effort. Institutional instability has been a constant presence in the Ministry of Agriculture.

The viability of the potato program and the potato seed program is questionable. The potato program is at present at a very low level of activity, down from 11 in 1982: now only two professionals are employed. The seed production research which led to the installation of the rapid multiplication system was supported by external funding. Indeed, a significant portion of potato research and of the experiment station's budget and its research facilities are supported from external funds. There is little to indicate that these programs would continue without that external funding.

While there has been relatively little direct assistance, especially to the small farmer, indirectly the potato sector has been profoundly affected by government policy. The overvalued exchange rate, land reform, urbanization, cheap wheat policy, subsidized fertilizer during the 1970's, and dairy development are among the many factors that have affected the potato sector both positively and negatively.

The principal impact of organized government efforts on the potato seed system has been the development and release of improved varieties. Four varieties have been released and currently they account for a significant portion of the seeded area. Up until 1987 potato seed production included only the improved Ecuadorian varieties. The native varieties used by the majority of small farmers have not been produced in the seed program.

Specific Conclusions

1. Potato production in Ecuador is dominated by small holder production dispersed over highland areas that are largely good natural seed producing areas. Seed from the informal sector supplies approximately 99% of the seed demand.
2. Potato production is largely market-oriented even among small farmers, and production technology makes extensive use of chemical inputs.
3. The technology of seed production, selection, storage, management, and marketing in the informal sector appears unchanged during the four decades covered by scientific investigations of the sector.
4. The formal seed sector is significantly under-funded to perform the task of producing and distributing certified seed.
5. Institutional changes within the agencies involved in seed production have had a negative effect on coordination and cooperation.

6. The area in which the government has had the largest impact on the seed potato system is in the development of improved varieties which have been diffused by the informal seed system.
7. The development of a rapid multiplication system for pre-basic seed production has substantially improved the health quality of official seed.
8. The impact of the rapid multiplication system is minimal, due to the absence of an effective seed multiplication and distribution scheme.
9. Due to separate large and small farm seed marketing channels, the seed distribution model currently used will not serve small farmers even if the volume of seed in the program is dramatically increased.
10. Despite the improved health quality of seed, recent research in Ecuador has shown that variety and location are more important factors than seed health in determining yields and profitability of potato production. This is consistent with results from other Andean countries.
11. Any recommendations should take into consideration the historic pattern of good recommendations not acted upon due to a lack of resources.
12. An alternative model of low volume, widely dispersed distribution designed to take advantage of natural seed production areas appears to be a promising way to connect the official and the informal seed system.

1. Introduction

Background

Potato cultivation in Ecuador is an important but declining activity. This decline is occurring in a country near the center of origin of the potato where the potato is still the principal dietary staple for the majority of the population. A potato food system has existed in the country for thousands of years. Farmers have, over the centuries, made variety selections and developed crop management techniques that are uniquely adapted to their own production environments. The country has a multiplicity of environments, further adding to the diversity in the system. Potato production is a highly commercial activity; one study showed that producers retained only 17% of production for home use (Barsky and Llovet, 1982).

The poor health conditions of seed potatoes are blamed by many observers for the perceived low level of productivity in potato production. In an ancient food system, presumably fine tuned to its environment, how has modern technology changed perceptions on what is the potential of production? What has modern technology done to create the impression that a constraint exists and what has it done to relieve that constraint? Modern potato and seed potato research have been functioning in Ecuador for several decades. Though potato production and seed production technologies have been developed, poor seed is still identified as a constraint to improved productivity. With continuing official activities designed to relieve this constraint, what are the bottlenecks remaining in the system?

Within the ages old traditional food system, modern agricultural technology made its first inroads in the 1950's when large farmers began using agrochemicals (Barsky, 1984). The use of these modern inputs spread rapidly and, within 20 years, the majority of potato farmers in the country were making regular use of chemical fertilizers and pesticides. In the early 1960's the government began organizing agricultural research and extension to support production. Potato has figured in the government efforts from the beginning. However because of its status as a domestic consumption crop, potato has been relatively ignored in favor of cash export crops which, because of their commercial production, figure more prominently in the official economy and therefore garner more official attention (Peterson et al., 1988).

The government program for supporting potato production can be characterized as one of good intentions seldom supported by sufficient financing. During the relatively brief modern period there have been special projects with several outside agencies that have provided financial and technical assistance to the government's research and extension efforts concerning potato. In recent years the focus of government efforts has been the establishment of a rapid-multiplication-based scheme for producing basic seed on a government seed farm.

This report examines the system of seed potato production and use. The efforts of the government in establishing a viable seed potato production and distribution system are described. The structure and functioning of the informal farmers' seed system is also discussed.

Methodology and Objectives

This report is one of a series of case studies on seed potato systems in selected countries. The main objective of the individual case studies is to identify strengths and weaknesses in organized seed potato programs. To do this effectively the organized potato program must be placed in the context of its environment. Thus a systems approach is adopted in these studies to categorize and evaluate the role of an organized program within the larger seed system. It is widely believed that the poor quality of the generally available seed, and the high cost of obtaining good quality seed are major limiting factors in potato production. Many seed projects have been conducted in developing countries with the aim of relieving these constraints. The

results of these projects have been highly variable. CIP and other organizations have been involved in seed systems work in numerous countries. Foreign assistance has taken many forms, including the direct placement of scientists in seed programs, technical backstopping, short term assignments, financial support, training, and provision of supplies, equipment and genetic material. However, records and results of these activities are dispersed throughout the developing world and their current status is largely unknown.

This case study series is designed to record the diversity of formal and informal seed systems and to determine how seed projects can be integrated into these systems. The intent is also to analyze the performance of different technical and institutional schemes in seed potato projects. A final objective is to document the importance to increased production of improved formal seed systems (as compared with informal systems).

Portions of the field work for this study were part of a CIP-FUNDAGRO-INTERPAKS[1] special project to examine the system of potato technology generation, transfer and utilization. The field work for that study was conducted in two phases, a month-long semistructured informal survey in the principal potato producing regions led by FUNDAGRO and a two week institutional analysis led by INTERPAKS. During the field work a large number of scientists and technicians participated in data collection and write up. The field work methodology and research results are documented in Uquillas et al., (1988). The institutional analysis consisted of wide ranging interviews with key informants in decision making and policy execution roles in the government, and extensive literature reviews. The methods and results are documented in Peterson et al., (1988). Additional field work was conducted especially for this study. During the investigation hundreds of open-ended interviews were conducted and the literature exhaustively searched. Thus both extensive primary data collection and secondary data sources have contributed to the information included in this report.

Seed potato systems contain many elements and require cooperative action by numerous institutions. A schematic diagram of a seed system is presented in Figure 1. The figure emphasizes the elements of the formal seed system. Analysis of individual elements is based on available information, interviews, publications and direct observation. Where possible the descriptive analysis is supplemented by quantitative documentation. However, the paucity of documentation and the time constraints on field work eliminated the possibility of formal efficiency or impact analysis.

The approach to seed potatoes as a system, used in this study stresses function rather than structure as the basic device by which to classify system parts. Special attention is paid to linkages between the different agencies which have roles in the organized seed programs and to the linkages between these agencies and the informal farmer-based seed system.

By omitting from Figure 1 other factors such as physical and cultural environment or macroeconomic policies such as trade restrictions or pesticide price subsidies, the issue of defining the boundaries of the system is raised. The elements included in the figure are directly related to the production, distribution or quality of seed, or are activities that can be influenced or managed by participants in the system. These elements are the primary focus of this case study. Other selected factors are described as they relate to this system.

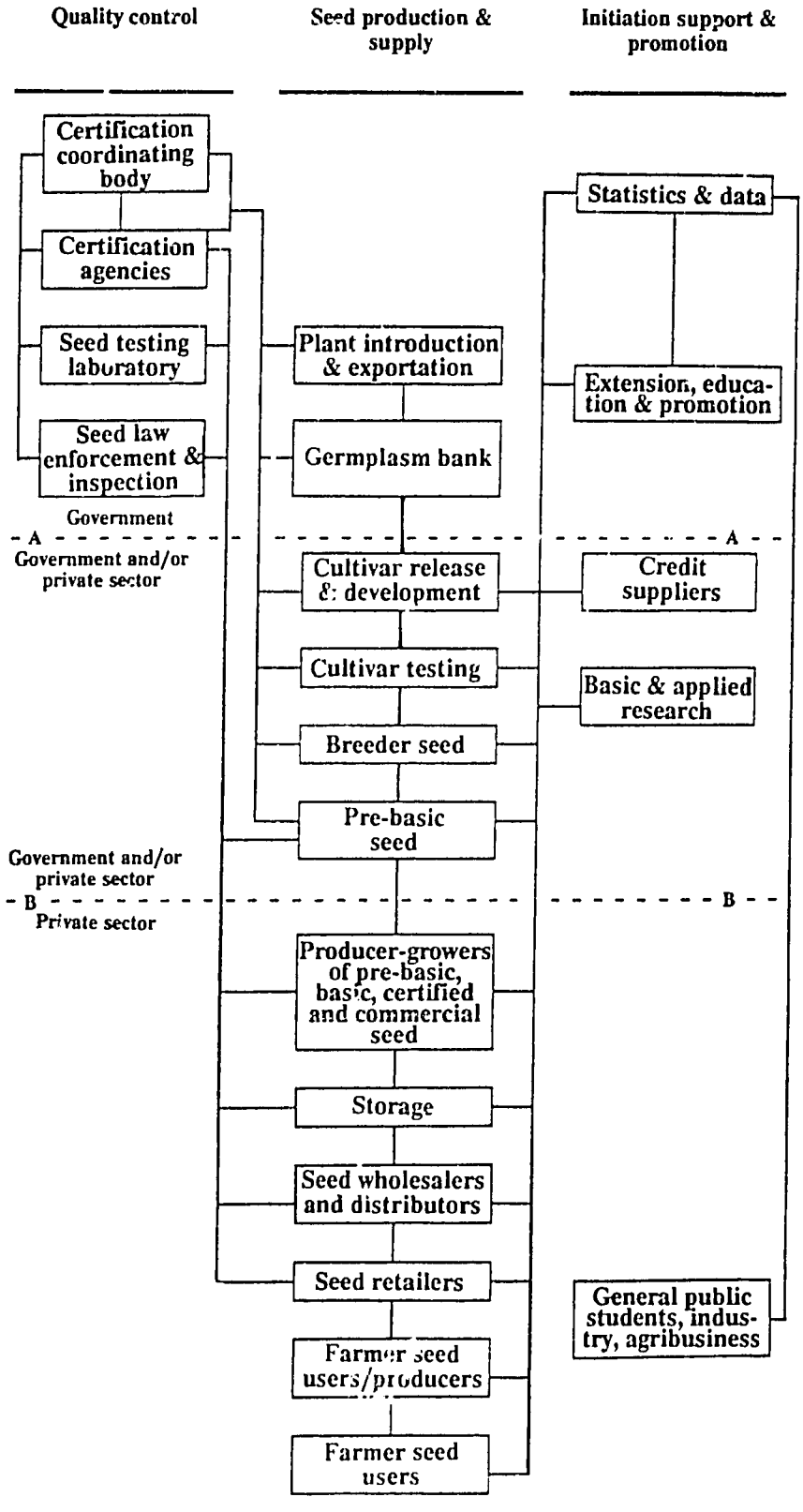
Format

The format of this study flows from the general to the specific. In Chapter 2 the status of the potato is discussed in terms of trends in area, production, and yield. What has happened to potato production in recent times? Why have yields stagnated after growing in the 1970's? Other elements of the potato food system, consumption, markets, and potato policy are also introduced.

In Chapter 3 the farm-level setting for potato production is presented and then the informal farmer-based seed potato system. Understanding the informal system is essential to any formal efforts to develop an official seed system. How does the informal system function? Are there points at which seed can be

[1] The definitions of these and other acronyms are listed in the glossary.

Figure 1. Essential elements of a potato seed system



Source: modified from Gregg, Delouche and Bunch, 1980

inserted into the system for maximum effect? What varieties are needed?

Chapter 4 begins the discussion of the formal seed system with an examination of the varieties in the country and those being handled by the official system. Are these the correct varieties and how does the breeding program get its information on farmer preferences?

Chapter 5 moves to an examination of the next phase in the formal seed system, the crucial first multiplications of a variety. These first multiplications are where important technological changes have occurred in seed potato production. The official seed program has incorporated some of these new techniques. Why and how has this happened?

In Chapter 6 the bulking of seed to volumes practical for release to farmers is examined. In this phase the process of seed production inevitably moves from wholly governmental control to one of interaction with farmer seed multipliers. How has the Ecuadorian government managed this interaction?

The final chapter introduces some issues for discussion concerning the potato seed system in Ecuador and presents conclusions of the report. Finally, the limitations of the study are noted.

A Note on Potato Physiology and Pathology

The functions of a seed potato system are in part governed by certain aspects of potato physiology and pathology. This section, relying heavily on Horton (1987), discusses some of these aspects and how they can be dealt with.

Physiology

The potato is a member of the plant family *Solanaceae* which also includes tobacco, tomato, eggplant and pepper. The potato tuber is an enlarged portion of an underground stem containing about 80% water. The plant can reproduce sexually through seed from its tomato-like fruits, but the vast majority of the world's potato farmers select tubers to use as "seed." Tuber-based multiplication is slow, averaging 1:10. Thus numerous generations are needed to produce large quantities of seed, an important consideration for seed programs as each generation of this perishable tuber must be properly stored and protected from diseases.

The tuber has dormant buds called "eyes" and passes through several physiological stages which affect the number of eyes that will sprout. Dormant tubers do not sprout, physiologically young tubers sprout only from the apical buds, mature tubers show evenly distributed sprouting, and old tubers produce few thin sprouts. Sprouting is important since yield is related to the number of stems produced by sprouts. The rate of physiological aging is controlled by several factors including variety and storage conditions. Storage temperature and exposure to light strongly affect sprouting and subsequent yields. Temperatures higher than about 4°C induce sprout growth and in dark conditions long thin sprouts develop. If exposed to light sprouts remain short and are more sturdy and vigorous.

Usually smaller whole tubers are preferred as seed. Undamaged tubers have fewer entrance points for disease. Per unit of weight, smaller seed produce larger yields than large seed of equal health and physiological condition.

The environment where seed tubers are grown and stored strongly affect the subsequent crop. If all other conditions are equal, seed grown and stored under cool, humid conditions will behave like young seed for a longer period. Young seed tends to be later maturing and thus higher yielding than old seed. Earliness or lateness of maturity is also dependent on variety.

Pathology

Seed tubers can transmit many yield-reducing diseases. The most important of these are virus diseases some of which may reduce yields by as much as 50%. One of the principal objectives of certified seed programs is the production of virus-free seed. Aphids are the principal vector for virus transmission. Thus seed farms are in cool, rainy and windy areas that inhibit the development and movement of aphid populations. In the tropics this means highland areas.

Bacterial wilt (*Pseudomonas solanacearum*) is a soil-borne disease that can also be transmitted by infected seed. This serious disease is

one of the most damaging to potato crops in developing countries. Farmers try to avoid it by purchasing seed from fields that have not been inoculated by the bacterium. Nematodes are an important pest that also reside in the soil.

A fungal disease, late blight (*Phytopthora infestans*), is one of the most important potato diseases. Capable of spreading rapidly and destroying entire fields, this disease accounts for the majority of pesticide costs incurred by many potato farmers, as repeated spraying is necessary to control infestation.

There are few varieties with effective resistance to these pests and diseases. Careful management and good controls are thus necessary to produce a good crop. An important part of good management is starting with healthy seed of the correct physiological age.

Implications for Official Seed Programs and Farmers

The intent of official seed programs is to produce true-to-type seed judged free of, or with only tolerable amounts of diseases or pests. The physiology and pathology of the potato define several basic parameters of these programs. In order to inhibit crop infection, seed programs need to be located in zones where the fields, water, and storage areas are free of disease and pests. There must be access to facilities or institutions capable of handling large volumes of a bulky perishable commodity for several multiplication cycles. The slow multiplication rate places a premium on any technology which can speed the process; thus the value of rapid multiplication techniques.

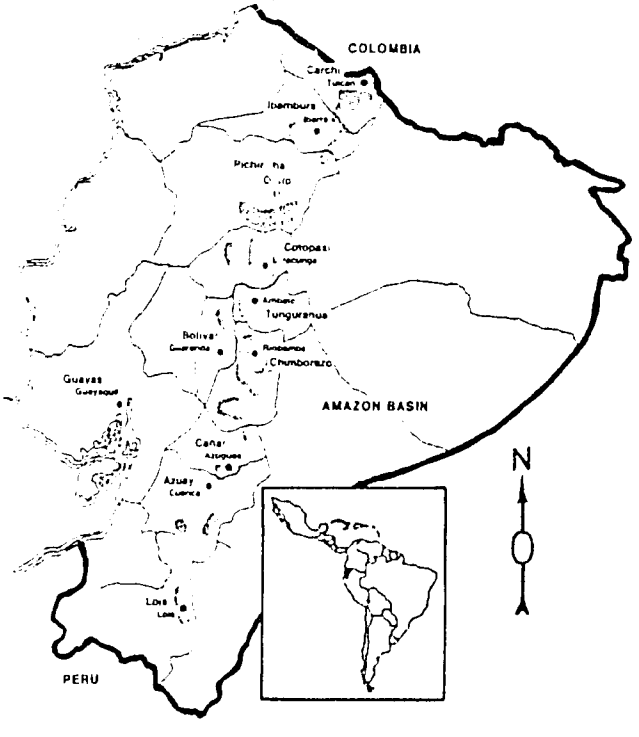
For farmers, the gradual build up of diseases among their own seed stocks requires that they be replaced periodically. In the absence of widespread certified seed, the source of the replacement seed requires careful consideration. In developing countries seed from higher altitude zones would usually be preferred. Thus there is often a distinctive flow of seed from one location to another. Once on the farm the farmer can manage his own seed in various ways to slow its rate of degeneration. These include proper post-harvest handling and storage, field or post-harvest selection, and pre-planting treatment.

2. Potatoes in Ecuador

This chapter provides a setting for the discussion of the potato seed system. General trends in production, area and yield are presented along with brief discussions on consumption and marketing. Also presented is an introduction to the physical environment for potato production and a discussion of major agricultural policies as they affect potato production and consumption.

Potato production in Ecuador is concentrated in several distinct regions of the *sierra*. This is illustrated in Figure 2. This map shows the areas of potato production as being concentrated in a north-south stripe through the central mountain valleys contained in the 10 *sierra* provinces. These provinces have been grouped into zones of north, central, and south. The moist, high, cool areas of Carchi and Imbabura Provinces comprise the northern zone while the much dryer Cañar, Azuay, and Loja provinces make up the south. The other five provinces are grouped in the central and largest zone.

Figure 2. Potato production areas in Ecuador



Area, Production and Yield

During the last several decades there has been considerable fluctuation in the area planted and the total production of potatoes in Ecuador. These trends are illustrated in Figures 3 and 4 which show the area planted and production on a national basis from 1962 to 1987 (data are in Appendix Table A1). Also illustrated in these figures are the regional production and area trends. The characteristics of individual zones are discussed more fully below.

Figure 3. Potato area. Ecuador, 1962-87

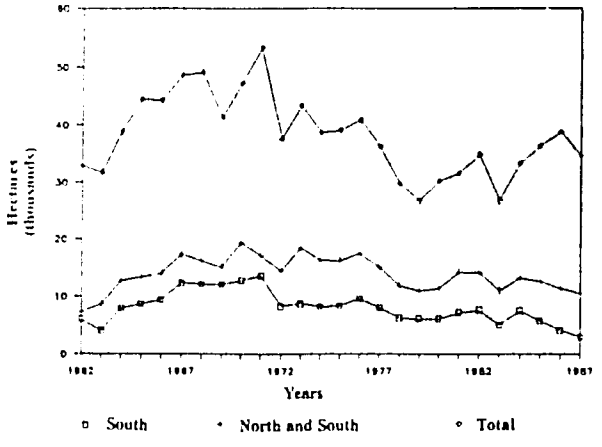
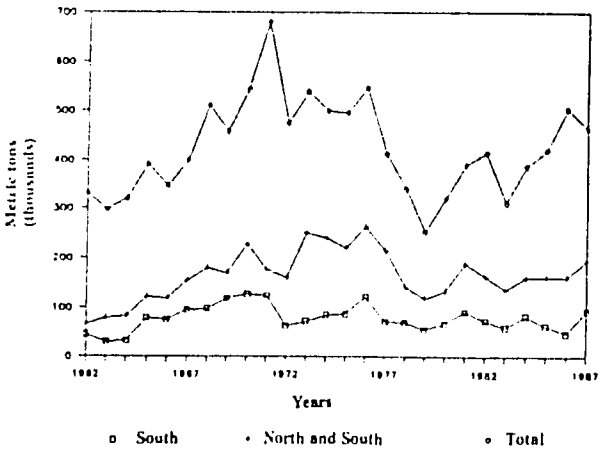


Figure 4. Potato production. Ecuador, 1962-87



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Data Sources

A cautionary note on the quality of the data is necessary here. Different agencies in Ecuador have been active in data collection and have produced different estimates on several aspects of the crop. For example, the National Statistics and Census Institute (INEC) has recently begun its own crop estimation service. Based on statistical sampling and farmer interviews, INEC estimates 1986 potato production of 388,660 t on 57,000 hectares (ha) for a yield of 7.3 t/ha (SEAN, 1986). In contrast, the Ministry of Agriculture (MAG) Directorate of Statistics estimates production of 420,155 t on 38,930 ha for a yield of 10.8 t/ha (Borja, 1987). These are dramatic differences. While conceding that INEC estimates of area might be better than MAG estimates, MAG officials contend that INEC field staff, unfamiliar with potato production, may have received deliberate underestimates of production from farmers fearing taxes. Thus trends or sudden movements in a data series may be the result of measurement error rather than real phenomena. With this cautionary note in mind, the discussion proceeds using MAG data.

Area and Production

Prior to 1962 and the initiation of data collection by MAG there were no systematic records of area planted. Intermittent records of production between 1938 and 1962 show annual production to be less than 100,000 t. However, assuming yields of one to two tons per hectare, a much larger area would have had to be planted that at present (Barsky and Llovet, 1982). Starting in 1962 area planted expanded nearly every year until 1971. Production grew likewise until 1971. In 1972 a sharp drop in area planted initiated a decade of declining, then variable, plantings. Due principally to a major drought in 1979 and a late blight (*Phytophthora infestans*) outbreak in 1983, there has been more variation in production than area. Since 1983 area planted has expanded again, reaching in 1986 its highest level in a decade.

A significant factor in these trends is the effect of government policy. Byerlee (1985) documents the relative profitability of dairy, wheat, and potato production in a northern region of the country. These are activities commonly found in the farming system of large farmers in the *sierra*. The economic returns for land employed in dairy production are higher than wheat, and dairy represents a lower risk than potatoes; as a result, large farmers have consistently reduced area planted in both these crops while increasing their area in pastures. Potato production has shifted over the decades from the provinces near Quito and spread to the north and south. These shifts are illustrated in Table 1. The decline of Pichincha and Cotopaxi as important potato production regions is explained by the shift to dairy production in the zone. The continued importance of potato in Chimborazo and Cañar is influenced by the predominance of small producers in the zone. Carchi emerged as an important region due both to the good growing conditions and the development of the small holder class, as well as the availability of Colombian seed, and the existence of an alternative Colombian market.

Table 1. **Potato production by province. Ecuador, various years**

	Percentage of total							% change
Province	1940's	1954	1974	1984	1985	1986	1987	74-87
Cotopaxi	39	23.8	27.8	10.5	9.6	16.6	10.4	-62.6
Pichincha	22	19.2	11.5	11.9	12.9	14.3	12.5	8.7
Tungurahua	11	14.9	15.3	11.4	13.5	14.1	10.4	-32.0
Chimborazo	10	18.4	22.1	20.7	21.6	18.9	27.5	24.4
Carchi	6	12.2	13.1	18.4	22.4	22.0	24.0	83.2
Imbabura	4	3.8	2.5	1.6	1.1	0.7	0.9	-64.0
Bolivar	4	3.6	1.6	4.3	4.1	4.1	5.5	244.0
Cañar	2	2.1	4.7	19.0	12.9	7.3	6.8	44.7
Azuay	1	1.3	1.1	1.5	1.1	1.1	1.2	.9
Loja	1	0.7	0.3	0.7	0.8	0.8	0.9	200.0

Sources: Barsky and Llovet, 1982; Borja, 1986.

The reduced planting of potatoes also is affected by the cost-price factors. During recent years, farmers have been caught in a squeeze between rising costs of production and the typically variable potato prices. A recent study of the terms of trade between the agricultural and non-agricultural sector in the Province of Loja showed that the index of prices paid by farmers for production inputs had, during the period 1980-85, risen at twice the rate of an index of prices received by farmers (Guerrero, 1986 cited in Peterson et al., 1988).

Several observers have noted that production surpluses and shortfalls are compensated by exports to or imports from Colombia. The southern border department of Colombia, Nariño, is restricted by internal quarantine and prohibited from shipping its production to departments further north. The Ecuadorian market, while theoretically closed by law, is in fact easily reachable. MAG estimates of domestic production deficits are presumably met by illegal imports from Colombia and some from Peru. Wallace (1985) reports that, in 1983, a year with domestic deficit, informants in Carchi estimated that half the volume of potatoes sent to Quito from Carchi for marketing were in fact from Colombia. In contrast, in 1987 and 1988, due to favorable exchange rates and ample production, Ecuadorian potatoes were being illegally exported to Colombia.

Yields

The national average shows that from 1962 until 1966 yields gradually declined even as area planted increased (Figure 5). Muñoz (1984) reports that this was due to the declining quality of the native seed stocks. In 1966, the variety Catalina was released and national average yields began climbing until 1977 when several years of drought brought declines. From 1980 yields recovered sharply but then began a slight downward trend that remains uninterrupted to the present time. The dip in average yield from 1986 to 1987 is blamed on rising fertilizer prices which caused farmers to reduce the amount applied.

The regional potato yields given in Figure 6 show the north, where the production is principally in Carchi, as consistently having superior though highly variable yields, though we must always keep in mind that some of this variability may be due to measurement error. The regional trends also highlight the ecological diversity of the three zones. There are very few years when the trends in yield move in the same direction for all three zones. However since 1978, the yields for the three zones converged, moving apart again only in the most recent years.

One aspect of this decline in yields may be a reflection of the changing composition of the potato producers. As noted above large farmers have gradually been shifting out of potato production, so that an ever larger percentage of production comes from small farms. The small farmer does not have the resources to apply inputs at the levels applied by the large farmer, thus average yields fall. Muñoz (1984) estimates that yields of the traditional, semi-technical and technical producers are 8, 16, and 35 t/ha.

Barsky (1984) provides, via a case study of Carchi, another explanation of yield trends. He notes that large producers began using modern chemical inputs in the 1950's and identifies a period of rapid technological transformation from 1955 to 1974 when 90% of producers in the area adopted modern production techniques. In 1954 the agricultural census estimated national potato yields were 0.7 t/ha (Barsky and Llovet, 1982). By the late 1960's, yields in Carchi were sometimes reaching 20 t/ha. In the second period from 1975 to 1981 there was stagnation in the adoption of new technology. The first period saw the extensive introduction of

Figure 5. Potato yields. National average, Ecuador, 1962-87

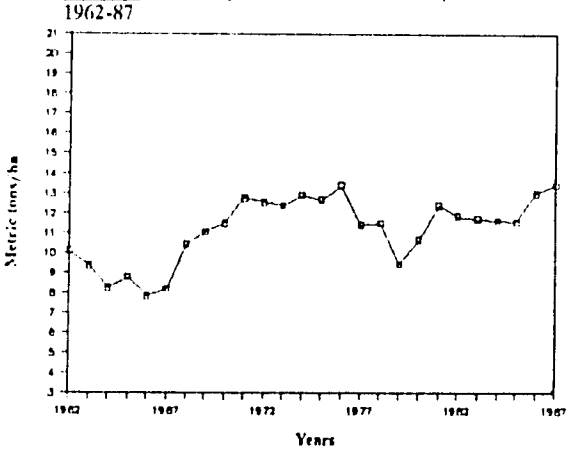
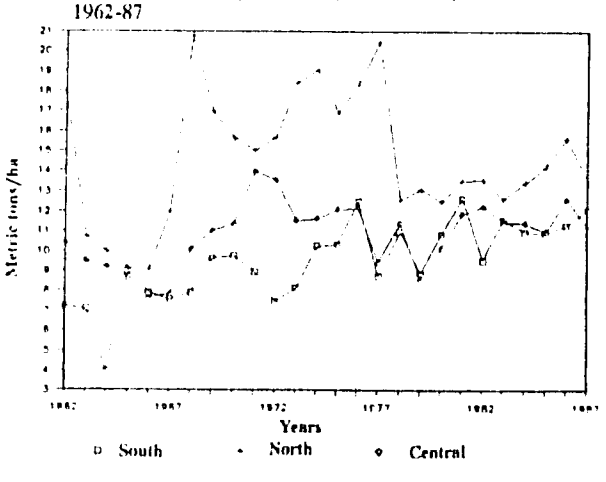


Figure 6. Potato yields. Regional averages, Ecuador, 1962-87



chemical inputs while the second period of slower growth illustrates limits on productivity improvement with agrochemicals. Thus during the initial period, use of inputs went from nothing to something and the farmers obtained a distinct crop response. During the second period input use levels have stagnated as have yields.

Consumption

Changing Diets

Potato consumption has changed significantly during the 1970's and 1980's. Generally speaking, the consumption of potatoes, barley and soft maize has declined while the consumption of rice and wheat, primarily in the form of bread and noodles, have risen. Food expenditure patterns for Quito residents in 1965 and 1976 and rural highland residents in 1976 are listed in Table 2. The data illustrate the significant changes in urban food expenditure patterns, primarily a shift from items that once claimed over 70% of expenditures to an evidently much more diverse food basket. Without 1965 data from the country-side, the pattern of consumption among rural households remains more similar to that of the urban dwellers of a decade before. Field work for this study confirmed that in 1987, a similar basket of items is still important for rural farm households. Wheat consumption is mostly in the form of noodles, and dairy consumption in the form of cheese. Though there are chickens in most farm households, the eggs are sold. Sugar is a big consumption item.

Byerlee (1985) shows that bread and rice prices dropped in real terms while those of potato rose slightly during the 1970's. The price of wheat and wheat flour has been heavily subsidized during this period. Consumed as either bread or noodles (*fideos*), wheat has made rapid gains in the diets of poor consumers in both urban and rural areas. Rice has been a special target for increased production and rice farmers have received a disproportionately large share of National Development Bank (BNF) credit (Peterson et al., 1988).

Table 2. Food expenditure patterns of Quito and rural highlands households, Ecuador 1965, 1976.

	Percentage of total food expenditures			
Food item	Quito 1965	Quito 1976	Rural non-farm 1976	Rural farm 1976
Wheat[1]	16.5	6.0	8.3	9.6
Meat	16.2	5.1	8.6	7.2
Dairy products[2]	12.6	11.0	7.2	2.1
Rice	7.0	5.3	12.1	13.8
Potato	6.3	4.1	11.4	9.9
Sugar	5.9	2.6	5.9	6.3
Oil[3]	4.6	1.3	4.3	4.9
Bananas	2.1	.4	1.2	1.7
Eggs	1.9	3.2	1.9	.6
Total[4]	73.1	39.0	60.9	56.1

Sources: 1965 data from Valderrama and Luzuriaga. 1976 data from Immick.
Notes: 1. Wheat is counted as bread and noodles for 1976. 2. Dairy products includes milk and cheese. 3. Oil is counted as pork lard for 1965 and vegetable oil for 1976. 4. Figures do not add to 100% as they are the nine most important items in the 1965 food basket.

Consumption Estimates

Estimates of potato consumption, like most other consumption estimates, are simply the remainder after other more easily countable sources of demand are subtracted from total production. Estimates of usage are usually the result of inspired guess work. One set of estimates indicate that consumption of fresh potatoes consists of 65% of total production, wastes and animal feed take 7%, seed 8%, and loses, rotting and dehydration take 20% (Maldonado, 1974). While many observers conclude that consumption has declined, MAG calculations of potato crop disposal show consumption increasing. Based on a strict mechanical formulation, consumption rises and falls with production. However, because of illegal trade with Peru and Colombia consumption is certainly more stable. Some recent estimates state that per capita potato consumption, after falling in the 1970's, has again risen and current estimates place it at 60 kg per year (Barsky et al., 1985).

There is very little processing of potato products by modern methods and in the country-side there is no use made of the traditional methods of processing which are commonly found in Peru and Bolivia. In the cities, fresh

potatoes are made into french fries and there are some small scale potato chip processors.[2]

There is very little storage of potatoes destined for the market. During the field work one informant noted that if the dirt on the harvested potatoes was dry then the price would drop by half. That is certainly an exaggeration but it emphasizes the market acceptability requirements of the Ecuadorian consumer. Wallace (1985) noted that potatoes harvested three days or less are acceptable to the consumer with an upper limit of eight days after harvest.

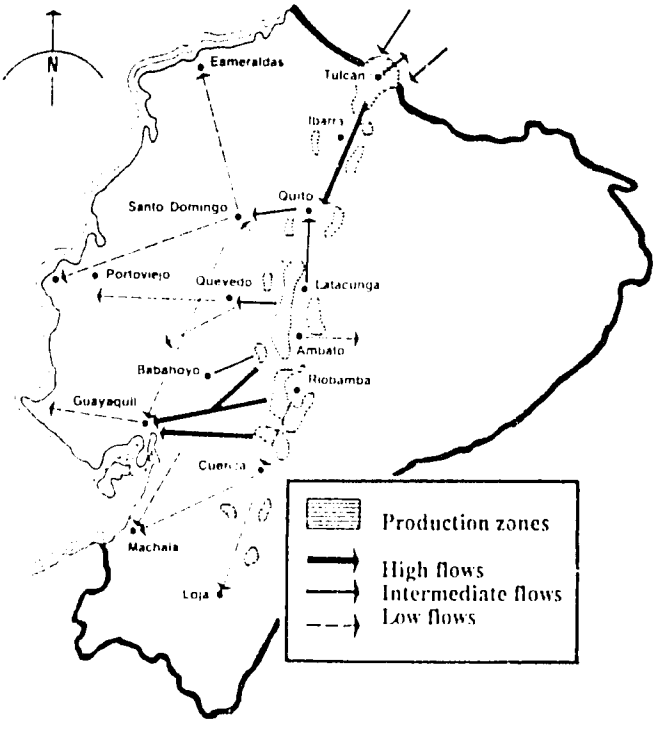
Marketing

Potato marketing in Ecuador has been extensively studied (Simmons and Ramos, 1985; Wallace, 1985; Ohms, 1984; Wiegand, 1975; Maldonado, 1974; Arévalo, 1973; Bromley, 1953). The basic environment of many relatively small periodic markets serving the rural area is made possible by numerous intermediaries who serve to collect and assemble the market produce into more efficient quantities before shipping them to the consuming markets (Karaska et al., 1985).

Marketing problems associated with fluctuating prices caused by production cycles and perceived monopolistic powers of market middlemen have caused continuing concern among policy makers in Ecuador. The flow of consumer potato marketing in the country is given by Figure 7 which illustrates the basic north to south flow of production from the producing regions to the urban markets. First described by Bromley (1953), the continued existence of these flows has been checked by Maldonado (1974) and Simmons and Ramos (1985).

Numerous market channels with distinctive trails have been identified for the small and large producer (Maldonado, 1974; Barsky and Llovet, 1982; Simmons and Ramos, 1985). These are illustrated in Figure 8. Again, notable in these channels are the large number of intermediaries, but also significant is the separation of channels employed by the large and small farmer. This separation of marketing channels between large and small farmers for consumer potatoes also has an influence on seed marketing, reinforcing the lack of contact between large and small farmers in this and most other aspects of the Ecuadorian potato food system.

Figure 7. Potato marketing flows

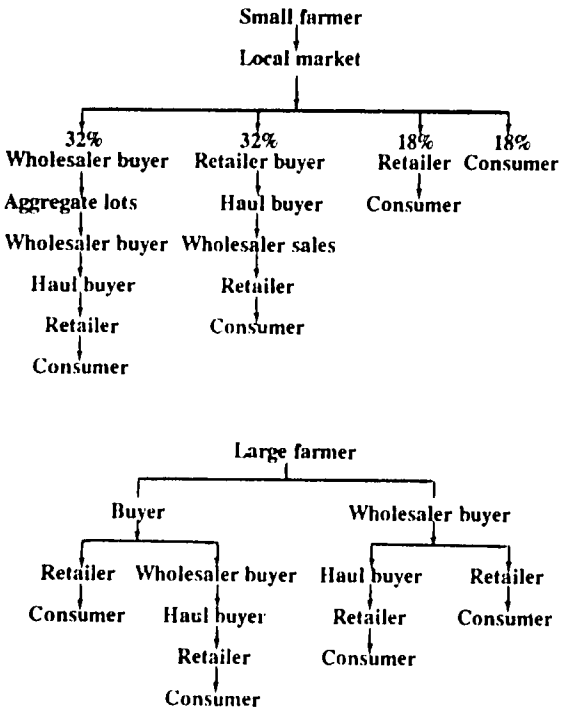


Source: Bromley, 1953

Arévalo (1973) described a three year price cycle affecting the production of potatoes. This cycle illustrates the reactive behavior of producers where high prices in one year influence the planting decisions of the next year, which increase production and this cycle is continued in the following seasons until production exceeds the original market demand and prices fall sharply, which induces producers to reduce plantings in the following season. The continued presence of this cycle was documented by Swett (1984) and Simmons and Ramos (1985).

2 The terms french fries and potato chips are American usage and correspond to the British terms chips and crisps

Figure 8. Potato marketing channels



Source: PRONAREG

Reinoso (1988) investigated the market for seed potatoes. Some of his preliminary conclusions are discussed in Chapter 6.

Policy Setting

In Ecuador, change is the only constant in the country's official agricultural institutions. Since the early 1970's, there have been 12 major reorganizations of the national research and extension agencies (Ramos, 1984). There is a 13th reorganization currently in progress, a process being facilitated by a large Interamerican Development Bank loan for the creation of the Program for Agricultural Technology Transfer (PROTECA). The adverse impact of this continual reorganization of potato technology generation and extension programs was noted by Peterson et al., (1988). Official potato research has been in progress since 1962 so the program has witnessed all these changes. For seed production the history is slightly shorter but nonetheless marked with several notable dates. Some of the more significant organizational factors as they relate to the formal seed potato system are listed in Table 3.

Agencies and Institutions

The principal actors in the government seed sector are MAG and the National Agricultural Research Institute (INIAP). MAG is responsible for extension and certification activities while INIAP provides the basic and applied research for potatoes and the production of basic seed. Within these two institutions are several departments that have responsibilities for potato and potato seed. INIAP consists of a central headquarters in Quito and several experimental stations scattered around the country (Cabezas and Espinosa, 1984). Research at these stations is organized in commodity programs. The activities of the Potato Program are in two stations with the program leader located in the Santa Catalina Experiment Station just south of Quito. A significant portion of INIAP's activities is also the production of basic seed for various crops. In the Santa Catalina station seed production represents approximately 15% of the annual budget (Peterson et al., 1988). Thus there is a Seed Production Department and within it, is a special Seed Potato Unit.

In MAG there are several entities which have ties to potatoes. The Technical Directorate of Roots and Tubers with regionally-based subject-matter specialists is the principal link between the researcher and the extensionist. There is also a Directorate for Seeds that is part of the National Seed Program (PNS) which is in charge of certified seed production in cooperation with a parastatal agency, Empresa Mixta de Semillas (EMsemillas). However, for technical and logistical reasons, EMsemillas does not cooperate with the Directorate for Seeds in potato seed production.

The creation, dissolution, or transfer of units or departments, highlights the institutional imbalance between research and production (INIAP) and certification, distribution and extension (MAG) elements of the seed potato system in Ecuador. The system has a new

structure every few years. This institutional instability emphasizes personal contacts at the expense of institutional contacts. Thus in matters where the different institutions need to interact, things flow smoothly only if the contact persons are friends.

Table 3. Institutional events related to the formal seed potato system in Ecuador

1962	INIAP Santa Catalina station is opened. INIAP receives potato germplasm from private national collection and Mexico and Colombia.
1968	Seed Production begins at Sta. Catalina experiment station in MAG.
1969	New Seed Law is passed. Department of Seed Certification is created.
1971	Roots and Tubers Program is created in MAG. Potato certification begins.
1977	Programas de Investigaciones en Producción (PIP's) on-farm research are begun.
1978	Programa Nacional de Semillas (PNS) containing the Dept. of Seed Certification is created in MAG. Roots and Tubers Program is disbanded.
1982	PRACIPA-funded seed potato research program begins at Sta. Catalina.
1983	Potato Seed Unit created in Seed Production Dept. at Santa Catalina station.
1984	Technical Directorate for Roots and Tubers is created in MAG.
1985	Seed Certification Units established in cooperation with PNS at Sta. Catalina
1987	PROTECA is created.

Sources: Naranjo, 1984; PRACIPA, 1983; Coronel, 1984; INIAP Seed Dept., 1985.

Summary of Institutional Analysis

The diagnostic institutional study by Peterson et al., (1988) identified several strengths and weaknesses in government policy toward potato research, extension, and seed production and distribution. The report notes that INIAP has a good record of producing new varieties and does considerable training and produces numerous technical publications. In a review of major efforts of INIAP in potato, Barsky et al. (1985) identified the development of new varieties, the work on combating insect pests, and storage as the principal research achievements.

Research. Concerning the generation of technology the Peterson et al. report noted that the agricultural research budget has dropped from .75% of agricultural gross domestic product (AGDP)[3] in 1980 to .31% in 1986 levels below the 1% the World Bank recommends as minimal to maintain a quality research system. Salaries are too low to attract and keep staff with post-graduate training. However, the majority of the research budget is devoted to payroll, and not to operations. In this atmosphere, the Santa Catalina experiment station director actively encourages his staff to seek outside funding for research. While for the entire INIAP system the figure is 15% of budget (Cabezas and Espinoza, 1984), the director of Santa Catalina estimates that 20% of his budget comes from such sources. He also asserts that this outside money does not cause the central office to subtract a like amount from the station's budget nor does this money affect station research priorities.

In this agricultural research context, the International Potato Center (CIP) and the Andean Program for Cooperative Potato Research (PRACIPA), a Canadian-funded research network, have established technical and institutional links with several units of INIAP; the Potato Program, the Seed Potato Unit of the Seed Production Department, and cooperating researchers in the central administration and the Departments of Nematology and Pathology (PRACIPA, 1983; International Potato Center, 1987).

Extension. In the area of technology transfer, the support of the government is similarly weak. The budget of MAG has dropped from 11.1% of AGDP in 1980 to 3.5% in 1985. During the last two years 12% of the budget has been for programs. In other words there has been a large staff without any money to spend on activities and as a result they have become deskbound. Extensionists are poorly paid and have low levels of education and training. Extension contact is limited and usually restricted to organized groups. Linkages with INIAP are poor. There is no communications unit in MAG for the dissemination of extension material. INIAP contact with extensionists and farmers is considered very weak.

Valderrama and Luzuriaga (1980) note that before it was disbanded in 1978, an objective of the Program of Roots and Tubers was the reduction of potato area planted together with the continued satisfaction of consumer demand through increased productivity. To this end the

3 AGDP is the measure of the total value of goods and services produced in the agriculture sector of the economy. The measure excludes foreign trade.

Program targeted large farmers and cooperatives as the most efficient means to reach this goal. They conclude that the main impact of this policy was to direct a larger share of National Development Bank (BNF) credit to large producers, a tendency that continues to the present. The current Directorate of Roots and Tubers also defines promoting increased production as an objective, and like its predecessor, views the large farmer as the vehicle to reach this goal.

This bias against small farmers persists in many forms. Repetto (1985) in his survey on pesticide subsidies, notes that the subsidies are captured by large farmers and farmer associations. The Agriculture Centers (*Centros Agrícolas*), which are dominated by large farmers are given direct grants to purchase imported pesticides. Small farmers purchase pesticides through retail outlets where, through lax enforcement of price controls, the value of the subsidy is captured by the retailer.

The most recent extension reform which created PROTECA is biased toward readily accessible production areas and uses the Training and Visit (T&V) extension system. The emphasis on the readily accessible area ignores many marginal communities not on the main roads. The T&V system limits the number of contacts a single extension agent can make. With few agents the tendency is to cover larger areas by seeing the larger farmers or farm organizations. This bias is perhaps not too surprising since key officials in PROTECA are from a large farmer lobby group. This lobby group is discussed in the section on farmer organizations below.

3. Farm Agroeconomic Setting and Informal Seed System

Farm Agroeconomic Setting

Potato production is central to the food system of most of highland Ecuador. An estimated 90,000 farms have potatoes and 90% of these farms are of less than 10 ha. The agroeconomic setting for potato production in Ecuador has been extensively studied, e.g. Llovet (1980), Barsky (1984), and Wiegand (1975). Much of the information in this section is drawn from other reports produced during the field research for this study including Peterson et al. (1988) and Uquillas et al. (1988).

Physical Setting

Potato production takes place on level valley bottoms or on fields with a slope of as much as 60 degrees, at altitudes that range from 2,400 to 3,800 m. The predominant soil type is the volcanic Black Andean, which is rich in organic matter and has a good texture for potato production. Hammond and Hill (1984) note that, according to national soil fertility tests, Andean soils require supplemental nitrogen and phosphorous for potato production. The Andean climate is characterized more by diurnal than by seasonal changes (Troll, 1967). Daily temperature fluctuations are largely a function of altitude, and effectively limit the upper level of potato production when the night temperatures fall below freezing. Though there is much local variability, INIAP studies have established two major potato planting seasons beginning in May and November (Muñoz, 1982). The extensive mapping done by the National Agricultural Regionalization Program (PRONAREG) in MAG has enabled the Technical Directorate to classify potato regions as preferential and secondary, depending on altitude, soils and rainfall. Carchi has the highest percentage of preferential relative to secondary potato area.

Small Farms and Large Farms

A dominant agroeconomic feature of agriculture in the *sierra* is the inequality of land distribution. In 1984 after two decades of land reform, 35% of the land is still occupied by 1.3% of the farm units of 100 ha or more (Chiriboga, 1986). As noted above, the vast majority of farmers in the *sierra* are *minifundistas* who work on farms which because of their location or size are insufficient to support the farm family. The small farm is defined as less than one hectare in favorable regions and as many as five hectares in unfavorable regions (Peterson et al., 1988).

Small farms are classified by MAG and BNF as those operating with traditional technology and large farms as those with modern technology. To facilitate planning, these agencies produce crop budgets for the different technology systems. Examples of these budgets can be found in Reinoso (1987). However, as will be discussed below, the large-modern, small-traditional linkage does not hold for potatoes. In the budgets there are not significant differences in production technology, except for the assumption of seed type (certified for large farms, common for small), use of mechanized land preparation, and degree of chemical input use. Medium sized farms bridge the two extreme cases and a semi-technical classification is defined for them. However the position occupied by these farmers is in fact measured by a sliding scale varying between the smaller and larger farms.

Farmer Organizations

Another distinctive feature of the farm sector is the degree to which small farmers are organized into cooperatives or communes. As a consequence of the land reform process, cooperatives have been formed for economic purposes such as agricultural production. Communes, which are mostly organized among

the indigenous population, have social dimensions for the association. Peterson et al. (1988) estimates that nearly 10% of the farmers in the *sierra* belong to one of these types of organizations, which are the principal point of contact between the government and small farmers.

Agriculture policy needs of large farmers are served by a lobby group known as the Chamber of Agriculture (*Cámara de Agricultura*). The Chamber of Agriculture is organized on the local level as a series of Agriculture Centers. Through various membership requirements these organizations, though chartered to serve all farmers are, in fact, open only to medium and large farmers. Various enrollment requirements make it difficult for small farmers to join (Peterson et al., 1988). Members of the Chamber regularly rotate in and out of government service and also serve as leaders of the national producer associations. That the Chamber does not represent small farmer interests is given by its position that land reform has had a severe negative effect on Ecuadorian agriculture and may be unconstitutional (Cámaras de Agricultura 1978, 1979, quoted in Seligson 1984:34).

Credit

The BNF is the principal governmental source of agricultural production credit in the country, supplying more than 90% of the total official credit.

The *sierra* received 26% of total crop credit in 1985. Though direct measurements are not possible with BNF records, small farmers are estimated to receive less than 15% of total credit (Peterson et al., 1988). In 1986, among crops most often found on small farms in the *sierra*; potatoes, barley and fava together received slightly more than 5.4% of total crop loans with potatoes getting 4.6% of that (Table 4). Thus although the potato is the fourth most valuable crop in the country it does not receive a proportional share of credit.

There are many private money lenders. Small farmers typically use loans from these lenders for short term consumption purposes. Interest rates on these loans range from 5-10% monthly (Uquillas et al., 1988). Interest rates at BNF are 18% for an 11 month potato loan.

Table 4. BNF credit for potatoes in Ecuador[1]

Year	Total crop credit[2] (Sucres)	total potato credit (Sucres)	%	No.of farmers crop credit	No.of farmers potato credit	%	Potato area with credit	% of total potato area
1981	2,065	125	6.1	17,823	1,260	7.0	5,641	17.9
1982	1,754	137	7.8	13,010	1,390	10.6	5,184	14.8
1983	3,720	202	5.4	21,905	1,549	7.0	5,215	19.5
1984	5,895	349	5.9	21,498	1,843	8.5	6,047	18.1
1985	10,715	443	4.1	23,902	1,750	7.3	5,875	16.1
1986	13,164	603	4.6	22,014	1,851	8.2	7,000	13.1

Source: BNF, 1987. Annex 11.
Notes: 1. Original credit only, no loan renewals. 2. Millions of current Sucres.

Farmer Seed System

The importance of the seed potato system in improving the yields and productivity of potato has been clearly recognized in Ecuador. Several studies have described components of the system. Among those which deal with the farmer seed system include Moya (1984), Figueroa et al. (1979), López (1987), Buitrón (1986) and Valderrama and Luzuriaga (1980). In this section, the discussion of seed covers the rate at which seed is renovated, sources and types of seed used, and farmer seed management practices. Included in seed management practices are selection, storage, and pre-planting handling.

Seed Renovation

The majority of the potato production areas in the country are also good seed potato producing areas. An extreme example of the suitability of the environment and the variety, is the observation of one informant that he had used the same seed for 15 years. Most other farmers reported a 3 to 5 year rate at which they replaced seed. Reinoso (1988) reports an average seed renovation rate of 3 to 4 years for a sample of farmers from the central zone.

In Carchi, the best potato area in the country, small farmers generally decide to renovate seed and thus enter the seed market for two reasons (aside, of course, from reasons of accidental loss of seed stucks from, for

example, a crop failure): because prices are lower during the harvest, or because they want to obtain a new variety. Neither of the reasons are related to the pathological degeneration of their seed stock, the usual incentive for rotating seed. A high price during harvest motivates the farmer to sell most of his production, saving little for seed. Thus there is an inverse relation between prices for table potatoes and the quality and quantity of seed saved by the farmer. This is a practical strategy since potatoes are always available in the market.

Seed Flows

In Ecuador a predominant feature of the informal seed system is its lack of any significant flow of seed material either between or within regions. There are, however, several areas with minor seed flows that can be detected. Most farmers save their own seed and when they need to renew seed stocks the usual source is neighbors or the local market. As discussed above, in most areas potatoes can be grown on a year-round basis, thus there are always stocks of seed available in varying states of maturity.

Based on responses from informants, some areas are locally known to have better seed. These areas were not widely known outside of the immediate region. For example, in Carchi, the parish of San Gabriel was mentioned by some farmers as a good seed area. Other farmers noted however that San Gabriel had this reputation not because of seed quality but rather because of seed availability. San Gabriel is located in an ecological zone that opens to the western jungle; it is more humid and has assured rainfall when the other parts of the province experience drought and, thus, has potatoes when the other farmer's supplies are short.

In the south, an area mentioned as having good seed was the El Tambo market. El Tambo was mentioned as a good seed source since the market was small and the seed were locally produced, as opposed to the Azogues market that may have potatoes brought in from the Riobamba area further north. Here too there are possible alternative explanations for this reputation. El Tambo is in a zone that opens to the western tropics, and near El Tambo is a special project of the Economic Recovery Center of Azuay, Cañar and Morona Santiago (CREA) which has a farm producing "selected" grade seed.

In lower altitude production areas where higher temperatures reduce the viability of seed storage, and seed degeneration rates are higher due to increased aphid pressure, there is some downhill seed flow from the surrounding higher production areas. For example, farmers from below and around Alausí (2,600 m) often purchase seed available in the Alausí market which is produced in the *páramo*, the high, humid and relatively flat areas (3,300 m), above the town.

Tracking the path of a new variety into an area is a convenient device to follow seed movement. One such example is the movement into Carchi of the Colombian variety Morasurco, prized by farmers for its quick maturity or earliness. Morasurco has been in the province for about three years and many farmers want it for seed. Farmers who had the variety were usually able to recall how they acquired the seed. The most common methods of getting seed were via family contacts by gifts, loans or purchases. Since Carchi is a border province many farmers have family members in Colombia. The quantity of seed acquired through this type of contact is seldom large and often only a few quintals.[4]

Other farmers mentioned theft of a few tubers as a method of acquiring seed particularly for a different variety. Seed was often given as gifts, especially among family members. This mechanism accounted for a significant portion of the small interregional seed flow that was observed. In a recent central zone survey, all the farmers who had seed to sell indicated they sold it to friends or relatives (Reinoso, 1988).

In the field work for this study, López (1987) in Tungurahua and Reinoso (1988) found large farmers to be the only ones who acquired certified seed. There were no reports of small farmers who used certified seed. One of the few points of contact between large and small farmers are those small farmers who work as day laborers on the large farms and/or are neighbors. In these cases the small farmers may acquire seed from a large farmer. However, given the distinct marketing channels used by

4 A quintal weighs 100 pounds (45.45 kg) and is a commonly used potato measure in Ecuador.

the different groups (see Figure 8) the seed produced by one group seldom reaches the other.

Seed Prices

Seed prices vary during the season, roughly following the price cycle of table potatoes. During the field work prices of seed-sized potatoes were found to be above, the same as, and below the prices for table potatoes. This was for seed-sized tubers that may or may not be sprouted.

In Ecuador the relationship between table and seed potato prices has much to do with the dynamics of an individual market on a particular day. During and after harvest, potatoes are graded and sacked according to size. An exception is some areas of Chimborazo where there is no grading. Prominent actors in most markets are the wholesalers who purchase, assemble, and market local produce to the nearby urban areas. These wholesalers often regrade the potatoes purchased, with the large size tubers destined for urban consumers who will pay a premium for the larger tubers. Rural consumers tend to prefer the smaller potatoes that are an appropriate size for the hearty soup called *locro*. Depending on the activity of the market on that particular day, the wholesaler may chose to remove to the urban market or sell locally the seed sized potatoes.

The farmer who wishes to purchase seed potatoes on a given market day may find sacks of pre-sprouted potatoes or sacks of freshly harvested seed sized tubers. Competing for the freshly harvested tubers are housewives who are looking for a table potato. Thus the price of seed-sized tubers can vary relative to the larger sized tubers.

Seed Management

Potato seed management is fairly similar among the different regions and farm sizes. When new seed is purchased and the farmer has reason to believe that it is of higher than normal quality, the harvest resulting from that seed will be conserved as seed. This is especially true of a new variety acquired by a farmer. Since the quantity purchased is usually small, the farmer can accelerate the multiplication of his stocks by not selling any of the production.

Farmers do not practice positive or negative selection. Valderrama and Luzuriaga (1980) and López (1987) also note that farmers do not consider the potato plant when selecting seed. Positive selection occurs when the farmer stakes individual plants or plots he recognizes as being healthy during the vegetative stage of growth. Negative selection is the removal of diseased or off-type plants. These practices are proven low cost devices by which farmers can improve seed stocks by slowing down the rate of transmission of some diseases from one generation to the next. There are several possible reasons why farmers do not employ these practices. First may be the result of lack of extension contact as discussed in Peterson et al. (1988) or the fact that in favorable seed producing areas the good growing conditions often mask many of the symptoms of disease making the positive selection process difficult. Finally and perhaps most importantly it may result from farmers having experimented over the years and realizing that the loss to production plus the additional labor costs of negative selection were not compensated by a measurable improvement in yields.

Several farmers with fields in different altitudes rotate seed from the high fields to the low ones and vice versa on the belief that the seed grow tired of always being put back into the same location.

Freshly harvested potatoes are graded by size in the field and the seed sized tubers are selected, sacked and transported to stores on the farm. The stores can be any convenient space in the house or outbuildings. Given the common type of house construction and climate, these sites offer cool, dark conditions. Generally losses from these stores are low. There are virtually no specially constructed seed stores. An exception to that is the Colta area of Chimborazo Province where a special project installed more than 100 diffused light stores in the early 1980's.

Potatoes are stored in either loose piles in the corner of rooms or sacks and are removed as needed. For small farmers in the Chimborazo area where there is no grading, the larger potatoes are removed for home consumption

and the remaining sprouted potatoes are used for seed.

Also in the Chimborazo area farmers reported using straw-lined holes covered with straw and rocks to store seed potatoes. No farmer reported serious pest damage during storage. Occasionally mice would damage tubers on the surface of piles. If aphids were seen on sprouts then all the sprouts would be removed. Farmers would sometimes spread lime in the store to inhibit the movement of the Andean weevil larva *Premnotrypes vorax*, known in Ecuador as *gusano blanco*.

When preparing seed for planting the longer sprouts are removed. Farmers recognize that by removing the longer sprouts, multiple sprout growth is stimulated. Virtually no farmers practiced any sort of chemical pretreatment on seed tubers. Cutting seed tubers is done very rarely, only in cases of extreme scarcity. Uncut egg-sized tubers are considered ideal but any size tuber can be planted. In an effort to get a certain number of sprouts per hill, farmers place one, two or three tubers to a hill depending on the size of the tubers.

Preservation of Varieties in the Farmer Seed System

Since the potato is native to the Andes, Ecuadorian potato farmers are blessed with a nearly unrivaled range of native germplasm that has evolved to fit ecological niches in the country. Over the centuries farmers have successfully exploited many of these varieties and a large number have traditionally been available either from the market or from neighbors. However, with the introduction of new varieties and with the increasing costs of production, the continued presence of many of the older varieties is threatened. The existence and fragility of this reserve of germplasm and its importance to the breeding efforts of the Potato Program were recognized via a project involving INIAP and the International Board of Plant Genetic Resources (IBPGR). The project sponsored germplasm collection trips of INIAP personnel in collaboration with CIP (Sola, 1986). Germplasm samples collected during the two year project numbered above 1,000. However, these trips serve to note the decreasing variability of varieties found in the market and to document the decline of the number o varieties currently cultivated by farmers. of these changes are noted in the fo chapter.

4. Breeding and Variety Selection for Production

The work of a seed program is dependent on having varieties with characteristics suitable for the needs of farmers, processors and consumers. Thus breeding and variety selection are essential components of the seed production system.

Brief History

The present-day breeding efforts had their start when, in the 1960's, the germplasm collection of the Central University was transferred to INIAP and named the Colección Ecuatoriana de Papa. About that same time the head of the potato program received germplasm from Mexico and Colombia. This donation was facilitated by the program's association with the Rockefeller Foundation. With this wealth of material, emphasis was placed on a screening and selection program, rather than on a breeding program. The variety INIAP Santa Catalina[5] was the result of the initial screening; selected from Colombian materials, it was released in 1966.

Actual breeding work started in the early 1970's with the growth of the potato program during that period. Material developed from crosses was given a letter designation for the year, starting with "A" in 1974. The program is now working with material designated "L" indicating numerous years of crossing work. In the mid-1970's several program people received further graduate training with, most importantly for the breeding program, a plant breeder going to the USA for a PhD.

Several promising clones were developed and released as varieties in the early 1980's. In rapid succession, INIAP Maria in 1980, INIAP Gabriela in 1982, and INIAP Esperanza in 1983 were all released. Another promising variety was identified in 1970 and proposed for release in 1981, but in trials of that year the variety was decimated by rust (*Puccinia pittieriana*) and withdrawn. However this variety, numbered 309, was picked up by farmers and renamed Leona Blanca or Cecilia and is now considered by them as a native variety. Though not officially released and therefore not officially entered in the INIAP seed production program, the production of Cecilia is maintained through the category of "selected" seed.

In 1982, the INIAP administration made the decision to utilize limited resources more efficiently by emphasizing seed production rather than breeding. In the early 1980's the potato program had a staff of 10; due to staff attrition and administrative changes there are currently only two, and breeding work is limited to relatively few crosses and screening existing lines for resistances. There are reportedly several promising clones, but these have not been put forward for registration and release.

Breeding Objectives and Methods

In the early 1980's the objectives of the national breeding program were to develop varieties with medium plant size, early maturity, high commercial and culinary quality, resistance to late blight, rust, nematodes, and potato virus Y, high yield, good adaptation, and the capacity for sustaining mechanized production (Muñoz, 1982). Current selection objectives are for yield, adaptation, and nematode resistance (INIAP, 1986). The breeding program plan has been for crossing and selection on station followed in later years by regional trials (Figure 9). Muñoz (1982) describes using material of female *ssp. tuberosum* and male *ssp. andigena* as the basic cross. *Ssp. tuberosum* brings earliness, shorter plant size, adaptability to mechanization, and resistance to some diseases; and *ssp. andigena* brings culinary quality, adaptability and also disease resistance. The philosophy on which this breeding program is based, is possible because of the extensive germplasm collection which includes many native Ecuadorian varieties of the diploid and tetraploid type.

5 The full names of varieties released by INIAP are not used here to conserve space.

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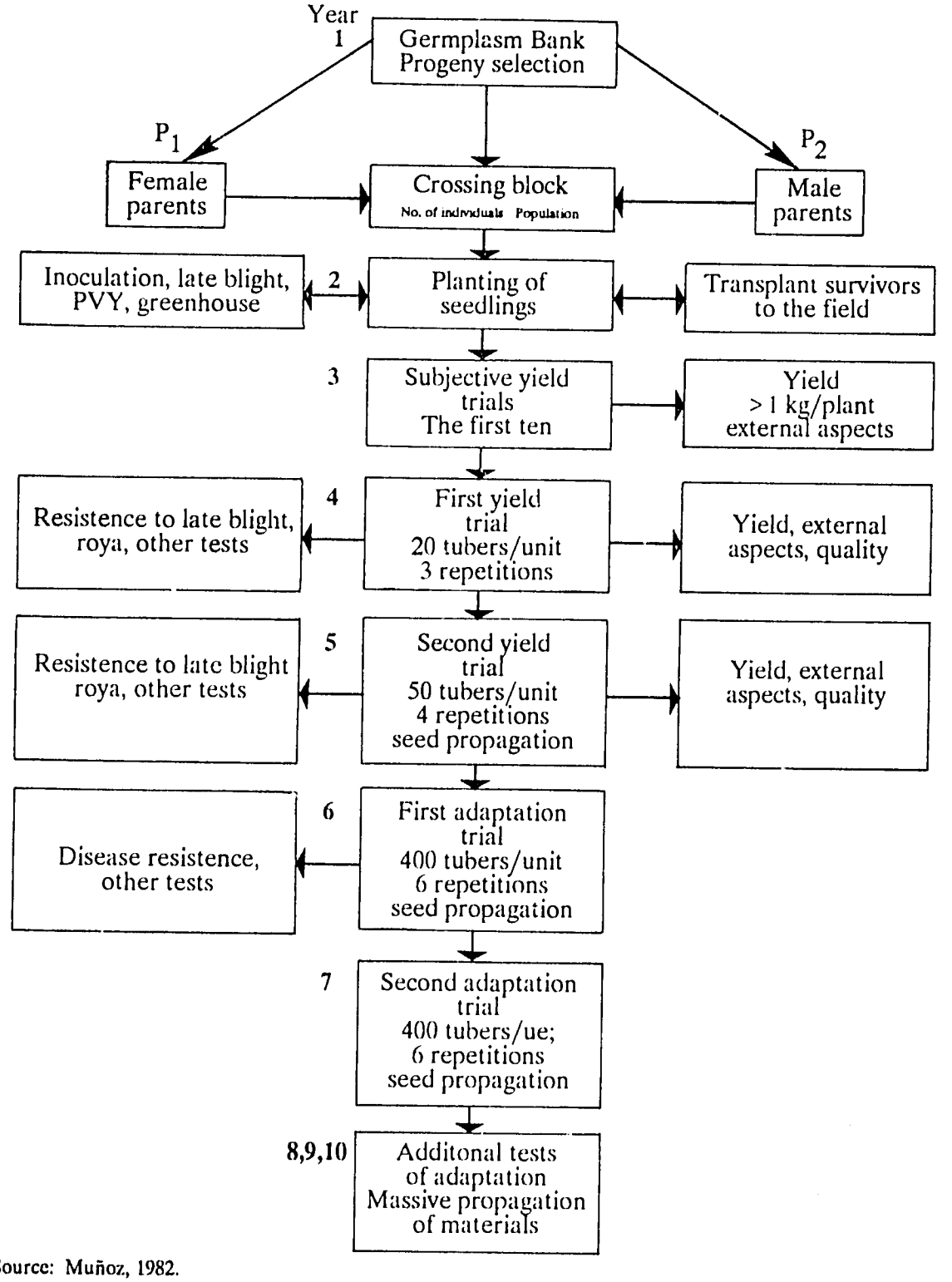
Figure 9. Scheme for potato breeding and selection



Source: Muñoz, 1982.

The INIAP program is the only organized potato breeding activity in Ecuador. There are however several individuals who do potato breeding as a hobby. During the 1987 field work, two of these amateur breeders, both of whom live in Carchi province, were contacted. One breeder had a locally successful variety in the San Gabriel area called Superchola. The other breeder while producing material that had superior culinary qualities, had not distributed these varieties except to friends.

Variety Characteristics and Distribution

Cecilia, Catalina, and Maria were all developed for the central and southern zones, while Esperanza was targeted for the north and Gabriela for the north and center (see Appendix Table A2 for variety descriptions). The results of surveys done in 1976 and 1985 are shown in Tables 5 and 6. The 1976 study ranks varieties by percentage of area planted to that variety in a given zone, and the 1985 study ranks by percentage of farmers using the variety. Though not strictly comparable, the studies permit a view of changes in the decade.

Table 5. Distribution of potato varieties used by farmers in Ecuador, 1976

North		Ranked by area by zone Center		South[1]	
Variety	%	Variety	%	Variety	%
Chola	69.4	Catalina	80.5	Bolona	47.2
Violeta	19.8	Uvilla	9.6	Juvalena	25.0
Curipamba	6.0	Chola	4.8	Catalina	19.4
Guantiva	2.7	Others	5.1	Blanca	8.3
Others	2.1				

Source: Valderrama and Luzuriaga, 1980.
Note: 1. For the south, the percentage represents percentage ranking by number of farmers, not percentage ranking by area.

Several items of interest can be derived from the tables. First, potato farmers grow many different varieties, both native and improved. Second, there has been a definite replacement of native varieties by improved varieties from Colombia and Ecuador. Third, varieties show distinct regional adaptation. Among the improved varieties Catalina is the most distinctively regional; it is especially well adapted to the central zone and is the leading variety in the four provinces --Bolívar, Cotopaxi, Tungurahua and Pichincha-- nearest to Santa Catalina INIAP station where it was developed. Ten years after its introduction it had become a popular variety in the central zone and 19 years later it still remained popular there. Catalina is the most widely distributed improved variety in the country. Though not an officially released variety, Cecilia is probably the second most widely distributed.

Table 6. Distribution of potato varieties used by farmers in Ecuador, 1985

North		Ranked by Area by Zone Center		South	
Variety	%	Variety	%	Variety	%
Carchi		Pichincha		Cañar	
ICA Huila	43.2	Catalina	71.0	Bolona	90.0
Chola	15.2	Gabriela	17.0	Cecilia	2.5
Roja	14.9	Leona Blanca	3.0	Catalina	2.0
Guantiva	5.4	Guantiva	2.0	Yema de huevo	1.0
Others	21.4	Others	8.0	Others	4.5
Imbabura		Cotopaxi		Azuay	
ICA Huila	33.0	Catalina	66.0	Bolona	46.0
Puraced	31.0	Uvilla	12.5	Gabriela	21.0
Violeta	14.0	L. Blanca	6.3	Catalina	19.0
Catalina	11.0	Cecilia	3.5	Others	14.0
Others	11.0	Others	5		
		Chimborazo			
		Uvilla	32.0		
		Cecilia	31.0		
		Catalina	24.0		
		Gabriela	9.0		
		Others	4.0		
		Bolivar			
		Catalina	51.3		
		Uvilla	22.5		
		Gabriela	10.8		
		Cecilia	10.5		
		Maria	5.1		
		Tungurahua			
		Catalina	51.1		
		Gabriela	21.3		
		Uvilla	12.7		
		Cecilia	10.9		
		Chola	4.0		

Source: Simmons and Ramos, 1988.

The field work of August 1987 provides some updates on variety diffusion. Maria was developed to compete with the native variety Bolona in the south, but the farmers consider it too different in both appearance and culinary qualities to substitute for Bolona. Maria has not gained wide acceptance and remains in a minority position in 1987. Cecilia has carved out a special niche; it is useful in the lower altitudes where the pressure from rust is not as severe, and its drought tolerance characteristics make it the preferred variety. Both Maria and Cecilia are considered important for processing to

french fries or chips, but neither has made any significant gains in distribution as compared to the 1985 survey.

Gabriela has gained the most of any variety in recent years. Though targeted by INIAP for the center and the north, this variety has shown particular acceptance in the south. In Cañar in the south, Gabriela has gone from being in the "other" category in the 1985 survey, to occupying second place with nearly 10% of provincial production according to informants. The diffusion of Gabriela in the south highlights the importance of the informal seed system in spreading new varieties. One reason suggested by informants for the rapid diffusion of Gabriela in the south was an outbreak of late blight in 1983. This outbreak seriously depleted seed stocks in the south, and available supplies of Gabriela from the center zone filled the shortfall. From the time of that introduction the presence of the variety was first recorded in the PRONAREG survey. There has been no systematic introduction of Gabriela into the area; yet it has diffused relatively rapidly.

Esperanza, a hybrid cross between the native variety Chola and the Mexican variety Florita was targeted to substitute for the Colombian varieties that are popular in the north. The variety was introduced via a short-lived potato growers association and after initial interest the variety has failed to take off. One large grower commented that the variety was declining in popularity due to a lack of interest by potato processors. Another grower cited the ease with which the tuber breaks during post-harvest handling as a limiting factor.

In the following paragraphs the discussion focuses on the varieties found in the individual regions.

South

Despite the increased diffusion of Gabriela, in the south the native variety Bolona has remained predominant. This is the only native variety commonly grown on the larger farms in the south, whose owners, like their counterparts in the other zones, tend to grow fewer different types and are more likely to plant the improved varieties. Bolona is the local name for the white version of the variety Uvilla which also comes in deep purple. Also in the south are a group of diploid varieties (*Solanum phureja*) called "Chauchas" that are popular for their high dry matter content. Other local varieties include Carrizo, Suscaleña and Chola. The germplasm collection trips to the area recorded farmer observations of at least ten native varieties that can no longer be found in the area (Sola, 1986).

The south, as noted by Muñoz (1982), has been the area least targeted by breeding work and has remained a stronghold for native varieties long after the penetration of improved varieties in the other zones. Today the south still has less area in improved varieties than the other zones. Muñoz (1982) considered the logistical problems of establishing a screening program in the south to be the limiting factor.

North

The area least affected by INIAP varieties has been the north, where however, improved varieties are commonly planted. Ecologically similar to the southern Colombian departments, varieties developed by INIAP's Colombian counterpart Instituto Colombiano Agropecuario (ICA) are popular. Though there are border restrictions on the movement of material they are ineffective and the Colombian varieties have readily moved into the northern production zone. Arriving in 1980, the variety ICA-Huila is predominant in the two northern provinces, Carchi and Imbabura. Other Colombian varieties found there are ICA-Nariño, San Jorge, Guantiva, and Morasurco --a recent arrival prized for its earliness. Note that in Table 6, ICA-Huila and Nariño, known locally as *Roja*, are in fact two names for the same variety, ICA-Huila.

Chola, a native variety, has remained popular despite its lower yields, due to the market preferences in Quito. Chola is the only native variety that can be found on both large and small farms. The 1987 field work found no small farms in the north growing any INIAP variety. Some large farms had the INIAP varieties as a result of a short-lived distribution scheme. Thus to date it is not certain whether the failure of INIAP varieties in the north is due to lack of a distribution scheme or to poor adaptation of the variety to local conditions and

preferences. Given the evidence of the efficiency of the informal seed system for diffusion of the variety Gabriela in the south, the latter may be the case.

In general, small farmers who grow improved varieties tend to grow them for the market and to grow the lower yielding native varieties for home consumption. Examples of these lower yielding varieties in the north are Violeta and Curipamba. All informants noted that acquiring seed for these varieties in the market was difficult since they usually did not appear there. Sola (1986) notes that in the north farmers reported many varieties have disappeared.

Center

The central zone has most of the improved Ecuadorian varieties, with the scene being dominated by Catalina, but Maria, Gabriela, and Esperanza are also found there. Chola had been the variety most often grown in the center, but it has been nearly completely displaced by Catalina. Production of Chola moved north where it in turn displaced the production of other native varieties.

Uvilla is the most popular native variety in the center and is the most popular variety in Chimborazo, the southern-most province in the zone. Here again this is the only native variety to be commonly found on the farms of large farmers. The popularity of Uvilla there is due to the relative distance of the province from the Santa Catalina station and the hence lower adaptability of Catalina, and to the relatively higher percentage of farmers from native population groups in the potato areas --groups of small farmers who are less likely to come into contact with the official seed distribution system. Also found in Chimborazo are selections from the Puna (high quality *Solanum andigena* tetraploids) and Chaucha groups. Cecilia was reported in the hotter, lower altitude areas around Alausí while Uvilla was not planted due to a too long vegetative cycle for the local growing season. Farmers encountered in the germplasm collection trips in the central zone reported more than 30 varieties as no longer available (Sola, 1986).

5. Initial Seed Multiplications

The next phase in the process of seed production in a formal program is the "initial" multiplication. Included in this phase are three steps: maintenance of the varieties, production of pre-basic seed, and production of basic seed. This chapter starts with a review of INIAP seed production, which is followed by a discussion of the germplasm maintenance activities. Next, two different techniques, "traditional" clonal selection and rapid multiplication, for production of pre-basic seed are presented, followed by a discussion of production of seed on the station. Finally, there is an overview of the seed potato research program in INIAP.

Brief History

Seed potato production at the Santa Catalina Experiment Station began in 1968. Santa Catalina remains the only site for INIAP potato seed production. With the creation of the Department of Seed Certification and the Program of Roots and Tubers in MAG, certified seed production began in 1971 with initial harvests in 1972 (Naranjo, 1984). Initially the program relied on clonal selection techniques for seed production.

In the late 1970's a series of on-farm experiments designed to test various seed management techniques revealed that the origin of seed, whether from INIAP or from the farmer, did not significantly affect yield (Reinoso, 1979). The experiments were designed and conducted on the assumption that INIAP seed was superior to farmers' seed. One conclusion of the report was that the experiment site was a natural potato seed area and the seed management technology of the participating farmers kept their seed in good condition. It was concluded that the health of the farmer's common seed was equal to that of INIAP seed.

The conclusion that seed health in the official program was a problem provoked a major reorientation in the Potato Program's view of seed production. INIAP officials looked critically at their own seed production scheme, and decided to improve the seed quality via several changes including the introduction of a rapid multiplication scheme for producing pre-basic seed. Over the next several years a series of institutional changes resulted, with the seed production activities of the Potato Program being reassigned to the Seed Production Department in a special Potato Seed Production Unit (INIAP, 1982). Thus the Potato Program and the Seed Potato Unit exist as distinct institutional entities with their own budgets, facilities, leaders and policies. Administrative coordination between these two groups is handled by the station director. Being in the Seed Production Department, the Potato Seed Unit should primarily function as a production unit. In recent years however it has also conducted research.

Germplasm Maintenance

Ecuador possesses a sizable collection of germplasm and has drawn from this for its breeding program. This collection is maintained by the Potato Program. The varieties in current use by the Potato Seed Unit are also maintained in seed unit facilities. The general objective of maintenance is to retain the varietal purity and health of the plant to keep it available for breeding or seed production purposes. Thus the germplasm collection should be planted in a secure field with favorable agroecological conditions, and managed and protected so as to produce a healthy crop. It is assumed that the Ecuadorian collection is infected with a variety of viruses and other diseases. In recent years damage due to infestations of *gusano blanco* have been severe. Due to disease and lack of proper storage facilities, some accessions have been lost. Given the relatively high risks involved in maintaining the collection in the field, the Potato Program is gradually shifting more and more of the collection to in vitro

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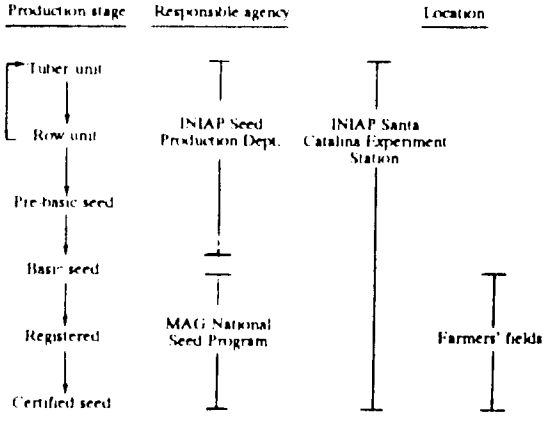
maintenance in cooperation with the Seed Potato Unit (INIAP, 1987).

Several varieties used in seed production have been sent to CIP for cleaning and then returned. Before the introduction of in vitro methods these varieties were rapidly reinfected. In vitro methods for germplasm storage were introduced in 1982. The technician managing the unit was trained at CIP and a laboratory was constructed.

Conventional Multiplication

The initial seed multiplication method used at INIAP was the tuber and row unit technique which starts with an elite tuber which is cut into segments which are seeded as tuber units (Figure 10). The elite tuber is a key element in this process. Drawn from the germplasm maintenance collection, it should be a healthy, disease-free tuber from the varieties being released to farmers. The resulting production is maintained separately and reseeded in a row unit. Carefully selected tubers from the tuber unit production are reserved and utilized as new elite seed.

Figure 10. Conventional seed potato production scheme, Ecuador



Source: Adapted from Muñoz 1984

In each stage intensive rouging --removal of off-type or diseased plants - is carried out. The harvested row units are then grouped and designated pre-basic seed. The pre-basic seed is grouped by variety without regard to row units, and stored for later multiplications (Estrella, 1987). The classes of seed from the sequence of multiplications of pre-basic, basic, registered and certified seed, are either sold to seed multipliers, or multiplied in limited quantities on the seed farm.

The Seed Potato Unit continues to produce by means of clonal selection as well as with the rapid multiplication process. There are no systematic records of production from tuber or row units. As more varieties are pathogen-tested as clean from diseases, and enter the rapid multiplication scheme, the conventional scheme is being slowly phased out.

As noted above, during the course of the decade, the quality of the INIAP seed became suspect, and with the on-farm yield comparison trials those suspicions were confirmed. Estrella (1986) describes some problems experienced by the Ecuadorian program while using the conventional seed multiplication system:

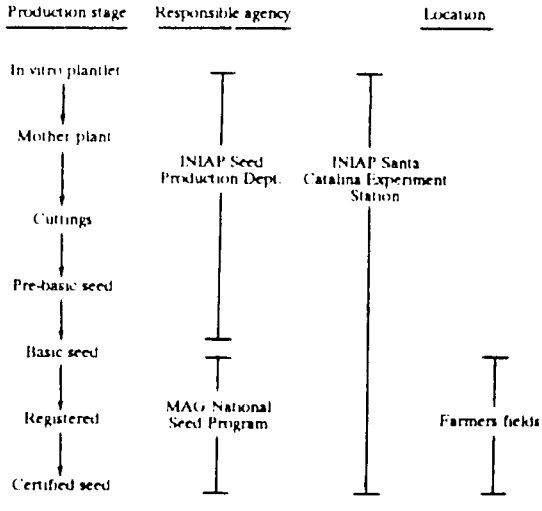
- Visual detection of disease symptoms did not give sufficiently reliable results. The excellent growing conditions at the seed farm resulted in healthy vegetative growth that tended to mask symptom expression.
- The technical knowledge needed for rouging, required qualifications not normally found in field staff. Rouging is a long and tedious process, particularly so when there is a high percentage of diseased plants.
- The health status of the elite tubers was questionable. Thus the key element for maintaining health standards was suspect.
- The excessive number of multiplication cycles created a slow and costly process that resulted in seed of insufficient quantity and quality to meet the program objectives improving potato production in the country.

Rapid Multiplication

Armed with the evidence of the yield comparison trials and of the problems noted above, the potato program began changing its seed-production scheme so as to base it on rapid multiplication. The development of this new scheme has been accomplished by an agenda of training and research that has enabled the

program to have individuals who, through their own research, adjust the basic rapid multiplication methodology to local conditions. This has been accomplished to such a degree that the rapid multiplication scheme in use has been dubbed the "INIAP model" (Naranjo and Estrella, 1987).

Figure 11. Rapid multiplication seed potato scheme used in Ecuador since 1984



Source: Adapted from Muñoz, 1984

The scheme maintains disease-free varieties in vitro from which cuttings are taken for micropropagation (Figure 10). The plants are developed initially in vitro and at the appropriate stage of development are transplanted to pots as "mother plants." The mother plants are maintained in a greenhouse. Cuttings taken from the mother plants are rooted in greenhouse beds. When roots are developed, the "rooted cuttings" are transplanted to the fields and the resulting tuber production is called pre-basic seed. The remaining steps consist of clonal field multiplications which are similar to the traditional multiplication schemes (Muñoz, 1984).

The distinguishing characteristics of the INIAP model are the use of smaller-than-recommended size pots with high fertilization rates. This practice, combined with cuttings from top and side shoots, produces 200-250 cuttings per mother plant instead of the usual 60-80 cuttings obtainable from the stem cutting method. The result is 2,000 tubers produced per mother plant every eight months instead of 600 every six months. This level of productivity per mother plant results in more than 3,000 cuttings per square meter of greenhouse space --an important saving since greenhouse space is limited. The basic advantageous features of rapid multiplication --the increased multiplication rate (1:200-300 instead of 1:10) in the crucial initial multiplications, the reduced number of multiplication cycles and improved health status of the resulting production-- are well documented (Bryan et al., 1983).

In 1978-79, INIAP sent the varieties Gabriela, Esperanza and María to CIP for virus eradication by thermotherapy and meristem culture. In 1980, the varieties were returned in vitro (Estrella, 1987). During that time INIAP had established the facilities for receiving this material. Included was a laboratory for maintaining the plants in vitro, and for the tissue culture operations and a greenhouse.

The tissue culture laboratory has the support of the laboratory facilities of the Department of Pathology where virus testing is possible. Currently the virus laboratory has the capacity to do virus testing via ELISA methods supplementing the latex and microprecipitation procedures previously used (INIAP, 1984). The virus laboratory is a vital element in the quality monitoring process which in the initial year of testing showed a virus level of 4% among cuttings examined. The laboratory spends approximately 10% of its time in routine testing of potatoes.

Micropropagation of Plants and Cuttings Production

With the first establishment of mother plants in September, 1983, there has been a rapid growth in production capacity. Both the volume of plants created and the number of varieties handled has expanded since 1983 (Table 7). The choice of initial varieties was based on the availability of virus-free material, with the three relatively newer INIAP varieties being the ones available. Later Catalina, Cecilia and Chola were added. The inclusion of Chola and Cecilia represents a significant policy decision since they

are not official varieties. Note that not all the plants produced become mother plants. For 1986 and 1987, the only years for which data are available, there were respectively 669 and 800 mother plants established. In 1986 the micropropagation production of Gabriela and Esperanza was expanded to accommodate research activities.

Table 7. Micropropagation from in vitro material. Potato Seed Unit, Seed Production Department, Santa Catalina Station, Ecuador (No. of plants)

Varieties	1984	1985	1986	1987	1988
Gabriela	250	750	2,152	400	200
Esperanza	200	500	2,000	220	550
Maria	120	300	430	500	600
CIP accessions[1]	-	300	75	200	-
Chola	-	-	100	110	100
Catalina	-	-	80	450	350
Cecilia	-			200	
Totals	650	1,800	4837	2,000	1,900

Source: Annual Reports, Seed Production Department 1984-88
Note: 1 Clones provided by CIP for breeding purposes

There have been no reported serious technical problems in the in vitro laboratory. As its duties have grown, the laboratory has added space and equipment. Starting with a rustic cutting chamber and basic sterilization equipment the laboratory now possesses more modern equipment capable of supporting the increased production demands.

In November, 1983, 4,000 rooted cuttings were transplanted to the fields for seed production purposes (Table 8). The average survival rate of transplanted cuttings is consistently above 90%. The laboratory and greenhouse work illustrated in the tables shows how quickly a rapid multiplication scheme can be put into place and expand production capacity. With a few trained workers, a basic laboratory, and greenhouse space, large volumes of planting material can be produced. However, this change is beneficial only if the productive capacity of the clonal multiplication stages can handle the increased output from the initial multiplication.

Pre-basic Seed Production and Storage

After the laboratory and greenhouse steps, the result is still to grow pre-basic seed in the field. At this stage the Potato Seed Unit faces familiar constraints such as the vagaries of climate and the lack of manpower to perform timely field management. The impact on production of the loss of environmental control is captured in the data in Table 9. The laboratory and greenhouse production illustrated in the previous tables shows steady gains in production, yet the pre-basic seed production shows considerably more variation in growth. Examination of the Seed Production Department's annual reports reveals the usual problems of water, weeds, pests and disease affecting production. There are no irrigated fields in the station. If, after the cuttings have been transplanted there is no rain, losses can be substantial. One method of avoiding the danger of losing the drought-sensitive cuttings is to retain them in greenhouse beds at high density until small mini tubers have been produced. Though they usually weigh less than 20 grams, these mini tubers have greater drought tolerance than seedlings and, therefore, in case of drought, losses are reduced.

Table 8. Cuttings production. Potato Seed Unit, Seed Production Department, Santa Catalina Station, Ecuador (No. of cuttings)

Varieties	1984	1985	1986	1987	1988
Gabriela	17,000	40,139	33,128	22,022	8,000
Esperanza	13,000	25,550	20,636	25,630	25,000
Maria	10,000	5,375	6,983	22,000	15,000
Catalina	-	-	740	14,400	10,000
Chola	-		1,190	10,000	8,000
Cecilia					1,200
Totals	40,000	71,364	62,667	94,112	67,200

Source: Annual Reports, Seed Production Department 1984-88

After the pre-basic seed is harvested, the seed is stored in a warehouse on the seed farm. There is no specific potato seed storage building. There was a project to build a 75-ton diffused light store (INIAP, 1986) but after the roof was constructed in 1985-86 funds ran out and the unfinished buildings have stood for more than a year awaiting completion. A portion of the stores will be completed in 1988. Though there

are no exact measurements, the storage losses from the warehouse are reported to be undesirably high as storehouse temperatures can exceed outside temperatures and; in this situation, rotting and premature sprouting are hastened.

Table 9. Pre-basic seed production from cuttings. Potato Seed Unit, Seed Production Department, Santa Catalina Station, Ecuador, (metric tons)

Varieties	1984	1985	1986	1987	1988
Gabriela	-	7.0	2.0	2.0	4.2
Esperanza	-	5.5	1.7	3.25	5.7
Maria	-	1.5	1.3	3.0	3.4
Catalina	-	-	-	1.2	4.2
Chola	-	-	-	.75	5.7
Totals	2.0*	14.0	5.0	10.2	23.2

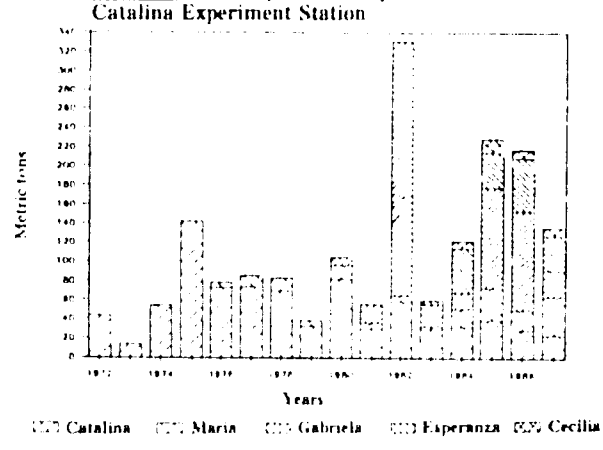
Source: Annual Reports, Seed Production Department, 1984-88.
Note: Production by variety not reported

INIAP Seed Production

Records of INIAP seed production show increasing but irregular growth (Figure 12, data in Table A3). Only Catalina was produced in the early years and the other varieties were added as they were registered. There have been significant differences between planned and actual production. The planned area has varied according to seed supplies, budget and the influence of special programs ranging from a low of 11 ha in 1982 to a high of 63 ha in 1987 (INIAP Seed Department Annual Reports). The original seed production manager left the program in early 1976, and since the clonal multiplication system requires vigilant management, the subsequent lack of management affected production: this was noted by several observers and proved by the decline in production after 1975.

Even when the newer rapid multiplication techniques are used, once the clonal multiplication cycle is begun, the later generations of basic, registered, and certified seed in the experiment station fields all of which are rainfed, are subject to the same problems faced by farmers seed. The INIAP Seed Department's annual reports tell of attacks of late blight, *gusano blanco*, drought, and choking by weeds, all of which cause the quality and quantity of seed to be diminished (INIAP Seed Department Annual Reports, 1982-87). The drought affected poor production years of 1979 and 1983 are also reflected in the on-station seed production. Once production shifts from the laboratory and greenhouse out into the fields there are severe budgetary restrictions which limit the numbers of field workers and machinery available to manage the crop. The fact that a seed crop be overcome with weeds is ample evidence of the shortcomings of the budget.

Figure 12. INIAP potato seed production. Santa Catalina Experiment Station



Source: Muñoz, 1984
INIAP, Seed Unit, Annual Reports 1963-87
Note: Totals for all grades of seed

Seed Production Research

In 1983 PRACIPA was created. A basic philosophy of the research network is the division of research responsibilities on common problems among its members. Ecuador is the lead country for research on rapid multiplication. The justification for the selection of Ecuador as the lead country in this subject was based on two criteria: a series of recognized constraints and existing work in the area. The constraints were listed as: lack of efficient transfer of technology to the growers, deficient marketing, lack of an efficient clean seed multiplication program and, finally, physical constraints for research (PRACIPA, 1983). It is beyond the responsibilities of INIAP to address the first two of these constraints. PRACIPA initiated a project with

INIAP which, through training and research, supported the already existing rapid multiplication scheme.

Thus in addition to production activities, the Potato Seed Unit has a PRACIPA-funded research and outreach program. The general objective of that research program is to "establish a viable fast system of seed production from virus-free tubers of native and improved varieties" (PRACIPA, 1983). The "INIAP model" of rapid multiplication is one result of the research program. Research projects include evaluating different laboratory methods for virus eradication, evaluating different rapid propagation techniques, and evaluation of planting distances for cuttings. Other research includes new yield comparison trials for different categories of official seed with farmers' seed, and an economic evaluation of different rapid multiplication systems (PRACIPA, 1986; Moreno, 1988; Pumisacho, 1988). A portion of the research program has been carried out as thesis investigations. These projects are planned and designed to assist the program to become technically self-sufficient in several seed production and quality control areas.

In 1987, PRACIPA began supporting social science research. In Ecuador this enabled a project to study seed potato marketing. Some of the preliminary results of this project are discussed in the next section.

6. Building Seed Supplies

The certified seed production steps after basic seed has been produced involve both INIAP and the Division of Seeds in MAG. The technology of steps beyond pre-basic seed production still require field multiplication and the accompanying management and storage. Expanding seed supplies to volumes needed to supply a reasonable percentage of the seed requirements necessitates a considerable area. There are several strategies to address this problem. One strategy which results in assured supplies of seed produced under strict control is to use government or parastatal corporate farms. For potatoes this requires a considerable investment in land and storage. Government farms are not usually found in optimal locations for seed production. It can also be a risky investment if the crop is damaged by the weather, pests or disease. Investment in or coordination with a seed distribution network is also required.

A second alternative is to contract seed growers to produce the seed crop. This requires less direct investment by the government and shifts some of the risk to the growers, but it also results in relatively less control of the produced seed. There is a wide range of contractual arrangements available that require more or less supervision or government control or investment. The options range from an active scheme of tightly contracted arrangements with government supply of inputs and control of production, to a passive scheme that sells seed to the multipliers and relies on their voluntary compliance for production and distribution. Thus there is a wide range of possibilities of government investment and involvement in further production and distribution.

A third choice is to sell or distribute small quantities of seed to a large number of growers, relying on the farmers' multiplication and distribution via existing informal seed flows. While this eliminates the possibility of certification or further testing, it is also the least costly option.

The first option is beyond the resources of INIAP or MAG. The third option is not considered under the current seed law. Variations of the second option are employed. The INIAP and MAG arrangements for the multiplication of botanical seed of crops such as maize, wheat, rice and barley are handled by private and mixed enterprise companies. These companies buy the basic seed produced by INIAP and are in charge of the production, processing and distribution of certified seed (Flores, 1984). The most important of these, EMsemillas, a mixed enterprise company, has declined to produce certified potato seed citing the special problems of bulkiness, slow multiplication, and perishability. Thus for certified potato seed production, MAG relies on farmer multipliers.

Seed Potato Multiplication in MAG

Two units in MAG have explicit business in the handling and multiplication of potato seed, the Technical Directorate of Roots and Tubers and the Seed Certification Service which is part of the National Seed Program (PNS). The Seed Certification Service coordinates the production of certified seed while the Technical Directorate is the coordinator of promotion and extension activities. These activities have included various attempts to establish seed producer associations and working with special projects that have necessitated coordination with INIAP in seed multiplication. There is not a clear distinction between these agencies in their methods of distribution of certified seed.

The market for seed potatoes is being investigated by Reinoso (1988). The initial round of field work for this survey took place in the central zone and contacted three groups of farmers: (1) farmers who were seed multipliers for INIAP or MAG within the last several years, (2) farmers who at sometime in the last four years used certified seed, and (3) farmers who never used certified seed. The latter two groups were selected randomly. The information gives a farmer perspective on different elements of

the seed system including the certification scheme. Some of the relevant points are introduced below.

The Planned System

The certification of all seeds is, according to the Seed Law, the responsibility of the NSP, and the actual work of certification is performed by the Seed Division of MAG (Flores, 1984) which maintains, for this purpose, seed multiplication programs and a staff of seed inspectors. The Seed Division inspects and certifies seed produced on INIAP stations and in farmers' fields. There is also promotion of certified seed done in cooperation with the National Farmer Training Institute (INCCA). For potatoes this mainly consists of pamphlets defining and describing the process of seed certification (MAG, 1987).

This data includes production from the INIAP Santa Catalina farm and from farmer multipliers contracted by the Seed Certification Service.

The usual multiplication scheme for seed potatoes calls for the field-based seed inspectors to contact proficient farmers in a representative sample of regions to act as multipliers. The farmers contacted are usually personally acquainted with the seed service inspectors. The seed service then arranges for seed requests to be made by the farmers and presents these requests to INIAP. Registration requirements include demonstrated expertise in seed production and the identification of the field intended for planting. The field must be certified free of nematodes, and its size and location recorded. The farmer must notify the Seed Division of planting and inspection dates. The harvest dates and production must also be supplied (interview notes).

In the central zone the distribution scheme is to select key farmers to act as regional distribution agents. This first level of farmers receives basic seed for multiplication, keeps some of the production and sells the remainder of that registered seed to other selected farmers who in turn keep and distribute the resulting certified seed. This scheme creates regional seed multiplication centers. Given a seed renovation rate of 3-4 years, the initial selected level of farmers will need new seed from INIAP only in those intervals. The impetus for the design of this system came from an individual who had attended several CIP-sponsored courses on seed production and distribution.

Official prices. The Seed Law provides that the National Seed Council (CNS) establish seed prices based on percentage margins over production costs. INIAP meets with the Price Setting Commission each season to establish the base for determining the prices it changes for seed.

The average price of consumer potatoes entering the wholesale market is used to determine the prices of seed potatoes as following:

x = average consumer potato price
x + 10% = selected seed
x + 20% = certified seed
x + 30% = registered seed
x + 40% = basic seed

These are also the prices at which the government will offer to buy seed. The government has rarely purchased seed potatoes from farmer multipliers. The farmers are free to sell their seed and fix their own prices.

Seed Certification Standards. The Seed Law was formulated in 1967. A 1976 Interamerican Development Bank loan instigated the formation of PNS and influenced a revision of potato seed certification regulations in 1978. Modeled on North American and European examples, certification standards were set unrealistically high for local conditions or requirements (Coronel, 1984). The changes in certification standards for field and tuber inspections are presented in Table 10. These are drawn from references citing the original standards (Coronel, 1975), the standards as revised during the creation of the new seed certification department (Murillo, 1978) and, finally, standards currently in effect (Coronel, 1984). The revisions document a gradual easing of standards as the needs and requirements of potato seed certification for Ecuadorian conditions have become better understood. The tolerances for virus content in particular have become more realistic, the total allowable virus content was first set too strictly, then relaxed too much and finally readjusted to higher standards.

Table 10. Changes in potato seed certification standards in Ecuador

	Basic seed						Registered seed						Certified seed					
	Inspection						Inspection						Inspection					
	1984	First 1978	1975	1984	Second 1978	1975	1984	First 1978	1975	1984	Second 1978	1975	1984	First 1978	1975	1984	Second 1978	1975
Mosaics PVX, PVS	8	8	8	2	2	2	10	10	10	4	4	3	12	12	12	5	5	4
Potato virus Y PVY	1	3	2	0	1	1	1.5	4	3	.5	2	1	2	6	4	1	3	2
Potato leafroll virus PLRV	2	5	2	1	2	1	4	6	4	2	3	2	5	10	5	2	4	2
Mosaic PVM	8	8	2	2	2	0	10	10	3	4	4	1	12	12	4	5	5	2
Yellow stunt			2			1			4			2			5			2
Calico y Aucuba diseases			2			1			4			2			6			3
Other viruses	3	3		1	1		5	5		2	2		8	8		3	3	
Total virus acceptable	8	10	8	2	3	2	12	18	12	4	6	3	18	20	15	8	10	5
Bacterial wilt (*Pseudomonas solanacearum*)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black leg (*Erwinia spp.*)	1	1	2	0	0	1	2	4	4	1	2	2	4	6	6	2	3	3
Stem canker (*Rhizoctonia solani*)	8	8	4	4	4	1	12	12	8	6	6	3	14	14	10	7	7	5
Black rot (*Roselina sp.*)	.02	.25	1	0	0	0	.02	3	3	0	3	0	.05	5	5	.02	.02	0
Nematodes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Early blight (*Alternaria solani*)			5			10			10			15			20			25
Roya (*Puccinia pitteriana*)			5			10			10			15			15			20
Varietal purity	.25	.25	0	0	0	0	.5	.5	1	.01	0	0	1	1	2	.1	.01	0

	1984	1978	1975	1984	1978	1975	1984	1978	1975
Laboratory									
Late blight (*Phytophthora infestans*)	.5	.5	1	1	1	2	1.5	1.5	4
Powdery scab (*Spongospora subterranea*)	1	1	3	2	2	5	3	3	7
Stem canker (*Rhizoctonia solani*)	5	4	2	8	6	4	10	8	6
Black rot (*Roselina sp.*)	0	0	1	0	.3	3	.05	1	5
Gangrene (*Tecaphora solani*)	0		1	0		2	.05		3
Common scab (*Streptomyceps scabies*)	1	1		2	2		3	3	
Black leg (*Erwinia spp.*)	.05	.5		.1	.1		.2	.2	
Bacterial wilt (*Pseudomonas solanacearum*)	0	0	0	0	0	0	0	0	0
Andean weevil (*Premnotypes vorax*)	.1	.2	0	.2	.5	0	.5	.1	0
Nematodes	0	0		0	0		0	0	
Dry rot (*Fusarium sp.*)			0			1			3

Sources: Coronel (1975, 1984); Murillo (1978).

Other categories show similar adjustments to standards set too strictly, and then relaxed too much, while others show a steady relaxation of standards. Some categories have been included and others dropped, and their importance has grown or declined. In the recent seed multipliers survey, however, farmer seed multipliers expressed the opinion that the standards still do not reflect actual conditions (Reinoso, 1988).

Some Constraints

A limited supply of basic seed, a failure of inspection, and a failure of the farmers to keep or sell the inspected and certified production as seed can disrupt the system of multiplication and pricing.

Restricted supply. In the recent survey of seed multipliers (Reinoso, 1988), most multipliers could not buy all the seed they wanted nor the varieties desired. As illustrated in Figure 12, INIAP seed production has been small and irregular. This is due in part to the serious budgetary, infrastructural and physical limitations on the farm's capacity. Additionally, during a reorganization of the seed service when the usual MAG-farmer contacts were not available, farmers learned to contact INIAP directly to obtain seed. Though the formal process is to obtain request certificates from MAG, often that is done after the seed has already promised and in some cases delivered. While it is legal for INIAP to sell seed directly to producers (Flores, 1984), this process has the effect of disrupting MAG Seed Division plans for multiplication based on expected supplies.

Crop inspection. Inadequate inspection is another point where the certification scheme can break down. When market prices are good, informants in the seed service reported that farmers dispense with the idea of inspection and sell everything to the table potato market. On the other side, as reported in the seed multipliers survey, farmers noted that occasionally the inspectors did not show up for scheduled inspection visits. There are currently eight potato seed inspectors for the *sierra* of Ecuador. Some of them, in the past have not been highly qualified in seed potato inspection or highly

motivated to inspect the fields rigorously. Since selected seed multipliers are usually in the preferential areas, the growing conditions are good, producing a strong vegetative plant that masks the normal disease symptoms, making the job of inspection difficult.

Another limitation on proper inspection is the personal relationship between the inspectors and the multipliers which may make the inspectors reluctant to downgrade the crop to a lower level.

Thus several reasons influence whether a field is certified. Not all of them are related to the health of the crop. Table 11 show the percentage of fields that were planted with INIAP-produced seed for multiplication that were actually certified. Also shown in the table is the production of seed and a calculation of seed yield per hectare. Assuming that yields of seed-sized tubers are approximately 40% of total yield, the farmer multipliers have been achieving an average yield that is almost twice the national average.

Table 11. Official seed area planted, certified and percentage approved and estimated seed production and yield. Ecuador, 1982-87

Year	Area seeded (has)	Area certified (has)	% seeded area certified	Production of seed (t)[1]	Yield of seed (t/ha)
1982	76.5	50.3	65.8	348.0	6.9
1983	55.5	47.4	85.5	312.0	6.6
1984	169.2	138.2	81.6	846.0	6.1
1985	241.3	175.2	72.6	1,098.0	6.3
1986	341.2	233.4	68.4	1,419.0	6.1
1987	207.0	148.4	71.7	584.0	3.9

Source: MAG Seed Certification Department, PNS. Calculated from Table A4.

Note: 1. Includes production of pre-basic seed.

The farmer seed multipliers. The most serious constraint on the smooth functioning of the regional seed distribution system, widely recognized by officials, is the failure of the selected farmer multipliers to hold and pass on seed to the other farmers in the chain. The problem may be more accurately described as a conflict between differing objectives reinforced by a poorly defined and enforced contract. The farmer multipliers come almost exclusively from the central zone (INIAP Seed Department Annual Reports, 1984-85) and 15 were interviewed in the Reinoso survey. The farmer multipliers interviewed are large farmers. The above-average yields they report are evidence of favorable field locations, liberal use of inputs, and the management ability brought to the production. They multiply one to two lots of seed purchased from INIAP of between one and two hectares each. While preferring Esperanza, the multipliers grow the seed that they can get. The farmers noted that they could not get all the seed they desired. The principal objective in multiplying seed is to use it for self supply, and seed for sale is only a secondary objective. These intentions were matched with their actual disposal practices, all the multipliers kept some portion of the multiplied seed, some keeping all, and others keeping a portion and selling the remainder as seed. The remainder sold averaged 20% of production. The little that is sold as seed is sold via personal contacts. These intentions and practices vary sharply from those desired by MAG officials.

The usual scenario described by officials is for farmers to decide to conform to the certification agreement only if market prices favor such an action. If market prices are above the established buying price of the government then the farmer sells his production to the consumer market. Any certified production that remains as seed is purely accidental. If the market price is below the government's buying price then the farmer multipliers seek out the Seed Division representatives to certify their crop, thus obtaining an additional quality to promote when selling their crop. Given the historically cyclical nature of potato prices, either condition could prevail during a given harvest.

Estimating the Area with Certified Seed

When the decision of the farmers is analyzed, the question is raised of how much area is actually planted with certified seed. There are various estimates of coverage, Table 12 shows one of these with annual estimates of area potentially planted with certified seed. The estimated area remained very low with the exception of the drought years of 1979 and 1983 which reduced total potato area. Then, in the last few years, with the expansion of seed

production, the coverage expanded several fold to over 2%.

Table 12. Estimated hectares planted with certified potato seed. Ecuador, 1972-87

Year	Total potato area	Potential area in certified seed	Percentage coverage
1972	37,729	50.6	0.1
1973	43,576	100.3	0.2
1974	39,138	135.6	0.4
1975	39,499	158.5	0.4
1976	41,223	212.6	0.5
1977	36,000	139.8	0.4
1978	29,843	168.8	0.6
1979	26,894	269.5	1.0
1980	30,380	179.0	0.6
1981	31,602	187.4	0.5
1982	35,101	212.2	0.6
1983	26,743	220.7	0.8
1984	33,489	597.7	1.8
1985	36,382	758.8	2.1
1986	38,930	1,013.7	2.6
1987	40,000	389.5	1.0

Sources: Coronel, 1984 for 1972-83 data. Seed Certification Dept. MAG, 1988 for 1984-87 data
Notes: Seed rate is calculated at 1.5 t/ha.

The estimates in Table 12 are based on the assumption that all the certified seed produced as recorded by the seed service is actually used as seed. As the above discussion illustrates that is a dubious assumption. First, a small but significant portion of INIAP seed is sent to different programs or departments for research purposes. Some seed sold directly to farmers by INIAP does not enter MAG records. Reinoso (1988) shows that farmer seed multipliers rarely sell the seed they have multiplied and concluded that more than 80% of the production of seed is retained by the farmer multipliers. The seed multipliers are usually large farmers who sell almost exclusively to wholesalers; thus it can be assumed that the 20% of seed-sized tubers not kept by the multipliers is sold to the consumer market. As there are no specialist seed wholesalers, there are very few beneficiaries, apart from the farmer multipliers, of the seed certified by MAG.

Some Additional Experiences in Potato Seed Multiplication and Storage

In addition to the work done by INIAP and MAG in the areas of generation and transfer of potato technology, the Subsecretariat of Integrated Rural Development of the Ministry of Social Welfare (MBS) has promoted the production and distribution of seed of new potato varieties, by means of integrated rural development projects in the *sierra*, usually in close coordination with MAG and INIAP.

Some private entities have also implemented potato seed multiplication activities in selected areas of the Ecuadorian *sierra*. Notably among them are the Agriculture Service Center of Ecuador (Central Ecuatoriana de Servicios Agrícolas), the Saint Luke Gospel Mission, and Save the Children/Ecuador (Desarrollo Juvenil Comunitario).

As illustrations of these efforts, different cases in the Provinces of Chimborazo and Cotopaxi are briefly described below (data are based on the authors' interviews and Bebbington's unpublished reports).

In the southern part of Chimborazo Province, since about 1984, the Guamote Integrated Rural Development (DRI), has been promoting Gabriela and Esperanza potato varieties with a project for a seed multiplication scheme. Working primarily with Indian communities such as the groups known as "Sablogs" and "Chacazas"; the Guamote DRI, during the first year of contact, supplies all external inputs (potato seed, fertilizer and pesticides), and the communities provide land and labor. The amount of fertilizer and pesticides is usually determined by the variety-specific recommendations established by INIAP. The potato seed is given as a loan, to be repaid at harvest in kind, at double the initial amount. Other inputs are given free of charge.

The DRI then uses the returned seed to work with the same community or to develop similar schemes with other communities.

The rest of potato seed harvested by the community can either be multiplied communally again, or loaned to member families to be multiplied for their own use. The usual amount at this stage is 2-3 quintals per household. Each family in turn receives some pesticides free of charge on condition that they provide the fertilizers. Again, at harvest, each family is to pay back the seed credit in kind, at double the initial amount. The rest of potato production is freely used by each family either for seed, sale or home consumption. The Guamote DRI

estimates that, by 1988, communities participating in the potato seed multiplication program had about 50 ha of improved potato varieties under production for seed.

In the Colta area of Chimborazo Province, the Saint Luke Gospel Mission, had helped Indian communities to organize a producers association and to utilize modern potato technology generated by INIAP. For several years now, the Saint Luke Producers' Association has been selecting and multiplying seed of improved potato varieties (particularly Gabriela, Maria and Esperanza) and then distributing it to interested Indian farmers as part of an active agricultural extension effort. Support for buying seed, fertilizers and pesticides has come first from the Saint Luke Mission, then from World Watch, another mission group, and in small amounts from other sources.

The producers association also does sharecropping activities with farmers in order to raise fund and transfer technology to its members. The organization supplies seed and agrochemicals while farmers provide land and labor. Another related unique experience of the Saint Luke Producer's Association is the implementation of a potato seed storage system based on diffused light. Although by 1986 it had built over 120 of such storage facilities, at the present only about 60 exist and their use is limited.

In the Salcedo area of Cotopaxi Province, in cooperation with the Salcedo DRI and the Casa Campesina (an association of Indian communal organizations), from 1982 to 1985, Save the Children carried out a community development project which included agricultural production, health and nutrition, and education activities. Work on agricultural production centered around potato as the main crop in the farming system. Initially, the project acquired improved potato seed, particularly Gabriela from INIAP and multiplied it in community fields. Improved seed and agrochemicals were supplied on credit by Save the Children; at harvest, farmers returned 50% of total production to the Casa Campesina. From this, the project agronomist and community agricultural promoters selected the potato seed (about 25%) for next planting, the rest is sold on the market and the returns are used to increase the Casas Campesina's capital, so that in the future it will be able to provide technical assistance and inputs to its members. In the process, local Indian farmers were trained in the new technology by a project agronomist. During the first year of seed multiplication, 200 quintals (enough for 10 ha) of potato seed were produced by 1983, there were 1,000 quintals (50 ha) and estimates are that the level of seed production has been maintained to the present. To store the seed, with project support, the Salcedo *campesinos* also built several large storehouses or *silos verdeadores*, most of which are still in use.

7. Issues

Historically, the informal seed potato system that has evolved from centuries of potato cultivation has succeeded in meeting the needs of potato producers. The agroecological characteristics of the potato producing zones, the numerous available varieties, and the traditional market system have all contributed to creating a system capable of meeting the needs of producers. However this effectiveness, based on measures traditional needs, is being eroded due to changes in modern potato production and seed technology.

This section examines some fundamental characteristics of the potato system and the effectiveness of the informal seed system as new technologies are incorporated. Though relatively young and still evolving, the official seed system has made strides in establishing a framework on which to build, and policies to assist that process. The existence and current status of the various elements of the official system are summarized and compared with the elements considered essential to a well functioning seed system as illustrated in Figure 1 above. Finally, limitations of this study are discussed.

The Informal Seed System

Climate, Varieties and Markets

Three important factors of physical, genetic, and institutional origin have profoundly influenced the structure and functioning of the informal seed system. Most potato production in Ecuador takes place in a fairly narrow altitude band that, due to temperatures and rainfall, is also a good potato seed production area. There are no significant low altitude potato production areas. Potato officials have identified two major planting seasons, but in many areas there is year round planting with the accompanying range of harvest dates. The moderate climate also makes traditional storage of tubers feasible with tolerable losses. In sum, the climate in the production zones of the country is similar to that which potato programs in climatically less well endowed countries specifically seek out for the placing of potato seed farms.

Small farmers utilize many potato varieties, often in the same field. Both *tuberosum* hybrids and *andigena* varieties are widely distributed. The *andigena* are, of course, well adapted due to centuries-long selection processes. The *andigena* varieties display a wide range of dormancy and storability characteristics in addition to field resistances to various types of diseases and pests. The benefits to farmers of planting many different varieties as a risk reduction strategy are well documented.

The Ecuadorian market system has also influenced the structure of the informal seed system. The most basic feature of the Ecuadorian market system is the network of periodic markets diffused through the country. Complementing this is the allied network of market intermediaries that serve as brokers among these markets, assembling and delivering all types of consumer and producer goods and disseminating market information.

Characteristics

With these three fundamental factors -- favorable climate, numerous varieties and well developed markets -- the Ecuadorian potato farmer has developed a potato seed system with several distinctive characteristics. Most importantly, the informal system is one of self supply, each farmer produces his own seed. Numerous scientific inquiries (Figueroa et al., 1979; Llovet, 1980; Valderrama and Luzuriaga, 1980; Barsky, 1984; Simons and Ramos, 1985; Lopez, 1987; Reinoso, 1988) and countless informed observations have noted the degree of self supply. Some observers conclude that 80% of seed in a given season comes from the farmer's own production. The capacity of self supply of this magnitude rests on the favorable agroecological conditions and varieties that

are well adapted. Storageis practical and numerous varieties store well in the ambient conditions.

Obtaining the relatively small remaining percentage of seed from outsiders is accommodated by several factors. Planting and harvest can occur in most months of the year. Thus there are always at least some potatoes in the market. Market intermediaries move among the markets, buying and selling according to local demands and supplies. Though no market intermediaries are specialists in seed, they do perform sorting and grading and do have customers buying potatoes specifically for use as seed. The short dormancy of commonly used varieties also fits well into this system. A farmer can purchase freshly harvested tubers in the market, store them himself, and within weeks there will be sprouted tubers ready for planting. However, farmers often do not need to enter the village market to obtain seed since neighbors and family are also frequent sources.

Farmers use specific seed management practices. There is a fairly high level of virus infection and other pests and diseases in the seed circulating in the informal system. Farmers have strongly held beliefs about seed becoming "tired" and a system of rotation and renovation is followed. They are perceptive of the effect of seed quality on yields and do make conscious seed selections eliminating damaged, diseased, or off type tubers. They contend that seed from higher places, when planted in lower fields, often gives a boost to yields. Those relatively fewer farmers in marginal, usually lower, production areas, constrained by heat from feasible storage, turn to higher areas as a seed source. Seed selection is based on size and form during harvest. Seed storage is in traditional dark stores. Farmers recognize the different physiological stages of seed dormancy and the benefits of well-sprouted seed. However, despite efforts of introduction in the past, there are very few diffused light stores in use.

In summary, the combination of flexible planting and harvesting dates, a highly dispersed system of markets, the ability to store, and the numerous varieties available (each with different dormancy and storage characteristics) creates for the farmer an extremely flexible environment for producing, managing, and procuring seed. There has been no need for farmer seed-production specialists and none exist. Effectively, everyone who wants potato seed is able to produce it or get it in a market that functions fairly well in placing into contact those that have seed with those that want it.

The Impact of Modern Technologies

The informal system evolved long before modern agricultural technologies were developed. Thirty years ago, agrochemicals made an appearance, then twenty years ago, improved varieties began arriving, and finally ten years ago improved seed production technology made healthy seed a possibility. These technical changes alter the perspective from which the effectiveness of the traditional seed system is judged.

Agrochemicals

Chemical fertilizers and pesticides were introduced by the private sector (Barsky, 1984). The chemical inputs made an intensification of production possible. Potatoes became a high cost, high income crop with the associated benefits and risks to the producer. The chemicals also change the perspective by which seed quality is judged. The response of healthier seed to fertilizer is greater than that of unhealthy seed. Thus there is an additional value for good seed.

New Varieties

The arrival of modern potato varieties also changed the informal seed system. Catalina and the later *tuberosum* hybrid varieties coming from Ecuador and Colombia are capable of producing higher yields than native varieties. With more farmers relying on potatoes as an income source and with potatoes costing more to produce, there are incentives to plant the higher yielding modern varieties. Many native varieties have disappeared.

When new varieties outperform old varieties in criteria relevant to farmers, then it is appropriate that the individual farmer replace

the old with the new. No individual farmer has a need to maintain old varieties, yet with a cumulative loss of varieties the system becomes dependent on a narrower genetic base. The loss of diversity leaves the system more vulnerable to outbreaks of pests or disease that may equally affect the remaining varieties leaving the producers without reserves.

The preservation of genetic diversity within the Ecuadorian potato food system is an activity which would confer benefits on all users, but no one individual would benefit sufficiently from the extra costs of maintaining varieties. Thus, it is not surprising to see the loss of varieties in the informal system. However, by failing to preserve the diversity provided by the numerous varieties, the informal seed system lost some of its flexibility and risk reduction capability.

The release of new varieties also places a new focus on the distribution system. The mechanisms of obtaining new seed have traditionally emphasized very local circulation. With new varieties being released, the informal seed system has not adjusted to the need for more rapid, broad dispersal of varieties.

Modern Seed Technology

The official seed production program brought the concept of introducing seed scientifically managed to contain lower virus levels and infection from other diseases or pests. In Ecuador the most important indicator of technical success of scientific seed production is a reduced incidence of virus in the seed. The motivating philosophy behind this third source of technical change is that a seed program provides a seed tuber that is healthier than seed selected and managed by traditional methods. The healthier seed should therefore produce higher yields than farmer-produced seed if health is a constraining factor in yields. Thus, all else equal, a scientific seed program should fundamentally change the basis by which the technical efficiency of a traditional seed system is judged, rendering the less healthy farmers' seed technically inferior to scientifically produced seed. To date this has not been the case in Ecuador.

Research in 1978 (Reinoso, 1979) showed that there was no significant yield difference between farmers' and INIAP seed. This led to the major technical changes in INIAP potato seed production discussed above. As gauged by the indicator of reduced virus load of certified seed the changes were successful. Estimates of virus content of INIAP seed in the late 1970's were as high as 30% (Reinoso, 1979). Recent measurements show the virus content to be well within the certification standards (Moreno, 1988; Pumisacho, 1988). Moreno measured the performance of INIAP seed against farmers common seed of the same varieties. The farmers' common seed had high virus loads (32% potato virus X) compared to INIAP seed (5% PVX). Yet the results of the trials showed that variety and location were more important than seed source in explaining yield differences. Pumisacho also examined differences between INIAP and farmers' seed. Although a higher virus load was found in farmers' seed, variety and location were more important than seed source for explaining yield differences. These are similar to results reported by Reinoso 10 years earlier.

The marginal contribution that seed health makes toward yield determination in Ecuador may explain the relatively basic traditional seed-health-management practices employed by farmers. It may also explain why negative and positive selection has not been, nor will be, a widely adopted process. The additional costs of management may not result in benefits sufficient to cover the costs. Farmers may be acting rationally and efficiently with traditional seed selection and management technologies.

The principal assumption of the benefit of a seed program, improved seed health, has been thrown into doubt. Among the sources of technical change in potato production in Ecuador discussed in the previous section, seed production technology is apparently the least important.

In sum, the very localized seed distribution and the absence of effective management practices to improve seed health, are weaknesses in the informal seed system in light of recent technological changes. The locally focused seed distribution inhibits the rapid dispersal of varieties entering the system. The lack of a seed health improvement mechanism limits the response of varieties to the application of fertilizers.

Given these weaknesses, how has the official seed system moved to support these portions of the informal system? Given the limited resources for an official seed system, which areas should be targeted for support?

The National Program and the Seed Potato System

As introduced above, Figure 1 contains elements of a hypothetical potato seed system divided into general categories of quality control, seed production and supply, and support, services and promotion since the national program has been broadly defined to include all potato-related activities originating from the Potato Program, the Seed Potato Unit and the Seed Division, has addressed many of these elements. As shown in the previous chapters some portions of the system have been better established than others. This section reviews the activities of the national program within the structure depicted in Figure 1 and in light of the strengths and weaknesses of the informal seed system.

Quality Control

Adequate seed quality control is one of the fundamental requisites of certified seed production. In the area of quality control the various elements depicted in Figure 1 are fairly well established in Ecuador. A seed law has been revised to reflect local needs. The law makes a clear division of responsibilities among participating agencies. The process of submission of varieties and certification of seed is also clearly stated. The seed certification agency is probably understaffed given the stated objectives of the government. However, for the quantity of inspection currently required, the capacity of the seed certification agency is sufficient. The quality of inspection is sometimes suspect and enforcement is practically non-existent, especially among the farmer multipliers. The obligation of farmers to complete the agreement with MAG for certification is rarely honored and not punished if broken. A seed testing laboratory exists in Santa Catalina station that has the ability and capacity to do the necessary testing for certification or research support.

Seed Production and Supply

This sector encompasses a wide range of activities that are divided among several agencies. The first four elements of this column are the responsibility of the Potato Program of INIAP.

Germplasm. Plant introduction and exploration and the germplasm bank have been long-run activities and have addressed the weakness in the informal seed system in preserving germplasm. This portion of the official seed system has received support in recent years from special externally funded projects from IBPGR and CIP. The germplasm bank is also a strong part of the seed system. It has numerous entries from a broad genetic base, and is being supplemented by materials that have been discovered, developed, or imported. These activities are a valuable contribution of the official seed system in supplementing the informal preservation of germplasm by farmers. Maintaining germplasm is a practice with immediate costs and poorly defined benefits. These benefits may occur only at some distant time in the future and not all of them accrue to the farmer. Thus it is an appropriate activity for the official seed system to supplement the informal seed system in the preservation of germplasm.

Varieties. Historically cultivar release and development have been strong parts of the national program. As discussed above, technological changes carried in germplasm have had a large and lasting impact on the productivity of the potato sector. However, in recent years, activity in this sector has stalled and no new varieties have been issued since early in the decade. Given the importance of well adapted varieties with broad resistance, variety development and release should have a high priority. New varieties are, in some respects, replacing the native varieties as sources of genetic diversity. The Ecuadorian potato farmer has a demonstrated ability in screening and maintaining a large number of potato varieties. The seed system also is capable of absorbing new varieties in large numbers. The large number of varieties are necessary to fill the numerous ecological niches formerly occupied by native varieties no longer available. Thus an appropriate strategy may be for a more aggressive program in screening and breeding material and the release of varieties.

Pre-basic seed production. The next set of activities are the responsibility of the Seed Potato Unit of the Seed Production Department at Santa Catalina Experiment Station. There has been a successful shift in the technology of pre-basic seed production. This has been completed in a timely manner and appears to have improved the efficiency with which pre-basic seed is produced, both in terms of the health quality of seed and the quantity of seed produced with the available resources. The Seed Potato Unit's activities have been extensively supported by CIP and PRACIPA. External funds have provided a research budget, training and facilities for the unit. Storage problems on the Santa Catalina station, recognized for years, are about to be solved with the completion of diffused light stores with sufficient capacity to serve the needs of the Seed Potato Unit and the Potato Program. The Seed Potato Unit has expanded the number of varieties in production, including Chola, a still popular native variety. Given the marginal benefits that healthy seed brings to improving productivity, the Seed Potato Unit could concentrate on including a larger number of varieties and not on producing larger volumes of the present varieties.

Seed multiplication. MAG is responsible for the later stages of seed multiplication and distribution. However INIAP has had a minor role in distribution by selling various categories of seed produced on the farm directly to farmers. Generally, this portion of the official seed system is very weak. The government has a policy to promote the utilization of certified seed and promotes the production of it. The current multiplication and distribution scheme used by MAG nearly exclusively favors large farmers in the central region of the country. Given the structure of the informal seed market there is no contact with the small farm sector and only accidental contact with large farmers of other regions. Farmer multipliers generally do not have a clearly defined seed market and the government has not been able to provide any mechanism to support such a market.

Given the importance of variety and location in determining performance, one strategy to address this weakness is to abandon the costly and unwieldy process of certifying seed that does not get circulated and, instead, concentrate efforts on strategic dissemination of seed produced by INIAP.

Seed distribution. The lower activities of the column move out of the official seed system and fall into the informal system. In Ecuador there are no specialist seed wholesalers or distributors or retailers. The seed system has not required specialists in these activities. The attempts of the official seed system to influence activities in these sectors have been ineffective. To enter into these activities would call for a large commitment of capital and a great deal of planning and flexibility. The official sector has a comparative advantage only in the planning. Thus one option would be to produce only smaller volumes of seed and plan very carefully when, where, and to whom the seed is distributed.

Services, Support and Promotion

The support given to any seed system by accurate statistics and data is invaluable for planning, monitoring and evaluation. The reliability of data on production, area, and yield is questionable. The data kept by the Potato Seed Unit and the Seed Division are not in agreement on such basic information as tons of production (compare data from Appendix Tables A3 and A4). These are given a spurious validity by being repeated in numerous papers and then being cited from one paper to another.

Good management accounting systems provide guidance to production managers and can assist in problem identification and in communicating the problems identified to others. There are apparently no such systems in place in either the Seed Potato Unit or the Seed Division. The disagreement in production data is symptomatic of the low level of communication between the agencies.

Extension, education and promotion are handled by the Technical Directorate. As documented in Peterson et al. (1988) these activities are constrained to low level localized efforts due to a lack of funds and personnel. These same activities are very well organized and are extensive in the private input supplies market. The national program could obtain an idea of the costs and effort needed to truly

make an effective effort at a national level by close observation of this sector.

Credit supplies are generally deficient and those that are available are absorbed by the large farm sector.

The research program of the Seed Potato Unit has made valuable contributions to the development and adaptation of rapid multiplication technology to local conditions. The economics research group in INIAP has done little potato research. There has been some research from other related agencies in MAG that has targeted specific areas and touched on aspects of the seed system.

Concluding Remarks

The official seed potato system has been developed over a period of more than 20 years in a variety of official agencies. During that time the system has strengthened existing activities and added new ones. The system initiated and completed a major change in pre-basic seed production technology. Aspects of quality control were added and modified. A system of certified seed production was initiated. However these efforts have not significantly affected the informal seed system or injected meaningful quantities of seed into it.

A strength of the official system was the breeding program. This has been dissipated in recent years and no new varieties have been released since 1983. Weaknesses of the official system are the poor communication between the various agencies, tenuous links with the informal system illustrated by the lack of a systematic seed distribution plan, and a focus on the commercial sector while ignoring the majority small farm sector.

An additional weakness has been the lack of on-farm research with active farmer participation. The official seed system has few points of contact with the informal seed system. The contacts that do exist are largely with the large and commercial farm sector and mostly in the form of seed sales and certification inspection visits. The lack of feedback information on the effectiveness or value of the product being offered, or how it was being offered, has been an important omission of the official system. The on-farm research reported by Reinoso (1979), and then followed by Moreno (1988) and Pumisacho (1988) are notable examples of the benefits of this type of research. However, an interval of 10 years is too slow a feed back link to be efficient. The initial revelation of lack of distinguishing value of official seed versus farmers' seed in 1979 set in chain a sequence of events spanning a decade that, when finally checked, revealed that perhaps there was an over-emphasis placed on seed health via rapid multiplication.

Limitations of the Study

This study has described several elements of the seed potato system including its informal and formal sub-systems, but has not provided complete coverage of all aspects of these systems. An important omission is an analysis of the several small scale seed potato projects that were or are in place in various communities. These projects are important examples of alternative methods in seed production and distribution. Another omission is a systematic treatment of external assistance offered to the seed potato program. There has not been a comprehensive project to strengthen all aspects of the seed potato system. Rather there have been a series of more focused projects which have addressed separate components of the seed system. The impact of these projects has been limited by bottlenecks in other parts of the system. There has been no financial analysis of the costs or benefits of these projects. Individuals in other parts of the system mentioned that their efforts had been thwarted by a lack of contact with some of the external technology transfer institutions. The impact of this was not investigated.

Future Research

This report has highlighted special problems faced by several seed potato systems in the Andes. Principal among these is the questionable impact that seed health has on yields. If it is accepted that there is minimal impact, it is necessary to have an agenda to test the validity of other aspects of seed technology that are

perceived as being ready to be transferred to the farmer. Such a research program should be strongly focused on off-station research and concerns testing assumptions on seed technology that is perceived as ready to be transferred to the farmer. The benefits of alternative seed storage technologies, positive and negative selection, and seed rotation between higher, and lower fields should all be tested with farmers' trials. The basic hypothesis to be tested is that variety and location are more important than any of these other seed technologies in explaining yield differences. Seed distribution in the informal system is complex and patterns are difficult to discern. For other investigation is needed to help make the various elements of this system interact effectively.

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Table A1. Potato area, production and yield. Ecuador, 1962-87

Production (mt)

Province	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Carchi	15,300	36,400	36,400	34,800	38,200	52,000	79,600	45,500	95,500	47,800	95,500	175,600	152,000	127,260	134,810	111,610	47,272	45,061	44,631	75,252	76,205	68,493	71,442	94,349	111,132	97,920
Imbabura	4,700	13,300	13,600	9,100	4,500	6,800	3,400	5,500	6,000	4,600	1,800	3,100	4,100	6,136	8,242	32,200	24,170	18,680	21,436	21,040	13,154	7,800	6,180	4,460	3,511	3,524
Pichincha	46,800	40,900	36,600	25,000	18,200	19,100	27,300	22,700	22,700	28,000	22,300	77,200	41,960	61,160	78,242	35,586	45,201	27,284	48,000	39,577	35,381	26,558	46,228	54,316	72,387	50,795
Cotopaxi	70,900	56,700	81,800	86,400	71,200	75,000	77,300	63,000	89,600	101,800	65,900	72,000	92,260	107,045	88,680	50,525	49,823	29,426	44,339	46,990	38,147	25,965	40,821	40,416	84,029	42,400
Tungurahua	40,900	36,400	40,900	35,500	40,900	45,500	45,500	106,800	107,000	163,800	120,000	45,600	54,134	42,045	48,792	38,815	37,572	15,310	20,250	27,924	43,546	41,665	44,444	56,745	71,442	42,276
Bolivar	6,000	6,800	11,400	10,900	10,000	14,500	17,800	13,600	14,100	20,500	18,200	22,500	59,090	52,000	57,000	57,949	39,675	33,525	51,710	57,267	104,228	63,505	80,196	90,874	95,256	112,190
Chimborazo	102,300	77,700	68,200	111,300	89,000	91,100	163,600	81,800	82,000	190,900	87,300	71,100	12,270	13,500	11,250	16,545	29,009	29,009	25,000	31,750	31,752	20,122	16,795	17,662	20,725	22,300
Canar	22,700	16,500	10,300	54,500	59,500	70,900	72,700	102,600	110,300	107,900	50,900	55,600	80,360	80,681	107,920	46,604	53,010	38,507	49,500	77,566	63,096	48,000	73,710	54,432	36,864	27,760
Azuay	21,700	12,600	7,300	14,100	3,600	10,900	12,700	14,300	15,000	12,500	9,100	14,100	2,100	5,700	11,550	22,934	14,553	12,389	15,500	11,850	8,573	8,169	5,806	4,679	5,806	4,763
Loja	0	0	13,600	9,100	11,300	12,600	10,900	600	500	2,600	2,000	2,000	1,512	200	900	731	1,146	3,471	1,318	1,089	1,046	2,867	2,722	3,429	4,001	3,674
North	20,000	49,700	50,000	43,900	42,700	58,800	83,000	51,000	101,500	52,400	97,300	178,700	156,100	133,396	143,052	143,810	71,442	63,741	66,067	96,292	89,359	76,293	77,622	98,809	114,643	101,444
Central	266,900	218,500	238,900	269,100	229,300	245,200	331,500	287,900	315,400	505,000	313,700	288,400	259,714	275,750	283,964	199,420	201,280	134,554	189,299	203,508	253,054	177,815	228,484	260,013	343,839	269,961
South	44,400	29,100	31,200	77,700	74,400	94,400	96,300	117,500	125,800	123,000	62,000	71,700	83,972	86,581	120,370	70,269	68,709	54,367	66,318	90,505	72,715	59,036	82,238	62,540	46,671	36,197
Total	331,300	297,300	320,100	340,700	346,400	398,400	510,800	456,400	542,700	680,400	473,000	538,800	499,786	495,727	547,386	413,499	341,431	252,662	321,684	390,305	415,128	313,144	388,344	421,362	505,153	407,602

Area (ha)

Province	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Carchi	670	4,000	4,200	4,000	4,200	4,400	3,500	2,500	6,000	3,000	6,000	9,200	7,600	7,000	6,500	4,248	3,694	3,445	3,514	5,530	5,600	5,471	5,250	6,500	7,000	7,200
Imbabura	450	620	800	800	500	500	500	500	500	500	200	510	600	900	1,300	2,780	2,009	1,430	1,800	1,600	1,000	600	545	470	337	298
Pichincha	2,900	2,000	2,200	2,500	2,200	2,200	2,200	2,500	2,500	3,660	2,740	6,820	3,550	5,384	7,100	5,057	4,562	2,625	4,800	3,966	3,900	2,788	3,981	4,315	4,824	4,100
Cotopaxi	5,950	6,100	6,200	6,500	5,400	5,500	5,600	4,950	6,500	7,000	5,000	6,000	7,000	7,850	6,000	4,362	3,983	3,298	3,910	3,572	2,900	2,602	4,615	4,455	7,410	5,381
Tungurahua	4,700	4,800	4,500	4,000	4,500	4,800	4,800	4,700	4,800	9,010	5,410	3,430	3,775	2,872	3,800	3,828	3,099	1,223	1,500	2,052	3,200	3,205	3,266	4,170	4,500	4,000
Bolivar	540	600	2,000	1,500	1,500	2,000	2,300	2,000	2,000	2,500	2,000	2,000	6,500	5,200	5,000	3,930	3,551	4,696	6,000	5,050	8,200	5,000	6,500	9,144	8,750	8,630
Chimborazo	11,500	9,500	11,000	16,500	16,500	16,700	18,000	12,000	12,000	14,000	8,000	6,750	1,500	1,500	1,500	3,989	2,442	3,831	2,500	2,500	2,500	1,869	1,683	1,589	1,825	1,980
Canar	4,050	3,100	3,720	6,400	6,500	9,500	9,000	10,000	10,500	10,500	5,600	6,050	7,000	7,100	8,000	5,900	4,809	4,270	4,500	5,700	6,500	4,000	6,500	4,800	3,020	2,040
Azuay	2,100	1,000	3,200	1,550	1,550	1,600	2,000	2,100	2,300	2,500	2,000	1,940	600	1,220	1,500	1,980	1,337	1,535	1,500	1,375	1,050	800	614	519	624	506
Loja	0	0	1,000	700	1,380	1,380	1,200	100	100	720	720	810	600	70	150	185	127	316	120	100	96	316	400	420	490	450
North	1,120	4,620	5,000	4,800	4,700	4,900	4,000	3,000	6,500	3,500	6,200	9,710	8,200	7,900	7,800	7,028	5,703	4,875	5,314	7,130	6,600	6,071	5,795	6,970	7,337	7,498
Central	25,590	23,000	25,900	31,000	30,100	31,200	32,900	26,150	27,800	36,170	23,150	25,000	22,325	22,806	23,400	21,166	17,657	15,673	18,710	17,140	20,700	15,464	20,045	23,673	27,309	24,091
South	6,150	4,100	7,920	8,650	9,430	12,480	12,200	12,200	12,900	13,720	8,320	8,800	8,200	8,390	9,650	8,065	6,273	6,121	6,120	7,175	7,646	5,116	7,514	5,739	4,134	2,996
Total	32,860	31,720	38,820	44,450	44,230	48,580	49,100	41,350	47,200	53,390	37,670	43,510	38,725	39,096	40,850	36,259	29,633	26,669	30,144	31,445	34,946	26,651	33,354	36,382	38,780	34,585

Yield (mt/ha)

Province	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Carchi	22.84	9.10	8.67	8.70	9.10	11.82	22.74	18.20	15.92	15.93	15.92	19.09	20.00	18.18	20.74	26.27	12.80	13.08	12.70	13.61	13.61	12.52	13.61	14.52	15.88	13.60
Imbabura	10.44	21.45	17.00	11.38	9.00	13.60	6.80	11.00	12.00	9.20	9.00	6.08	6.83	6.82	6.34	11.58	12.03	13.06	11.91	13.15	13.15	13.00	11.34	9.49	10.42	11.83
Pichincha	16.14	20.45	16.64	10.00	8.27	8.68	12.41	9.08	9.08	7.65	8.14	11.32	11.82	11.36	11.02	7.04	9.86	10.39	10.00	9.98	9.07	9.53	11.61	12.59	15.01	12.39
Cotopaxi	11.92	9.30	13.19	13.29	13.19	13.64	13.80	12.73	13.78	14.54	13.18	12.00	13.18	13.64	14.78	11.58	12.51	8.92	11.34	13.16	13.15	9.98	8.85	9.07	11.34	7.88
Tungurahua	8.70	7.58	9.09	8.88	9.09	9.48	9.48	22.72	22.29	18.18	22.18	13.29	14.34	14.64	12.84	10.14	12.12	12.52	13.50	13.61	13.61	13.00	13.61	13.61	15.88	10.57
Bolivar	11.11	11.33	5.70	7.27	6.67	7.25	7.74	6.80	7.05	8.20	9.10	11.25	9.09	10.00	11.40	14.75	11.17	7.14	8.62	11.34	12.71	12.70	12.34	9.94	10.89	13.00
Chimborazo	8.90	8.18	6.20	6.75	5.39	5.46	9.09	6.82	6.83	13.64	10.91	10.53	8.18	9.00	7.50	4.15	11.88	7.57	10.00	12.70	12.70	10.77	9.98	11.12	11.36	11.26
Canar	5.60	5.32	2.77	8.52	9.15	7.46	8.08	10.26	10.50	10.28	9.09	9.19	11.48	11.36	13.49	7.90	11.02	9.02	11.00	13.61	9.71	12.00	11.34	[illegible]	12.21	13.61
Azuay	10.33	12.60	2.28	9.10	2.32	6.81	6.35	6.81	6.52	5.00	4.55	7.27	3.50	4.67	7.70	11.58	10.88	8.07	10.33	8.62	8.16	10.21	9.46	9.02	9.30	9.41
Loja	0	0	13.60	13.00	8.19	9.13	9.08	6.00	5.00	3.61	2.78	2.47	2.52	2.86	6.00	3.95	9.02	10.98	10.98	10.89	10.90	9.07	6.81	16	8.17	8.16
North	17.86	10.76	10.00	9.15	9.09	12.00	20.75	17.00	15.62	14.97	15.69	18.40	19.04	16.89	18.34	20.46	12.53	13.08	12.43	13.51	13.54	12.57	13.39	18	15.63	13.53
Central	10.43	9.50	9.22	8.68	7.62	7.86	10.08	11.01	11.35	13.96	13.55	11.54	11.63	12.09	12.14	9.42	11.40	8.59	10.12	11.87	12.22	11.50	11.40	10.98	12.59	11.21
South	7.22	7.10	3.94	8.98	7.89	7.56	7.89	9.63	9.75	8.97	7.45	8.15	10.24	10.32	12.47	8.71	10.95	8.88	10.84	12.61	9.51	11.54	10.94	10.90	11.29	12.08
Total	10.08	9.37	8.25	8.79	7.83	8.20	10.40	11.04	11.50	12.74	12.56	12.38	12.91	12.68	13.40	11.40	11.52	9.47	10.67	12.41	11.88	11.75	11.64	11.58	13.03	11.79

Sources: Borja, 1986; Wiegand, 1975.
Note: North represents Carchi and Imbabura. South represents Canar, Azuay and Loja. Central represents the remaining provinces.

Table A2. Main characteristics of INIAP potato varieties, Ecuador

Characteristics	Catalina	Maria	Esperanza	Gabriela	Cecilia
Release date	1966	1980	1983	1982	-
Production zone	Center	Center-south	North	North	Center
Yield (qq/ha)[1]	612	593	792	784	597
Specific gravity	1.086	1.087	1.079	1.10	1.096
Dry matter (%)	22.5	21.1	20.0	24.5	23.2
Tuber					
Size	Medium	Large	Large	Large	Medium
Shape	Red-oval	Round	Round	Oval	Extended-oval
Depth of eyes	Superficial	Medium	Superficial	Superficial	Superficial
Skin	Pink	White-beige	Beige-pink	Beige	White
Flesh	Yellow	White	White	White	White
Resistance[2]					
P. infestans	M.R.	M.R.	R	R.	M.R.
P. pittieriana	M.R.	M.S.	M.R.	M.R.	S.
P. vorax	M.S.	M.S.	M.S.	M.S.	M.S.
G. pallida	S.	S.	T.	T.	S.

Source: Muñoz, 1982.
Notes: 1. Yield calculated considering 28,000 plants/ha. 2. M.R. = medium resistant, R. = resistant, M.S. = medium susceptible, S. = susceptible, T. = tolerant.

Table A3. Production of certified and selected potato seed by variety and grade from INIAP Santa Catalina Experiment Station, Ecuador, 1972-87 (metric tons)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Catalina																
Basic	43.9	14.5	54.1	141.8	72.7	73.5	69.1	32.7	81.4	30.1	24.4	4.5	3.4	26.5	4.5	-
Registered											34.8	25.6	29.5	13.4	8.9	23.7
Certified															15.7	-
Mariva																
Basic					5.5	11.1	13.2	5.8	14.2	5.7	0.9	-	9.8	6.4	14.9	15.9
Registered											4.9	2.4	8.7	26.4	1.1	24.7
Certified															4.6	-
Gabriela																
Basic									8.9	19.9	-	-	12.1	-	22.9	12.5
Registered											7.3	23.2	4.7	105.7	10.8	13.8
Certified											259.2	-	-	-	70.6	-
Esperanza																
Basic													45.2	18.6	45.4	7.6
Registered												5.1	-	18.6	10.4	29.7
Certified																
Cecilia selected													8.6	14.1	9	8.7
Total	43.9	14.5	54.1	141.8	78.2	84.6	82.3	38.5	104.5	55.7	331.5	60.8	122.0	229.7	218.8	136.6

Source: INIAP Seed Production Department Annual Reports.
Note: A dash indicates no production recorded.

Table A4. Production of certified potato seed. Ecuador, 1976-87

Year	Cultivar	Category	Planted area (has)	Certified area (has)	Estimated production (t)
1976	Catalina	-[1]	317.7	91.8	624.60
	Maria	-	35.3	10.2	69.40
1977	Catalina	-	112.0	75.0	275.00
	Maria	-	3.0	3.0	15.00
1978	Catalina	-	69.0	53.0	326.00
	Maria	-	50.0	25.0	154.00
1979	Catalina	-	52.0	40.0	277.00
	Maria	-	22.0	14.0	98.00
1980	Catalina	-	65.4	50.3	715.00
	Maria	-	17.6	5.5	78.60
	Gabriela	-	3.0	3.0	50.00
	Esperanza	1.5	0.0	0.00	
1981	Catalina	-	38.5	19.5	140.00
	Maria	-	7.8	3.8	27.00
	Gabriela	-	17.2	16.7	120.00
1982	Catalina	Pre-basic	2.0	2.0	14.40
		Basic	3.2	3.2	23.40
		Registered	9.8	5.5	39.60
		Certified	9.5	2.0	14.40
	Maria	Basic	1.5	1.5	10.80
	Gabriela	Certified	50.4	36.0	259.20
	Total		76.5	50.35	361.80
1983	Catalina	Pre-basic	2.0	2.0	14.40
		Basic	37.5	35.0	252.00
	Maria	Pre-basic	1.0	0.0	
		Registered	0.3	0.0	
	Gabriela	Pre-basic	0.7	0.7	5.40
		Basic	0.7	0.7	5.40
		Registered	3.0	0.0	0.00
		Certified	9.0	7.0	50.40
	Esperanza	Pre-basic	0.5	0.5	3.75
		Basic	0.7	0.7	5.04
	Total		55.5	47.4	336.39
1984	Catalina	Pre-basic	1.0	1.0	6.5
		Basic	2.0	2.0	13.00
		Registered	35.2	29.3	190.58
		Certified	13.0	12.0	78.00
		Selected	21.8	21.8	141.70
	Maria	Pre-basic	1.1	1.1	7.02
		Basic	8.3	8.3	53.95
		Registered	2.0	2.0	13.00
		Certified	12.4	8.0	52.33
		Selected	0.5	0.0	--[2]

Table A4. (cont.)

Year	Cultivar	Category	Planted area (has)	Certified area (has)	Estimated production (t)
	Gabriela	Pre-basic	2.5	2.5	16.06
		Basic	13.9	13.9	90.68
		Registered	9.5	8.5	35.32
		Certified	2.0	2.0	13.00
		Selected	9.0	6.5	42.26
	Esperanza	Pre-basic	3.3	3.3	21.45
		Basic	11.6	0.0	--
		Registered	1.7	1.2	7.54
		Certified	18.0	14.5	94.25
	Total		169.2	138.2	896.63
1985	Catalina	Pre-basic	0.6	0.6	3.90
		Basic	2.5	1.5	9.75
		Registered	13.5	6.7	43.55
		Certified	82.9	74.4	483.60
	Maria	Pre-basic	0.4	0.4	2.60
		Basic	6.2	6.2	40.30
		Registered	10.5	3.8	25.03
		Certified	4.5	4.5	29.58
	Gabriela	Pre-basic	2.4	2.4	15.41
		Basic	7.2	7.2	47.00
		Registered	41.4	26.9	174.85
		Certified	25.1	19.5	126.75
	Esperanza	Pre-basic	2.0	2.0	13.00
		Basic	19.8	15.3	99.78
		Registered	17.6	0.0	--
		Certified	2.8	2.8	181.20
	Cecilia	Selected	1.7	0.7	4.88
	Total		241.4	175.2	1,138.18
1986	Catalina	Pre-basic	4.0	4.0	26.00
		Basic	9.5	8.5	55.25
		Registered	18.0	11.0	71.50
		Certified	47.6	29.0	188.83
	Maria	Pre-basic	2.0	2.0	13.00
		Basic	9.6	5.2	33.15
		Registered	15.2	12.1	78.65
		Certified	7.5	7.5	48.75
	Gabriela	Pre-basic	6.0	6.0	39.00
		Basic	5.7	3.0	19.50
		Registered	38.3	22.4	145.93
		Certified	76.6	38.6	251.23
	Esperanza	Pre-basic	3.0	3.0	23.00
		Basic	17.8	16.8	109.20
		Registered	53.2	39.2	255.13
		Certified	27.0	25.0	162.50
	Total		341.2	233.4	1,520.62

Table A4. (cont.)

Year	Cultivar	Category	Planted area (has)	Certified area (has)	Estimated production (t)
1987	Catalina	Basic	1.0	1.0	2.80
		Registered	7	4.5	34.00
		Certified	49.6	38.4	235.28
		Selected	18.8	6.5	40.50
	Gabriela	Basic	1.3	1.3	5.50
		Registered	13.8	10.6	40.90
		Certified	10.4	6.6	22.00
		Re-certified	5.7	4.7	41.15
	Maria	Basic	0.5	0.5	9.00
		Registered	8.1	5.8	32.20
		Certified	10.5	6.2	21.00
		Seleccionada	15.0	4.0	12.00
	Catalina	Registered	3.6	0.0	--
		Certified	13.4	13.4	83.00
		Re-certified	15.2	7.6	--
		Selected	38.6	19.3	--
	Cecilia	Selected	22.5	22.5	5.00
	Total		207	148.4	584.2

Source: Ministerio de Agricultura y Ganadería, Dirección Nacional Agrícola, División de Semillas.
Note: 1. No records of categories were kept during 1976-1981. 2. No records available.