*Potato Research 39 (1996) 395 – 401*

# Twenty-five years of international potato research, a retrospective and forward look

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*Additional keywords*: germplasm, TPS, resistance, rapid multiplication, virus, collaborative research, research priorities

## Summary

After an initial phase of development and programme establishment the activities of the International Potato Center (CIP) grew rapidly from 1981 to 1985, putting emphasis on germplasm distribution, research on diffused-light storage and TPS, and exploration of sources of resistance. Later, strong emphasis was given to genetic resource utilization and field resistance to late blight. The impact of CIP research showed internal rates of return ranging from 26 to 102 percent.
At the end of the 1980s CIP's financial resources were cut severely and restructuring the programme was necessary. Through a careful process of prioritizing, programmes are identified which will contribute most to ensuring the continued increase of potato production in developing countries and to continuing the leading role of CIP in potato research.

## Introduction

Twenty-five years ago the Government of Peru and North Carolina State University established the International Potato Center (CIP), a nonprofit scientific organization designed to conduct research on potatoes and "tuberous roots" (CIP, 1973). The Center joined the Consultative Group on International Agricultural Research (CGIAR) later that same year.

Our founding Director General, Dr Richard Sawyer, had a vision for CIP that drew upon the experiences of the International Rice Research Institute in the Philippines and the International Maize and Wheat Improvement Center in Mexico. Both institutions were created to avert food shortages in developing countries, and both played a major role in the Green Revolution of the 1960s and 1970s. Building upon their success, CGIAR donors provided support for similar research on potato, the world's fourth most important food crop following rice, maize, and wheat.

Dr Sawyer established CIP with its own institutional model. Unlike other CGIAR centers, CIP would channel a substantial portion of its budget to research contracts with advanced laboratories. It would also confine its activities to those for which it had a unique comparative advantage. For example, CIP relied heavily on outside expertise for programme planning and it invested approximately 50% of its funds in research at regional locations. Work within the regions would serve as a focal point for the transfer of genetic materials and for providing technical assistance and training to national programmes.

This paper provides a partial view of the dynamics of potato agriculture in the developing world and insights on what these trends may mean for scientists involved in potato research for developing countries.

**Evolution of CIP's potato programme**

CIP's first four years were developmental: staffing, construction, diagnostics, and research planning. In vitro storage and pathogen elimination techniques allowed us to share germplasm with regions by 1975. The next six years led to the establishment of programme and project units. In addition, true potato seed (TPS) research began, as did extensive work on virus detection, on-farm trials, the study of potato production systems and the development of the "farmer-back-to-farmer" approach to participatory research. Most other research activities in pest management, disease control and resistance breeding also started during this period. Regional focal points were established and the first collaborative research network was developed involving Central America, Mexico and the Caribbean.

From 1981 to 1985, CIP distributed promising germplasm to 80 developing countries. Most of this germplasm came from outside sources, but 14 accessions originated from CIP's breeding programme. Research on diffused-light storage and TPS, rapid multiplication for clonal seed production, exploration of wild species for resistance traits, improved virus detection techniques and virus resistance breeding became more dominant during those years. Activities on breeding for late blight resistance became a formal part of the programme in 1981. CIP also supported the establishment of four new regional collaborative research networks in Africa, Asia and South America.

During the next five years, strong emphasis was given to genetic resource utilization and a new breeding programme for field resistance to late blight. The latter included the development of an R-gene-free population for the selection of durable resistance to late blight, started in 1986. During this period, increased emphasis was given to the establishment of a pathogen tested list of materials available for distribution. Research on PSTVd detection and breeding work for PVY- and PVX-resistant materials were strengthened. The rate of germplasm exchange and evaluation of potato at regional locations and at "hot spots" increased greatly during this period.

CIP's potato programme grew rapidly in size and complexity until the late 1980s (CIP, 1987). At that time, the deterioration of social and economic conditions in Peru began to threaten the viability of CIP's operations. Donor support to CIP remained strong when compared to other international research initiatives. Despite this, and mostly because of increased costs caused by hyperinflation, the real value of the Center's research and operations budget for potato dropped by nearly 40 percent. Following a period of restructuring between 1991 and 1993, CIP emerged with six programmes (down from 10), five regional offices (down from eight) and 30 percent fewer staff (CIP, 1991).

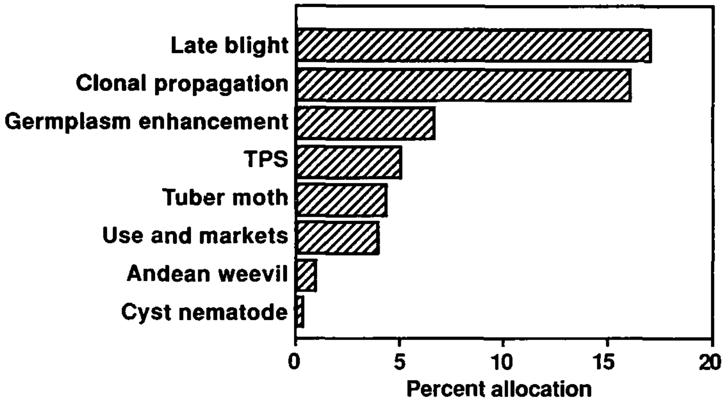


Fig. 1. Sample of project priorities for potato research, CIP, 1992.

To accommodate these reductions, CIP scientists were asked to assign priorities to each of the Center's research projects. Projects were carefully ranked on the basis of expected benefits, likelihood of adoption, potential for success and impact on natural resources (Collion & Gregory, 1993). Late blight and low-cost clonal propagation substantially outranked all other activities (Fig. 1). Many lower ranking activities were discontinued or amalgamated within other projects.

By 1994, the Center's potato research programme could be characterized by the mottoes "fewer things in fewer places" and "participation by national research systems". The result was the shifting of resources toward more effective germplasm utilization and the development of improved capabilities in molecular genetics and pathology to underpin the use of genetic markers for germplasm management and breeding. Additional funding was also channeled to work on late blight, integrated pest management, genetic engineering and natural resources research. Geographically, Asia would receive a proportionally larger share of Center resources in response to population growth. By 1996, CIP had recovered its financial standing and was positively reviewed by external examiners.

## Achievements

CIP's most important achievement since the early 1970s was the strengthening of national research programmes through training, networks and support for research planning. These efforts led to the development of more durable potato research capabilities in developing countries. Outputs included stronger seed production capabilities at the national level, improved seed storage capacities and higher international seed-quality standards.

More recently, these efforts have encouraged a wider use of integrated pest management and biological control practices and have stimulated the use of new

Table 1. CIP impact case studies of nine technology changes (Walker & Crissman, 1996).

| Technology | Location | Internal rate of return (%) | Net benefits ($ million)* |
|---|---|---|---|
| Late blight breeding | East Africa | 84 | 30.3 |
| Late blight breeding | Peru | 26 | 5.4 |
| CIP-24 | China | 102 | 12.7 |
| Integrated pest management | Tunisia | 64 | 6.4 |
| Integrated pest management | Dom. Republic | 27 | 1.1 |
| Integrated pest management | Peru | 30 | 1.9 |
| True potato seed | India | 33 | 52.6 |
| Rapid seed multiplication | Vietnam | 70 | 2.4 |
| Seed program development | Tunisia | 81 | 3.2 |

* At project maturity.

genetic materials for potato processing and ware consumption. The spread of new varieties, many of which carry improved resistance to late blight and viruses, also has important commercial applications. Many other varieties are available as true-seed hybrids that can be rapidly introduced to farmers even those located in remote areas.

To assess the impact of these technologies, CIP conducted nine impact case studies in the mid-1990s covering research on varietal development, seed and integrated pest management (Walker & Crissman, 1996). The impact of CIP research showed internal rates of return ranging from 26 to 102 percent (Table 1). In 1993 prices, net profits per hectare (discounting research and implementation costs) varied from $100 to more than $1,300, figures that do not include environmental benefits associated with reductions in the use of pesticides.

The nine case studies represent a very partial view of CIP's contributions. They do not quantify the benefits from activities that did not generate specific technologies, such as training and institution building, or the collection, description, evaluation and maintenance of wild and domesticated germplasm. They also represent less than half of the potential technological impact associated with CIP research. They do not include successes with bacterial wilt control (Costa Rica, East Africa) and diffused-light storage (Central America and other regions), as well as the impact of several other TPS, IPM and varietal change activities. Nevertheless, annual returns (in 1994 dollars) to investments in CIP since 1971 based on only the nine technologies studied were calculated at $230 million, more than ten times the Center's 1996 annual budget (CIP, 1995).

**Prospects for developing countries**

Present trends show that developing countries will produce more than a third of the world's potatoes by the end of the century (CIP/FAO, 1995). Since 1962, potato production in the developing world has expanded at a rate of 3.6% annually. In

Table 2. Changes in potato production in selected regions.

| | 1961-1963 average | | 1991-1993 average | | Average annual growth | |
|---|---|---|---|---|---|---|
| Region | Production (000 t) | Area (000 ha) | Production (000 t) | Area (000 ha) | Production (%) | Area (%) |
| Developing world | 29,066 | 3,562 | 84,957 | 6,677 | 3.6 | 2.1 |
| Asia | 20,280 | 2,327 | 66,037 | 4,995 | 4.0 | 2.6 |
| Africa | 1,826 | 238 | 6,693 | 700 | 4.1 | 3.7 |
| LAC* | 6,959 | 998 | 12,226 | 981 | 1.9 | -0.1 |
| Industrialized world | 236,048 | 18,592 | 190,398 | 11,456 | -0.7 | -1.6 |
| Total | 265,114 | 22,154 | 275,355 | 18,133 | 0.1 | -0.7 |

* Latin America and the Caribbean
Source: CIP/FAO, 1995.

nearly 100 developing countries, production rose from 30 million tons in the early 1960s to 85 million tons in the early 1990s, an increase second only to growth in wheat output (Table 2). Production is projected to rise another 2.8% annually by the year 2000, compared with 0.3% in industrialized countries. At that rate, developing countries will produce 105 million tons annually by the beginning of the next century. Should this trend remain stable, production would rise to approximately 170 million tons by the year 2020, a level that approaches current production in industrialized countries.

Asia now accounts for almost 80% of potato production in the developing world. Production grew at an average rate of 4% annually between 1962 and 1992. China, the world's second-largest potato producer, and India, the world's sixth-largest producer, account for about half of this increase. Pakistan, Indonesia and Vietnam are also projected to show strong gains in production as potatoes are produced in rice- and wheat-based cropping systems. Growing demand and the desire of Asian consumers for more diversity in their diets will further contribute to these trends.

Africa also experienced extensive growth in potato output during this period. Production in sub-Saharan Africa increased nearly 150%, though from a lower base. Potato production is currently growing faster than that of any other major food crop in the region, with the exception of rice and yams.

In Latin America, expansion has been due to an increase in productivity, as well as growth in area planted. Andean countries are expected to recover from sharp cutbacks of the previous decade, while production in the region's Southern zone is forecast to benefit from greater commercialization. Potato production in Latin America increased roughly three-quarters during the 1962–92 period.

The CIP/FAO study also noted that global potato use is shifting away from the fresh market and livestock feed toward processed products, such as french fries, chips and frozen and dehydrated products. Processing, the report says, is the fastest growing sector within the world potato economy, a trend that can be seen in countries such as Argentina, Colombia, China and Egypt.

**The potato's future contributions to world food security**

If trends in demand and production growth continue as in the recent past, potatoes will have the potential to contribute much more to future food needs in developing countries. The question is, will it be technologically possible to increase yields and planted area to double the amount of potatoes produced in these regions?

Concerns about world food requirements in the 1960s led to the development of new, higher yielding rice and wheat varieties. Physiologically, this was possible because cereal harvest indexes increased by 35% and the short, stiff straw encouraged higher nutrient responses. But gains in cereal production in developing countries have levelled off and will be increasingly limited by difficult-to-break physiological yield barriers. During the next 25 years, farmers will need to produce, at the same price, food for approximately 2.3 billion additional people (UN, 1993), albeit from a much reduced land and water base (Oldeman et al., 1990).

The potato allows farmers to harvest up to 80% or more of their dry matter production as edible, nutritious food. Only 50% of a typical cereal crop can be harvested as grain. This difference accounts for the high potential yield of the potato. Crop physiologists estimate the potential yield of potatoes at about 120 t $ha^{-1}$ (Kooman & Haverkort, 1995) or roughly 30 t $ha^{-1}$ grain equivalent.

Researchers estimate that they can increase global potato yields to 36 or 56 t $ha^{-1}$ depending on the availability of irrigation (Van Keulen & Stol, 1995), up from 15 t $ha^{-1}$ at present.

To achieve this full potential, biological and institutional constraints have to be removed. While the demand for potato in developing countries is far from satisfied, costs of production are such, however, that in a number of countries potato production will not be able to compete with imports. This shift to dependency on imported produce will become more important as processed potatoes (with longer shelf life) become a greater part of the market.

Major causes of the high cost of production in developing countries continue to be high-cost and poor-quality seed materials and the control of pests and diseases. In some regions, low productivity caused by lack of access to fertilizer becomes an important factor in maintaining product costs high. Most of these yield-reducing constraints can be overcome by continued emphasis on the development of potatoes with durable resistance to major insects and diseases; this can underpin integrated pest management practices. In the past, each of these areas has produced usable results in a relatively short period of time. These genetic improvements have been the driving force for the rapid varietal change observed in developing countries, where they have been necessary because of a lack of strong seed industries, limited access to pesticides and the absence of freezing winters.

CIP's recent studies show that informal seed systems based on rapid multiplication techniques have much potential for improving seed quality. Similarly, after a long gestation period, TPS technology has improved prospects for wider use as a low-cost source of clean seed. The latest advances in biotechnology will allow scientists to incorporate desirable resistance and quality traits into adapted varieties more easily and may result in a much shorter gestation period for improved varieties. With sufficient research support, CIP believes that potato production can be doubled in developing countries by the year 2020 so that the world's potato farmers would be able to feed an additional 250 million people annually.

To assure continued expansion of potato production in developing countries, however, the decline in funding for potato research must be reversed. CIP's budget, though comparatively stable, has been seriously reduced in recent years. More important, structural adjustments have severely weakened public institutions that support agriculture in developing countries (Trigo, 1995). National potato programmes are in urgent need of strengthening. In many countries, CIP has lost much of the counterpart capability that it helped to build through nearly a quarter century of training and technical assistance. The main constraint to the future expansion of potato production in developing countries therefore appears to be institutional rather than the result of limitations imposed by nature or science.

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