Biotechnology
Seminar Paper

CIP's Approach to Resource Allocation and Priority Setting: Potato Late Blight Research

M. Ghislain
P. Gregory

October 1996

ISNAR Biotechnology Service

Seminar Papers reflect the views of the authors and not necessarily those of ISNAR. They are not official ISNAR publications.

isnar

CIP's Approach to Resource Allocation and Priority Setting: Potato Late Blight Research

Marc Ghislain and Peter Gregory

Introduction and Objectives

In this paper we use research on potato late blight to illustrate the priority setting and resource allocation mechanisms used by the International Potato Center (CIP). We have given special emphasis to biotechnology, particularly in relation to collaboration with National Agricultural Research Systems (NARS).

The three main issues addressed are: (1) Research priorities at CIP: priority setting for international agricultural research using procedures involving full staff participation, as well as partners in developing and industrialized countries. (2) Partnership with NARS: the balance between strengthening the in-house biotechnological capacities of NARS versus collaboration with international centers and industrialized-country laboratories. (3) Intellectual property rights for biotechnological innovations.

CIP's Approach to Priority Setting

CIP uses an array of priority setting procedures to maximize participation of both its in-house scientific staff and its partners in the developing and industrialized world. The foundation of CIP's approach to priority setting is an institution-wide, highly participatory method developed with the assistance of the International Service for National Agricultural Research (ISNAR) (Collion and Gregory 1993).

Projects are prioritized on the basis of their contribution to CIP's three major objectives:

- Increased agricultural productivity and efficiency to produce more products of better quality at lower costs in order to raise farm income and increase consumer welfare (efficiency).
- Improved living conditions of the poorest populations (equity).
- Protection of the natural resource base (sustainability)

Precise scoring of a particular project was formulated using several criteria to reflect its contribution to increasing producer and consumer welfare and to protecting the environment. The criteria used by CIP's management were: (1) potential for increased production and higher product value through research efforts; (2) importance of the constraint to be addressed; (3) the likely extent of technology adoption; (4) probability of obtaining research results; (5) importance of the research results for other CIP projects; (6) importance of the project at the regional level; (7) effect of the technology(ies) on the environment; and, (8) cost. Projects were prioritized in global terms and on the basis of agroecological zones (arid and Mediterranean, temperate, subtropical lowlands, highlands, humid tropics, semi-arid tropics). This exercise is conducted jointly by CIP directors and scientists, and is assisted by a facilitator. The global meeting lasts about one week, with approximately three weeks of preparation and writing of the final documents. Direct financial costs are minimized by the contribution of the institution's own staff and ISNAR staff time and expertise. The results of this exercise were translated into project scores. Table 1 shows that late blight research emerged as CIP's top research priority (adapted from Collion and Gregory 1993).

Details of which activities are needed to remove constraints and by which institution they should be carried out are discussed with research partners in international planning conferences, annual program reviews, workshops, and project design meetings.

International planning conferences, in which scientists from developing and industrialized countries are invited to participate, play a key role in the prioritization of research. Together with staff, the invited experts iden-

Table 1. Overall project score compiled for CIP's potato agroecological zones

Project title	*Score*
Control of late blight	259,900
Low-cost propagation of clonal planting materials	242,500
Technology integration and adaptation	174,100
Germplasm enhancement and molecular techniques	100,900
Combined resistance to viruses/fungi	99,200
Integrated control of bacterial wilt	95,100
Collection and characterization	92,100
Improvement of sexual propagation	76,300
Identification and control of viruses	75,800
IPM control for PTM	64,900
Expanding utilization for developing countries	59,000
Characterization of production systems	51,200
Molecular approach to identify/control pathogens	37,200
Resistance to insects/mites	36,500
Abiotic stresses and crop management	31,900
IPM for Andean weevil1	4,200
Management of cyst nematode	5,200
Control of field and storage diseases	4,900

tify areas of comparative advantage and elaborate a five-year plan of action, evaluating CIP's activities in the light of work being accomplished elsewhere. The recommendations derived from planning conferences are thought of as essential guidelines for research and program development, and as a basis for coordinating research staff, funding, and time frames.

Priority setting efforts at all levels draw heavily on impact assessment studies, which not only serve to teach what went right or wrong and why, but also provide our donors with feedback on the practical returns of their investments. CIP has been conducting impact assessment studies since 1992 (Walker and Crissman 1996). Achievements in its 25 years of existence have been appreciated and recognized to various degrees. For example, the impact of CIP-related technologies in farmers' fields and in consumers' markets has been largely underestimated. These economic studies show that the cost-effectiveness of our agricultural research program is adequate compared to other examples in the literature (Fuglie et al. 1996).

In the past five years, CIP has implemented a project-based accounting system to improve resource allocation based on institutional priorities. A new financial information system, CIPFIS, has also promoted decentralized decision making and budget monitoring. This computerized system, now fully operational at CIP headquarters, is being implemented in regional offices in Africa and Asia. Scientists and managers will have on-line access to their budgets.

Priority Setting Applied to Late Blight Research

In the past decade, late blight disease has become a global threat to potato production. The value of crop losses due to late blight in developing countries is currently estimated at US$ 2.75 billion (CIP 1996). The threat of even larger-scale losses comes at a time when developing-country potato production is expanding. Annual potato production grew from 30 million tons in the early 1960s to 85 million tons in 1993. Yields are expected to rise by 2.8% per year in the foreseeable future. By the year 2000, economists predict that developing countries will produce more than a third of the world's potato harvests (CIP/FAO 1995).

New strains of the fungus have emerged and some are resistant to the systemic fungicide metalaxyl. The presence of both A1 and A2 mating types in farmers' fields now permits the formation of oospores (Drenth 1994), resulting from sexual recombination. This is an additional threat to potato production as they can survive in the soil for several years. The fungi may colonize the potato plant at an early developmental stage. Hence, late blight could also become an early blight. Farmers may soon have to start fungicide spraying at a very early stage of the growing season. Long exposure to toxic chemicals and genetic recombination will favor the evolution of even more aggressive strains with higher levels of resistance to other fungicides.

Increased use of fungicides to combat this threat may render potato agriculture less profitable. Environmental concerns and threats to farmer safety in developing countries are also likely to be an impediment to sustainable potato production.

Late blight research has been carried out at CIP since its foundation 25 years ago. From then on, research priorities have been periodically reviewed and new research strategies undertaken. As a consequence of these various priority setting mechanisms, additional resources have been gradually allocated to late blight research.

A planning conference was convened specifically on potato fungal diseases in 1978 to review progress, set priorities, and establish collaborative links with other institutions (CIP 1978). As chemical control had become increasingly expensive and beyond the means of farmers in many developing countries, the panel recommended the development of new genetically-resistant cultivars. Much of this research was impeded by the presence in the potato test populations of R genes, which proved to be rapidly dominated by new strains of the fungus. Further breeding for LB resistance was focused more on general resistance in an integrated pathogen management program.

However, during annual meetings in the early 1980s and the 1982 "Post-Congress Workshop" related to late blight research, it was recognized that the simply inherited R-gene resistance present in advanced materials was impeding progress and that the R genes should be eliminated from our breeding lines. The next planning conference held at CIP further refined research priorities on late blight. At this stage, the late blight breeding strategy became based on the use of so-called populations A (with R genes) and B (without R genes), with the former being progressively replaced by the latter (CIP 1989). This conference also brought to light the potential of biotechnology as an aid to the development of new cultivars.

In the report on a review of CIP's late blight program held in 1994, a panel of international experts endorsed the continuous efforts by NARS to promote the use of population B and pointed to a number of developments in biotechnology that might be applicable to our late blight research.

During the 1996 annual review, late blight research was debated extensively. This resulted in the building of an integrated project on late blight research to promote interdisciplinary collaboration. This new research framework involves multidisciplinary teamwork and, in addition to the further development of partial resistance to late blight, it includes studies on disease monitoring and integrated disease management techniques. Biotechnological tools are being meshed with traditional approaches in breeding work and in breed characterization and identification of pathogens. We expect to find new sources of valuable resistance from several wild *Solanum* species as well as primitive Andean potato cultivars.

The incorporation of priority setting into a new research program required phasing out some activities that were no longer considered a priority. As late blight research became increasingly important, the Center progressively transferred its research efforts on nematode diseases to the Peruvian NARS. Similarly, breeding for resistance to bacterial diseases, which in the early days of CIP was an important research area, dropped to a lower priority level as scientists found that integrated disease management programs could secure potato production in most environments. These shifts are examples of necessary decisions, often difficult to make, that will eventually make a more successful research program.

Priority Setting Applied to Molecular Technologies

The first biotechnology planning conference on the "Application of Molecular Techniques to Potato Germplasm Enhancement" took place early in 1990 to formulate a set of recommendations that would serve as guidelines for in-house research and for collaboration with scientists around the world (CIP 1991). In its 1991 Strategic Plan, the Center's research programs included the integration of several biotechnological tools for germplasm conservation and enhancement.

The use of molecular markers was encouraged so as to bring to light the genetic base of resistance to late blight, and, later, to use these markers to efficiently monitor the introgression of this complex trait into improved potato clones. Steps to achieve this goal were established and many have been completed, such as: the development of a potato base map (collaborative research with Cornell University); the establishment of an in-house molecular marker laboratory; the development of suitable populations that segregate for late blight resistance; in-house training for interested NARS, etc. This blend of molecular techniques has a wide acceptability among breeders and geneticists because it is a multidisciplinary approach, it builds on existing knowledge, it expands the use of potato germplasm, it raises little concern about patenting and biosafety issues, and, last but not least, it is affordable.

Table 2. Research and development objectives of GILB

	GILB priority areas	*Rank*
Phase I: Years 1-3	Identify sources of resistance in existing cultivars, wild species, and primitive forms	1
	Develop and characterize segregating populations (2x & 4x)	2
	Refine and standardize testing for resistance	3
	Update and extend present GxE study on resistance	4
	Refine molecular techniques, identify quantitative trait loci	5
	Conduct studies on fungal population dynamics	6
	Update current IPM strategies	7
	Enhance R&D on restricted gene/chromosome transduction techniques	8
	Develop transgenic approach using non-potato genes	9
Phase II: Years 4-6	Extend field trials (in situ breeding, LB + adaptability)	1
	Use QTL to increase breeding efficiency and eliminate GxE effects	2
	Extend studies on the pathogen complex: epidemiology/aggressivity, etc.	3
	Clone R genes, determine mechanisms, transform responsive cultivars.	4
	Conduct controlled field trials of transgenic potatoes with LB resistance	5
	Use restricted chromosome transduction techniques for cultivar improvement	6
Phase III: Years 7-10	Transfer improved germplasm to NARS, NGOs, etc.	1
	Conduct training: IPM and application of modern techniques	2
	Conduct impact assessment studies	3
	Follow-up: prospective studies, future R&D prioritization	4
	Risk assessment and durability testing of non-host options	5

Genetic engineering techniques were also recommended because of their potential application to diverse sources of germplasm to solve problems not resolved through conventional procedures. It was suggested that analysis and decisions on further action be made on a case-by-case basis. In light of the lack of well-characterized resistance genes for late blight, this technology was not applied to our late blight research. It is only recently, after the last late blight meeting, that CIP has been considering the direct transfer of late blight-resistant genes into potatoes.

CIP's Response - A Global Initiative on Late Blight (GILB)

The Center is currently investing US$ 1.5 million in its late blight project, up from US$ 1.2 million in 1995. To sustain production increases into the 21st century, however, additional research is urgently needed. To this end, CIP, in cooperation with national program collaborators, has called for a coordinated effort to accelerate the development of greater and more durable host-plant resistance and the use of resistant varieties in integrated pest management (IPM) programs. A global effort focusing on developing countries is being organized to provide solutions with greater and wider applicability to the late blight threat worldwide. This global initiative on late blight, known by the acronym GILB, will draw upon the talents and resources of national research programs, universities, NGOs, and the private sector (French & Mackay 1996).

A project-design meeting took place in March 1996 to organize the GILB and identify priority areas for research and development and transfer of technology to developing countries (see Table 2).

A major objective of GILB is to expand the genetic base to achieve polygenic, durable resistance in potato cultivars through the transfer of resistance genes from wild species and primitive varieties (see Table 2). A blend of traditional and molecular approaches is considered. The project will also promote the transfer of broader-based durable resistance to locally adapted potato varieties and advanced breeding lines.

CIP's Partnership with NARS and Biotechnology

Until recently, CIP operated its biotechnology research largely through collaboration with advanced laboratories in developed countries. This approach was our response to the following question, which we pose again regarding partnership with NARS in agricultural biotechnology: Should the emphasis be on long-term development of NARS facilities and expertise or is it more effective to rely on collaboration with advanced laboratories in collaborating industrialized countries? Two technologies are regarded as potentially important for late blight research: molecular markers and genetic engineering.

Marker-assisted selection and studies of environmental interactions in the expression of resistance to late blight are the main tasks of NARS in successful collaborative projects. Partnership with CIP involves the consideration of national program capacity in achieving research and development objectives. Several Latin American national programs are already involved in the evaluation of segregating populations for genetic mapping of durable resistance to late blight (INIAP-Ecuador and IBTA-Bolivia), in the development of molecular tools to assist breeding for late blight (INIA-Uruguay), or in both (INTA-Argentina). This research network on late blight resistance will help ensure efficient technology transfer to NARS and the sharing of research findings and material.

Direct gene transfer technology, referred to as genetic engineering, has a great deal of promise in modern agriculture and several products are already commercially available in developed countries. This technology will no doubt also have to be implemented in all developing countries as well. But this raises three major questions:

1. How can genetic engineering be successfully integrated into the NARS conventional agricultural research agenda?
2. How do we manage the potential risks asso-

ciated with the introduction of genetically modified organisms in the environment?
3. How do we protect developing-country interests in a technology increasingly dominated by commercial companies?

These issues need to be addressed country by country on a case-by-case basis before deploying genetic engineering in the agricultural biotechnology of NARS. Some answers to these questions are:
1. The introduction of gene technology in NARS will be successful over the long term if it complements existing R&D activities combined with basic research and a plant breeding program. If this integration is not successful, the gap with industrialized countries in biotechnology R&D will continue to grow.
2. The introduction of genetically modified potatoes into the environment of developing countries raises several concerns about potential risks associated with gene flow, horizontal gene transfer, weedy behavior of transgenic potatoes, etc. Several official documents and legislative bodies exist to provide guidance to policy makers who will have to implement regulatory safety legislation in their countries. For example, the safety of introduced transgenic potatoes in Andean countries was discussed recently during a workshop held in a Latin American country (BAC/IICA 1995). Participants indicated that in the absence of regulations gene flow of foreign genes would probably occur among the natural relatives of potato. New interspecific hybrids would be produced and would represent a threat to the genetic diversity and natural evolution of populations of the genus *Solanum* if the transgene conferred significant fitness. The panel recommended the use of male-sterile transgenic potatoes when fitness and hybridization could occur. Although risks will persist, we believe they will not become comparable to other threats to the environment caused by natural climatic changes or humans.
3. CIP and NARS in developing countries should protect their research results, new products and technologies. Many countries have established national policies, agreements on germplasm transfer, and intellectual property rights (IPR) or protection rights on plant varieties to negotiate germplasm exchange with industrialized countries. IARCs have clarified their role on these matters and developed new guidelines which will ensure equitable access to their germplasm. Centers should not claim legal ownership of the germplasm, products, or technologies derived from centers' research, except when it is needed to facilitate technology transfer or prevent others from appropriating it and later restricting access by third parties. The transfer of biotechnology to developing countries has been restrained by the reluctance of private companies, which currently dominate this sector, because of the lack of enforceable laws in some countries and the unrestricted open-door policy of the centers.

CIP has developed agreements with private companies for the benefit of NARS. Already two companies have contributed to the Center's biotechnology research. Plant Genetic Systems of Belgium has provided genes and technologies to improve insect pest resistance using Bt genes. AXIS Genetics of the United Kingdom has provided genes and transgenic potatoes and sweet potatoes using cowpea trypsin inhibitor and snowdrop lectin genes. The results of collaborative research with private companies are freely available for developing countries, provided the recipient will not appropriate them unfairly or seek profit through their commercialization in industrialized countries. CG centers should position themselves at the forefront of biotechnology transfer in developing countries by setting up guidelines to protect mutual interests, private companies' ownership, and their own missions to improve the conditions of developing countries.

Conclusions

Optimizing the potential of the potato for the developing world requires well-focused collaborative research designed to remove the constraints of primary production and utilization. To maximize efficiency, CIP has developed a framework for priority setting that not only ranks constraints in terms of their importance but also indicates the best methodological approaches to be used.

Using late blight research as an example, we have illustrated how we decided that this was our top priority and how we plan to remove this constraint through the development of durable genetic resistance as a component of integrated disease management. Molecular marker technology and genetic engineering are expected to play an important role in this work, as CIP continues to seek efficiency through collaborative work with high-tech laboratories in industrialized countries. In the longer term, NARS capabilities in biotechnology will have to be further developed so that they can become leading partners in this endeavor.

To achieve this, it will be necessary for NARS to integrate, within each country, their molecular work with ongoing traditional activities. They will also need to address risk management related to genetically modified organisms and to ensure that they adequately manage possible difficulties associated with the ever-growing involvement of the private sector in this area.

We expect that these issues will be addressed adequately now that they are being addressed not only at the level of individual IARCs and NARS but also by the CGIAR as a whole.

References

BAC/IICA. 1995. Environmental concerns with transgenic plants in centers of diversity: Potato as a model. Proceedings of a regional workshop, Parque Nacional Iguazú, Argentina.

CIP. 1978. Control of important fungal diseases of potatoes. Planning conference. Lima: International Potato Center.

CIP. 1989. Fungal diseases of the potato. Planning conference. Lima: International Potato Center.

CIP. 1991. Molecular methods for potato improvement. Report of the planning conference on "Application of Molecular Methods to Potato Germplasm Enhancement". Lima: International Potato Center.

CIP/FAO. 1995. Potatoes in the 1990s: Situation and prospects of the world potato economy. Lima/Rome: CIP/FAO.

CIP. 1996. Late blight: A global initiative. Lima: International Potato Center.

Collion, M. H., and P. Gregory. 1993. Priority setting at CIP. An indicative framework for resource allocation. Lima: International Potato Center.

Drenth, A. 1994. Molecular genetics evidence for a new sexually reproducing population of Pi in Europe. Ph.D. thesis. DLO Research Institute for Plant Protection (IPO-DLO), Wageningen, The Netherlands.

French, E. R., and G. R. Mackay. 1996. Enhancing the global late blight network. Report of the Project Design Meeting on the Global Initiative on Late Blight, CIP. Lima: International Potato Center.

Fuglie, K., Ballenger, N., Day, K., Klotz, C., Ollinger, M., Reilly, J., Vasavada, U., and J. Yee. 1996. Agricultural research and development: Public and private investments under alternative markets and institutions. Agricultural Economic Report No. 735. Washington, D.C.: USDA Natural Resources and Environment Division.

Walker, T. S., and C.C. Crissman. 1996. Case studies of the economic impact of CIP-related technology. Lima: International Potato Center.