Generation Challenge Programme
Follow Up on Executive Council and Science Council Inquiries

for

Autumn Meetings of ExCo and SC

Rome, September 2004

The Generation Challenge Programme's (GCP[1]) development goal is to increase food security and improve livelihoods in developing countries by unlocking the genetic potential of crop biodiversity and enhancing the scale, scope and efficiency of using public genetic resources in plant breeding programs through the concerted generation, management, dissemination, and application of comparative biological knowledge. In pursuit of this goal, the Challenge Program will create an integrated platform for dissecting genetic diversity in crop plant genetic resources, identifying important genes to reduce the impacts of environmental and biotic stresses on crop productivity, enhancing yield, and improving nutritional quality of crop products. Beyond this, the Challenge Program will identify, manipulate, and validate gene expression resulting in plants with potential value, productivity and resilience far beyond present-day crops. These plants, through seeds or vegetative propagules, together with the necessary tools and expertise required to effectively track added value traits, will be transferred to national, regional and international breeding programs across the developing world. An important GCP contribution will be to enhance the capacity of NARS scientists to participate in this program.

In various meeting summaries and correspondence leading up to and following the approval of the Generation Challenge Programme inception phase, a number of questions have arisen concerning the founding principles underlying this Challenge Program and the application of those principles in this CP. It is opportune to address these at this time. Please note that many of these have been addressed at an earlier stage by Dr. Masa Iwanaga and in a previous submission to the ExCo. The following points are meant to update and not repeat these earlier submissions.

Value added

The first question to ask of a Challenge Programme is if it is adding value to the system. The following highlights clearly demonstrate that the GCP is enabling, promoting, and supporting an entirely new and higher level of integration and collaboration across the CGIAR and its partners in NARS and Advanced Research Institutions (ARIs). This allows the system to address previously intractable problems in ways that were beyond the scope of the pre-GCP CGIAR. Indeed, the approaches, research agenda, priorities and methodologies are a striking match with the sweeping recommendations made by Dr.

[1] List of acronyms is found in Appendix A, page 15.

Michael Gale in his paper "Applications of Molecular Biology and Genomics to Genetic Enhancement of Crop Tolerant to Abiotic Stress" for the Interim Science Council (SDR/iSC/10 Rev. 1).

In brief:

Mechanism for comparative biology in CGIAR. There is a convincing case that the revolutions in biology, data management, and communications provide tremendous opportunities for solving some of the world's most serious agricultural production and food security issues. From a strictly scientific perspective, it is clear that the major advances in crop improvement will be derived via comparative biology and comparative genomics. The insights afforded by the discovery of broad synteny in genome organization among related species – first illustrated within the cereals – argue that it is more informative and efficient to study genetic variation in sets of related species than to focus on one alone. Moreover, it is increasingly clear that we cannot rely entirely upon model systems and major crops in order to generate a comprehensive understanding of the genetic basis of importance agronomic traits (PNAS 101: 9045-9050). The GCP offers a mechanism to envision and support research programs that cross institutional boundaries and in particular that coordinate their research on a crop group basis. Under a model where support for an individual crop species was simply increased, it would be extremely difficult to develop a program to assess, for example, differences in floral development under water deficit in cereals where four or more CGIAR centers should participate. Similarly, fundamental questions related to the genetics and physiology of adaptation to drought, root architecture, and/or low phosphorus in legumes must be addressed by teams that systemically integrate the work of scientists from several centers, regions, crops and disciplines. By creating a framework in which cross species research can be conducted, the GCP captures the expertise and knowledge specific to individual crops in different centers and incorporates this into a common research program.

Ability to address intractable problems. Drought affects virtually all of the GCIAR mandate crops. A concerted and coordinated research effort is required to identify additional traits, the genetics behind their expression, and the interactions among genes, traits and the environment. The expertise to do this is disbursed among the CGIAR centers, as well as numerous ARIs and NARS. Experience has shown that *ad hoc* funding will not advance the field at the rate the urgency of the need demands. Instead, a structured and strategic program is required to establish the research agenda and execute it. This can only be done via an entity like the GCP.

Benefits to orphan crops. Many crops that are not important in developed countries or not highly valued in global trade risk being left behind by the plant genomics revolution despite their fundamental importance in the diets of hundreds of millions of people in developing countries. The GCP is supporting the basic analysis of the germplasm collections of these crops. The comparative biology approach of the GCP and the public platform it is creating will assure that "orphan" crops will have access to the tools and data that will allow them to move ahead in applying genomics and comparative biology to their improvement programs. It is highly unlikely that without a public program structured like the GCP these crops would continue to fall further and further behind in their capacity to adopt modern approaches to plant breeding.

Capture additional intellectual and financial resources. This framework for multi-institutional research extends to the involvement of ARIs and NARS. A mechanism that is available to a cross institutional program like the GCP, and for all practical purposes unavailable to individual centers, is a competitive grants program. The GCP has initiated such a program as a transparent, merit-based process to attract new and powerful partners to address its research agenda. The strong response from the research community indicates that this will be a successful model. For example, in the 80 pre-proposals submitted in response to the GCP's first call for proposals, over 130 non-consortium institutions were recruited as partners. This represents on the one hand the ability of the GCP to tap into the enormous store of global scientific capacity, and on the other the attractiveness of the GCP's agenda and framework.

Although there was no required specification of in-kind contributions in competitive grant pre-proposal submissions, where there was in-kind specified, the amount averaged over 50% of the requested funding. Since this is mostly salaries, the partnerships created by the GCP are really means by which the CGIAR can procure specialized expertise without incurring long-term commitments. It is noteworthy that institutions typically did not include highly specialized and costly equipment, such as high throughput DNA sequencers, microarray spotters and readers, or mass spectroscopy facilities in their in-kind contributions. Therefore the value of the in-kind contributions is most likely underestimated. Thus, a $5 million competitive grants program will likely translate into at least a $10 million annual focus on this critical research agenda.

Mechanism for development of norms and standards. An important component of the GCP comparative genomics approach is that common procedures for data collection and measurement must be developed. As an independent program, the GCP provides the global forum appropriate to create these common operating procedures. In addition to standard and agreed upon means of data collection, a comparative biology approach demands that data from many experiments be accessible to the broader community. This means that there must be common standards for data capture and storage, as well as assured interoperability among databases and the analytical tools used to query them. The GCP offers the means to develop these standards and to create a global public platform for data access, analysis, and interpretation. It is actively engaged in creating these norms and has taken this to be one of its first major outputs of value to the system as a whole. This reflects a mountain of data that would not otherwise have entered the public domain in a readily accessible and easily compared format.

Leveraging investments in resources and human capital. The creation of this platform requires a major investment in computer hardware, software, and personnel. Broadband internet access allows us to query remote data bases and apply tools hosted on distinct servers. Within the GCP framework much of the investments in hardware, software, and analytical capacity need be made only once through a centralize capacity, rather than replicated across centers. Not only does this represent a massive capital saving for the system but equally important allows the generation of a critical mass of expertise for maintaining and using these facilitates which is far beyond the capacity of most centers to achieve. It is not necessary for every CGIAR center to make a massive investment in bioinformatics if the GCP provides the means to rationalize investments. For example, IRRI invests over $400,000 per year in bioinformatics expertise. The GCP provides the

mechanism to capture and leverage this investment such that it serves the entire community. Similarly, by negotiating favorable terms on cluster computing facilities and associated grid access, the GCP has helped to create a resource that empowers all members of the international agricultural research community. Rather than purchase its own computer cluster, any GCP member or its partner institutions, can simply use its broadband internet access to avail itself of the massive computing power required to undertake comparative genomics analyses.

CGIAR representation in international bioinformatics fora. For the international agricultural research community to fully participate in the genomics revolution, it must have a voice in how international plant genomics data bases and web services are constructed, accessed, and managed. Otherwise the requirements imposed by the needs of our clients and beneficiaries may go unmet. It is not possible for each international center to be represented in the fora where such decisions are made. The specialized expertise would be difficult to justify for each center, and it is unlikely that the fora would welcome that many participants. However, the GCP is already a participant in the Plant Ontology Consortium and contributes to the Gene Ontology Consortium and MOBY-S, the emerging standard for biological web services. By assembling the needs and perspectives of all the CGIAR centers with crop programs, the GCP assures that our needs will be met.

A new model for organizing research: Competitive grants

In the following sections we will be referring to our competitive grants program. It is useful, then, to describe it here. More detail can be found in our call for proposals at www.generationcp.org. A competitive grants program was designed to create opportunities, provide a fair and transparent mechanism to allocate resources, and to overcome old impressions. By inviting proposals that address key areas of our research agenda, we aim to stimulate creative thinking. Having the proposals evaluated by an external panel of internationally recognized scientists gives a degree of credibility that is essential to a program of this nature in which participation of some of the world's best scientists is sought. This process has proved to generate novel approaches and has identified a wealth of new partners. By opening the proposals (indeed, requiring) to partnership we also help dispel the notion that access to the expertise and resources of the CGIAR is available only to a few traditional partners.

The grants process was designed to encourage GCP members to put their best ideas and people forward. This was done by limiting the number of pre-proposal an institution could submit. In some cases we were told that an internal assessment of relative strengths and weakness' in genomics was conducted for the first time. A total of 80 three-page pre-proposals were received. These were reviewed by an external panel of 10 scientists, with each pre-proposal receiving up to three reviews based on a set of criteria that were included in our call for proposals. Twenty five full proposals (10 pages) were invited, based on the rankings from the external panel. These are due at the end of August and will be reviewed by the same panel at GCP headquarters in Mexico in October. We expect to award about half the full proposals, pending full approval of the GCP by the Executive Council in its fall meeting in Rome in September.

The competitive grants process will result in awards of about $4.5 Million. The remainder of our funds will be awarded via a commissioned grants process that will be structured to assure that all of the work envisioned in our MTP is covered. However, to maintain the GCP's transparent quest for high quality science, commissioned grant proposals will also be evaluated by independent reviewers.

Garnering "new" funds

One rationale for the CP concept was that by addressing intractable and globally important problems with new and innovative approaches new resources could be brought into the system. There is every indication that this is happening with the GCP. Indeed, the GCP is already effectively at its projected funding needs for 2005. DFID has made a major increase in its funding to the CGIAR. The reform of the system, epitomized by the Challenge Program concept, no doubt contributed to the willingness of the UK to significantly increase its contribution. This is borne out by the DFID contribution of £2.5 million this year (and presumably subsequent years) to the GCP. Rockefeller Foundation has indicated that it is interested in directing significant funding (possibly reaching $1 million next year) to GCP drought tolerance and molecular germplasm analysis and crop improvement for South Asia and Africa. The Syngenta Foundation and the GCP are discussing how the GCP can participate in targeting and managing a major humanitarian donation by the foundation to support comparative cereals genomics and improvement – one of the mainstays of GCP activities. The GCP and DuPont Pioneer are discussing specific joint research undertakings and Pioneer has agreed to make one or more multi-year fellowships available to the GCP.

Perhaps more import than simple, the GCP is attracting considerable attention in the international advanced scientific community. It is essential for meeting its mandate that the CGIAR be at the leading edge of science. Nowhere is this more important than in the fast moving field of plant genomics – central to the core mission of the CGIAR. Based on the response to its competitive grants program, the GCP is attracting new and powerful partners to the CGIAR mission. These partnerships bring highly skilled scientists with specialized expertise that the CGIAR would not otherwise have at its disposal. The costs of having this expertise, along with the infrastructure that accompanies it, would be prohibitively expensive. In this sense the GCP is attracting new resources beyond what was ever envisioned.

A way of quantifying these new resources for the CGIAR system is in-kind contributions by non-CGIAR institutions. In our competitive grants program this year, in-kind non-CGIAR contributions amount to approximately 50% of the grants requested (that we can project to be roughly $5 million). This is almost exclusively in the form of salaries for senior scientists in ARIs. Thus the CGIAR is capturing essential skills, expertise and knowledge that do not exist in the system without incurring long-term liabilities. Since ARIs rarely, if ever, count the value of their equipment and facilities in the value of their in-kind contributions, the value of these contributions is probably greatly underestimated.

Like salaries, appropriate partnerships in the GCP translate into major savings in equipment purchases by the system

The meeting with USDA ARS referred to aboveshould translate into significant further access to major resources of relevance to all three Challenge Programs and the CGIAR in general.

New partners

One of the first partnership impacts of the GCP has been to foster research partnerships and collaboration among CGIAR centers. By providing support for research projects that complement, yet transcend, the research agendas of individual CGIAR centers, we stimulate collaborative projects based on comparative biology and genomics. CGIAR scientists have told the GCP Director that prior to the GCP they could not realistically attempt the kinds of partnerships – both within the CGIAR and beyond – they are now formulating.

As described earlier, the first round of GCP competitive grant proposals yielded 80 pre-proposals with one hundred forty different non-consortium members included as partners. These institutions included ARIs, NARS, the private sector, NGOs, and Universities in both developed and developing countries. This shows great potential for the kinds of activities supported by the GCP to attract new and diverse partners to the CGIAR research agenda.

The GCP is establishing strong linkages between the CGIAR and the international genomics and bioinformatics communities. In addition to the partnerships already described, strong linkages have been forged with Maize GDB, Gramene, TAIR, Genome Canada, EBI/MyGrid, PlaNet/MIPS, and NCGR.

The Harvest Plus GCP effort to develop a "reaching the end user" strategy and practice will no doubt result in a range of new partnerships with seed companies, food distributors and retailers, other relevant private sector companies, and NGOs.

Governance

The GCP is governed by a Program Advisory Committee (PAC) that is composed of an independent Chairman, one voting member representing each Consortium member, and the GCP Director (*ex officio*). The PAC is advised by a five-member Program Advisory Committee on scientific matters and a 16-member Stakeholders' Committee on program focus, priorities etc. While much of the discussion and decision making are done electronically, there is still need for the various committees to meet face-to-face. However, there may be means to streamline the governance by creating an Executive Committee of the PAC and perhaps reducing the size of the Stakeholders' Committee.

Appropriateness of the competitive process

It is essential that the GCP have a transparent, fair, merit-based and open process to allocate its resources. We believe that in an environment where demand exceeds available resources some kind of refereed competition is the best way to achieve this. Our first round of grant solicitation has gone smoothly thus far. The expectations from the GCP from the proposed projects were communicated with the call for proposals, the process was clearly laid out, the expectations of success were communicated to the participants at the time of the call, the criteria for evaluation were published with the call for proposals, and an external panel was convened to evaluate the pre-proposals and the full proposals.

In our first call for proposals we "cast the net wide"; i.e. we were relatively broad in the areas we invited proposals. This was done intentionally to attract new partners and to stimulate creative thinking. In the future projects funded from this broader competitive process will probably represent a smaller proportion of our portfolio We expect to move towards more "commissioned" work. However, this must still retain a significant transparent competitive dimension. We expect to release calls for bids to undertake certain kinds of fundamental, structural and routine gap filling work that will be critically peer reviewed.

If we deviate from a fair, competitive and peer-reviewed process for allocating resources, the GCP will risk losing its credibility and will fail to fully capture the richness of expertise and imagination that are available in the scientific community.

An unexpected benefit of the competitive grants program was to promote internal institutional analyses of strengths and weaknesses relative to the GCP mandate. In the call for proposals a strict limit was placed on the number of per-proposals that a Consortium member could submit. We were told by several centers that in order to determine which pre-proposals to submit they undertook their first internal analyses of their capacity in crop genomics at an institutional level.

Focus

This Challenge Program will serve as a platform to assemble and use the intricacies of applied genomic sciences for the benefit of crop improvement efforts by NARS and others targeting the world's poorest regions. A major challenge, however, is how to satisfy the needs of a very large set of stakeholders both within and outside the CGIAR. The key feature of the GCP platform will be its applicability to any crop and any trait, thereby ensuring that all 22 CGIAR mandate crops may be supported by the platform. The platform will also be applicable to the Water for Food, Biofortification, and Sub-Saharan Africa Challenge Programs.

Drought was selected as the trait for the GCP to focus on because of its critical importance to resource poor farmers world-wide and its importance for virtually every CGIAR mandate crop. It has been an intractable problem; but, as pointed out in Gale's paper, the tools are now available that will give us the ability to transfer drought tolerance to our major crop species in a reasonable time-frame. Thus, drought remains our focus

Despite the broad applicability of the GCP platform and a clearly identified trait, there is still a need for focusing GCP activities. Even considering the power of comparative genomics and biology, resources must be allocated to only a limited set of crops for primary analysis at any one time. Likewise, crops must be selected so as to benefit the greatest numbers of the resource poor as soon as possible, implying regional considerations in setting research priorities. The predominance of just a few cereal crops in the diets of so many in the developing world is both an opportunity and a challenge. Clearly by focusing on these crops the GCP can be perceived to be targeting the most needy. However, diversified diets off the quickest route to development of healthy and resilient people in resource poor areas. In turn, diversified cropping systems offer both improvement in dietary nutrition and resilience of the of the cropping system to environmental challenges.

The GCP is establishing three processes to establish and maintain its focus and relevance. First, with the support of GFAR we have created a diverse global Stakeholders' Committee comprised of representatives of NARS from the regional fora, NGOs, farmer associations and the private sector. Second, we are exploring the possibility of working with the new CGIAR program on Institutional Learning and Change (ILAC) to establish a learning-oriented monitoring an evaluation system. Third, with IFPRI we will develop crop/region/trait prioritization model within the context of applied crop genomics and improvement. In addition to these GCP prioritization activities we expect to receive guidance from the Science Council as it completes its prioritization exercise.

As we refine our priorities over the next 12 months, we will work within the following guidelines that have remained our pillars throughout the establishment of this program.

Poverty alleviation: The world's greatest absolute numbers of the very poor are in South Asia (SA), the greatest proportion of the population that is poor is in Sub-Saharan Africa (SSA), and a very large zone of stagnant agricultural productivity associated with recalcitrant rural poverty is in Central and West Asia and North Africa (CWANA). While Latin America is relatively wealthier, there are serious pockets of poverty in northeastern Brazil and the Andean Zone into Central America. Thus, our crop x drought focus must first and foremost address these areas of greatest need.

Crop targets: Our comparative biology approach requires us to first arrange our target crops into three broad groups: cereals, legumes, and the Solanaceae. Within the cereals both the availability of scientific tools and poverty alleviation potential indicate that our initial concentration should be on rice (SA), maize (SSA, Andean zone and Central America), and wheat (CWANA). Research on these species will be complementary in that they will generate knowledge of broader applicability. For example, rice will focus on functional genomics, maize on the development of association genetics capacity, and wheat on gene identification taking advantage of global deletion stocks (the advantage of hexaploidy). The legumes are behind the cereals in research, yet investment in *Phaseolus* and cowpea genomics will have important impact for breeding programs targeting SSA, SA, CWANA. Modest and targeted investment in potato should yield insights into

carbohydrate metabolism and starch accumulation that is relevant to cassava, sweet potato, and *Musa*, as well. Since we expect the "orphan crops" to benefit substantially from our investments in the major crops, we will complete the initial characterization of their germplasm collections begun in the GCP inception phase.

Trait targets. As indicated earlier, drought was chosen as the long-term case study because drought affects all of the CGIAR mandate crops, it is the main constraint in the largest poverty stricken areas of the world, and it has resisted resolution using conventional approaches. This effort will be reinforced by the long history of drought research and by current global interest in water conservation. Furthermore, drought and associated water use efficiency emerged as the top priorities in the CGIAR System Priorities (preliminary results as presented by Alain de Janvry at the USAID SOP conference in Davis, California, June, 2004). The interactions of plants with water deficit ("drought") is a complex phenomenon, as are the genetic and physiological strategies by which plants manage water deficit. Thus we will examine a range of traits associated with this broader target. Non-drought related traits – especially those with a shorter time horizon for impact such as disease and pest resistance, food quality, and plant architecture – will be addressed if they contribute substantially to tool and technique development. There is a need for parallel analysis of stress-response. An important aspect of the comparative biology underpinnings of the GCP is to make use of well-characterized systems, not only for bringing near-term results, but for enabling identification and manipulation of "drought tolerance genes". Understanding and predicting the interaction of stress–response traits, either synergistic or antagonistic, is critical to assembling useful combinations for pre-breeding products

We do not underestimate the challenge of going from "gene" to "trait" to "breeding program" to "crop" for a trait such as drought. Therefore we will incorporate a significant modeling component to critically evaluate our assumptions and predict the consequences of various approaches *in silico*. This will present opportunities to understand the interactions of multiple pathways with bearings on whole-plant stress response.

Truly time-bound?

The creation of a public platform to identify and manage genetic resources, the identification of genes conferring drought tolerance to crops, the incorporation of these into crop varieties and the adoption of these by resource–poor farmers are all clearly verifiable outputs. Therefore, the GCP is clearly time-bound in that when these are completed, the tasks of the GCP are completed. More specifically we have laid out near-medium- and long term outputs. These will serve as verifiable measures of our progress to meeting our ultimate goal of drought tolerant varieties of crops growing in farmers' fields and markedly improving the quality of their lives. These intermediate products (detailed in our MTP) will also be of immediate value on their own and will serve to advance other crop improvement programs, as well.

Intellectual property

As part of the development of a Generation Challenge Program Consortium Agreement, we have devoted considerable effort to crafting an IP policy that is consistent with the policies and needs of each Consortium member. We obtained legal advice from internal and external counsel as well as CAS. In addition we have consulted with a large multinational company to determine if our IP policies would permit their participating in GCP activities. Nonetheless, our policies fall squarely within the context of CGIAR IP guidelines and conform to all relevant international treaties. We are confident that we have developed IP policies that allow the GCP to operate without concern that our products could somehow be encumbered from reaching resource poor farmers because of IP restrictions. A copy of our Consortium agreement is available on request and will be posted on our Web site once all members have signed.

Private sector

The private sector holds a wealth of knowledge in crop genomics for model species and several crops important to the GCP (e.g. rice and maize). Freeing this knowledge for use in projects targeting resource poor farmers would no doubt significantly accelerate our progress. The GCP has had discussions with several private sector companies on how to access this information without placing at risk a company's competitive advantage. A first step is the development of clear GCP policies on IP. However, we should not underestimate the difficulties in reconciling the very different objectives of the public and private sectors.

Having said that, we have made concrete progress in involving the private sector in GCP activities:

- As a result of GCP – Pioneer Hybred discussions, several pilot collaborative projects are underway between CIMMYT and Pioneer. These projects are set up to test the possibility of broader private sector participation in GCP.
- Pioneer Hybred has agreed to provide at least one graduate student fellowship per year to the GCP. Each fellowship lasts five years. And, we are in substantive discussions with Pioneer over their providing significant support for our in-depth marker assisted selection training courses.
- Syngenta and the Syngenta Foundation have asked GCP to assist them in establishing their humanitarian effort to provide useful cereals genomics data, software and, possibly, training in their use to African scientists. This will be an attempt to apply cereals comparative genomics information to crop improvement in Africa.
- We have initiated discussions with the Kilimo Trust (Nairobi) to explore the possibility of linking with some of the small entrepreneurial companies they are supporting in East Africa.
- We negotiated very favorable terms for purchase of four computer cluster systems from Paracel Inc. that will serve the entire GCP and ultimately the CGIAR. The terms include access to a global supercomputing grid designed specifically for handling biological data.

When considering the potential for collaboration with the private sector, we should move beyond seeing it only as a source of technology or knowledge. We believe that their experience in delivering their products to farmers in a way that adds value to the farming system is something we can learn and benefit from. Especially intriguing is the emergence of small, entrepreneurial seed companies in Africa. These target niche environments that frequently are home to the very farmers we are targeting. There would appear to be great potential for innovative partnerships with this branch of the private sector.

Transaction costs

Operating any sizeable global program involves some transaction costs. Some of these are inherent in establishing any independent program and include: establishment of a management entity, separate financial and research reporting, preparation of separate medium term and strategic plans, oversight, board, advisory, and stakeholder committee meetings, communications, resource mobilization, and monitoring. The GCP strives to keep these as low as possible by outsourcing when appropriate, combining meetings when possible, and using electronic means of communications. Our current administration consists of a director, a communications officer, a half-time secretary and an intern. Projected total non-research and training costs for 2005 are under 8% of our projected budget. We have found that it is very cost effective to contract out specific time-bound tasks, such as web design and drafting of legal documents, such as our Consortium Agreement.

Other transactions are outside the control of the Challenge Programs. These include multiple and independent reviews by donors, and non-synchronized and heterogeneous reporting requirements, formats, and timetables.

Conducting a global research program involves a number of new activities that demand scientists' time, but are not transaction costs. Such activities include the establishment of norms and standards for genomics experiments, phenotyping, data base structure, management, and access, standard software, and Web services. These would have to be established in any case if the CGIAR centers are to participate in any meaningful way in the next generation of genomics-supported crop improvement. The GCP arguably offers a more efficient, cost-effective, and successful way to do this than ad hoc agreements among a few CGIAR centers. Periodic (typically annual) research progress and planning meetings are probably not transaction costs, though we did include them in our estimates of our management costs above.

We seek to reduce the transaction costs and otherwise maximize use of GCP participants' time by efficient scheduling of meetings and use of various telecommunications tools (conference calls, videoconferencing, remote preparation and presentation of lectures) and Web based information exchange (virtual work space, e-newsletters, e-mail, information rich Web site, including Web postings of meeting outputs etc.). Our research meetings are scheduled around other major international meetings to save on travel time

and costs and/or provide our members the opportunity to take part in an important meeting they might otherwise be unable to attend. (We have scheduled major meetings around the Plant and Animal Genome Conference, the International Crop Sciences Congress, and INTERDROUGHT 2).

In addition we combine Challenge Program activities whenever possible. For example, the three CPs jointly participated in an IP meeting in Rome in June. The GCP participated in a "Reaching End-Users" planning meeting with Harvest Plus and will launch a joint effort in technology delivery and dissemination initially in East Africa and South Asia. Similarly, GCP and Harvest Plus are coordinating their crop improvement and capacity building activities in East Africa with the NEPAD BARC facility in Nairobi. We are also coordinating our interactions with the Private Sector Committee.

We restricted the number of pre-proposals that could be submitted in our competitive grants program. This was done explicitly to be sure that we did not involve excessive staff time in the preparation of pre-proposals with very small likelihood of success.

The GCP is organizing a major planning meeting with USDA Agricultural Research Service for early next year. With all three Challenge Programs participating there will be an orderly process for the CGIAR to establish a coherent and significant research partnership with this major research institution in the areas of crop genomics and improvement, biofortification of food crops, and natural resource and water shed management. Structuring such a partnership would be almost impossible with every center, crop and research theme approaching USDA independently. Thus, in addition to reducing transaction costs, the Challenge Program model opens new opportunities for a higher level of research partnership with major institutions.

Lessons learned

- The response to the call for proposals and the energy with which scientists from different CGIAR centers entered into research partnerships across centers and with ARIs and NARS indicate that there is a very strong untapped potential for developing powerful collaborations in the field of applied comparative crop genomics.
- There is a range of proposal writing skills within the GCIAR and consortium partners. We will need to provide some assistance in basic proposal formulation and writing skills.
- Members of the GCP Consortium have shown flexibility in adapting their institutional policies to fit within the Consortium. This demonstrates the importance these institutions attach to the GCP agenda and mission.
- The NARS partnership requirement of our competitive grants program has been very welcome. The GCP is seen as one way of helping to reinvigorate the historically very strong NARS – CGIAR relationship.

- Based on our first needs assessment meeting, the NARS continue to look to the CGIAR centers as sources of capacity building and knowledge in crucial cutting-edge areas of science related to crop improvement.
- The bioinformatics capacity in the CGIAR system is so low as to preclude any realistic participation of most centers in the plant genomics revolution or even any significant access to the wealth of knowledge being generated by it. The GCP is very well positioned to address and help solve this critical shortcoming.
- The original GCP proposal may not have had adequate mechanisms to obtain input from stakeholders. This has been addressed by the addition of a Stakeholders' Committee.
- The original GCP proposal did not include mechanisms to assure that our products reach end users (resource-poor farmers). We are actively working to establish the linkages in our major target regions to have the means to reach resource-poor farmers when our products become available. The linkages with the Harvest Plus efforts in this area should help develop this capacity within the GCP in a timely manner.
- A globally distributed management team can function effectively with quarterly face-to-face meetings, periodic conference calls and judicious use of other electronic means of communication.
- While laid out as conceptually distinct in the original GCP proposal, the Sub-programs overlap considerably. More importantly there are significant feedback loops among them. This will require more communication among Sub-Program Leaders in the future.
- The IP policies and philosophies of CGIAR centers, universities, and national agricultural research entities in the North and the South are quite diverse. The IP policies incorporated in the GCP are flexible enough to accommodate all member institutions. The GCP IP approach may merit inspection as a possible starting point for a CG system of IP procedures, if such system is warranted.
- Establishing meaningful partnerships with the private sector is probably possible; but, the following points must be recognized: 1) The private sector is very diverse and heterogeneous; 2) Projects will have to be developed case by case (i.e. how effective will a "private sector strategy" be?); 3) Care must be exercised to assure clarity and precision in handling intellectual property that is brought to the GCP as well as the products of research; 4) The private sector has legitimate and very different objectives for operating. These differences should not be minimized.
- Some obvious and key partners were not included in the original GCP consortium. These are: WARDA, India (ICAR), South Africa (CSIR), and Australia (ARIs). Steps have been taken to rectify this situation.
- Since the Generation Challenge Program is a virtual program in most respects, it can be difficult for member scientists to stay abreast of their colleagues' work, as well as GCP workshops, changes in management, funding opportunities, publicity, and other organizational development issues. Providing GCP member scientists with regular, concise updates on GCP activities has proven to be essential. The monthly e-newsletter has been useful in "looping in" scientists and partners alike on the progress of the GCP.

- In efforts to reduce transaction costs, proposals invariably come up to use videoconference tools so colleagues may have virtual face-to-face meetings. Meeting face-to-face, albeit virtually, is always preferred, but in our experience videoconferencing equipment seems prone to failure which wastes time and wears on the patience of the participants. Surely videoconferencing tools will advance enough in the next few years to avoid some of the problems we are having now. But our recommendation is, for the time being, to use the lowest-tech alternative available to ensure that activities run smoothly and on time.
- There is a clear need for institutional contacts for GCP activities. Without a designated representative at each institution, it is easy for requests to fall through the cracks, deadlines to be missed, and important information neglected to be shared. By the end of the Annual Research Meeting in Brisbane, we hope to have identified these institutional "hubs of contact."
- Because the Challenge Programs are forcing changes in the CGIAR and how activities are funded, there was some distrust in the early stages of the first year. Our policy of being as transparent as possible with information and research results appears to be paying off, given the feedback we have received and the buy-in to various activities. Information, policies and explanations are provided in a timely manner on our Web site and e-newsletter, as well as whenever anyone makes a specific inquiry.
- Both the website and the GCP virtual workspace have shown to be integral communication portals, both among member scientists and the general public. But as the program grows and the number of documents and data to be shared, and reports to be both processed and submitted increase, managing these two tools will be a full-time job. e want to avoid logjams of information and ensure that our members can access updated GCP information anywhere, anytime. We have engaged a communications assistant to help with the design, maintenance, and content management of the website and virtual workspace.
- We must consolidate the Web site and virtual work space on one server via a commercial provider with 24-hour, 7-day per week maintenance. Currently, there are too many down periods.

Appendix A: Acronyms Used.

Acronyms and Abbreviations

AGROPOLIS	International Complex for Research and Higher Education in Agriculture (France)
ARI	Advanced research institute
BAC	Bacteria artificial chromosome
BECA	Biosciences facility for East and Central Africa, NEPAD, in ILRI
BioMOBY	Open source biological web services project, "Model Organization Bring Your Own Database"
CAAS	Chinese Academy of Agricultural Sciences
CAS	Central Advisory Service on Intellectual Property
CBR	C-repeat binding factor
cDNA	complementary DNA
CENARGEN	National Center for Genetic Resources and Biotechnology Research, Brazil
CGIAR	Consultative Group on International Agricultural Research
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)
COS	Conserved orthologous sequences
DNA	Deoxyribonucleic acid
DREB	Dehydration responsive element binding
EMBRAPA	Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuaria)
eQTL	Expressed quantitative trait loci
EST	Expressed sequence tag
FAO	Food and Agriculture Organization of the United Nations
Gramene	A comparative mapping resource for grains
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIS	International Crop Information System
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIBAP	International Network for Improvement of Banana and Plantain
IPGRI	International Plant Genetics Resources Institute
IRIS	International Rice Information System
IRRI	International Rice Research Institute
IWIS	International Wheat Information System
JIC	John Innes Centre, UK
LD	Linkage disequilibrium
LIMS	Laboratory information management systems
MAS	Marker-assisted selection
MOBY	See BioMOBY
MOBY-S	See BioMOBY
MTA	Material transfer agreement
MTP	Medium term plan
NARS	National agricultural research system
NEPAD	New Program for African Development
NCGR	National Center for Genome Resources
NGO	Non-governmental organization
NIAS	National Institute of Agrobiological Sciences, Japan
PAC	Program Advisory Committee
PCR	Polymerase chain reaction
PRMT	Program Research Management Team
PSC	Program Steering Committee
QTL	Quantitative trait loci

RFLP	Restriction fragment length polymorphism
RIL	Recombinant inbred line
SGRP	System-wide Genetic Resources Programme
SINGER	System-wide Information Network for Genetic Resources
SME	Small- and medium-sized enterprises
SNP	Single nucleotide polymorphism
SSR	Simple sequence repeat
TRIPS	Trade-Related Aspects of Intellectual Property Rights
USDA	United States Department of Agriculture
WARDA	West African Rice Development Association
WTO	World Trade Organization