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Agriculture -Related Science and Technology Priorities for Poverty Reduction and Sustainable Development in Developing Countries to 2020

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Agriculture -Related Science and Technology Priorities for Poverty Reduction and Sustainable Development in Developing Countries to 2020

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INTRODUCTION

Alleviation of poverty in developing countries depends on four factors: (1) supportive political, social, and economic environments that foster investments in infrastructure, enterprises, markets, and natural resource conservation, (2) sustainable development and income growth, (3) a continued decline in population growth rates such that the human population ultimately stabilizes at about 9-10 billion people by 2050, (4) access to affordable and nutritious food supply. Of these, the CGIAR system of research centers have a comparable advantage in contributing to sustainable development and income growth by ensuring adequate food production in systems that conserve natural resources and protect environmental quality. To make such contributions requires a tight focus on an appropriate mix of basic and applied research and research capacity development in the national agricultural research systems (NARS[1]) to address issues confronting agricultural productivity and natural resource conservation in developing countries.

Despite considerable progress in establishing agricultural research capacity in the NARS since the CG Centers were established 35 years ago, current NARS investments have been decreasing in real dollars for the past decade. Moreover, existing NARS capacity is not sufficient to address the increasingly complex ecological challenges embodied in the quest for food security and natural resource protection. Given this situation, the need has never been greater for the CG system to help focus international scientific expertise on key scientific issues and to serve a catalytic role for enhancing scientific capacity in the NARS. Increasingly limited resources, however, require a tight focus on highest priority areas, which in turn depend on identification of the key scientific issues and technology needs to address constraints in the major agroecological zones, cropping systems, crop species, and environmental concerns. Despite donor demand for verifiable impact, the CG system must also avo id becoming a development agency because other institutions have a comparative advantage in this arena.

Given this vision for the general scope and focus of CG efforts, the following sections will first discuss underpinning assumptions about agricultural productivity and its relationship to poverty, food security, natural resource conservation, and environmental quality, followed by a discussion of key research issues for which the CG system has a comparative advantage. A final section briefly considers operational modes and mechanisms to achieve CG goals.

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[1] For the purpose of this discussion, NARS are broadly defined to include public-sector research institutions as well as research capacity in the private sector and in non-governmental organizations (NGOs).

UNDERPINNING ASSUMPTIONS

The economic status and health of urban and rural poor in developing countries are especially sensitive to the cost of food, which typically consumes more than 50% of their disposable income. One of the greatest achievements of the green revolution was to sustain rates of gain in cereal production that exceeded demand from population growth such that staple food costs decreased steadily. The increased cereal production resulted largely from achieving greater yields on existing cultivated land in favorable environments, which minimized the need to expand agriculture into natural ecosystems with the associated loss of biodiversity and environmental services.

Achieving further reductions in poverty and hunger while protecting natural resources for future generations will depend on sustaining rates of gain in cereal yields on existing cultivated land (Cassman, 1999; Tilman et al., 2002). If rates of gain falter such that cereal prices increase, the prognosis for poverty alleviation and natural resource conservation in developing countries becomes very dim. Hence, priorities of the CG system depend on the magnitude of the scientific challenge associated with sustaining yield gains of major cereal production systems in developing countries. If the magnitude of this challenge exceeds current levels of research investment to overcome it, then the CG System must devote more resources towards sustaining productivity increases of major cereal production systems in an environmentally sound manner. If current research investment towards these objectives are adequate or excessive, resources should be directed towards diversifying and stabilizing production systems in less favorable environments where intensive cereal production is not feasible—such as slash and burn systems in the humid tropics and subsistence cropping systems on poor soils in water-limited environments.

Trends of research investment in the CG system during the past decade have clearly been based on the latter view because there has been a significant shift of funding towards improving production systems in less favorable environments and a concomitant shift away from maize, rice, and wheat systems in high potential agroecosystems. Justification for this shift is based largely on projections from econometric models that provide scenarios of food supply capacity and demand as driven by income and population. One such model is IMPACT, developed by economists at IFPRI. This model is widely used in the CG system to help prioritize the research agenda (Rosegrant et al, 1995; Rosegrant et al., 2001). Given the substantial influence of this model on the CG research portfolio, and also on donor priorities, the model projections and underpinning assumptions deserve critical analysis.

The assumptions with the greatest influence on food supply-demand projections to 2020 from the IMPACT model are:

- Rates of economic development and population growth in developing countries.
- Maintaining an exploitable gap between genetic yield potential and average farm yields in the major cereal cropping systems.
- The rate of return from investment in agricultural research going forward will be equivalent to the rates of return on such investment in the past 20-35 years (in terms of productivity gains at the farm level per dollar invested in research).

- Expansion of cultivated area is limited primarily by the cost-benefit of expansion, which largely depends on trends in commodity prices; a related assumption is that there is a large reserve of uncultivated land suitable for cropping in a sustainable fashion.
- There is no provision for a substantial increase in demand for grain in the production of renewable energy (eg ethanol from maize and sorghum) or as industrial feedstocks for bio-based products.

Suffice it to say that there are significant uncertainties embodied in each of these assumptions. In particular, there are substantial differences of opinion surrounding the assumptions concerning yield gaps, research rate of return, and the availability of land reserves for agricultural expansion (Cassman et al., 2003). A modest change in any one of these assumptions has a substantial influence on IMPACT projections, and also on the implications for CG system research investment. For example, the new Energy Bill in the USA will promote renewable energy sources with an emphasis on bio-based energy replacement of fossil fuels. Hence, it is likely that 10% of total North American maize production, which represents 42% of global maize output, will be diverted to ethanol production within 10-15 years. Likewise, genetic engineering of industrially useful traits and improvements in chemical engineering processes to 'refine' bio-based products into raw materials for industrial use and manufacturing will provide increasing incentives to divert grain and biomass from agriculture to non-food and livestock feed uses. What if non-food or feed uses of grain eventually consume 10-15% of the global grain supply?

CGIAR PRIORITIES AND COMPARATIVE ADVANTAGE

Briefly, I believe that the magnitude of the scientific challenge of sustaining increases in yields of the major cereals in high potential systems while meeting environmental standards with regard to water quality, greenhouse gas emissions, and protecting soil quality has been grossly underestimated. IRRI's effort on creating a new plant type rice with 25-50% greater yield potential is a case in point—after 12 years and many millions of dollars invested, it will be a major breakthrough if IRRI scientists can achieve a 5-10% increase in yield potential because the challenge of raising rice yield potential is much greater than anticipated. None-the-less, it remains a priority of critical importance because yields in many of the most productive rice-producing areas in southeast and eastern Asia are stagnating as average farm yields approach 80% of the yield potential ceiling (Fig. 1, from Cassman et al., 2003). A similar case can be made for wheat (Fig. 2, from Cassman et al, 2003) and maize in high potential systems.

Given the potential difficulty in sustaining yield advances in the most productive cereal cropping systems, I believe there has been too great a shift in CG priorities towards low-input cropping systems in less favorable environments. Moreover, there seems to be a bias in the CG agenda towards 'silver bullet' solutions, typically based on genetic improvement, to alleviate complex abiotic constraints such as drought and nitrogen use efficiency in these less favorable production environments. Improved resource management, such as conservation tillage or even no-till systems and judicious use of inputs based on synchronizing nutrient availability with crop demand, have a much greater potential for impact. I would argue that the CG system will need to devote more resources towards research on developing appropriate technologies related to conservation tillage and nutrient management for small-farm situations in developing countries.

In summary, I would make the following points with regard to strategy, priorities, and operational modes of the CG system:

Strategy

- Conduct a critical analysis of the key underpinning assumptions in the IMPACT model, especially with regard to rate of return on research investment, yield potential and yield gaps, and available land reserves, to strengthen reliability of projected scenarios and explore a wider range of scenarios.
- Assess the relative investment by the CG system in high potential systems located in environments well-endowed with natural resources for crop production versus investments in crops and cropping systems for less favorable environments.
- Over the past 13 years, the CGIAR system has made substantial investments in building research capacity in molecular genetics and biotechnology in both the Centers and in the NARS. It is now time to make a careful assessment of specific impact from these CG investments with a focus on the contribution of these investments towards alleviation of poverty, conservation of natural resources, and economic development targeting the urban and rural poor in developing countries. From this assessment, there is a need to establish a sound conceptual framework to guide further investments in this area (see Denison, 2003 for such a framework).
- Identify 'winner' technologies that have a high probability of success and substantial impact within a 5-year time frame, and invest adequately in seeing them through—from basic scientific understanding to practical technologies, to partnerships with development agencies for implementation and impact assessment. Examples might include conservation tillage systems, improved nutrient management practices that increase yields and profit while reducing environmental concerns, and a number of other high-probability/high impact technologies. Leverage these success stories to gain greater donor support and buy-in for CG programs.

Priority Areas for Global Research Leadership in the CG Portfolio

- Increase crop yield potential through investment in research on physiological understanding of yield formation processes and net primary productivity, coupled with efforts on genetic improvement using conventional and molecular tools. Note that the CG system has a comparative advantage in this area because it is largely ignored by the private sector and also by advanced public-sector research institutions.
- Understand the biophysical and economic benefits derived from conservation tillage in small-scale farming systems to conserve soil moisture and improve soil quality in cereal production systems—especially in water-limited environments, as well as the economic challenges and constraints to adoption. Here again, the CG system has a comparative advantage because this topic is largely ignored by the private sector and also by advanced public-sector research institutions.
- Increase nutrient use efficiency through improved understanding of crop nutrient requirements and soil nutrient supply dynamics in time and space, which allows

development of improved management practices that respond to field-specific variation and environmental conditions in small-farm production systems.

- Partner with NARS to assess the quality and extent of land and water resources available for agriculture, understand causes of trends in the quality and availability of these resources for future agricultural production, and use this information to help guide land-use planning and economic development planning in developing countries.
- Systems analysis, simulation, and geospatial analytical tools should be foundational components of all applied and adaptive research to ensure the widest possible extrapolation and to increase research efficiency.
- Germplasm conservation for the major mandate crops and the development of improved varieties for crops and cropping systems for which NARS capacity is not adequate to produce improved germplasm. Both conventional and molecular approaches should be used as required to achieve the specific objectives for each of the mandate crops.
- Improve basic understanding of pest-crop interactions as the basis for developing appropriate integrated pest management systems that minimize the use of pesticides and adequately protect against yield losses.

Operational Modes

- Allow individual senior scientists to be more entrepreneurial in the acquisition of external funding from donors so long as the objectives of the grants obtained are consistent with the mission and strategy as defined in the Strategic Plan and Mid-Term Planning documents.
- Eliminate weak Centers or merge Centers where efficiencies and programs permit.

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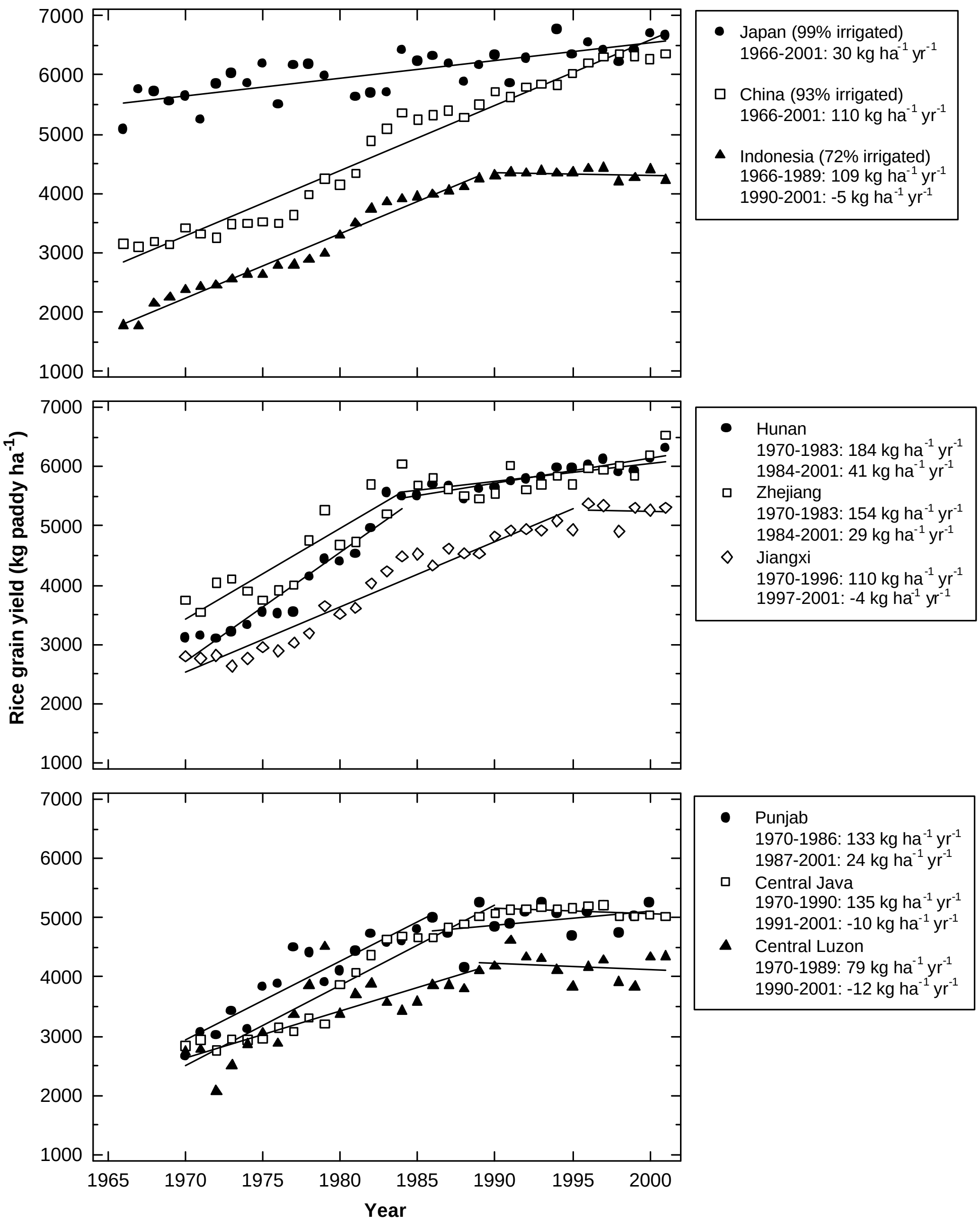

Figure 1. Yield trends in major rice producing countries and provinces where there is evidence of stagnation in the rate of gain in average rice yields. Country data obtained from FAOSTAT. Province data were based on national agricultural statistics provided by D. Dawe, Social Sciences Division, IRRI. Note that yield data for China refer to official statistics. Actual yields are likely to be lower because of the apparent underestimation of crop harvest area in China. From Cassman et al., 2003.

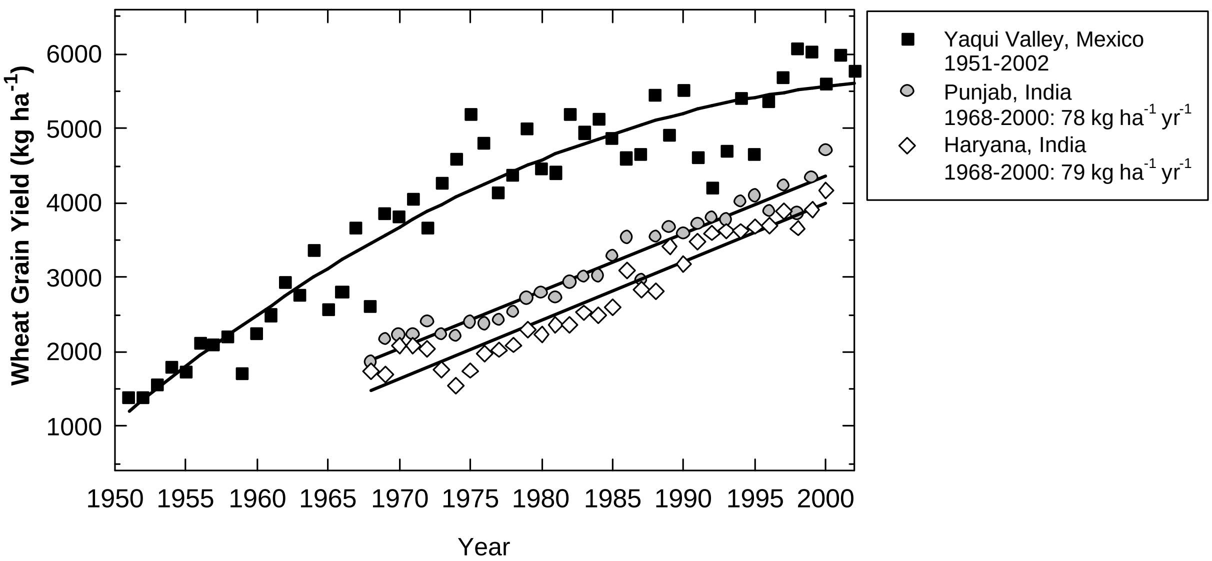

Figure 2. Yield trends of wheat in the Yaqui Valley of Mexico and major wheat-producing provinces in India. Data for the Yaqui Valley were provided by K. Sayre, CIMMYT, while data for the Indian provinces were provided by Derek Byerlee, World Bank. From Cassman et al., 2003.