Review

Plant Biotechnology, 16(1), 1–6 (1999)

The Global Situation of Population, Land Use and Food Production

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Several scenarios of rapid population increase in developing countries are indicating that the world population would reach 8 billion in 2025 and 10 billion in 2050. To feed this ever-increasing population, existing agricultural land is likely to be subjected to a higher intensity of cultivation in populous areas, and farmland development will be extended to areas only marginally suited for agriculture. These practices will further accelerate farmland degradation and desertification on a global scale.

In order to overcome the global scale problems, Consultative Group on International Agricultural Research (CGIAR) was established in 1971. The mission of the CGIAR is to contribute through its research to promoting sustainable agriculture for food security in developing countries.

Japanese Government has established of The Japan International Research Center for Agricultural Sciences (JIRCAS) in 1993 in order to contribute to the global food security through agricultural research and technology. The mission and activities of CGIAR and JIRCAS are described.

1. Introduction

There are several scenarios concerning food supply to keep pace with the rapid growth of the human population. In this paper, the author will first review the problems related to global population increase, land use for agricultural purposes and food production. In the second part, the author will outline how the international agricultural research communities and Japanese agricultural research groups are dealing with these serious problems through scientific research. The mission and activity of the Consultative Group on International Agricultural Research (CGIAR), and of the newly established research center—Japan International Research Center for Agricultural Sciences (JIRCAS)—will be described.

2. Situation of global population increase, land use and food production

Several scenarios on rapid population increase in developing countries predict that the world population will reach 8 billions in 2025 and 10 billions in 2050. Ismail Serageldin [1], Chairman of CGIAR stated "We already have 840 million people going hungry and 3 billion who are malnourished and we are going to have 2 billion additional people on the planet in developing countries before the population becomes stabilized". The ratio of population in developing countries and developed countries in 1950 was 67/33. This ratio in 1995 had changed to 78/22 and it is expected to reach 83/17 in 2025 as shown in **Fig. 1**.

The rapid increase of the population particularly in developing countries will lead to serious problems for sustainable food supply on a global basis. The population and food production loop described by Gordon Conway [2] explains the various factors involved in population increase and food production (**Fig. 2**).

On the other hand, crop productivity drastically increased due to the progress made in agricultural technologies. World crop supply in 1961 was approximately 800 million tons and it doubled to 1.8 billion tons in 1991 (**Fig. 3**), although the area of land used for crop production remained at roughly 6.9 million ha. without drastic change. The drastic increase of productivity was mainly achieved by the so-called Green Revolution in the late 1960s to 1970s. The technological innovations in agricultural research increased the productivity of crops, particularly rice and wheat through the introduction of a high input of agricultural chemicals, chemical fertilizers, new cultivars of crops and expansion of irrigated area. However, the rate of crop productivity during this period decreased. For example, annual increase of productivity which was 2.3% during the period 1950 to 1984, decreased to 1.8% during the period 1980 to 1994 and has further dropped to 0.5% since 1990 whereas the annual population increase reached the level of 1.5%.

The decrease in the rate of productivity is a major concern since it may result in future food shortage. The problems associated with the increase of food production are different in developing and developed countries. The main constraints faced by the developing countries are the limitation of agricultural land expansion, desertification of arable land and grassland by drought, excessive cultivation and overgrazing. On the other hand, in the developed countries, the difficulty to achieve an increase in crop productivity is based on the changes in people's attitude to maintain sustainable food production. This is due to the concern about environmental degradation caused by excessive application of agricultural chemicals and chemical fertilizers. In addition, there is a shortage of water for

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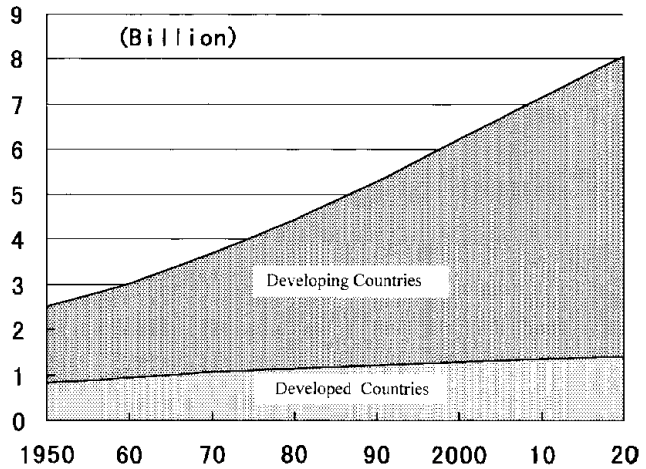

Fig. 1 Projection of World Population Increase (United Nations, World Population Prospects, the 1992 Revision).

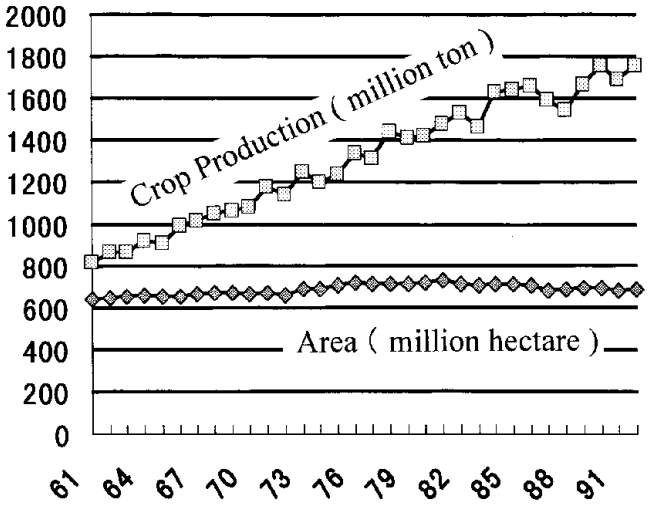

Fig. 3 Changes in World Crop Production and Production Area under Cultivation (Foreign Agricultural Service, USDA).

agricultural use.

Other demands for achieving higher crop production are related to the changes in the food habits particularly in developing countries due to the increase of income. Many statistics indicate that the food constituents are shifting from plant foodstuffs to animal foodstuffs along with the increase of family income, which implies that feed grains are converted to animal meat with a lower efficiency. The conversion of grains into animal meat depends on the feeding systems such as those based on grains or grasses. As shown in **Fig. 4**, India, Australia and China where the feeding systems are based on grasses show a relatively high conversion rate of 0.45 to 0.8. In contrast, U.S.A. Russia and Japan where the feeding systems are based mainly on grains showed a very low conversion rate of less than 0.2.

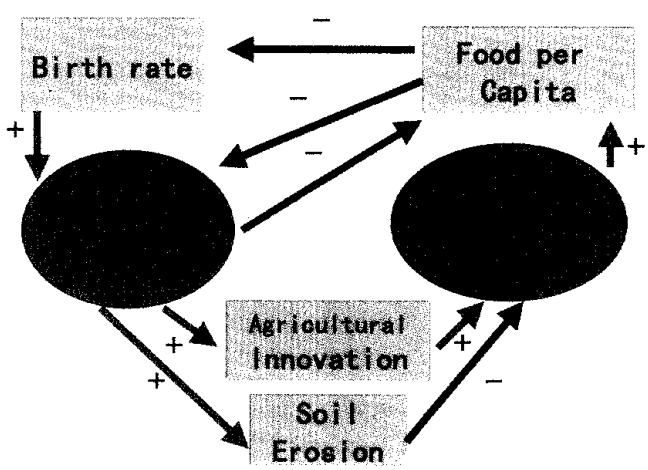

Fig. 2 Feed Back Loops indicating possible linkages between population size and Food Production described by Gordon Conway. To interpret the diagram note the direction of the arrow and the sign: soil erosion negatively affects food production—the more the erosion the less the food production, and conversely the less the erosion the more the production; agricultural innovation, however, positively affects food production—the more the innovation the more the production, and conversely the less the innovation the less the production.

New Zealand shows the highest conversion rate of 3.0.

To feed this ever-increasing population, existing agricultural land is likely to be subjected to a higher intensity of cultivation in highly populated areas, and farmland development will be extended to areas only marginally suited to agriculture. These practices will further accelerate farmland degradation and desertification on a global scale. According to UNEP statistics of 1994, roughly 6 million ha of agricultural lands undergo degradation each year, including 3.2 million ha of grasslands out of 3,700 million ha, 2.5 million ha of rainfed agricultural lands out of 570 million ha and 0.13 million ha out of 131 million ha of irrigated agricultural lands, with eventual progression to desertification.

In order to address the problems of population increase, land use and degradation and food production, and in view of the need for the developing countries to promote agricultural, forestry and fisheries activities compatible with the preservation of the environment, inter-

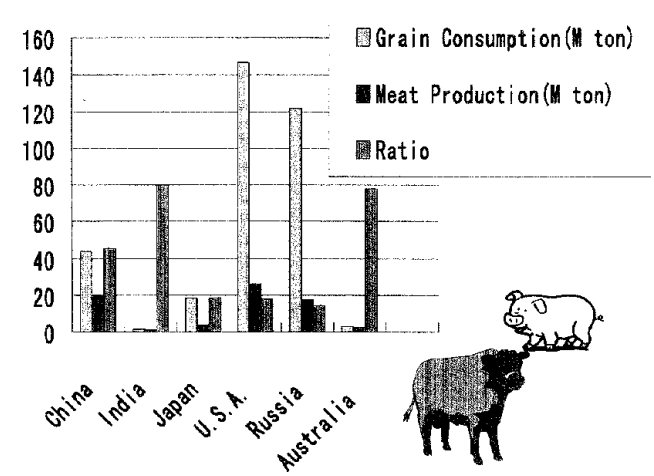

Fig. 4 Grain Consumption (million ton) and Meat Production (million ton) in various Countries. Ratios of Conversion between Grain Consumption and Meat production are also indicated.

national cooperation is of paramount importance for mankind.

3. Global system for international agricultural research —Consultative Group on International Agricultural Research (CGIAR)—

In order to overcome the global food shortage, the Consultative Group on International Agricultural Research (CGIAR) was established in 1971. CGIAR is an informal association of 4 co-sponsors-World Bank, UNDP, UNEP, FAO and 54 members from the public and private sectors from developing (South) and developed (North) countries that supports a network of 16 international agricultural research centers (**Fig. 4**) covering agriculture, forestry and fisheries, which are located all over the world. The mission of the CGIAR is to contribute through research activities to the promotion of sustainable agriculture for food security in developing countries through close collaboration with all the segments of an emerging global agriculture research system.

The vision of the CGIAR is a world in which agricultural research exerts a positive impact on food security, income and employment generation, conservation of natural resources and environment. The CGIAR is convinced that new, science-based agricultural technologies could be effective in the fight against hunger and poverty. In the past, the CGIAR contributed a great deal to food security in developing countries. The International Rice Research Institute (IRRI) in the Philippines developed a high-yielding rice cultivar IR-8 and the International Wheat and Maize Improvement Center—Centro Internacional de Mejoramiento de Maize y Trigo (CIMMYT)—in Mexico also developed high-yielding wheat cultivars to increase productivity. These major achievements of the CGIAR Centers had enabled to prevent chronic food shortage in the developing world during the 1960–1970 period under the name of "Green Revolution".

Recently, the CGIAR has been focusing its research thrusts on the following five major areas over the next twenty years [3].

1. Improving Productivity—The CGIAR strives to increase the productivity of agriculture in the developing countries through genetic improvement in plants, livestock, fish and trees through better management practices. One important feature of the CGIAR's breeding research is its focus on developing plants with greater resistance to insects and diseases that adversely affect productivity and the stability of production in the tropics.

2. Protecting the Environment—Conserving natural resources, especially soil and water, and reducing any impact of agriculture on the surrounding environment, are an essential, and growing part of the CGIAR's efforts. The CGIAR plays a leading role in developing new research methods to identify long-term trends in major agricultural environments, and in developing solutions to urgent environmental problems.

3. Saving Biodiversity—The CGIAR holds in trust for the future one of the world's largest collection of ex situ genetic resources, with more than 600,000 accessions of approximately 3,000 crop, forage and pasture species. Duplicates of these materials are freely available to researchers around the world so that new gene combinations can alleviate current problems. The CGIAR has placed its collections under the auspices of FAO as part of an international network of ex situ collections.

4. Improving Policies—Agricultural producers are markedly influenced by public policies. The CGIAR's policy research aims to help streamline and improve policies that strongly affect the spread of new technologies and the management and use of natural resources.

Table 1 JIRCAS unidisciplinary research collaboration projects

	Project title	Research site
1	Biorational approaches to long term and sustainable management of desert locusts in East and Northeast Africa	Kenya
2	Development of technology for sustainable management of grasslands in Central Asia	Republic of Kazakhstan
3	Afforestation technology for useful tropical tree species and the development of related research	Philippines
4	Development of diagnosis and prevention technology for shrimp viral diseases	Malaysia
5	Development for effective water management in Paddy fields in the dry season	Sri Lanka (IWMI)*
6	The role of local people in the degradation and rehabilitation of tropical forests	Indonesia (ICRAF)*
7	Rehabilitation of secondary degraded forest	Malaysia
8	Improvement of high-yielding wheat varieties through biological procedure	Mexico (CIMMYT)*
9	Development of technology for water distribution management for large scale paddy fields in tropical monsoon area	Malaysia

* Abbreviation of CGIAR Centers: IWMI, International Water Management Institute; ICRAF, International Centre for Research in Agroforestry; CIMMYT, International Center for the Improvement of Maize and Whea.

5. Strengthening National Programs—The CGIAR is committed to strengthening national agricultural research in developing countries through the development of working relationships with colleagues in national programs, upgrading of skills in research administration and management, and organization of formal training programs for the research staff.

Research is the means by which the world's knowledge of agriculture can be increased and new agricultural technologies are created. The CGIAR Centers are conducting research to improve plants and crops by the development of new technology to obtain environmentally friendly disease and pest resistance, and plants resistant or tolerant to drought, salinity and low temperature.

The Doubly Green Revolution is proceeding in the CGIAR Centers to obtain environmentally friendly higher-yielding crops by the combination of conventional breeding technologies with newly developed biotechnology.

Fig. 5 Names and Locations of 16 CGIAR Centers.

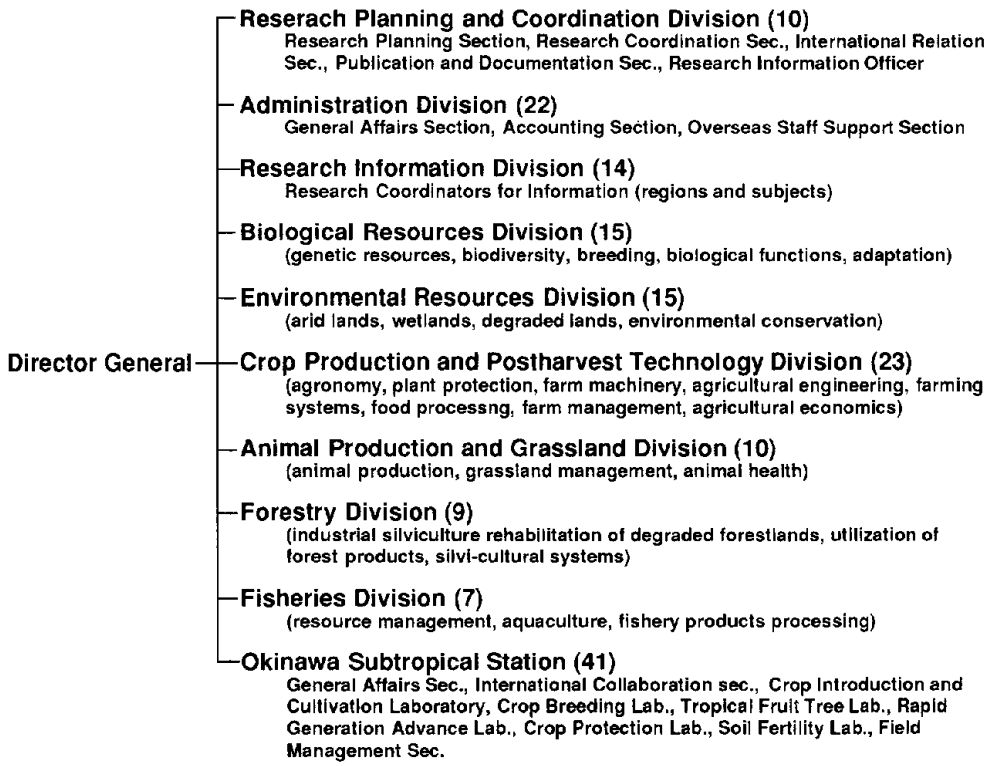

Fig. 6 Research and Management Organization of JIRCAS.

4. Establishment of Japan International Research Center for Agricultural Sciences (JIRCAS)

Great expectations have been placed on the role of Japan in the solution of global food security since Japan has become one of the major contributors of the official development aid (ODA). In order to respond to the demands from the global agricultural research community, the Ministry of Agriculture, Forestry and Fisheries (MAFF), has established a new research center—Japan International Research Center for Agricultural Sciences (JIRCAS)—by restructuring the existing research organization—Tropical Agricultural Research Center (TARC) in October 1993. JIRCAS is a research center engaged in international research collaboration, particularly with developing countries. TARC, predecessor of JIRCAS, had placed emphasis on the solution of individual problems for the stabilization and improvement of

Table 2 JIRCAS comprehensive research collaboration projects

	Project title	Research site
1	Evaluation and improvement of farming systems combining agriculture, animal husbandry, and fisheries in the Mekong Delta	Vietnam
2	Productivity and sustainable utilization of tropical and subtropical brackish water ecosystem	Malaysia
3	Development of sustainable agricultural technology in Northeast Thailand	Thailand
4	Comprehensive studies on the development of a sustainable agro-pastoral system in the sub-tropical zone of Brazil	Brazil (CIAT)*
5	Development of sustainable production and utilization of major food resources in China	People's Republic of China
6	Comprehensive soybean research project in South America (Multinational)	Paraguay, Brazil, Argentina
7	Evaluation and improvement of regional farming systems in Indonesia	Indonesia
8	Improving food security in West Africa through increased productivity in rainfed rice system	Cote d'Ivoire (WARDA)*

* Abbreviation of CGIAR Centers: CIAT, International Center for Tropical Agriculture; WARDA, West Africa Rice Development Association.

Table 3 Examples of basic research projects conducted at Tsukuba Campus and Okinawa Subtropical Station (In-house research)

1	Modeling food demand and supply in Shandong, China
2	Improving plant tolerance to environmental stress by gene transfer
3	Using neural networks to assess vegetation stability
4	Developing evaluation methods to quantify mechanical properties of collapsible soils
5	Search for endophytes from tropical grasses
6	Enzyme activity of early maturing high sugar content sugarcane stalk
7	Evaluating mungbean cultivars for resistance to iron deficiency

agriculture, forestry and fisheries production in the tropical and subtropical countries. Although these problems remain important, JIRCAS shifted its orientation to deal with problems on a global scale, and on comprehensive agricultural systems of a country including the preservation of the environment, conservation of genetic resources and maintenance of biodiversity, etc.

Organization of JIRCAS depicted in **Fig. 6** shows that JIRCAS covers all research areas of agriculture, forestry and fisheries as natural sciences and also carries out socio-economic studies. The research projects implemented by JIRCAS in collaboration with the CGIAR Centers and developing countries are listed in **Tables 1 and 2**. There are two types of research, one aims at solving specific individual problems and the other aims at solving much wider, comprehensive problems covering various research areas. JIRCAS dispatches each year approximately 30 scientists on a long-term basis to conduct collaborative research at the CGIAR Centers and national agricultural research systems in countries located in Asia, Africa, Central and South America. Besides the collaborative research on a long-term basis, JIRCAS also dispatches scientists to various countries to conduct research on a short-term basis.

JIRCAS conducts in-house research at its Tsukuba Campus as well as at the Okinawa Subtropical Station by inviting foreign visiting scientists for collaborative studies (**Table 3**). These fundamental studies are closely related to the problems faced by developing countries.

Now, JIRCAS has acquired a high reputation from the international agricultural research community for its contribution to collaborative research to solve the problems in the developing world.

5. Global efforts to seek possible solutions

Food security is becoming a global issue to be solved by the collaboration between the developed and developing countries.

In March 1998, a Workshop of the OECD Megascience Forum was held in Sweden to discuss issues on a global scale. They selected Land Use and Food Production, Biodiversity and Ocean as case studies. The outcome of the workshop will be presented to policy makers of each country as a message from the scientific community to policy makers.

Recently, the Japan Science Foundation has recommended the implementation of "A new scheme for international research collaboration to solve issues on a global scale" to the Science and Technology Council of Japan. In both cases, the development of new technology in plant and crop science will be a key issue to overcome the expected future food shortage. Plant biotechnology is considered to be one of the most promising, environmentally friendly technologies for global food security.

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[2] Conway, G., 1997. The Doubly Green Revolution, Penguin Books.
[3] Annual Report, 1995-1996. Consultative Group on International Agricultural Research (CGIAR).
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