CGIAR NEWS

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

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Phenomenal Increase in Maize Production

in West and Central Africa

A phenomenal increase in maize production has occurred in West and Central Africa in recent years. It is the result of the introduction of high-yielding, drought-tolerant, early, and extra-early maturing varieties coupled with the combined activities of a collaborative network of scientists in the region. The introduced varieties have a yield potential of 5 tons per hectare, and are ready for harvest as green maize (eaten boiled or roasted) in 60 days, or as dry grains in only 75 to 80 days. Ordinarily, the maize crop matures in about 120 days.

The average annual growth rate of maize production in the region for the period 1983-1992 was 4.1 percent. The comparable figure for Eastern and Southern Africa for the same period was 0.9 percent, or less than a fourth of the growth rate in West and Central Africa. Some countries recorded extremely high annual growth rates: Burkina Faso (17.1 percent), Ghana (8.3 percent), Guinea (7.6 percent), and Mali (7.5 percent).

The land area devoted to maize production has also increased significantly (an average of 2.7 percent per year for the region). Much higher expansion rates were reported for several countries: Guinea (9.4 percent),

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West Asia and North Africa: A Regional Vision

by Adel El-Beltagy

Upon invitation of the Egyptian government, the CGIAR will hold its Mid-Term Meeting 1997 (MTM97) from May 26 - 30 in Cairo. It will coincide with the inauguration of the new ICLARM facilities at Abassa, Egypt, and the 20th anniversary of ICARDA based in Aleppo, Syria. The CGIAR meeting will be hosted by the Ministry of Agriculture and Land Reclamation in association with the Agricultural Research Center (ARC). In this context, CGIAR News is pleased to present this overview of regional aspects of agricultural development, by Adel El-Beltagy, Director General, International Center for Agricultural Research in the Dry Areas (ICARDA).

The West Asia North Africa (WANA) region, with Morocco in the west, Pakistan and Afghanistan in the east, Turkey in the north, and Ethiopia and Sudan in the south, is characterized by high population growth, low and erratic rainfall, limited arable land, and severely limited water resources. There are very few possibilities for expansion of farming areas or irrigation. Methods for more efficient and sustainable use of these limited resources must be found.

Poverty, Agricultural Employment and Migration

Poverty in many WANA countries is masked by averaging the poor with the

Continued on page 12

(ICARDA)

How Efficient Are Modern Cereal Cultivars?

Modern cereal varieties, as is well known, are more productive and exhibit greater yield stability than earlier varieties and landraces. Since the cultivation of modern varieties is usually combined with the application of mineral fertilizers it is legitimate to ask how much of the increased productivity is due to higher fertilizer inputs.

When plant breeders showcase yield increases achieved by their recent releases over older materials, they often fail to mention the respective levels of fertilizer applied. Conversely., when fertilizer experts show the correlation between cereal yields and fertilizer input over time, they often fail to indicate which cereal varieties their time series relates to. When environmental activists discuss the historic Green Revolution and related phenomena, they occasionally criticize the alleged fertilizer dependence of modern varieties as proof that a mere conversion of precious fossil energy to food (or feed) calories is taking place, suggesting some sort of an environmental zero sum game.

CIMMYT has recently published interesting data on the relationship of land and fertilizer input in the production function of old and modern wheat varieties (Fig. 1). Varieties typical of the 1950s, 1960s, 1970s and 1980s were compared to show how their respective yields changed with variations in land and fertilizer inputs.

To show the changes in the efficiency of input utilization CIMMYT chose a production function which takes output as fixed; in the case of Fig. 1 five tons of wheat. The functions show which combinations of area and fertilizer are needed to produce 5 tons of wheat with the respective cultivar.

The comparison is illuminating. It indicates that the traditional tall wheat of the 1950s needed 2.5 hectares of land in the absence of fertilizer to produce the 5 tons of wheat whereas the 1980s semidwarf wheats needed only 1.5 hectares, also without fertilizer.

It is hence not true—as sometimes claimed—that modern wheats cannot perform well in the absence of fertilizer. Even without this input they are more productive than the old tall varieties. In addition, they are also more productive than earlier "Green Revolution" semidwarf wheats. Decade after decade, CIMMYT wheats use less land and less fertilizer to produce the same level of output.

CIMMYT's data also show, for instance, that producing 5 tons of wheat on 1 hectare

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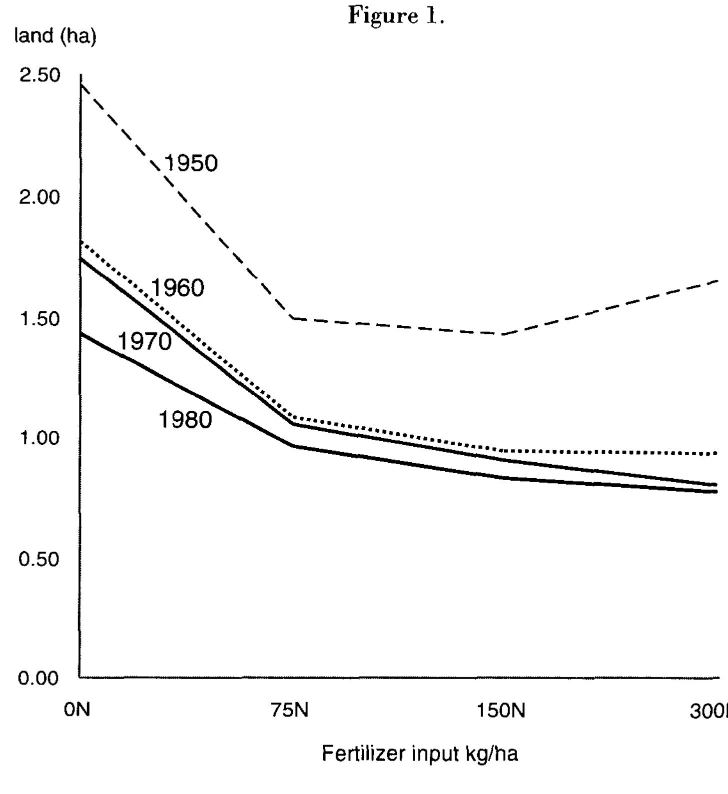
Figure 1.



(Continued from page 2)

Modern Cereal Cultivars

of land was impossible with the 1950s varieties, no matter how much fertilizer was applied. With the 1960s cultivars 110kg of fertilizer was needed to obtain 5 tons of wheat; with the 1970s varieties the fertilizer requirement had slightly dropped to 100kg while the 1980s varieties met the output target with only 70 kg of fertilizer input, always on 1 hectare of land. Certainly no zero sum game.

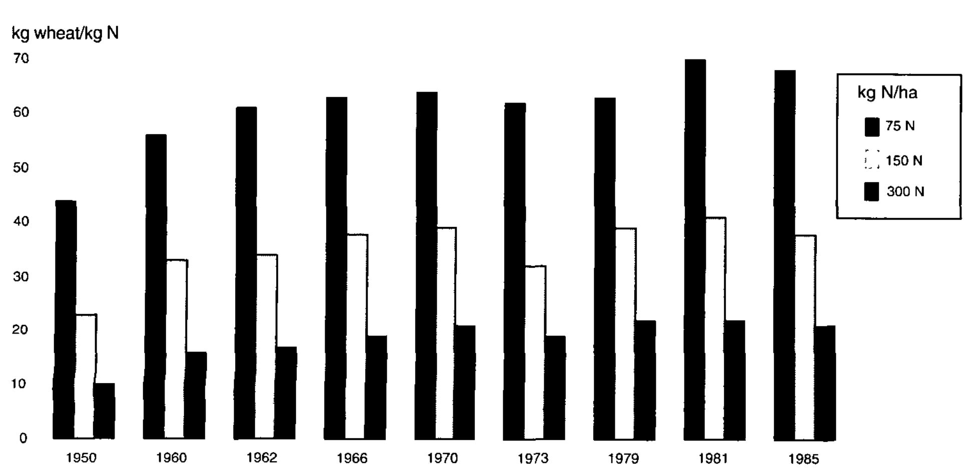
The superior performance of modern varieties also shows up quite strikingly when looking at the production functions at the 1.5 hectare point. To produce 5 tons of wheat on an area of 1.5 hectares, the tall varieties needed some 75 kilograms of fertilizer per hectare; the 1960s and 1970s semidwarfs required about 30 kilograms of fertilizer whereas the 1980s varieties needed no fertilizer at all.

Fig. 2 shows how the nitrogen/grain conversion ratio of CIMMYT cultivars developed over time. With 300 kg of nitrogen fertilizer input per hectare, the 1950 variety (Yaqui 50) yielded 10 kg of wheat for 1 kg of fertilizer. At the same input level, the 1985 variety (Opata 85) yielded more than double, i.e. 21 kg of grain for 1 kg of fertilizer. The highest fertilizer conversion efficiency was attained by the 1981 variety (Genaro 81) which yielded a stunning 70 kg of wheat for each kg of fertilizer input at the moderate application level of 75 kg of nitrogen fertilizer/hectare.

These results contradict conventional wisdom that modern semidwarf cultivars require more nitrogen fertilizer than older cultivars. CIMMYT's experience with wheat is certainly not unique. Similar progress in nutrient conversion efficiency has been achieved in other grains such as rice and maize. But higher efficiency in nutrient conversion is only one among several goals of cereal improvement work. Other important crop research objectives include conservation of genetic resources; water use efficiency; enhancing yield stability in terms of improved tolerance of biotic and abiotic stresses; improved palatability, as well as better milling, baking and cooking qualities.

When looking at modern crop research it is important to realize that the creativity of scientists is the *only* non-finite resource in the production equation. Raising the efficiency of crop production by improving plants and fertilizer management is arguably the best way of protecting natural resources such as land and fossil energy reserves, while contributing to the food supplies needed by a growing planetary population.

Figure 2. Nitrogen Use Efficiency



China Will Remain A Grain Importer

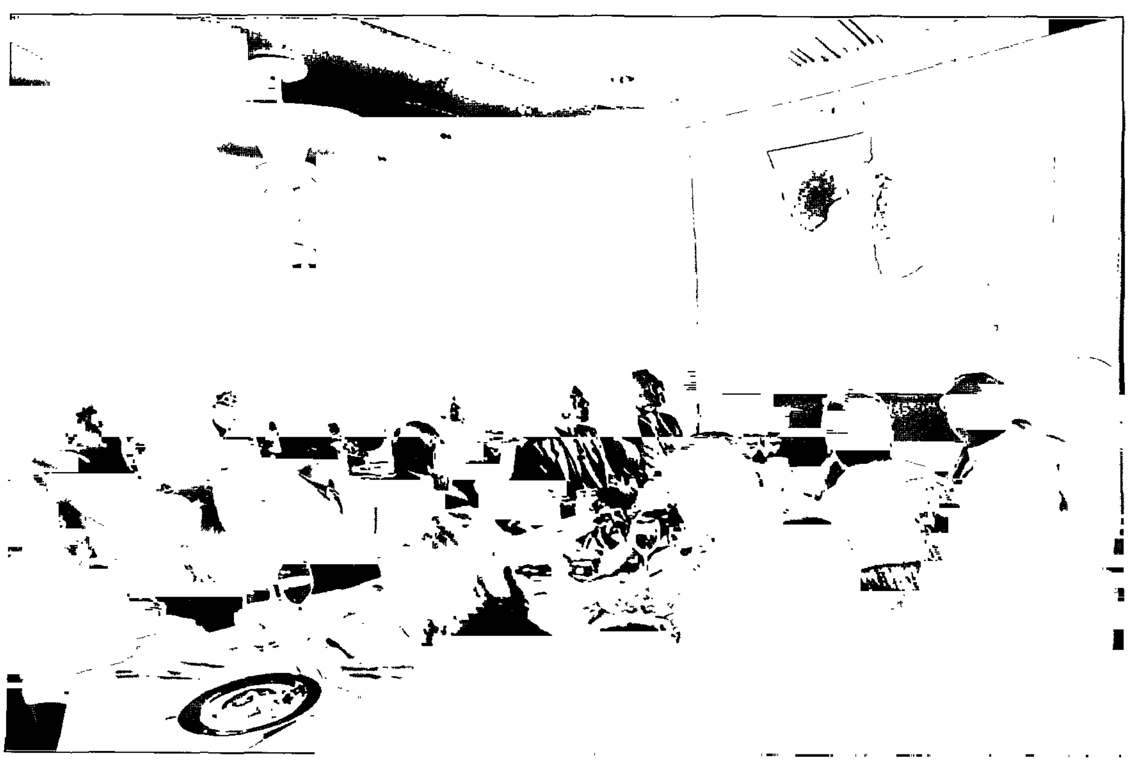
China is not expected to produce enough grain to meet its own needs in the coming decades, according to "China's Food Economy to the Twenty-First Century: Supply, Demand, and Trade," recently released by IFPRI as 2020 Vision for Food, Agriculture, and the Environment Discussion Paper 19. Although the country will likely remain a large grain importer, its imports will probably not be large enough to deplete world markets and starve other countries, say authors Jikun Huang, Scott Rozelle, and Mark W. Rosegrant.

Projections of China's grain situation in other recent studies vary wildly. While some predict that China will import massive quantities, exhausting world supplies and driving up prices, others believe that China will become a grain exporter. Huang, Rozelle, and Rosegrant use an integrated model of supply of and demand for grain through the year 2020 and carefully account for structural changes now taking place in China. They show that China is likely to rely on world markets to meet a small portion of domestic demand for grain but will require significantly less than some suggest. The IFPRI study projects that China will need to buy 24 million metric tons of grain from abroad by 2000—about 25 percent higher than its historic high—but that imports will then stabilize.

Several factors will help keep China's grain imports from rising too high. First, China's leaders are concerned with maintaining near self-sufficiency in agricultural production. Second, huge imports would raise prices, reducing China's ability to buy more grain. Third, fluctuations in foreign currency markets could make imported grain less affordable for China. Fourth, there is a limit on how much imported grain could be moved through China's ports and transportation systems.

In the end, the study shows, China's grain balances will depend on actions taken by the country's leaders with regard to population growth and investment in agriculture and other facilities and institutions. (IFPRI)

- CIFOR has a new chair of its Board of Trustees: Gillian Shepherd, Research Fellow, Forestry Research Programme, U.K. Overseas Development Institute. She succeeded Bo Bengtsson in February 1997.
- IFPRI's new chair of the Board is Martin Piñeiro. He replaced David Bell in March 1997.
- New chair of the IIMI Board of Trustees is Zafar Altaf, Secretary, Pakistan Ministry of Food, Agriculture and Livestock. He succeeded Leslie D. Swindale in January 1997.
- ISNAR's new chair of the Board of Trustees is Amir Muhammed, chairman of the Agriculture and Water Committee for Pakistan's 8th Five-Year Plan. He replaced Charles Edward Hess in December 1996.
- New chair of the ICRISAT Board of Trustees is R.S. Paroda, Director General of the Indian Council of Agricultural Research (ICAR) and Secretary, Department of Agricultural Research and Education (DARE). He replaced H. J. von Maydell in February 1997.
- A Change Management Team has been set up by the ICRISAT Board to carry out important tasks related to the management transition and all other institute matters. The eight-member team led by Director General James G. Ryan will function until a new Director General assumes charge.
- Kurt J. Peters, Professor and Director of the Institute of Applied Animal Sciences and Tropical Aquaculture, Humboldt University Berlin, is the new chair of the ICLARM Board. He replaced John Dillon who is now vice-chair.
- John Dillon was made an Officer in the General Division of the Order of Australia for his service to tertiary education, particularly in the field of agricultural economics and international development economics. John Dillon is Professor emeritus of the Department of Agricultural and Resource Economics, University of New England.
- The CGIAR welcomes two new regional representives. For Europe, Professor Jure Pohar of Slovenia, and for the Near East and North Africa, Mr. Ali Shafic Shehadeh of Syria, replacing the Czech Republic and Iran respectively.
- Ismail Serageldin, CGIAR Chairman and World Bank Vice President for Environmentally Sustainable Development, received an award of an honorary doctorate for his vision of based endeavors to release the world's disadvantaged from the demeaning grip of poverty. In the presence of the Union Minister of Agriculture, Shri Chaturanan Mishra, Mr. Serageldin received the degree from the Post Graduate School of the Indian Agricultural Research Institute, New Delhi.
- Per Pinstrup-Andersen, IFPRI Director General, received an honorary doctorate from the Swiss Federal Institute of Technology for his contributions to research in nutrition economics and his leadership in efforts to achieve worldwide food security, especially in the poorest nations.
- A CD-ROM containing spatial data on Tropical Moist Forests and Protected Areas is available from the IUCN Publications Services Unit (Fax: 44-1223-277175). The CD provides GIA users with the capability to carry out analyses using either the forests or the protected areas data sets, or both. It was compiled by the World Conservation Monitoring Centre (WCMC) and CIFOR and contains the original GIS data from which the maps of the Conservation Atlas of Tropical Forests have been produced.
- The CGIAR Secretariat has issued a booklet "The CGIAR at Twenty-Five: Into the Future" containing policy statements by Chairman Ismail Serageldin delivered at International Centers Week 1996.



Presentation of the IIMI Water and Climate Atlas (page 16) to Washington-based media (World Bank photo)

The International Year of the Reef

The year 1997 is designated the International Year of the Reef (IYOR) worldwide by a group of non-governmental organizations and institutions. This effort was endorsed by the International Coral Reef Initiative (ICRI), an international partnership of 75 nations seeking to implement Chapter 17 of Agenda 21, the Action Program adopted by the Earth Summit in Rio de Janeiro. Agenda 21, to date, is the most comprehensive action plan to halt and reverse the effects of environmental degradation and to promote environmentally sound sustainable development. Chapter 17 presents integrated strategies and programs for the protection and rational use of resources from the oceans, all kinds of seas, and coastal areas. IYOR is intended to provide a global context for national and regional efforts to save coral reefs. As such, it promotes collaboration among organizations and programs with common interests in reef management and research.

The International Center for Living Aquatic Resources Management (ICLARM), based in Manila, Philippines, with its interest in increasing production and preserving biodiversity, has pledged to contribute to the implementation of IYOR. Three of ICLARM's programs, the Fisheries Resources Assessment and Management Program (FRAMP), the Aquatic Environments Program (AEP) based in Manila, Philippines and part of the Coastal Aquaculture and Stock Enhancement Program (CASEP), based at the Coastal Aquaculture Centre (CAC) in the Solomon Islands, conduct activities which are part of the worldwide effort to manage and conserve coral reef resources.

FRAMP includes studies of target fisheries those for species and communities which live on coral reefs. Coral reef fisheries are highly productive, but the community structure is fragile, and can be *disrupted* by heavy exploitation. It has become clear in recent years that such fisheries need to be managed at the ecosystem level. The program has developed numerous methods for assessing the status of multi-species fisheries, which are epitomized by those on coral reefs, and good progress has been achieved in modeling the exploited communities, using a program called ECOPATH II.

In attempts to manage coral reef fisheries, many marine protected areas (MPAs) or marine fishery reserves (MFRs) have been created worldwide. It has been clearly shown that such areas will quite rapidly develop a large biomass of adult fishes which can either contribute directly to adjacent fisheries by out-migration of stock from the reserve into exploited areas, or indirectly, by increasing the numbers of eggs spawned and thus the numbers of juvenile fish which are produced to replenish the exploited stocks. However, there is no reliable scientific information on the rates at which heavily exploited stocks will recover if they are given protection, nor on the optimum size for an MPA. We also know little of the fate of eggs and larvae that are produced in MPAs and whether the local communities who have foregone some of the fishing grounds will benefit or whether the effects will principally be realized in downstream areas.

Answers to some of these questions are being sought by FRAMP staff in three projects, located in Jamaica, the British Virgin Islands and the Solomon Islands. In the Solomon Islands, studies in the reefs around the remote Arnavon group are documenting the rate of recovery of stocks of giant clams, pearl oysters and sea cucumbers which have been devastated by overexploitation. In Jamaica and the British Virgin Islands, the projects are investigating comparative rates of replenishment of exploited coral reef fish stocks, the stocks in British Virgin Islands being relatively lightly exploited, while those on the north coast of Jamaica are overexploited to the extent that many important species have be-

Continued on page 6

Reefs are highly productive communities of importance to over 100 countries worldwide. Though reefs appear as huge and formidable, they are actually very fragile communities. Information on the state of the reefs and the pressures from human populations are key to their survival and proper management. (IIMI)

(Continued from page 5)

Reef

come virtually extinct. Additionally, coral reef fish in and around a small, newly created Marine Protected Area at Discovery Bay in Jamaica are being tagged and released in order to shed light on the potential degree of out-migration of various species from protected areas.

The Aquatic Environment Program is directly involved with the IYOR through its ReefBase activity. ReefBase is the global database of coral reefs and their resources. The ReefBase project, which began in late 1993, aims to gather information on the ecology, harvest practices, tourism, stresses and management of coral reefs of the world into a relational database designed to accommodate a wide spectrum of uses. The first version of ReefBase on CD-ROM was formally released at the 8th International Coral Reef Symposium in Panama in June 1996. ReefBase 2.0, which is currently in production, may be purchased for US$95 by June 1997. Aside from the CD-ROM, as much of the information as may be accommodated is available through the ReefBase website (http://www.cgiar.org/iclarm/resprg/reefbase).

ReefBase is the information resource center of the International Coral Reef Initiative and is also the repository of summary reports of the Global Coral Reef Monitoring Network (GCRMN). In addition to this, ReefBase, through its Aquanaut Survey Program, enables marine park rangers, resort operators, recreational and sports divers to be a part of efforts to monitor coral reefs via a simple methodology and certification scheme.

The information, gathered from the existing literature, through collaborations with national, regional and international organizations, volunteer divers, International Coral Reef Initiative and GCRMN, is made available to the general public through an annually produced CD-ROM and the worldwide web. The information will also be used to come up with sets of criteria to determine reef health. The ability to determine the state of health of a reef is necessary for proper management.

The Coastal Aquaculture Centre (CAC) in Solomon Islands is developing methods to improve the productivity of economically valuable species associated with coral reefs through aquaculture and stock enhancement. The methods are being tested in partnership with traditional villagers in Solomon Islands, but are intended for use by coastal communities throughout the Indo-Pacific. The current focus is on several species of giant clams and the blacklip pearl oyster. These species yield products of high value, and can be cultured in a way that is not detrimental to wild stocks or other species associated with coral reefs. For example, juvenile giant clams can be produced in simple hatcheries, grown-out at coastal villages and then exported to lucrative markets in the aquarium and live seafood trade.

The CAC is also developing methods for restoring overfished populations of giant clams and increasing the harvests of sea cucumbers by producing juveniles in hatcheries, for release into the wild. Giant clam farmers assist in nurturing a proportion of the juvenile clams until they are large enough to be "released" onto reefs. In the case of sea cucumbers, ICLARM aims to increase the catch rates of traditional fishers by augmenting wild stocks with juveniles reared in captivity.

(ICLARM)

RESEARCH HIGHLIGHTS

Saving The Genes of Our Future Food

A new crop-breeding strategy that will help ensure food security for the world's poorest has been developed by ICARDA. The objective is twofold: to breed crops that will give greater yield stability, and thus food security in the world's harshest environments; and to preserve, through use, the plant biodiversity that is the raw material of such crops.

ICARDA's new strategy includes:

- **Using local landraces and crop wild relatives to breed new crops, for example Arta barley, derived from landraces, which has been returned to farmers' fields in the Middle East, and is outperforming local landraces by 70 percent, despite a harsh environment and lack of inputs.**
- **Bringing in farmers as partners in the crop-breeding program, so that their feedback can be incorporated but also so that the varieties thus produced are already in the fields when the process is completed, making it easier for their neighbors to adopt them. And it means that the genetic diversity used in the process stays in the countryside and is preserved.**
- **Besides maintaining a genebank of over 110,000 accessions, working with national programs on new ways of preserving wild relatives and landraces *in-situ*, where they will continue to adapt. This is being done through a project that may become a model for *in-situ* conservation worldwide.**

Cooperating with IPGRI in the drive to preserve biodiversity in West Asia, North Africa and the newly-independent republics of Central Asia.

"Since the Earth Summit in Rio de Janeiro, organizations like ICARDA have worked hard to spread the word that the store of genetic material used in agriculture is the most vital area of biodiversity to human existence," says ICARDA's Director General, Adel El-Beltagy. "There have been numerous conferences and seminars, but that's not enough. It's time to stop talking, and act."

(ICARDA)

SPOTLIGHT

Triticale: A Reappraisal

by G. Varughese, W.H. Pfeiffer, and R. J. Peña

"From a scientific curiosity to a viable crop in the course of a few decades" is the message of two articles "Triticale: A Successful Alternative Crop" which appeared in CEREAL FOODS WORLD (vol. 41, Nos. 6&7) and are excerpted here. Only two developing countries—South Africa and Brazil—are among the major triticale producers but others are planting small areas between 3,000 and 16,000 hectares: Algeria, Kenya, Mexico, Morocco and Tunisia. A full text reprint of the articles is available from CIMMYT.

Humans have existed on earth for more than two million years—over 99 percent of this period as hunter-gatherers. It was only during the last 10,000 years that they learned to domesticate plants and animals. During this period, they played an enormous role in shaping the evolution of cultivated plants. Today's agricultural crops are their creation. Humans cannot survive without them—nor can the crops they have selected and bred survive without their presence.

The past century was a remarkable period in history because of the human ability to manipulate the earth's natural resources to our advantage. Our knowledge of the basic principles governing the evolution of crop species, their relationship to their kins, and inheritance of traits have culminated in an array of improved cultivated crops including the creation of triticale (X *Triticosecale* Wittmack).

To date, progress made by triticale has been remarkable. The time span from its creation to its commercialization has been less than 100 years, as compared with thousands of years for a species to evolve in nature. In 1979, Arne Müntzing said in his book on triticale: "It can be expected that the new, manmade cereal, triticale, will definitely join the old cereals as food for the rapidly growing human populations and their domestic animals." The first commercial triticale cultivars were released in 1969 and as of today, 25 years later, triticale is grown on more than 2.4 million hectares worldwide. This crop contributes more than 6 million metric tons per year to global cereal production. See Table 1.

Today's successful triticales are the secondary amphiploids of durum wheat and rye. Durum wheat, the donor of the A and B genomes, is known for its high yield potential and adaptation to relatively dry environments. On the other hand, rye, the R genome donor, has lower yield potential but is well adapted to extreme cold, drought, and acidic soils and is grown in almost all geographic ranges. Triticale cultivation around the world during the last 25 years indicates that it possesses the yield potential of wheat and the hardiness of rye. Consequently, triticale is successfully grown in almost all environments where its parental species are grown.

The yield potential of triticale under optimum crop production environments has reached the level of wheat while outperforming wheat in marginal environments. A recent comparison between triticale and wheat indicates that triticale accumulates more nitrogen during heading and physiologic maturity than does wheat. The difference in nitrogen accumulation is maximum under lower levels of N application, indicating that triticales are better crops for soils with low nitrogen fertility. Most studies, to date, would indicate that the initial biologic problems, such as partial sterility, shriveled seed, excessive height, and lateness in establishing triticale as a productive crop, have been resolved. Acceptance of triticale by producers and consumers in different parts of the world would also indicate that triticale is here to stay as a classical example of ingenuity in modifying crops to our needs.

History

The first deliberate hybrid between wheat and rye was reported by A. S. Wilson in Scotland in 1875. However, the first doubled—and hence fertile hybrid between wheat and rye—was produced by W. Rimpau in 1888. It was during the crop season of 1918 at the Saratov Experimental Station in Russia that thousands of natural hybrids between wheat and rye appeared in many wheat fields. For the next 16 years, Meister and his colleagues exploited these hybrids. The name "triticale" first appeared in the scientific literature in 1935 and is attributed to Tschermak, one of the rediscoverers of Mendelian Law. It was also during this same year that Arne Müntzing at Svalov, Sweden, initiated his lifelong dedication to triticale.

Table 1. Main Triticale Producers (Area Harvested in thousand hectares)

COUNTRY	1986	1991/92
Australia	160	100
Brazil	5	90
Bulgaria	10	100
France	300	162
Germany	30	207
Poland	100	659
Portugal	7	90
South Africa	15	95
(former) USSR	250	500
Spain	30	80
USA	60	180
World	1,076	2,468

Today, CIMMYT/Mexico and Poland have the two most successful triticale programs in the world; they were initiated in 1964 and 1968, respectively. Several people have contributed to the success of triticale and the details of their efforts are summarized in several

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Sustainable Crop Protection
An Update on The System-Wide Program on Integrated Pest Management

Origins of the System-Wide Program

The CGIAR agenda has evolved during recent years, broadening to encompass a more holistic, multi-disciplinary approach to problem solving and emphasizing sustainable natural resource management. This evolution in the CGIAR agenda as a whole has been reflected in an increasing, and changing role for crop protection research.

Pesticides were initially an important part of the package of inputs which supported the increasing yields of the Green Revolution. However, as pests became resistant to chemicals and pesticides had to be applied more and more heavily, their natural enemies were destroyed while human health and the environment were threatened by the unforeseen side-effects of these chemicals. Integrated Pest Management—or IPM, as it is generally known—is an approach to crop protection designed to help agriculture escape from this vicious circle of pesticide dependence. Based on an increased understanding of biological and ecological processes in the agro-ecosystem, IPM combines biological control and appropriate farmer management practices with host plant resistance, to minimize or eliminate the use of pesticides. IPM has become so important to environment health that it was identified in Agenda 21 as one of the key elements in sustainable agricultural development.

The CGIAR, as part of its response to Agenda 21, decided to undertake a review of all IPM-related activities within its research Centers. An initial planning meeting, attended by eight CG Centers and nine partner organizations, was held in Aas, Norway, in May 1994, with support from the host country. The participants concluded that a considerable body of IPM research was already being conducted within the Centers, but was failing to achieve its full impact on sustainable agricultural development, for want of a coherent CGIAR policy on IPM and for lack of coordination. To address these weaknesses, the establishment of an IPM Network was proposed.

"In principle, all sixteen International Agricultural Research Centers belong to the Program, though to date only ten have actively participated."

Plans were further defined at a second meeting, held at ISNAR in February 1995. The participants developed a policy statement, designating IPM as the CGIAR's preferred approach to crop protection (see Box 1) and proposed that the IPM initiative be formally established as a System-wide Program. This proposal was endorsed by the CG Technical Advisory Committee, financial support was pledged by Norway and Switzerland and the program was formally launched in January 1996.

The System-Wide Program

The System-wide Program on IPM (SP-IPM) is one of several inter-Center initiatives established as part of a re-structuring of the CGIAR research agenda. These initiatives draw together relevant resources from all or several Centers and bring them to bear, in a coordinated manner, on a problem of global or inter-regional importance.

The SP-IPM is envisaged as encompassing the totality of Center activities in the field of sustainable crop protection. The Lead Center of the SP-IPM, for the current three year period is the International Institute of Tropical Agriculture. In principle, all sixteen International Agricultural Research Centers belong to the Program, though to date only ten have actively participated. In addition, two research Centers which are not affiliated to the CGIAR but which have a strong interest in IPM, ICIPE and AVRDC, are also full members. Many other partners participate in Program activities, and indeed it is explicitly recognized that the success of the program depends on its ability to forge effective partnerships: these involve both other research organizations (in industrialized and developing countries) and those principally concerned with IPM implementation, including governmental, inter-government and non-governmental organizations. Special emphasis is placed on forging close partnerships with national agricultural research and extension services.

Responsibility for steering Program activities lies with the Inter-Center Working Group on IPM, which comprises representatives of the participating research Centers. To ensure proper coordination with other IPM activities worldwide, the Working Group also includes representatives of two other important entities: the IPM Forum, concerned mainly with coordination and information issues, and the IPM Facility, whose priority is IPM implementation. The IPM Forum is an entity, still in the process of evolution, which was originally constituted as the International IPM

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Crop Protection

Working Group, to promote the wider use of IPM. The IPM Facility is a joint enterprise of the World Bank, UNDP, UNEP and FAO, managed by FAO. The SP-IPM is similarly represented on the steering groups of these two organizations. In the first meetings, during 1996, a number of opportunities for productive collaboration have already been identified.

Successful coordination depends on effective exchange of relevant information and IPM is a discipline which depends heavily on sharing information: between researchers and implementers, and between practitioners of different disciplines, as well as among a wider constituency involved in agricultural development

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Box 1
CGIAR Policy Statement on Integrated Pest Management

Integrated Pest Management (IPM) is here defined as ecologically-based pest management that promotes the health of crops and animals, and makes full use of natural and cultural control processes and methods, including host resistance and biological control. It uses chemical pesticides only where and when the above measures fail to keep pests below damaging levels. All interventions are need-based and are applied in ways that minimize undesirable side-effects.

The Consultative Group for International Agricultural Research (CGIAR) has stated that its mission is, "through research and related activities...to contribute to sustainable improvements in the productivity of agriculture, forestry and fisheries in developing countries in ways that enhance nutrition and well-being, especially of low-income people." In pursuance of this mission and recognizing the key role of IPM in sustainable agricultural development as a system that contributes to productivity in an environmentally sound and equitable manner, the International Agricultural Research Centers (IARCs), affirm that IPM principles should guide all pest control efforts within the CG system and strongly support research leading to its wider application. This IPM policy is in full accord with the articles of UNCED Agenda 21 and the Biodiversity Convention and is a significant element in the response of the CGIAR to these initiatives. To ensure full use of the potential and actual capacity that exists within the IARCs, the CGIAR will create a System-wide Program on IPM according to the guidelines elaborated below.

The IARCs promote IPM development and implementation as follows:

- IPM development and implementation will be inter-disciplinary and holistic in approach to management of agricultural and natural ecosystems.
- IPM strives to maintain and exploit biodiversity as a fundamental principle of pest management in the context of sustainable agricultural development.
- The IARCs will develop their comparative advantage in pest problem diagnosis, IPM component development, pilot project implementation and impact assessment. The IARCs will give increased emphasis to collaboration with NARS, NGOs, and other appropriate national, international and bilateral organizations with experience or interest in IPM. In full-scale IPM implementation, the IARCs will play a supporting role to organizations such as national extension services, NGOs and FAO.
- The IARCs recognize that, due to the diversity of agronomic and socio-economic systems, IPM implementation requires farmer participation in problem diagnosis, research and on-farm testing. Adoption of IPM depends on the ability of farmers to make informed decisions using the best available knowledge. The IARCs fully subscribe to this empowerment of farmers and furthermore view IPM as building on indigenous knowledge systems for pest management.

An IPM course. (CIP)

- An important element of sustainable IPM development will be decision support systems for policy makers as well as farmers. Communication between farmers, implementation organizations and policy makers should be encouraged.
- The IARCs acknowledge the role agrochemicals and drugs have played in control of plant and animal pests. The IARCs encourage improved strategic use of these products in an IPM context, as well as development of new products that promote sustainable agricultural production and minimize environmental degradation. IARCs will seek effective collaboration with the private sector in developing these component IPM technologies where appropriate.
- Recognizing the potential contribution of biotechnology to IPM, the IARCs will continue to be involved in further development and application. In accordance with IPM principles, application of biologically engineered products will be carefully evaluated for their possible nontarget effects before deployment.

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Crop Protection

efforts. The SP-IPM has joined the IPM Forum, IPM Europe and the US-based Consortium for International Crop Protection in establishing IPMfocus, a partnership whose specific objective is to facilitate the exchange of IPM information related to sustainable development. A number of initiatives are already under way, including the establishment of databases of IPM resource persons and projects and the establishment of an Internet website as a common access point to the wealth of electronically published IPM information. As well as improving coordination, such initiatives help to raise general awareness and impact of CGIAR activities in sustainable crop protection.

The viability of IPM as a part of production systems is very sensitive to the regulatory climate in which agriculture is conducted. The SP-IPM also has an important role in advocacy—providing a common voice with other IPM practitioners on issues which affect their work. For instance, the Inter-Center working group at its 1996 meeting felt so strongly about the issue of pesticide misuse that it issued a statement (Box 2), pinpointing their importance as a major cause of pest outbreaks. Wildly inaccurate estimates of pest losses were identified as another concern to be addressed, in so far as they can seriously distort policy decisions in agricultural development.

Finally, the SP-IPM affirms the comparative advantage of the CGIAR in conducting research on IPM. Such research should be closely linked with the implementation efforts of partner organizations, to ensure its relevance and impact, and farmer participatory methods should be used wherever appropriate to strengthen the link between research and implementation. Guidelines have been established to ensure that research efforts are demand-driven and address issues of widespread economic importance. Improved sustainability, conservation of biodiversity and enhancement of human well-being are also key criteria. The Centers are seen to have a special strength in carrying out multi-disciplinary research on the biological and ecological processes that underpin agricultural production systems.

Project Task Forces

New initiatives of the SP-IPM are tackled through the establishment of

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Box 3

Current project Task Forces of the System-wide Program on IPM

- cereal stem borers (CIMMYT)
- insect pests of grain legumes (ICRISAT)
- whiteflies and associated virus diseases (CIAT)
- parasitic weeds (IITA)
- weed management in rice (WARDA)
- tsetse and trypanosomiasis management (ILRI)
- methodologies for farmer-participatory research (CIAT) and
- functional agrobiodiversity (ICIPE).

New Task Forces to be established

- IPM of soil-borne pathogens (ICARDA)
- Evaluation of methodologies for IPM implementation and impact assessment (CIP)
- IPM of weeds (interim leader: WARDA)
- IPM of multi-host diseases (IRRI)

Discussion Groups recently formed

- Biotechnology in IPM (CIP)
- Entomopathology (IITA)
- Crop loss assessment (IRRI)

(IITA)

Box 2
Statement on Insecticides

The CGIAR Inter-Center Working Group on IPM, including representatives of the Global IPM Facility, at a meeting held at ISNAR, Den Haag, March 4-6 1996, expressed serious concern about insecticide overuse and agreed that this concern, summarized in the following statement, should be communicated through the Chairperson of the IPMWG to the CGIAR Centers, donors, and policy makers.

Insecticide overuse is the major cause of insect pest outbreaks in intensified agriculture in developing countries. Examples of insecticide-induced, production-threatening pests include: whiteflies, planthoppers, armyworms, thrips, leafminers, mites, etc. In addition, field use of insecticides is also a major occupational, public health, and environmental hazard.

Insecticide overuse continues to be associated with: i) outdated government policies, promoting the use of insecticides, that do not reflect the current state of scientific knowledge; ii) aggressive marketing and promotion by the pesticide industry, especially as markets shrink in developed countries; and iii) continuing use of development assistance, grant- and loan-funds to subsidize insecticide sales.

The SP-IPM urges IARC scientists and managers to inform policy makers, scientists, and the general public about the impact and causes of insecticide overuse. The SPIPM also urges multilateral and bilateral agencies to link their development assistance to commitments by recipient countries to reduce insecticide dependency.

To provide our readers with a glimpse of what others are saying: a few soundbytes from the heated debate on IPM

Sustainable Agriculture

by Jos Bijman[1]

...India, in recent decades, adopted chemical-intensive farming techniques in order to achieve self sufficiency in food production. While this goal has been reached, particularly with the help of high yielding wheat and rice varieties, the natural environment has seriously deteriorated, due to heavy use of chemical fertilizers and pesticides. New environmentally friendly technologies, which maintain or increase current levels of productivity, are needed if the use of chemical inputs is to be reduced. Biofertilizers, biopesticides and transgenic pest and disease resistant plants could possibly contribute to solving the environmental problem (and also reduce the concomitant threat to human health).

Problematic Alternatives

by Leonard Gianessi[2]

Ironically, the search for nonchemical alternatives to pesticides may be thwarted by many of the same regulatory concerns and public fears that currently surround chemical pesticide use. Although traditionally viewed as environmentally safe, biological control methods—which include the breeding and releasing of natural enemies, such as parasites, predators, or pathogens, to reduce pest populations—are being increasingly viewed by entomologists as carrying unrecognized risks. Once released into the environment, these species can multiply, cause unpredictable negative effects, and be impossible to recapture. Biological control activities can even lead to species extinction; Francis G. Howarth of the J. Linsley Grassit Center for Research in Entomology has concluded that species introduced for biological pest control have been strongly implicated in the extinction of nearly 100 species worldwide. Insects or pathogens introduced to control a plant pest may become pests themselves.

There is little regulation of biological control methods and subsequently little analysis of any unintended side effects. Recently, however, the U.S. Department of Agriculture canceled a plan to release a parasitic wasp and a fungus from Australia to control grasshoppers on U.S. rangelands—a project intended to replace synthetic chemical insecticides—for fear that the parasitic wasp might attack some beneficial grasshopper species.

Microbial pesticides, which consist of microscopic living organisms (viruses, bacteria, or fungi) and can be applied like chemical pesticides, are drawing increasing scientific attention as alternatives to chemical pesticides. Since the registration requirements for biological pesticides are essentially the same as those for chemical pesticides, the U.S. Environmental Protection Agency (EPA) will need to anticipate all possible problems. Experiments will have to be designed to show that each virus is not a threat to humans, animals, or the environment. If, as has been pointed out by Louis A. Falcon, an insect pathologist at the University of California at Berkeley, some negative effect were to be caused by a living, replicating virus, it probably could not be controlled or stopped. The public may have considerable apprehension about having their foodstuffs sprayed with viruses.

Another longstanding method of nonchemical pest control is crossbreeding. For example, plants can be bred for increased tissue hardness, so that they are protected by a structural barrier that limits insect damage. Often, crop breeders intentionally alter the chemical profile of the plant. By concentrating naturally occurring chemical repellents, feed deterrents, and toxicants, crop breeders can create cultivars that by themselves can deter or overcome pest attack.

Unfortunately, as Marcus Kogan of the University of Illinois has pointed out, crop breeding has proceeded without great concern for the underlying biochemical mechanisms involved. Some resistance factors may be broadly toxic to beneficial insects, animals, or humans. For example, certain alkaloids of potatoes defend the plant against the Colorado Potato Beetle but are hazardous to humans. So far, traditional crop-breeding methods remain largely unregulated. As risk-assessment procedures and toxicity measurements become more refined, however, these altered crop cultivars may become increasingly suspect.

Some researchers are using genetic engineering to find new ways to reduce growers' dependence on chemical pesticides. In most cases, this research is focused on large-acreage crops. Genetically engineered plants may resist certain pests or diseases; some may even release their own insecticides. In addition, viruses may be genetically altered to make them more potent. Already, public concern over the potential risks has blocked the release of a number of biotechnology products. Though the relative risk of most biotechnology products is likely to be low, the public's fear may be high, creating a further obstacle to the development of nonchemical alternatives to pesticides.

The public research agenda should consider the potential risks of the nonchemical alternatives and weigh them against those of the chemical pesticides that they are intended to replace. Otherwise, millions of research dollars may be spent on nonchemical control techniques that prove to be unacceptable.

One other option that deserves mention is the small group of nonsynthetic pesticides. Organic farmers spurn synthetic chemicals, relying instead on natural compounds such as sulfur and copper. But human health and environmental concerns have been raised about several of these natural pesticides, and the use of others has been disruptive to integrated pest management programs because they affect beneficial predators and parasites. In addition, because they are generally less effective in controlling pests, natural compounds must be used in greater amounts than synthetic chemicals.

Pesticide Poisons

by Robert J. Spear[3]

By 1980 nearly 500 major insect pests were resistant to pesticides, and at least 20 now are resistant to all widely used insecticides. The National Academy of Sciences reports that resistance to chemicals has developed in 150 plant diseases, 133 species of weeds, 70 species of fungus and 10 species of rats. It expects that by 2000, practically all major insect pests will have gained some form of genetic resistance. This does not sound to me like a situation that Mr. Gianessi and his group have under control.

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[1] Biotechnology and Development Monitor 24

[2] Senior Research Associate, National Center for Food and Agricultural Policy, Washington D.C. Excerpts from "The Quixotic Quest for Chemical-Free Farming," in: *Issues in Science and Technology*, Fall 1993.

[3] *Excerpts from a letter to the Editor, Washington Post* (February 11, 1997) commenting on Mr. Gianessi's views as expressed in a letter to the Editor (January 29, 1997) on an article (January 13, 1997) "After Century of Pesticides, Getting Bugs Out of Crops Naturally," dealing with IPM practice in the U.S.

(Continued from page 1)

A Regional Vision

rich. Consider Libya, Oman, Saudi Arabia, Kuwait and United Arab Emirates as examples of the major oil exporters. We find large disparities between these and the remaining WANA countries. The oil exporters with only 7 percent of the region's population represent the region's highest per capita GNP, averaging just over US$9,400 which, even so, is only a quarter of the per capita GNP of industrialized countries. The remaining 93 percent of WANA's population has a far lower per capita income. The four most economically disadvantaged states of South WANA (Eritrea, Ethiopia, Somalia and Sudan) have a per capita GNP of only US$88 that is less than 1.2 percent of the oil exporters with small populations. In fact, 42 percent of the total population of 239 million people has a per capita GNP of less than US$1.0 per day and is thus in the grip of severe poverty.

There is more absolute poverty and incidence of poverty in rural than urban areas in WANA. Even though infrastructure in the rural sector has improved in the last twenty years, there has not been a proportional increase in employment or poverty alleviation. Economic disparities will continue to fuel migration from rural to urban areas and from poor to rich countries both within and outside the WANA region.

WANA's agriculture employs large parts of the population; nearly 50 percent, for example in Turkey and Morocco. Women contribute about half the agricultural labor, well above their share of the total labor force.

Food Consumption and Production

Most calories and protein in human diets in WANA comes from plant sources—mainly cereals—with some pulses. Diets have improved in most of WANA over the last two decades, but still lag well behind in quantity and quality of protein. Dairy, poultry and fish production are rising in WANA, but are still far behind those of industrialized countries. Deficiencies of micronutrients in diets of women and children can have permanent negative effects on the quality of life.

In Egypt, agriculture is almost totally dependent on irrigation, but this is not the case for the majority of WANA countries which rely mainly on rainfed agriculture. Grain production has just kept pace with population growth, benefiting from research results and policies aimed at putting these to good use. Per capita consumption of all grains has increased, while pulse consumption has held constant. Income growth and concessionary

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Crop Protection

Task Forces. Each Task Force is led by a research Center with a special interest in the particular field. The first responsibility of the Task Force leader is to undertake a wide process of consultation with other interested parties, within and outside the CGIAR system, to establish the current state of knowledge and define any outstanding needs. The process is intended to be flexible, with the scale and nature of activities tailored to the particular problem addressed. A Task Force may go on to establish a full-scale inter-Center project or it may be decided that holding a workshop or establishing a discussion group is sufficient. Task Forces currently being undertaken are shown in Box 3. Centers and partners have already shown considerable support for the Task Force approach. The first to lead to implementation of a project is that on whiteflies and associated viruses which is expected to begin work, with support from Denmark, early in 1997.

Conclusion

In summary, the SP-IPM seeks to draw attention to, make better use of, and further develop the wealth of resources available within the CGIAR Centers and partner organizations in the area of sustainable pest management. The goal of the Program is thus to ensure that this work can realize its full potential in contributing to sustainable agricultural development.

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Soundbytes

Mr. Gianessi's contention that we should not continue experiments with natural controls because previous experiments have failed is a rather odd comment. I cannot imagine that he has never learned of the many success stories of natural controls in entomological and agricultural history. His contention that the several thousand insect "crop pests" are best controlled with "about 100 broad-spectrum pesticides" rather than with "nature's own controls" that are specific to a single species, is off the mark. From both a scientific and environmental view, if controls must be used, to have an agent that deals with one single "pest" and harms nothing else is exactly what one would want.

Modern pesticides are not necessarily safer: they are more concentrated and potent than ever before. Some remain effective in concentrations as low as a few parts per billion and less. The paradox is that the damages caused by such small amounts become increasingly difficult to discover, and the period of time during which harm may be occurring grows longer as the technology needed for detection and verification lags behind the technology of production.

One must wonder then if the sustained misuse of synthetic chemical poisons on our crops is part of the problem rather than part of the solution.

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A Regional Vision

pricing have enabled the import of grains for food and feed to fill the gap.

The role of pulses in human diet is greater than their small quantities suggest, due to their high protein and energy content and their use in diets of the poorest people as substitutes for animal products. Faba beans, lentils and chickpeas enhance the value of cereal dominated diets as they provide complementary essential amino acids and minerals. Pulses are 'the poor man's meat."

ICARDA's projections of Egyptian grain production in 2020 are based on the five-year average around 1990. Four assumed rates of production growth, and the UN's population projections, allow us to imagine upper and lower limits for per capita production in 2020. Sustaining a 3 percent yearly production growth rate to the year 2020 would be enormously challenging. A zero growth rate, on the other hand, is possible but positive rates of production increase must be expected. A respectable 2 percent growth is achievable, but will require concerted technological and policy advances.

In addition to grains and pulses, Egypt produces and consumes fruits, vegetables, edible oils, meat, dairy products and eggs. Consumption of all foods has risen on a per capita basis. Assuming no change in per capita consumption of all foods from that in 1990, domestic production must grow at well over 2 percent annually to close Egypt's food import gap by 2020. An additional per capita increase in food consumption would make this an even bigger challenge.

Egypt's approach has been to seek the best economic balance of crops by allowing their prices to match the world market. Research has been enhanced by active partnerships with the IARCs—in particular with IRRI on rice; with ICARDA on food legumes, cropping system resource management, and regional cooperation (Nile Valley Regional Program); with ISNAR and IFPRI on research organization and agricultural policy; CIMMYT/ICARDA on wheat; and CIMMYT on maize. There have been important positive impacts on productivity in these areas.

Other countries of the region face a more serious and challenging situation than Egypt. Pakistan. Afghanistan, Sudan and Ethiopia, for example, import little grain though their population growth has outpaced production growth. Their per capita consumption levels were lower in 1990 than in 1970. The 1990 per capita consumption of all grains was about half of that in Egypt. In such countries, increases in per capita consumption over the 1990 levels are much needed. Per capita consumption, however, is a function not of want or need but of effective demand and is directly related to income.

"Even though infrastructure in the rural sector has improved in the last twenty years, there has not been a proportional increase in employment or poverty alleviation."

In contrast, Turkey's per capita production of grain is nearly double that of Egypt. With abundant rainfall, good soils, and policies promoting private investment in agriculture, Turkey is the only substantial net exporter of grain in WANA but it exports grain not necessarily to other less well endowed WANA countries. Most analysts include Turkey in the WANA aggregate; this has the effect of overstating the region's productive capacity.

If per capita consumption of all grains remains constant at 1990 levels to the year 2020, and the UN population projections prove as realistic as in the past, we should expect a total aggregate grain consumption of about 217 million tons in 15 countries of WANA proper, without the burgeoning populations of Sudan, Ethiopia and Pakistan.

The grain gap in 1990 was of the order of 27 million tons. If the rate of production growth can be sustained at 2 percent per year to 2020, the 15-country grain gap will increase to 70 million tons. If we exclude Turkey and consider only a 14-country WANA aggregate, the 1990 grain gap was about 33 million tons. This deficit will easily reach 86 million tons by the year 2020.

Again, this is a conservative estimate which assumes no growth in per capita income or consumption.

Assuming grain will cost only $100 per ton, 86 million tons of grain per year will cost $8.6 billion, no less than 30 times the size of the current annual budget of the CGIAR system. To visualize the quantity of 86 million tons of grain imports for WANA in 2020, imagine a railroad train 12,000 kilometers long.

The challenges facing these grain-importing WANA countries are formidable:

- how to sustain production growth?
- how to achieve income growth sufficient to fill the remaining grain gap with imports?
- and how to do both while sustaining the natural-resource base.

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In the next issue...

— The CGIAR and Biotechnology in a Changing World

— Information Needs of Small Scale Farmers in Africa: The Nigerian Example

— Diversity by Design

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Maize Production

Burkina Faso (7.4 percent), Mali (6.6 percent), and Zaire (5.5 percent). Nigeria, the most populous country in the region, scored substantial gains as well. The annual rate of growth in area cultivated to maize was 3.5 percent, and the annual gain in production was 5.3 percent.

In each country, the rate of growth of production exceeded the rate of growth of land area devoted to cultivation. This indicates that the increases in production were due to gains in yield per unit area, and not merely to expansion of area.

Evidence abounds

Evidence of the gains in maize production in the region literally stares an investigator in the face. Green maize boiled on-the-cob, or roasted, has become a common sight along roadsides in villages and towns and along highways in the Sudan savanna. Green maize is available as early as April where farmers take advantage of the residual soil moisture along the river banks. This early production helps alleviate hunger when the previous harvests have been largely depleted, and when the new plantings of other crops and traditional varieties are not ready for harvesting.

Women traders come to the roadside to sell maize to middlemen and market "queens," who will move their produce on to major markets. (CIMMYT)

As a result of increased production, dried maize is available in local markets for much longer periods than in the past. This is true not only of markets in large Sahelian towns such as Bamako and Ouagadougou, but also in many villages and small towns throughout the region. Moreover, new uses have been found for the increased production. Maize is being substituted for sorghum and millet in some local dishes, and industries are using it for brewing and for oil extraction. Everybody seems to have benefited—the farmers who grow the crop, the major distributors, the so-called middlemen and women, the petty vendors selling green maize on the roadside or selling dried maize by the cup, as well as industrialists.

Regional collaboration

IITA scientists started work on new maize varieties under the auspices of the Semi-Arid Food Grain Research and Development Project (SAFGRAD). The SAFGRAD Project, covering maize, sorghum, millet, and cowpea, was sponsored by the Scientific, Technical, and Research Commission of the Organization of African Unity (OAU/STRC) and the US Agency for International Development (USAID). IITA was responsible for the maize and cowpea components of the Project.

The development of extra-early varieties of maize (varieties maturing fully in 80 days) became a research objective in 1984 and followed earlier success in breeding early (90-day) varieties. Achievement of the new objective called for activities that only an international research organization stood any chance of successfully carrying out. Maize varieties with potentially appropriate characteristics were assembled from around Africa, Colombia, India as well as from the extensive collection at Centro Internacional de Mejoramiento de Maizy y Trigo (CIMMYT) and evaluated in field experiments.

Two yellow-grained indigenous varieties (landraces) from Burkina Faso and one white Colombian variety were selected following careful experimental assessment of 80 varieties. The three varieties had the virtue of being extra-early (for example, the Colombian variety flowered 42 days after planting, 7 days earlier than the local check variety). But both had relatively low yield potential—2 tons per hectare. The three extra-early varieties were crossed to selected promising, improved white and yellow varieties to develop new varieties combining extra-early maturity with other desirable agronomic characteristics.

By 1987, one yellow and three white varieties that mature in 75-80 days and with a yield potential of 3 tons per hectare had been developed. By this time, the West and Central Africa Maize Network (WECAMAN) had become the maize component of the second phase of the SAFGRAD Project. The network comprised maize scientists in the various national agricultural programs of the region and in the international agricultural research and development centers. The four extra-early varieties were offered to national programs of the region for evaluation and further development.

Disease resistance

National program scientists were enthusiastic about the new varieties' extra-earliness in the humid ecological zones of the region, although the varieties had been developed for the Sudan Savanna. Yet, to grow them in the humid zones would require them to be protected against several diseases.

Historically, diseases were not a problem in the Sudan Savanna. However, scientists surmised that climate change, including erratic rainfall at the beginning of the season, would cause changes in farming practices. Such changes could induce an increased buildup of maize disease organisms, and usher in hitherto nonexistent diseases.

For these reasons, scientists began, in 1988, to breed resistance to diseases into the extra-early varieties, including the

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Maize Production

maize streak virus disease, a disease unique to the African continent.

IITA had already bred resistant varieties and developed techniques for incorporating the resistance into other varieties (an accomplishment for which it won the King Baudouin Award for International Agricultural Research in 1986).

Promising streak resistant, extra-early varieties were tested by scientists, members of WECAMAN. They also conducted agronomic trials to determine the optimal farming practices for the new varieties. The recommendations they came up with raised the yield potential of the varieties to 5 tons per hectare.

Inherent advantages

The new extra-early varieties were released by WECAMAN, the maize network. They have been adopted widely by farmers in the Sudan Savanna and in the Sudan-Sahelian transition ecological zone. Their extra-earliness ensures that they fit into the shortening growing season, enabling them to escape drought, and generally reducing the risk to farmers caused by climate change. Their multiple disease resistance enlarges their zones of ecological adaptation, leading to a considerable expansion of maize area in West and Central Africa.

Adoption and spread of the varieties have been facilitated by the participation of many national agricultural programs. Internal trade within countries has aided the movement of the new varieties across ecological zones. The increased trade among neighboring countries in West and Central Africa (much of which is informal) has also helped the spread of the varieties.

The quiet revolution represented by the expansion of highly productive, disease resistant maize varieties across the savanna belt of West Africa is a testimony to the efficacy of scientific creativity and well-conceived research collaboration.

(IITA)

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Triticale

historic reviews.

In 1965, when CIMMYT's Triticale Program was initiated, plants were tall, highly sterile, and late maturing. They also had shriveled grains—commercially unusable. Progress in overcoming triticale's technical limitations has been made in incremental steps. Improvement was driven by the genetic variability scientists were able to generate. The techniques to systematically produce primary triticales and create genetic variability opened the door for directed genetic improvement.

"Today, CIMMYT/Mexico and Poland have the two most successful triticale programs in the world..."

Production statistics in Europe indicate increased adoption of winter triticales due to their low-input features under conditions of low-cost production and/or better adaptation compared to other small grains, for growing on both barren rye soils and high productive wheat soils. Triticale appears to be an ideal low-input crop for nonextractive, sustainable agriculture and organic farming. Differences in N uptake and efficiency favor spring and winter triticales when compared with other small grains. Genetic variabilities for these traits among triticales could be exploited in future breeding efforts.

Yield Potential

There has been considerable progress made in improving genetic yield potential in winter and spring triticales. In CIMMYT spring triticales, maximum grain yields measured at Ciudad Obregon under irrigated, near optimal conditions increased from 2.5 t/ha in 1968 to 9.7 t/ha in 1991. Comparison of complete triticales developed in the 1980s and 1990s over three years in maximum yield trials at Obregon reveals overall yield progress to be 17 percent. Major contributions resulted from increases in harvest index (16%) and spikes per square meter (12%) with an associated increase in grains per square meter (17%). Average plant height decreased from 140 to 125 cm (11%) and test weight increased 12 percent from 68 to 76 kg/ha. Modest reductions in days to maturity and grain-fill duration by four and three days, respectively, were accompanied by a 10% reduction in vegetative growth rate and straw yields but a 21 percent increase in the grain biomass production rate.

Agronomic Traits

For most of the earlier problems (e.g. excessive plant height, low head fertility, low test weight, poor winterhardiness, and late maturity), significant improvements have been achieved. Existing genetic variabilities for value-added traits, trait heritabilities, and correlations among these traits suggest high projected genetic gains for agronomic components associated with grain yield, test weight, most of the traits associated with plant morphology and phenology, and agronomic traits such as threshing ability. Traits, like grain-fill duration, where projected progress may occur in small incremental steps, warrant special attention in future breeding efforts.

Abiotic Stresses

Breeding for marginal lands (acidic, sandy, or alkaline soils), trace element deficiencies (copper, manganese, and zinc), or trace element toxicities (high boron), and the different types of moisture stress environments constitutes a major effort in spring and winter triticale improvement. Breeding for acid soils, moisture stress, and enhanced tolerance to high and low temperatures is generally addressed by exploiting key locations during germplasm selection, screening, and yield testing, as well as by shuttle breeding and

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The World Water And Climate Atlas For Agriculture

A New Technology

Scientists at the International Irrigation Management Institute (IIMI) and Utah State University have created a new global database called The World Water and Climate Atlas for Agriculture that will serve as a high-tech tool for farmers, agronomists, engineers, conservationists, meteorologists, researchers and government policy makers.

"The Atlas integrates the available agricultural climate data into one computer program and represents the most comprehensive, quality-controlled climatic data set in existence," says CGIAR Chairman Ismail Serageldin.

The Atlas enables users to zoom in on any 2.5 square kilometer region of the globe and extract critical data such as precipitation and probability of precipitation, maximum and minimum temperatures and average temperatures.

"All of this data is converted into maps that clearly delineate climatic conditions, no matter how remote an area of land may be, in a user-friendly computer program that agronomists can use to assist even the poorest farmers," says Mr. Serageldin. "The Atlas will help identify the agroclimatic conditions appropriate for specific crops."

Donald T. Jensen, Director of the Utah Climate Center at Utah State University in Logan, Utah, and Andy Keller, Ph.D., of IIMI, created the Atlas from data received from 56,000 weather stations around the world. The Atlas covers the 1961 to 1990 period, in order to conform with World Meteorological Organization (WMO) specifications for a "normal period" of climate examination.

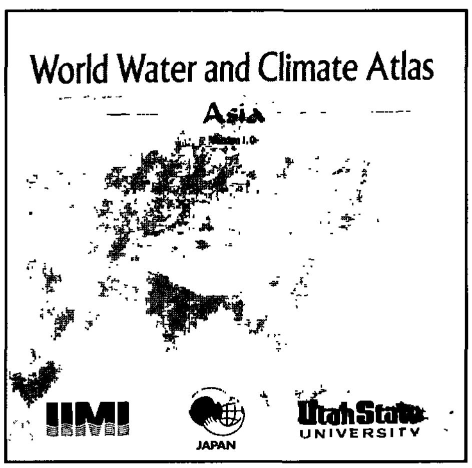
"The Atlas, because of its precise mapping of weather data over a 30-year period, could help scientists increase their understanding of the global warming phenomenon," says Mr. Jensen. "We expect scientists to find many other important applications for the Atlas that we haven't even dreamed about ourselves."

Some of the data is now available on CD-ROM. In July, the entire Atlas will be accessible on the Internet. The project was funded by the Government of Japan through the CGIAR.

"The Atlas will assume even greater importance in coming years, as water, especially for agriculture, becomes scarcer," says David Seckler, IIMI Director General. "Some 70 percent of all water used each year goes for irrigation, which produces 30-40 percent of world food crops on just 17 percent of all arable land."

Practical Applications

The Atlas will provide an extremely powerful base for further mapping of water-related data—for river basins, land usage projects and population centers—and as the basis for exploring the changes in agricultural potential that would result from independent estimates of climate change. The Atlas itself is not a predictor of such changes, but will be a valuable tool in interpreting the effects of any changes.



Using this meteorological encyclopedia, engineers can develop very specific plans for irrigation and water conservation projects for districts, states and entire countries. The quality of irrigated land in many places is declining due to increasing soil salinization, overpumping and contamination of groundwater aquifers.

Agronomists and researchers can use the Atlas' long term climate data to assess the potential for plant adaptation to climatic conditions. "The Atlas will show, for instance, where rice or potatoes, or any crop, could be grown where they are not now being grown," says David Seckler. "It will also show what more valuable or more nutritious food crops farmers might grow on their land."

The Atlas demonstrates how the two most important measured values—available water and temperature—influence plant growth, crop yields, and the choice of various management practices. Scientists can combine the long-term data with crop growth simulation models to assess the value of different plants and plant traits for plant selection and/or plant breeding.

The Atlas will serve the interests of small and poor farmers in at least three ways:

- International funding agencies such as the World Bank, along with national and local governments, will have a much clearer picture of how to direct increasingly scarce agricultural investment resources;
- Extension agents can print and distribute data generated by the Atlas for specific areas to help improve the performance of water resource and irrigation systems, ultimately leading to improved crop production by poor and small-scale farmers;
- By helping poor farmers to increase their incomes, the Atlas would help to better preserve the Earth's environment—where too many people are poor, hungry or unemployed, preservation of nature, forests and wildlife will deteriorate.

What the Atlas Contains

The World Water and Climate Atlas includes ten-day, monthly, and annual summaries of average, maximum and minimum temperatures, precipitation and precipitation probabilities, evapotranspiration (the total water evaporated from bodies of water or used in crop growing) and two indices. One index, the moisture availability index, delineates regions where moisture is adequate to grow crops. The second index measures a new concept, NET, or net evapotranspiration, which is

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Atlas

the difference between evapotranspiration and precipitation. It helps locate areas needing irrigation.

If the NET in a designated area during a certain period is positive, it means not enough rainfall exists to maintain current cropping patterns without supplementary irrigation. Where the NET is negative, enough rainfall for crops exists. The NET is not the same throughout each year. In Southern California, for example, in winter, the NET is negative; in summer, it is positive.

The CD-ROMs contain monthly and annual summaries of rainfall and temperature, which are displayed on maps. For example, net rainfall (rainfall minus evaporation) is designated by different colors; deep blue marks heavy rainfall, green less and red signifies dry. In South Asia—mainly India, Pakistan and Bangladesh—only the southern region is blue in February, with the northern regions of the Indo-Gangetic plains green and red. By May through August, the entire South Asia region turns all blue as the monsoon season reaches its peak. By September and through December, the northern regions again become red and green, showing that they have dried out significantly.

A user can then focus onto a smaller area, which will then fill the computer screen to get more detailed information about climate variation on that smaller area of interest. A user can extract information from a point on a map, or by delineating an area, such as a water basin or irrigation system.

"By looking at patterns of the past, we can find patterns on the future. We will see that when some regions of the globe are dry, it will mean that other areas will be wet," Mr. Jensen says.

For monthly data, the Atlas is produced on 6 CD-ROMs, which divides the world into sections. The first section—covering data for Asia—is provided on the initial CD-ROM, with additional data on the Internet. For 10-day data, IIMI and the Utah Climate Center will issue 17 additional CD-ROMs.

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Triticale

laboratory screening methods.

Human Consumption

As a food grain, triticale uses—although in many cases proven to be suitable—have not been extended to the commercial level. Given its generally inferior breadmaking quality, triticale is not yet envisioned to be a suitable flour for breadmaking, particularly if wheat flour is available. In limited cases and due to wheat shortages, triticale has been used, particularly by small-scale landholders, alone or blended with wheat, for the manufacture of local homemade breads. Rolled triticale ("flakes") and whole meal flour, whole meal specialty breads, and other health foods have been marketed in small amounts in different countries. See Table 2.

Table 2. Food Uses of Triticale in Some Major Producer Countries

Country	Product	Proportion of Triticale Flour
Australia	Breads, cookies & biscuits	100%, blend
Brazil	Variety breads	35%
Germany	Leavened bread	40%
Poland	Rye-type bread	100%
Russia	Rye-type bread	100%, blend
U.S.A.	Layer cake	50%

Animal Feeding

Most triticale production is utilized as a feed grain forage, or both in animal feeding, including poultry, monogastrics, and ruminants. Triticale serves as a substitute for other cereal grains or as a partial substitute for protein sources such as soybean meal.

One important problem faced by the feed grain industry in Australia is that the large variation in grain protein content exhibited by triticale in a given cropping year does not permit incorporating a steady amount of triticale in the feed formula.

Miscellaneous Uses

Triticale has been used as a cover crop to prevent runoff and erosion in vineyard soils of South Africa and to control wind erosion in Texas cotton production areas. Triticale has proven suitable in the reclamation of highly compacted and polluted mine spoils in Czechoslovakia. However, further studies are needed to determine triticale's potential in metal uptake (cadmium, lead) for specific pollution situations and to compare it with other crops. Triticale also has been considered as a raw material in bioethanol production and as insulation material in building construction. Although bioethanol production equivalent to 1,000 L of fuel per hectare can be achieved, feasibility will depend on energy input per hectare and government policies.

Outlook

The transformation of triticale from a scientific curiosity to a viable crop in the course of a few decades has been a remarkable achievement in plant breeding. However, several grain and nongrain factors have caused triticale to fail as a commercial food grain. Over-enthusiastic promotion of triticale as a "great nutritious new grain" in the early 1970s disappointed those who attempted to exploit it commercially, greatly damaging the "image" of a cereal that was still far from having more stable and acceptable attributes. Global wheat surpluses, lack of year-to-year consistency in the composition of triticale grain, absence of official triticale grading systems, and lack of proper promotion are additional factors that have not permitted the formation of the farmer-industry-consumer chain necessary for triticale to become established as a commercial food grain. This resulted in disappointment for both

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Triticale

farmers and researchers in developed and developing countries.

Despite this, efforts to resolve the basic problems of triticale continued. As a consequence, the areas under triticale production worldwide during the 1986-1992 period increased from 1 million to nearly 2.5 million hectares. At present, most triticale cultivation is in Europe (78%), followed by North America (7%), Africa (6%), Latin America (5%), and Australia and New Zealand (4%). Except for a few planted areas in China, the crop is not commercially grown in Asia. Active research in enhancing the productivity and end-product quality and promotion of triticale is underway in more than thirty countries.

Farmers in every part of the world have adopted new techniques and accepted new crops that are considered profitable and consistent with their circumstances. The first factors, which favored farmers' adoption of triticale, were its superior performance under unfavorable production conditions including acidic soils, severe disease or insect pressures, or drought. Second, it had the ability to produce higher biomass and high regrowth capacity after grazing and ability to grow better under relatively cool temperatures, making it an excellent forage crop. Third, and equally important, was the usefulness of triticale as a feed grain mainly for monogastric animals.

Considerable effort is underway to improve the milling and baking qualities of triticale. Millers and markets find it difficult to accept a new crop because of the additional investments involved in modifying the milling procedure or adding new holding facilities. However, when the world is faced with the problem of slowing productivity of established crops like wheat, maize, and rice and the population keeps growing at its high rate, options like triticale to enhance sustainable production will continue to be important in feeding the world population.

(CIMMYT)

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A Regional Vision

Natural Resource Stewardship

Heading the list of resources that are no longer abundant in the region is water. Despite the scarcity of water in WANA, many countries have poor water use efficiency. Open access to aquifers by private wells is common. The costs charged for the maintenance and operation of irrigation structures in agriculture often do not fully reflect the investment, let alone the cost to future generations of exhausting groundwater supplies. Water harvesting and supplementary irrigation are alternatives for increasing and stabilizing yields of crops grown in rainfed areas.

Land itself must be protected from degradation through the use of judicious technologies. Inheritance traditions and land tenure laws have caused land fragmentation, hindering productivity and resource stewardship.

Rangelands in WANA, covering about 30 percent of the land area and providing a third of the diet of some 300 million small ruminants, are typically open to unrestricted grazing and therefore severely degraded. Traditional grazing management, which integrates crop by-products and rangelands, is under serious stress. Hand in hand with this goes loss of soil from wind erosion, water runoff, and other causes and, where it has not been lost, the draining of nutrients through inappropriate management.

A key resource which should not be overlooked is biodiversity. Desirable plant species have been lost or diminished in large areas of WANA. These are the genetic centers of origin of some of the world's most important cereals (wheat and barley) and legumes (lentil, chickpea and forage legumes), and where the wild relatives of these plants are found.

Continued degradation of the natural resource base in this region is hence of grave consequence for all of humanity.

Global Economic Integration and Food Security

Wise use of natural, human and capital resources in each country will allow agriculture to make sustainable contributions to food security. This would imply dropping the uneconomic goal of food self-sufficiency in favor of economic self-reliance. Given the fluctuating nature of productivity in rainfed farming systems, optimizing storage and imports of grain must receive greater attention in the future.

WANA countries that are increasingly dependent upon food imports will find their food bills rising as developed countries reduce production and export subsidies under GATT.

Greater integration with world markets will become more urgent. Investments in human capital, natural resource management, research and technology development are essential.

The following are a few important issues on which agricultural research in WANA can contribute to food security and prosperity:

1. Methods for determining the best agronomic practices (economically and environmentally), and for encouraging their adoption, are essential for sustaining productivity and for improved water use efficiency.
2. Research on livestock management and nutrition should be intensified, given the current emphasis on national veterinary and animal breeding investments and the importance of livestock in the region.
3. Conservation and enhancement of plant and animal genetic resources are essential to the future not only of WANA but of the planet's entire food production system.
4. Where pastoralists and farmers are insecure tenants they cannot be expected to take long term responsibility for the natural resources they use. This issue is central to policy research.
5. Informal seed sectors should be enhanced by strategic research on methods, followed up with well informed extension.

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A Regional Vision

It is no coincidence that ICARDA's mandate is focused on these areas of need for strategic research. This research work is aimed at yielding knowledge (including genetic information) and human capital for the sustained benefit of mankind. Partnerships with and among the national agricultural research systems (NARS) of WANA are a key to success and essential for bringing resources and critical masses of research skill to bear on the issues. This will require concerted efforts of NARS with international research centers like ICARDA.

The challenges to agriculture and natural resources of WANA are tremendous, and must be faced now because agricultural development is needed not only to fill food consumption gaps in future but also to encourage overall development and job creation. Agricultural development is important for reducing poverty, and for conserving and enhancing the natural resources that are vital for the future of people in WANA and beyond.

Adel El-Beltagy is Director General of ICARDA.

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Atlas

To accomplish the mapping, state-of-the-art spatial interpolation techniques are used—daily data from the weather stations are plotted on the map electronically, and daily estimates are made for locations between the stations.

The Atlas also incorporates digital elevation modeling, or DEM, which captures effects from mountains and other high areas, such as temperature lapses (temperatures decrease with altitude) and rain shadows (more rain falls on the windward side of mountains than the leeward sides).

The Atlas also improves the quality of the maps through careful screening of data, which is important because many of the sites at which data is collected are "biased"—for example, by airfields and towns, where large expanses of concrete result in higher temperatures than prevail in surrounding agricultural areas. Also, by comparing climatic data of one station with other nearby, similar stations, data that was not properly collected or recorded is screened.

The "cleaned" data is processed through advanced mathematical procedures to produce a grid of 2.5 km squares (1 square mile) of interpolated data for the surface of the earth. Each "grid" includes all selected climatic variables. The Atlas estimates temperature to within 1 degree Celsius (Centigrade) and precipitation to within 10 percent for most locations. The grids may be less accurate along the coasts and for hilly and mountainous regions.

The Atlas also estimates what the past temperatures and rainfall were like for most cities and towns around the world.

Future Versions

The Atlas contains data that has met rigorous quality control standards during the mapping process. "This is the first issue of the Atlas," says David Seckler, "and like other new software development, feedback is required from users to correct any errors and add new data." When new or improved data becomes available, especially from local stations, it will be incorporated in subsequent versions of the Atlas.

"We already have begun work on a second edition, which will be even more accurate," explains Mr. Seckler. "The next version will improve the precision by more than 50 percent, presenting the data at one kilometer intervals. Such a fine resolution of the instrument will make it something akin to electricity when it was first invented—no one can predict how many uses the Atlas will be put to in time."

(IIMI)

Past & Upcoming

The CGIAR Mid-Term Meeting (MTM97) will take place in Cairo, Egypt (May 26-30). Main topics on the agenda are: CGIAR Research Plans 1998-2000; Positioning the CGIAR in the Global System; CGIAR System Review; Evaluation and Impact Assessment in the CGIAR; Implementation of CGIAR Decisions on Central/Eastern Europe. Before the meeting, on May 25, the new ICLARM research facility in Abbasa, Egypt, will be inaugurated. After the meeting, a visit to ICARDA Headquarters in Aleppo, Syria, will be organized, coinciding with the center's 20th anniversary (June 2).

The Ecoregional Fund. A *Fund for Methodological Support to Ecoregional Programs* was established in 1995 with the objective of stimulating ecoregional initiatives within and outside the CGIAR. The Dutch government made a founding contribution of $5.8 million in 1995 through the Netherlands Ministry of Development Cooperation. Other donors have been invited to contribute. The fund supports research projects of maximally five years for up to $500,000.

"Agricultural Research and Development: The Need for Public-Private Sector Partnerships" is the title of a study by Clive James, Chair of the Board of Directors of the International Service for the Acquisition of Agri-biotech Applications (ISAAA), a non-profit network with centers in several regions. He had helped the CGIAR in establishing the Private Sector Committee. The study, published as *Issues in Agriculture* 9, is available from the CGIAR Secretariat.

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