Scientific and ethical challenges in agriculture to meet human needs

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The world around us is transforming itself at an unprecedented pace, in terms of population and income growth and of access to technology. Even more significant are the dramatic changes that have been taking place in the world of science. Science should certainly be congratulated for the major progress that has been made in crop research, as witnessed by the fact that average crop yields have increased fourfold and total crop harvest sixfold in the course of the last century. Agricultural research can be considered one of the most profitable areas of investment. Nevertheless, research in agriculture is still underfunded and the share of total lending devoted to agriculture has fallen from US$19 billion in the 1970s to US$10 billion in the 1990s (FAO, 1996a).

The public at large equates biological agricultural science with the failure to protect human health, the destruction of the countryside and, above all, with the creation of "Frankenfood". The United Kingdom's Prince of Wales, who is widely credited with generating this term, questions humanity's right "to experiment, Frankenstein-like, with the very stuff of life" (H.R.H. Prince of Wales, 1996). Popular perception has it that agricultural science has isolated itself from the man in the street (or the woman in the field), and is seeking to impose its ideas on the planet. These views are not new, but recently they have rapidly become more firmly and widely held.

In his opening address to the last International Crop Science Congress in 1992, Vernon Ruttan covered three areas of social concern: potential limits on growth, pollution, and environment and human health (Ruttan, 1992). These concerns are still valid, and so are Ruttan's recommendations, but the picture today is definitely more complex. While agricultural science has never taken place in a vacuum, it now has to stand up to intense public scrutiny. So it is above all the agricultural scientist who should take to heart what Sir Julian Huxley, eminent scientist, writer and

[1]The contributions of many FAO colleagues who collaborated in the preparation of this paper are gratefully acknowledged. Special thanks go to C. Batello and A. Hodder, Agricultural Officers with the Crop and Grassland Service, Agriculture Department.

international public servant – a rare combination even in his time – wrote in 1957:

> It is as if man had been appointed managing director of the biggest business of all, the business of evolution ... whether he is conscious of what he is doing or not, he is in point of fact determining the future direction of evolution on this earth. That is his inescapable destiny, and the sooner he realizes it, the better for all concerned.

Some world agricultural trends

Uneven distribution of food

Food production has increased dramatically over the last 35 years: in spite of a 70 percent increase in world population, the per capita supply of food has increased by almost 20 percent (FAO, 1996b). In developing countries, the population has almost doubled while the per capita food supply grew by almost 30 percent. As a result, the percentage of hungry people has halved from 36 percent in 1970 to 18 percent in 1995-1997. However, in absolute numbers, the decline is less spectacular: 790 million people in developing countries and 34 million in developed countries are still undernourished.

At the 1996 World Food Summit, countries committed themselves to decreasing the number of hungry people in the world to 415 million by 2015. However, the latest assessment indicates that 580 million individuals could still be undernourished 15 years from now and that, in 23 countries, more than 25 percent of the population will be undernourished (FAO, 2000). In spite of urbanization, the majority of those suffering from food insecurity are in rural areas.

Cereals will remain the principal source of food supplies, accounting for about half of daily energy intakes. About half of the projected increase in cereals will be for human consumption, and about 44 percent for animal feed. Feed use, especially in developing countries, will be the most

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dynamic element driving the world cereals economy.

The unbalanced availability of food is mirrored by the uneven application of improved production technologies. There are inequalities in effective demand, productive capacity and economics. For example, the production of 1 tonne of rice costs approximately US$1 000 in Japan, US$300 in Italy and the Niger and US$80 in the Philippines. Although the uneven application of technology is caused, to a large extent, by factors outside the realm of science, there is no reason for complacency among scientists. They do bear a part of the responsibility for the selective applicability of technologies to more favourable ecological circumstances. The ethical questions here relate to what crops are addressed and what type of production systems are targeted.

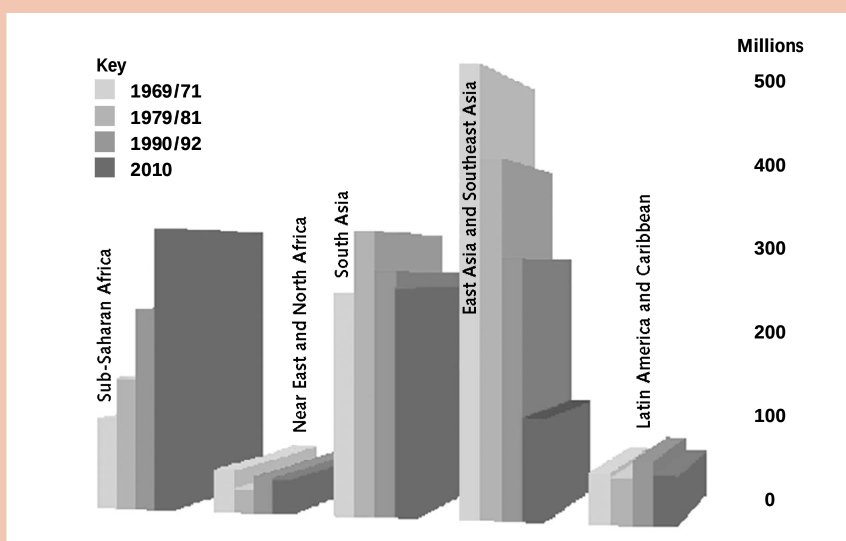
Globalization

In recent years, the world has expanded beyond the global village to include the global market where there is ever-increasing mobility of capital, labour and goods. Globalization is not only a question of size, but also of kind: it is inextricably linked to privatization. It stimulates major economic restructuring in both developed and developing countries, and has greatly changed the balance of the public and the private sectors. Globalization also affects science, especially because of the privatization of knowledge through intellectual property.

Furthermore, globalization results in concentration. For instance, in the seed and agrochemical subsectors it has been estimated that the world's top ten industries account for about 85 percent of the global market. In 1998, just four companies

FIGURE 1

Chronic undernourishment in the developing world



controlled 69 percent of the United States seed market (Hayenga, 1998). What effects will the development of such huge conglomerates have on the direction of scientific research, in particular in view of evolving food needs?

In many countries, agricultural production for export is seen as one of the driving forces of development. This implies control over the various phases of production and a dependable export certification programme that meets the regulations of importing countries. Although the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures has set standards, it has not yet resulted in reduced regulation and easier market access. Harmonization through the setting of international standards still needs considerable efforts.

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The ethical questions relate to what crops and production systems are targeted, how choices are made and priorities set with respect to the needs of specific underprivileged groups

Whatever its potential benefits, the outcomes of globalization are mixed. On the one hand, it may exacerbate the existing differences among countries and regions and calls for specific strategies to be developed according to different needs while, on the other hand, it has offered opportunities to the poorer countries and driven rapid development and local capital accumulation.

Diversification of diets and crops

Partly in response to globalization, but mostly as a result of rising incomes and urbanization, food demand in developed countries is becoming more diversified and more quality-oriented. This trend is also appearing in developing countries, albeit more slowly. As affluence increases further, there is a growth in consumer demand for food produced with technologies that are regarded as being environmentally sustainable, especially organic agriculture. But diversity in food production and consumption is not just for the urban rich; it is also essential for the poor, whose low intake of micronutrients has lasting detrimental health effects (Ames, 1998).

New crops for food and industrial purposes may open up rural employment opportunities. The recent widespread adoption of sunflower as an oilseed in the Loess plateau of China is only one example. The production and marketing of local traditional crops and varieties may satisfy urban food demand and drive rural development, as in the case of indigenous leafy vegetables being grown for urban markets in eastern and southern Africa. Similar examples of the value of local varieties of foods are also known in Europe.

Diversification of crops and products and increased nutritional quality demand a sophisticated scientific approach. Here, the ethical issue is again how choices are made and priorities set with respect to the needs of specific underprivileged target groups.

Agricultural services to society

The diversification of diets and products does not imply diversification of cropping systems *per se*. Intensive monoculture is still very much the trend in market economies. However, there is growing recognition that agriculture provides more services to society than just the production of energy or money. By its very nature, agriculture deals with common goods and public concerns. Next to its economic services, the agricultural sector is increasingly held responsible for environmental services such as the preservation of watersheds, the protection of agricultural biodiversity, the sequestration of carbon and, possibly, the production of renewable energy. Moreover, balanced national development implies maintaining rural livelihoods and traditions in order to keep remote areas alive. As a result, rural activities such as nature conservation and agrotourism set new standards and limits for agricultural production systems; and the term sustainability acquires an even broader meaning than it had. Such multipurpose land use systems also herald an era of decentralized and participatory decision-making. The ethical question facing scientists is how to provide an objective scientific basis, including indicators of environmental, economic and social impact, that allows adequate decision-making on balanced agricultural growth.

The information revolution

Information technology is shaping agricultural science and its application. Developing countries are quickly taking advantage of this situation. However, on the Internet, inadequate and misleading information exists side-by-side with examples of scientific excellence. While information technology may be a great transboundary equalizer, the need for reliable sources of scientific data is growing. The ethical issue is whether scientists, in the private and public sectors alike, are sharing their results, including their doubts and failures, sufficiently.

Scientific and technological challenges

Much is at stake for agricultural science: in order to contribute to poverty alleviation, sufficient food and a balanced diet for an increasing world population. Intensive cropping systems need to be developed that have a beneficial, or at least non-harmful, effect on the environment and provide a multitude of services to society. In this respect, the following five specific scientific issues can be highlighted.

Responsible land and water use

The optimal use of land and water is the basis for land use intensification. Today, worldwide, the average area of cropland per capita has decreased to only 0.27 ha, and in China it has dropped to 0.08 ha per capita (Lal, 1989). It has been estimated that more than 25 billion tonnes of topsoil is lost yearly (FAO, 1996b), mainly as a result of deforestation and overgrazing. Erosion and soil chemical changes induced by cropping systems all require research aimed at a better matching of crop species and cultivation systems with specific environments. Figure 2 shows 93 selected developing countries that have critically high water withdrawals. In Africa alone, average per capita freshwater availability dropped from 20 600 to 5 100 m^3 between 1950 and 2000 as a result of population growth (FAO, 1994). A case in point is Morocco, where per capita water availability in 2025 is projected to be only 780 m^3, while irrigation currently represents 92 percent of all water use in the country (FAO, 1994).

A maize crop producing about 8 tonnes/ha of grain consumes more than 5 million litres/ha of water during the growing season, requiring approximately 1 000 mm of rainfall or 10 million litres of irrigation water (Pimentel *et al.*, 1997). Balancing the requirements of agriculture with those of the population and industry forces crop science to re-examine crop yield performance. If crop yield were expressed as per unit of water rather than as per unit of land, and if realistic water pricing were applied, a significant shift may be made towards crops that show a high return per unit of water. The expected shift from rice to wheat in China over the next 25 years,

FIGURE 2

Agricultural water withdrawals as percentages of total renewable supplies

for instance, will have important implications in terms of water saving (FAO, 2000). More research is needed, not only on physiological mechanisms to increase water use efficiency, but also on simple techniques such as water harvesting that can both reduce risk and increase yields.

As the draft Hamburg Declaration[2] states, water-saving strategies in irrigated systems and better adaptation of crops to limited water availability deserve special attention. Within an integrated land and water approach, the logical complement to this is the development of new lines that are drought-tolerant. The revolution in molecular genetics makes it possible, at least in theory, to direct research towards quantitative trait loci (QTL),* and thus increase the efficiency of breeding, for some traditionally intractable agronomic problems such as improved root systems.

*Editor's note: QTL refers to a specific location in the genome that contributes in part to the expression of a phenotypic character.

Harnessing diversity

Nine plant species alone provide more than 75 percent of all human food. A mere three plant species (rice, wheat and maize) provide more than half the dietary energy of the world's population (FAO, 1999).

This is largely an effect of the selective focus of agricultural science, which has hitherto neglected the domestication of many species. FAO recognizes that food security calls for continuing work on the genetic improvement of the main crops. However, there is also a need to explore a wider range of the species that are already adapted to different ecological niches.

The domestication of new crops may be time-consuming, but there seems to be a lot of potential for the improvement of locally important minor crops, which attract limited research and development resources. There is a key role here for international public science.

Whatever the species, a promising research line seems to be for higher net photosynthetic rates. Again, new molecular technologies may increase the possibilities of adapting C4 species (e.g. maize) to new environments and of transferring the C4 metabolism to important C3 species (e.g. rice).

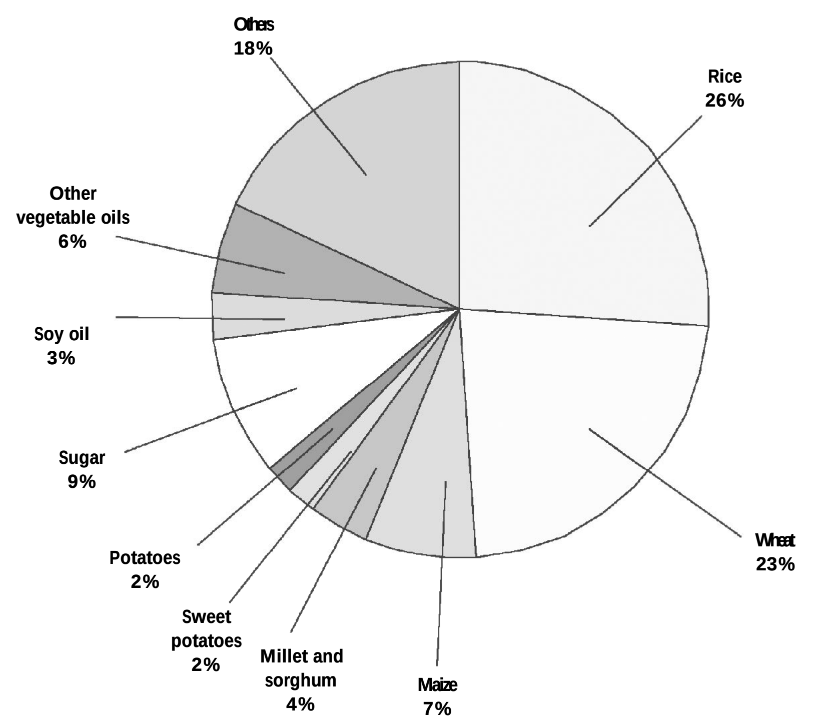
Food-insecure populations would also benefit from a focus on multipurpose species. Chinese scientists have demonstrated the huge potential of sweet sorghum in terms of grain and biomass production for food, sugar, animal feed and bio-energy (Li Dajue, 1997). To date, insufficient attention has been given to biological nitrogen fixation (BNF). Although it is recognized that possibilities exist for enhancing the BNF performance of crop legumes, increasing the role of legumes in cropping systems and transferring BNF capabilities to non-leguminous crop species (especially the major cereals), research has been fragmented, sporadic and underfunded (Boddey *et al.*, 1997).

Furthermore, there is considerable scope for taking a fresh look at perennial crops versus annuals, because of the formers' reduced fertilizer requirements, protection against soil erosion and provision of shelter for useful species. For example, the date palm (*Phoenix dactylifera*) is a perennial species with high potential on irrigated arid lands. Recently its cultivation has been introduced successfully in arid regions of southern Africa.

The potential for crop diversification strategies that promote the mitigation (or reduction) of greenhouse gas emissions and favour carbon storage should also be considered. Advances in agricultural ecology may lead to cropping systems that harness a wider range of natural resources and thereby divert solar energy to non-harvest species. FAO's Integrated Pest Management Programme has demonstrated the benefits of enhancing associated biodiversity and promoting the role of non-harvested species that are critical to the functioning of ecosystems, even when actual crop diversity is low.

FIGURE 3

Most important crops for food and energy supply



Source: FAO. *Food balance sheets* 1994-1996. Rome.

[2] The Declaration of Hamburg highlights the need for sustainable development of agroproduction and resource conservation in order to achieve and maintain food security. For more information, see the International Crop Science Congress Web site: www.cch.de/cropscience/

Sustainability: more empirical and integrated approaches

Farming systems may be deemed sustainable and efficient if organic matter, nutrient cycling rates, soil structure, erosion and ease of root penetration are all at acceptable levels, and if this is proved by crop yields that are fully satisfactory in terms of yield potentials and off-site loss rates (Tinker, 2000). This implies that research institutions must become more closely involved with real farms on a long-term basis in order to ensure that advances in science can be adapted to the scale and reality of production, especially in food-insecure regions. Such pragmatism could help to offset the risks of concentrating too much on theoretical models and neglecting the empirical and applied work that needs to be done in the field.

There is a tendency to regard work that is done behind the computer and in the lab as being more prestigious. Some disciplines may have become too atomized and specialized to be able to perform the integrating function needed to achieve sustainability. At present, neither existing curricula nor career development structures allow much opportunity for the creation of a new generation of empirical agronomists who are capable of designing sustainable systems.

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The ethical question facing scientists is how to provide an objective scientific basis for decision-making

Genetically modified organisms

The most forceful public questions are those that regard the sharing of benefits and the perceived negative effects on health and the environment of the uncontrolled application of genetically modified crops. FAO's position is that every available means to improve food security should be used, subject to careful assessments being made. Biotechnology is certainly one of the promising technical ingredients for agricultural development because it allows a more precise adaptation of genotypes to environmental conditions, nutritional and dietary needs, and market preferences. However, it is less clear that biotechnology is increasing the amount of food in the world or making more food accessible to the hungry.

Regarding the potential risks associated with the transfer of genes, it should be acknowledged that even the very latest knowledge is not yet adequate to predict either the adverse effects from the inserted gene itself or the way in which the inserted gene may alter expression of existing genes. To date, no human health problems resulting from biotechnology have been documented, but a lack of evidence of adverse effects does not necessarily mean that genetic modification is safe. Internationally, food safety is addressed in the Codex Alimentarius Commission (CAC), while the effects of living modified organisms on biodiversity are addressed in the Cartagena Protocol.[3] However, international and national regulation and risk assessments are relatively new, and public trust in these processes is low.

Plant breeding and biotechnology depend on naturally occurring genes. Agricultural biodiversity differs qualitatively from wild biodiversity and requires specific solutions. The most important genes, at the intraspecific and interspecific levels, are held within agricultural systems which have been evolving in a way that is truly international since Neolithic times. No country can do without genetic resources that come from elsewhere. A number of tropical and subtropical countries that are poor from an economic point of view contain the centres

[3] The Cartagena Protocol on Biosafety was adopted by the Parties to the Convention on Biological Diversity in January 2000, at Montreal, Quebec, Canada.

of origin of crop plants and are rich in agricultural diversity. International cooperation for the management of plant genetic resources as a global common good is therefore not an option but a necessity, which FAO's member countries are pursuing through the revised International Undertaking on Plant Genetic Resources.[4] An important step in this direction has been the unanimous recognition of farmers' rights as the complement to plant breeders' rights. The current challenge is to make this concept operative and to find a solution to the problem of access to the enabling technologies and end products that are subject to patent protection.

Transparency of information and decision-making

At the basis of public concern is a feeling of not being fully informed or, worse, of not being told the truth. With hindsight, it seems that science, and particularly agricultural biotechnology, could have done much more to get the public's support by being open and communicative about pioneering work in molecular biology and genetic engineering. *Post factum* attempts to overcome consumers' doubts through information campaigns have not done much to allay suspicions that have, by now, become entrenched.

The current debate over the labelling of foods that contain ingredients from genetically modified organisms (GMOs) has highlighted the need for transparency. Food industry leaders recognize that public confidence is essential to the success of any product and are aware of the public's ambivalence towards genetic engineering. Some leading food companies have excluded genetically engineered ingredients from their products, but others are lobbying strongly against the public pressure to segregate genetically modified foods. The net result is that polarization over the issue of labelling continues to perturb public administrations and industry throughout the world.

There can be no doubt that scientists have an absolute moral responsibility to provide objective, peer-reviewed information to the public and to refrain from publicizing immature, insufficiently tested results – whether they are positive or negative.

FAO and the need for concerted international efforts

FAO and the international public sector have been referred to several times in this article. As well as the taking up of issues of common interest for which no immediate and remunerative markets exist, two related areas should be highlighted where the existence of intergovernmental fora is essential. One is the area of sanitary and phytosanitary regulations, including food standards. In this era of globalization, international regulatory mechanisms need to be developed to maximize the potential and minimize the risks. Despite divided opinion, FAO is confident that consensus on standards for genetically modified foods can be achieved. The Organization also believes that the conclusion of the Cartagena Protocol is a large step towards facilitating the protection of the environment. Other international agreements, such as the International Plant Protection Convention, may play a role in the sustainable use of GMOs. FAO has just established an international ethics committee to discuss, among other things, the implications of modern technology for food security and agriculture.

The second area in which intergovernmental fora are essential is that of information sharing. A massive amount of information is now quickly available. However, there is a shortage of mechanisms to enhance the access of poor countries to information and to help decision-makers to sift through the significance and applicability of bewildering and often contradictory data. FAO is concerned that information resulting from scientific research is not adequately shared and spread, and that the information tools used are not always the most appropriate ones. FAO is actively promoting ways to remedy the situation.

FAO therefore concurs with the proposal made in the draft Hamburg Declaration – that DNA sequences of plant genomes should be released to a public database. In the context of the negotiations on plant genetic resources, such proposals could perhaps be regarded as a form of tax in kind whereby institutions and corporations would effectively devote some of their resources to respond to world food problems and open questions about equity.

Whether scientists, in the private and public sectors alike, are sharing their results (including their doubts and failures) sufficiently is an ethical issue

It is not easy to be an agricultural scientist today, especially as young and brilliant minds are being lured away into other fields and when public opinion considers that scientists are interfering with evolution. However, all scientists have a responsibility towards the weak and the poor even if, in the rapidly globalizing world, this is not self-evident. Scientists need to look beyond their disciplines and support policy and regulatory measures to protect international public goods.

Distinctions should be made between the emerging global economy, which is a reality, and global society, which has yet to

[4] Drawn up in August 2000 at the 3rd Inter-sessional Meeting of the Contact Group of the Commission on Genetic Resources for Food and Agriculture (CGRFA) in Tehran, Islamic Republic of Iran.

be built. It is perhaps in pursuit of the latter that the moral responsibility of science needs to be particularly emphasized. As global markets and privatization are not matched by global governance, many transboundary issues of concern to humanity remain to be solved. These include phytosanitary standards and risk analysis, optimal use of the earth's land and water resources, and the mitigation and contributing role of agriculture in global change. While there is greater awareness of the need to manage international public goods responsibly, the political tools to do so are weak and, in the globalized economy, small countries, small companies and small farmers have very small voices. Scientists have a moral responsibility to speak for the weak, and scientists' are also sometimes those who understand best the likely results of not doing so.

The first concern must be to regain the credibility and public acceptance of agricultural science. To return once more to Sir Julian Huxley: the scientists' drive should be: "... curiosity, initiative, originality, and the ruthless application of honesty – much more than feats of logic and memory alone."

This is the ultimate challenge for the scientist: to put these moral qualities at the service of the problems of development and food security.

references

Ames, B. 1998. Micronutrients prevent cancer and delay ageing. *Toxicology Letters,* 102-103: 5-18.

Boddey, R.M., de Moraes SA, J.C., Bruno, J., Alves, R. & Urquiaga, S. 1997. The contribution of biological nitrogen fixation for sustainable agricultural systems in the tropics. *Soil Biol. Biochem.*, 29(5/65): 787-799.

FAO. 1994. Water policies and agriculture. Special chapter of *The state of food and agriculture 1993*. Rome.

FAO. 1996a. Investment in agriculture, evolution and prospects. *In World Food Summit. Technical Background Documents 6-11. Volume 2.* Document No. 10. Rome.

FAO. 1996b. *Food for all.* World Food Summit, November 1996. Rome.

FAO. 2000. *Agriculture: towards 2015/30.* Technical Interim Report, April. Rome.

Hayenga, M. 1998. Structural change in the biotech seed and chemical industrial complex. *AgBioForum,* 1(2): Fall.

Huxley, J.S. 1957. *New bottles for old wine.* New York, Harper.

Lal, R. 1989. Land degradation and its impact on food and other resources. *In* D. Pimentel, ed. *Food and nature resources,* p. 85-140. San Diego, California, United States, Academic Press.

Li Dajue. 1997. Developing sweet sorghum to accept the challenge problems on food, energy and environment in the 21st century. *Proceedings First International Sweet Sorghum Conference.* September 1997, Beijing, China, FAO/Commission for Atmospheric Sciences (CAS).

H.R.H. Prince of Wales. 1996. The 1996 Lady Eve Balfour Memorial Lecture. 50th Anniversary of the Soil Association. United Kingdom.

Pimentel, D., Houser, J., Preiss, E., White, O., Fang, H., Mesnick, L., Barsky, T., Tariche, S., Schreck, J. & Alpert, S. 1997. Water resources: agriculture, the environment and society. *Bioscience:* 47(2): 97-106.

Ruttan, V.W. 1992.Research to meet crop production needs: into the 21st century. *In* D.R. Buxton, R. Shibles, F.A. Forsberg, B.L. Blad, K.H. Asay, G.M. Paulsen and R.F. Wilson, eds. *International crop science* I, p. 3-100. Madison, Wisconsin, United States, Crop Science Society of America Inc.

Tinker, P.B. 2000. Future NRM Work. Background paper for special Technical Advisory Committee meeting on Consultative Group on International Agricultural Research (CGIAR) Vision and Strategy January 2000. (unpublished)

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summary | résumé | resumen

Scientific and ethical challenges in agriculture to meet human needs

Science has changed dramatically, and public attention to agricultural science has increased. The author of this article identifies global trends in agricultural production and poses some of the key ethical questions that scientists face. While food production has outpaced population growth over the last 35 years, 790 million people in developing countries and 34 million in developed countries are still undernourished. Scientists cannot be complacent about the uneven application of improved production technologies.

Much is at stake for agricultural science: in order to contribute to poverty alleviation and provide sufficient food and a balanced diet for an increasing world population, intensive cropping systems need to be developed that have a beneficial, or at least non-harmful, effect on the environment. Five scientific issues are highlighted: responsible land and water use; the need to harness diversity and make better use of neglected species; more empirical and integrated approaches to research; biotechnology; and transparency of information and decision-making.

Agriculture provides more services to society than merely producing energy or money. By its very nature, agriculture deals with common goods and public concerns. Today, the public views agricultural science as being isolated, failing to protect human health and destroying the countryside. Balanced national development implies maintaining rural livelihoods and traditions to keep remote areas liveable. Such multipurpose land use systems also herald an era of decentralized and participatory decision-making. Scientists need to provide an objective scientific basis, including indicators of environmental, economic and social impacts, to allow adequate decision-making on balanced agricultural growth.

Défis scientifiques et éthiques que pose l'agriculture pour répondre aux besoins de l'humanité

La science évolue de manière spectaculaire et l'intérêt du public pour les sciences agricoles ne fait qu'augmenter. L'auteur identifie les tendances mondiales de la production agricole et pose certaines des grandes questions éthiques auxquelles les scientifiques doivent répondre. Alors que la production vivrière augmente depuis 35 ans plus rapidement que la population, 790 millions de personnes vivant dans les pays en développement et 34 millions dans les pays développés sont encore sous-alimentées. Les scientifiques ne sauraient se satisfaire de l'application inégale des technologies de production améliorées.

Les sciences agricoles doivent relever un défi considérable: pour lutter contre la pauvreté et assurer une alimentation suffisante et équilibrée à une population mondiale toujours croissante, il convient de mettre au point des systèmes de culture intensive qui protègent l'environnement ou, du moins, ne le détruisent pas. Cinq domaines d'étude sont cités comme particulièrement pertinents: l'utilisation responsable de la terre et de l'eau; la nécessité d'exploiter la diversité et les espèces négligées; l'approche plus empirique et intégrée de la recherche; les biotechnologies; et la transparence de l'information et de la prise de décisions.

L'agriculture ne vise pas seulement à produire de l'énergie ou de l'argent, mais rend également d'autres services à la société. De par sa nature même, l'agriculture porte sur des biens communs et répond à des préoccupations générales. Aujourd'hui, le public voit la science agricole comme une discipline isolée, incapable de protéger la santé humaine et détruisant les campagnes. Un développement national équilibré suppose le maintien des moyens de subsistance et des traditions des populations rurales, afin que même les régions reculées demeurent habitables. De tels systèmes polyvalents d'utilisation des terres s'appuieront également sur un processus décisionnel décentralisé et participatif. Les scientifiques doivent assurer une base scientifique objective, incluant des indicateurs écologiques, économiques et sociaux, à la prise de décisions en matière de croissance agricole équilibrée.

Desafíos científicos y éticos en la agricultura para satisfacer las necesidades humanas

La ciencia ha realizado progresos espectaculares y el público presta más atención a la agronomía. El autor señala las tendencias mundiales en la producción agrícola y plantea algunas de las preguntas éticas más importantes con que se enfrentan los científicos. Aunque la producción de alimentos ha crecido a un ritmo más rápido que la población en los últimos 35 años, 790 millones de personas en los países en desarrollo y 34 millones en los países desarrollados siguen estando desnutridas. Los científicos no pueden sentirse satisfechos ante la aplicación desigual de las tecnologías perfeccionadas de producción.

Es mucho lo que está en juego para la agronomía: con el fin de contribuir al alivio de la pobreza, a la consecución de alimentos suficientes y a una dieta equilibrada para una población mundial en aumento, es necesario desarrollar sistemas de cultivo intensivo que beneficien o por lo menos no perjudiquen al medio ambiente. Se ponen de relieve cinco cuestiones científicas: utilización responsable de la tierra y el agua; necesidad de aprovechar la diversidad y sacar mayor partido de especies descuidadas; métodos de investigación más empíricos e integrados; la biotecnología; y transparencia en la información y la toma de decisiones.

La agricultura proporciona a la sociedad otros servicios además de la mera generación de energía o ingresos. Por su propia naturaleza, la agricultura se relaciona con bienes comunes e intereses públicos. En la actualidad, el público considera que la agronomía está aislada, no protege la salud humana y destruye el medio rural. Un desarrollo nacional equilibrado entraña el mantenimiento de los medios de subsistencia y las tradiciones rurales para que las zonas remotas sigan siendo habitables. Los sistemas de utilización de la tierra con fines múltiples anuncian también una era de adopción descentralizada y participativa de decisiones. Es necesario que los científicos proporcionen una base científica objetiva, incluidos indicadores de los efectos ambientales, económicos y sociales, a fin de poder tomar decisiones apropiadas para un crecimiento agrícola equilibrado.