SUSTAINABLE AGRICULTURE IN THE THIRD WORLD: DEFINING A ROLE FOR TRANSGENIC CROPS AND RESEARCH

Seminar
Brussels, 26-27 March, 2001

FEDERALE RAAD
VOOR
DUURZAME ONTWIKKELING

FRDO CFDD

CONSEIL FEDERAL
POUR LE
DEVELOPPEMENT DURABLE

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VLAAMSE INTERUNIVERSITAIRE RAAD

CONSEIL INTERUNIVERSITAIRE DE LA COMMUNAUTE FRANÇAISE DE BELGIQUE

KONINKLIJKE ACADEMIE
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FOREWORD

From international forum to international forum, the appalling famine affecting populations or some of their elements in many non or little industrialized countries is inevitably brought up. The causes of such situation are numerous and closely linked : they are political, economic and social. Given the scale of the problems, it is obvious that deep reforms are necessary in these different fields and that no sustainable development is conceivable if research and especially the implementation of solutions are not tackled in a spirit of justice and international solidarity.

Does it mean that the improvements brought by modern technologies to food production would be pointless ? That would be a misappreciation of the lessons from the past which has shown the capacity of today industrialized countries to maintain, through the growing application of science and technology, a tremendous increase in their agricultural productivity and an unprecedented food security in their history.

But now, for less than twenty years, the traditional ways of improving plant and animal species, *i.e.* sexual crossbreeding, have been challenged by a new mode of transformation, transgenesis, which consists in introducing into a living being one or several genes with particular properties so that he also expresses those properties, which are new to him. The method is innovative for two reasons. First because the genes transferred go beyond the sexual barriers between species ; an improving gene coming from a plant, but also from a bacterium or an animal, can be integrated into the genetic inheritance of another species, even of another type of organism. Secondly because this method allows the transfer of a unique characteristic, without any transmission of the other genetic characteristic which, owing to crossbreeding between varieties, would have certainly been distributed at random among the descendants.

This creation of transformed living beings, the genetically modified organisms (GMOs), represents a huge scientific advance, welcome by some for the countless underlying potentialities of production improvement and diversification, but dreaded by others due to the possible harmful effects for health or environment.

Actually, the debate does not refer only to the qualities or defects of GMOs and derived products. Plants particularly, which are the basic source for human food, have a strong symbolic charge and the crossing of barriers between plant species or the identical replication of animal populations from one individual cell are the cause for some people of metaphysical concern. But especially the commercialization of GMOs by transnational agro-industrial groups, having financial power and monopolistic strategies, raises concern and even violent opposition among farmers. How will the countries of the South, which are already weakened by the drop in the price of agricultural products, be able to protect their production system, their cultivation methods and the local varieties of their cultivated plants ?

The account and particularly the debate on these essential matters for the definition of a cooperation policy towards sustainable development formed the topic of a seminar organized in Brussels on 26 and 27 March 2001 by the Federal Council for Sustainable Development, the Conseil interuniversitaire de la Communauté française de Belgique, the Vlaamse Interuniversitaire Raad and the Royal Academy of Overseas Sciences, with the appreciable support of Mr Eddy Boutmans, Secretary of State for Development Cooperation. The present volume gathers all the texts received and approved by a review panel composed of representatives from every organizing institution. Rather than the account of GMO production methods and their agricultural applications, the texts show mainly the participants' views on the introduction of these organisms into developing countries. As the authors enjoyed total freedom of expression, the opinions formulated do not necessarily reflect the views of the organizing institutions.

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WOORD VOORAF

Van internationaal forum tot internationaal forum komt onvermijdelijk de verschrikkelijke hongersnood die in talloze niet- of weinig geïndustrialiseerde landen de bevolkingen of bepaalde van hun componenten treft, ter sprake. De oorzaken van deze situatie zijn veelvuldig en nauw met elkaar verbonden, tegelijkertijd van politieke, economische en sociale aard. Gezien de omvang van het probleem, spreekt het vanzelf dat op elk van deze vlakken diepgaande hervormingen noodzakelijk zijn en geen enkele vorm van duurzame ontwikkeling overwogen kan worden indien men geen werk maakt van het zoeken naar oplossingen en vooral ook van het aanwenden ervan in een geest van rechtvaardigheid en internationale solidariteit.

Betekent dit dan dat de verbeteringen die de moderne technologieën aan de voedselproductie kunnen aanbrengen onbeduidend zouden zijn ? Dit zou neerkomen op het verloochenen van de lessen uit het verleden, waar men vaststelde dat de vandaag geïndustrialiseerde landen, door de groeiende toepassing van de verworvenheden van wetenschap en techniek, een opmerkelijke toename van hun landbouwproductiviteit en een voedselzekerheid zonder voorgaande in hun geschiedenis verzekerden.

Sedert minder dan twintig jaar krijgen de traditionele methoden ter verbetering van planten- en diersoorten, d.w.z. de geslachtelijke kruisingen, concurrentie van een nieuwe transformatiewijze, de transgenese, die erin bestaat in een levend wezen een of meerdere genen met welbepaalde eigenschappen te introduceren opdat dit, op zijn beurt, deze nieuwe eigenschappen bij hem zou laten verschijnen. Dit procédé is op twee manieren vernieuwend. In de eerste plaats omdat de getransfereerde genen de geslachtelijke barrières tussen soorten overschrijden ; een gunstige eigenschappen verwekkend gen, afkomstig van een plant, maar ook van een bacterie of een dier, kan geïntegreerd worden in het erfelijke patrimonium van een andere soort, en zelfs van een ander type organisme. Vervolgens, omdat de methode de overdracht van één enkele eigenschap mogelijk maakt, los van de andere erfelijke eigenschappen die bij kruisingen tussen soorten ongetwijfeld lukraak onder het nageslacht verspreid zouden worden.

Het ontstaan van op deze manier getransformeerde levende wezens, de genetisch gemanipuleerde organismen (GGO's), betekent een ongelooflijke wetenschappelijke vooruitgang, door de enen toegejuicht omwille van de vermoedelijk ontelbare productie-verbeterings- en diversifiëringsmogelijkheden, maar door anderen geducht omwille van de voor de gezondheid of het milieu mogelijk schadelijke gevolgen.

Eigenlijk gaat het debat niet enkel over de kwaliteiten of de gebreken van de GGO's en de daarvan afgeleide producten. Meer in het bijzonder de planten, wezenlijke bron van de voeding van de mens, zijn zwaar symbolisch belast ; zelfs de overschrijding van de barrières tussen plantensoorten of de identieke reproductie van dieren vertrekkend van één enkel individu veroorzaakt bij sommigen reeds een metafysisch onbehagen. Maar vooral de commercialisering van de GGO's door transnationale agro-industriële groepen, met monopolistische strategieën en financieel machtig, leidt in boerenmilieus tot ongerustheid en zelfs hevig verzet. Hoe kunnen de door de ineenstorting van de prijzen van landbouwproducten reeds zeer kwetsbaar geworden landen van het Zuiden zich wapenen om hun productiesysteem, hun teeltwijzen en de plaatselijke varianten van de door hen verbouwde planten te beschermen?

De uiteenzetting en vooral de bespreking van deze voor de bepaling van een op duurzame ontwikkeling afgestemd ontwikkelingsbeleid essentiële punten vormden het voorwerp van een seminarie op 26 en 27 maart 2001 in Brussel georganiseerd door de Federale Raad voor Duurzame Ontwikkeling, de Conseil interuniversitaire de la Communauté française de Belgique, de Vlaamse Universitaire Raad en de Koninklijke Academie voor Overzeese Wetenschappen, met de steun van de Heer Eddy Boutmans, Staatssecretaris voor Ontwikkelingssamenwerking. In dit boek werden de bijdragen opgenomen die na afloop ingediend en door een Redactiecomité, bestaande uit vertegenwoordigers van elk van de organiserende instellingen, goedgekeurd werden. De teksten handelen niet zozeer over de productiemethoden van de GGO's en hun toepassingen in de landbouw ; zij geven eerder de standpunten weer van de deelnemers ten overstaan van de invoering van deze organismen in de ontwikkelingslanden. Aangezien de auteurs vrijheid van meningsuiting kregen, vertegenwoordigen de uiteengezette meningen niet noodzakelijk de standpunten van de organisatoren.

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AVANT-PROPOS

De forum international en forum international est immanquablement évoquée l'effroyable famine qui affecte les populations ou certaines de leurs composantes dans nombre de pays non ou peu industrialisés. Les causes de cette situation sont multiples et étroitement liées, à la fois politiques, économiques et sociales. Il est évident, vu l'échelle des problèmes, que de profondes réformes à ces divers plans sont nécessaires et qu'aucun développement durable ne sera envisageable si l'on n'aborde pas la recherche et surtout la mise en œuvre de solutions dans un esprit de justice et de solidarité internationale.

Est-ce à dire que seraient futiles les améliorations que les technologies modernes peuvent apporter à la production alimentaire ? Ce serait là méconnaître les enseignements du passé où l'on a vu les pays aujourd'hui industrialisés assurer par l'application croissante des acquis de la science et des techniques, une augmentation prodigieuse de la productivité de leur agriculture et une sécurité alimentaire sans précédent dans leur histoire.

Or voici que depuis moins de vingt ans, les méthodes traditionnelles d'amélioration des espèces végétales et animales, c'est-à-dire les croisements sexués, se voient concurrencées par un mode de transformation nouveau, la transgenèse, qui consiste à introduire dans un être vivant un ou plusieurs gènes dotés de propriétés particulières afin qu'à son tour, il exprime ces propriétés, nouvelles pour lui. Le procédé est doublement innovant. D'abord parce que les gènes transférés franchissent les barrières sexuelles entre espèces ; un gène améliorateur provenant d'une plante, mais aussi d'une bactérie ou d'un animal, pouvant être intégré au patrimoine héréditaire d'une autre espèce, voire d'un autre type d'organisme. Ensuite, parce que la méthode permet le transfert d'un caractère unique, sans transmission des autres caractères héréditaires que les croisements entre variétés n'auraient pas manqué de répartir au hasard dans la descendance.

Cette création d'êtres vivants ainsi transformés, les organismes génétiquement modifiés (OGM), constitue un progrès scientifique immense, salué par les uns pour les innombrables potentialités d'amélioration et de diversification des productions qu'il fait entrevoir, mais redouté par les autres en raison des effets nocifs possibles pour la santé ou l'environnement.

A vrai dire, le débat ne porte pas uniquement sur les qualités ou les défauts des OGM et des produits qui en dérivent. Les plantes, en particulier, source essentielle de l'alimentation humaine, sont fortement chargées de symboles et, déjà, le franchissement des barrières entre espèces végétales ou la reproduction à l'identique de populations animales à partir d'un seul individu suscitent chez certains un malaise d'ordre métaphysique. Mais surtout la commercialisation des OGM par des groupes agro-industriels transnationaux, financièrement puissants et aux stratégies monopolistiques, soulève l'inquiétude, voire l'opposition violente des milieux paysans. Comment les pays du Sud, déjà fragilisés par la chute des cours des produits agricoles, seront-ils armés pour protéger leur système de production, leurs pratiques culturales et les variétés locales de leurs plantes cultivées ?

L'exposé et surtout la discussion de ces questions essentielles à la définition d'une politique de coopération en vue du développement durable ont fait l'objet d'un séminaire organisé à Bruxelles les 26 et 27 mars 2001 par le Conseil Fédéral du Développement Durable, le Conseil interuniversitaire de la Communauté française de Belgique, le Vlaamse Universitaire Raad et l'Académie Royale des Sciences d'Outre-Mer, avec l'appui éclairé de M. Eddy Boutmans, Secrétaire d'Etat à la Coopération au Développement. Le présent volume reprend l'ensemble des textes reçus et acceptés par un Comité de rédaction formé des représentants de chacune des institutions organisatrices. Moins que l'exposé des méthodes de production de OGM et de leurs applications agricoles, les textes reflètent davantage les points de vue des participants vis-à-vis de l'introduction de ces organismes dans les pays en voie de développement. La plus grande liberté d'expression ayant été laissée aux auteurs, les opinions énoncées ne représentent pas nécessairement les points de vue des institutions organisatrices.

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Farming Systems and Challenges in Relation with Sustainable Development

by

Marcel MAZOYER*

In less than a century, the difference in productivity between the least performing manual agriculture in the world and the best performing mechanised-animal traction, which started to spread in the industrialized countries, was from 1 to 10. Today, the difference in productivity between manual agriculture, which has disappeared in the developed countries, but is far more widespread in the developing countries, and the most powerful motor-mechanised agriculture in the world, is in the order of 1 to 1,000.

1. In effect, the contemporary agricultural revolution in its classic form (heavy motor-mechanisation, selection, use of chemicals, specialization,...), which has triumphed in the developed countries and in some limited sectors of the developing countries, has multiplied by almost ten times the yields per hectare and per animal and by close to twenty times the cultivatable surface and the number of reared animals, through agricultural activity.

2. As for the green revolution, a variant on the contemporary agricultural revolution, it has in some respects prospered in the regions and the most advanced agricultural operations in the developed countries. But if, thanks to selection, the use of chemicals and the management of water, this green revolution has brought yields close to those of the developed countries, it has not brought on the other hand, through a lack of motor-mechanisation, an increase in surface area and the number of exploitable animals through active agriculture. So that the productivity of agriculture

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provided through the green revolution remains ten times inferior to that of the heavily motor-mechanised agriculture coming from the agricultural revolution.

3. However, if one looks farther, more than a half of the world's small farmers are under-equipped and situated in the most disadvantaged regions, are continuing to cultivate a variety of plants and to raise animal strains which have not benefited from any selection. These small farmers have never had the means to buy fertilizer, concentrated foodstuffs or plant or animal protection products and even less do they have the means to buy a tractor, a traction animal, or even more perfected and diversified manual tooling. Therefore, the yields they obtain, the surface and the number of animals they exploit and the performances they attain, are still practically the same as those of the least performing manual culture at the turn of the century.

4. Therefore, the agricultural revolution, bolstered by the agricultural policies of the developed countries and by the competition between operations and between regions, has advanced production, techniques, equipment, the structures and the most performing regions, to the point where the gains in productivity in agriculture have been clearly superior to those of industry and the services. It has resulted in a very substantial secular tendency towards lowering actual agricultural prices. Since the last war, in regard to produce, the actual agricultural prices have been cut by 3, 4, 5 or more, this lowering of prices has plunged into crisis and finally eliminated one by one production, techniques, equipment, structures, the regions and the agricultural operations which are the least productive. In such a way that more than 90 % of the operations existing at the beginning of the century have today disappeared and less than 10 % will continue to participate in the selective process of unequal development in the course of the coming decades.

5. However, from continuing the agricultural revolution, the transport revolution and due to liberalization, all things which facilitate international agricultural exchanges, the actual lowering of agriculture prices, has extended to all the agricultural produce and this tends to have repercussions for all countries including the poorest. This reduces still further the derisory low income of the least performing, under-equipped small farmers, and prevents them acquiring any investment or development possibilities thereby forcing them into extreme poverty.

6. This crisis which is always ongoing for the poor, small agricultural farmers of the developing countries permits one to understand why the majority of the 800 million people affected by chronic undernourishment

(famine) and the majority of the 2 billion people who suffer from a serious lack of food are, paradoxically, rural.

It also allows one to understand why hundreds of millions of rural people have been pushed towards the under-equipped and under-industrialized urban peripheries, where unemployment and precarious under-remunerated employment predominate.

We can also understand why, with small farmer poverty becoming urban peripheral poverty, the underconsumption of the greater part of humanity has become the principal factor limiting the development of the global economy.

Finally, we understand how the international free exchange of agricultural products is a doubly malthusian mode of regulation in the sense that it limits consumption and production at the same time.

Only a new impartial organization of international agricultural exchanges can permit the durable development of all the agricultures of the world and triple the production of global agriculture which will be necessary to adequately feed 9 billion humans in fifty years.

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The World Food Supply : Prospects and Constraints

by

Per PINSTRUP-ANDERSEN * & Marc COHEN *

KEYWORDS. — Agriculture ; Agricultural Research ; Agroecology ; Biotechnology ; Food Security ; Developing Countries ; Hunger ; Poverty ; Rural Development ; World Food Supply ; Transgenics.

SUMMARY. — Hunger persists not because of inadequate food supplies, but because the affected people are too poor to afford the available food and do not have access to resources to produce food. Nearly 800 million people in developing countries are food insecure. That number will decline only to 576 million by 2015. Global food demand will rise substantially from 1995 to 2020, with virtually all of the increase coming from developing countries, due to population growth, urbanization, and income growth. The world's farmers will have to produce 40 % more grain, mainly through yield gains. Developing countries' cereal imports will double and real food prices will remain steady. The outlook may be shaped further by globalization, declining aid, violent conflict, environmental factors, technology, and health. Poverty's center of gravity will remain rural, so broad-based agricultural development is essential. Public policies must create opportunities for small farmers and other poor people while protecting natural resources. Public investment in agricultural research utilizing all appropriate scientific tools and methods is crucial. With concerted action and political will, substantial progress against hunger is possible.

Introduction

In January 2001, the Indian government faced the dilemma of having more surplus rice and wheat on hand than it had space to store. Policy makers and parliamentarians debated where to put the 50 million ton stock – nearly five times more than what is considered an adequate reserve – in light of prospects of another bumper harvest. At the same time, 208 million Indians were suffering from chronic undernutrition,

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including 150 million affected by severe drought, and a majority (53 %) of the country's preschool children were malnourished. As the *Hindustan Times* newspaper put it, "Grain, grain everywhere, but not enough to eat" (ABDI 2001, FAO 2000c, UNDP 2000).

The problem of hunger amidst plenty is a global one that extends far beyond India. Hunger persists in the 21st century not because global food supplies are inadequate, but because the people who are food insecure are too poor to afford the food that is available and do not have access to resources such as land, water, and credit to produce food for themselves. Food security is a situation where every person has access to sufficient food to sustain a healthy and productive life, consistent with the principle that everyone has a basic human right to access to adequate food and nutrition and general human dignity [1]*. It is generally viewed as having three dimensions : food availability, access to food, and appropriate utilization of food.

Current State of Global Food Insecurity and Prospects to 2020

With respect to food availability, according to the Food and Agriculture Organization of the United Nations (FAO), global food production has been adequate every year since 1974 to permit everyone to meet their minimum calorie requirements if the available food were distributed according to need. In 1996, about 2,600 calories were available per person per day in developing countries, compared to minimum requirements of 2,200 calories (FAO 2000a). The International Food Policy Research Institute (IFPRI [2]) projects that the level will rise to 2,800 calories per person per day by 2020 [3]. Increases in per capita food availability are expected in all regions, but will only reach 2,300 calories per person per day – the bare minimum – in Sub-Saharan Africa (fig. 1). Since this food will not be equally distributed, many Africans will actually have less than the minimum required (PINSTRUP-ANDERSEN *et al.* 1999). The rapid increases in food production have been obtained in part at the expense of natural resources. Unless the development and use of appropriate technology and production practices are accelerated, unsustainable food production will continue.

* The numbers in brackets [ ] refer to the notes pp. 42-43.

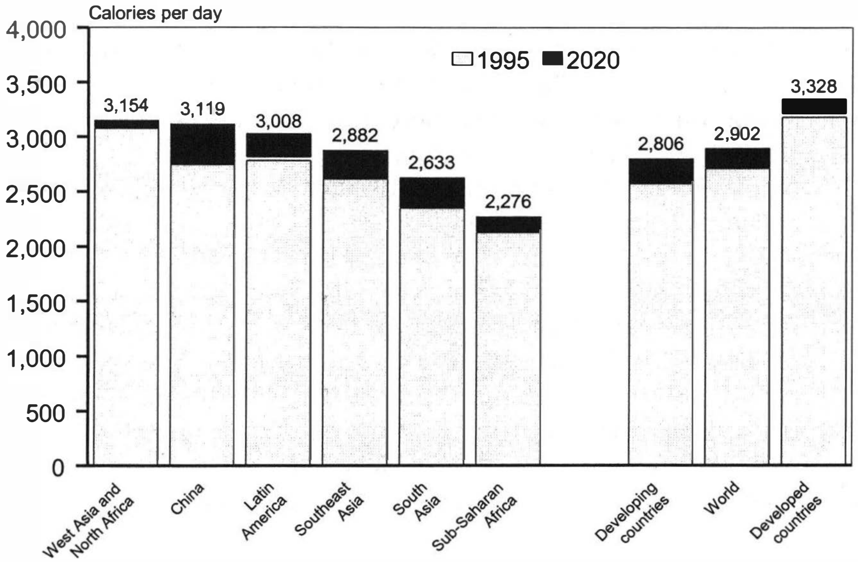

Fig. 1. — Daily *per capita* calorie availability, 1995 and 2020 (*source* : IFPRI IMPACT simulations, July 1999).

Turning to the question of access, the World Bank reports that 1.2 billion people in the developing countries live on the equivalent of less than $1 a day, and are too poor to afford food and other necessities on a sustainable basis, although they frequently spend as much as 50-70 % of their incomes on food. Sixty-eight percent of these absolutely poor people live in South Asia and Sub-Saharan Africa (World Bank 2000a, Deaton 1997). The World Bank projects that the number of poor people will remain unchanged over the next decade if growth remains slow and inequality increases from current levels. However, if countries adopt policies and interventions that foster inclusion and broad-based growth, the number of poor people could decline to 680 million by 2008 (World Bank 2000b).

Despite rapid urbanization in developing countries, 75 % of the people living in poverty remain in rural areas (IFAD 2001). The majority of poor people in developing countries will remain rural through at least 2035, although a majority of the overall population will be urban by 2020 (IFAD 2001, U.N. Population Division 2000). Rainfed and smallholder farmers, pastoralists, artisanal fisherfolk, landless labourers, indigenous people, people in female-headed households, and displaced persons are the rural people most affected by poverty (IFAD 2001).

In 1997 (the last year for which data are available), 792 million people in developing countries (18 % of the developing world's population) were food insecure (FAO 2000c). The number of undernourished people in developing countries has declined since 1980, when it stood at 937 million, or 29 % of the total (FAO 2000a).

Two of every three undernourished people in the developing countries live in the Asia-Pacific region, and 44 % live in China and India. In South Asia, 23 % of the population is undernourished, compared to 13 % in Southeast Asia and 12 % in East Asia. The incidence of Asia-Pacific undernourishment fell from 32 % in 1980 to 17 % in 1997, but half a billion people remained food insecure in the latter year (FAO 2000a, 2000c).

Sub-Saharan Africa is the developing region with the highest proportion of its population (34 %) undernourished. This is somewhat lower than the 1980 figure (38 %). The number of food insecure Africans jumped nearly 50 % during this period, from 125 million to 186 million (FAO 2000a, 2000c).

FAO projects that by the year 2015, the number of undernourished people in developing countries will fall to 576 million, or 10 % of the people in the developing world (fig. 2). Although a reduction from

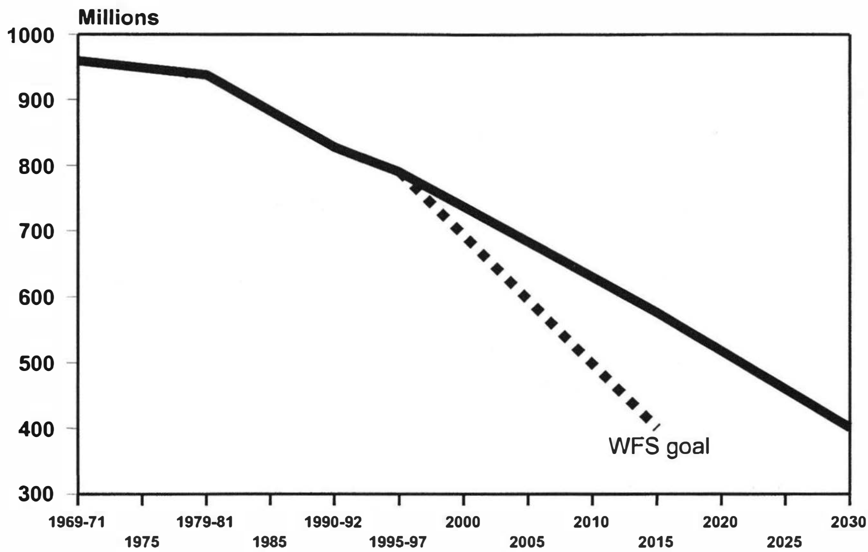

Fig. 2. — Food insecurity in the developing world, 1969/71 – 2030 (*source* : FAO 2000a).

current levels of food insecurity, this is far short of the goal agreed upon by the high-level representatives of 185 countries, including many heads of state and government, at the 1996 World Food Summit. They had pledged "our political will and our common and national commitment to achieving food security for all and to an ongoing effort to eradicate hunger in all countries, with an immediate view to reducing the number of undernourished people to half their present level (*i.e.* to 400 million people) no later than 2015" (FAO 1997). The international community's failure to achieve adequate progress toward the Summit goal is not just a political failure to keep a commitment, but a moral failure as well. It makes the Summit's reaffirmation of the right of every human being to adequate food and freedom from hunger ring hollow.

FAO projects that in 2015, 315 million South and East Asians will remain food insecure, although the incidence of undernutrition will be 10 % or less in both subregions. In Africa, 184 million people (22 % of all Africans) will face undernutrition. The center of gravity of hunger will remain squarely in South Asia and Sub-Saharan Africa, which will be home to 61 % of all food insecure people, about the same share as in 1997 (FAO 2000a).

People with real names and faces stand behind these rather dry statistics. They are such people as an elderly Egyptian man, who says, "My children were hungry and I told them the rice is cooking, until they fell asleep from hunger" (World Bank 2000b). Or Kone Figue, who weeds and harvests her small rice farm in Côte d'Ivoire by hand, and seldom produces enough to feed her family of eight for a whole year (SCHIOLER 1998).

Of particular concern are the 160 million malnourished preschool children in developing countries (ACC/SCN & IFPRI 2000). Malnutrition is a factor in 5 million child deaths annually (a toll equivalent to half the population of Belgium), and those who survive face impaired physical and mental development (WHO 1999). Food insecurity robs humanity of countless scientists, artists, community and national leaders, and productive workers. Without significant changes in national and international policies, IFPRI projects that by 2020, the number of malnourished preschoolers in the developing world will fall only about 16 %, to 135 million. This means that every fourth child will still be malnourished, compared to one in three in 1995. Child malnutrition is expected to decline in all major developing regions except Sub-Saharan Africa, where the number of malnourished children is forecast to increase by 25 % to 40 million by 2020. In South Asia, despite a reduction in the number of malnourished children by 18 million, as many as two out of five children will still be malnourished in 2020. Child malnutrition is even more heavily concentrated in these two regions than overall food insecurity : they are presently home to 73 % of all malnourished preschoolers, a level that is projected to rise to 77 % by 2020 (Pinstrup-Andersen *et al.* 1999). Many of the countries in these two regions are among the "least developed". They will require special assistance to avert widespread hunger and malnutrition in the years to come.

The expected decline in child malnutrition over 1990-2020 for all developing countries will not reach 25 %. Yet in 1990, the international community had pledged at the World Summit for Children to work to cut severe and moderate malnutrition among preschool children by half by 2000.

Low birth weight is a major contributor to child malnutrition. About one in four children in developing countries are born with low birth weights, usually as a result of poor maternal nutrition both before conception and during pregnancy. In effect, malnutrition is directly transmitted from one generation to the next (ACC/SCN and IFPRI 2000).

IFPRI research has examined the so-called "Asian enigma" — the paradox of significantly higher rates of child malnutrition in South Asia than in Sub-Saharan Africa, even though on most indicators of human well-being (access to safe water, school enrollment, food availability per person, income per person, degree of democratic governance), South Asians fare better than Africans. With respect to women's social status relative to men's, as measured by the female-to-male life expectancy ratio, Africa is doing better than South Asia ; the South Asian poverty rate (43 %) is also somewhat higher than that of Sub-Saharan Africa (39 %). Some other possible factors include climate, population density, and cultural norms that discourage sound childcare and feeding practices (Smith & Haddad 2000).

IFPRI has found four critical reasons why child nutrition improved in the developing world between 1970 and 1995. Improvements in women's education accounted for 43 % of the total reduction in child malnutrition during this period, followed by improvements in per capita food availability, improvements in the health environment, and improvements in women's status relative to men. Together, improvements in women's education and improvements in per capita food availability accounted for nearly 70 % of the reduction (fig. 3) (Smith & Haddad 2000).

With regard to food utilization, the discussion to this point has focused on food insecurity and malnutrition exclusively in terms of calorie

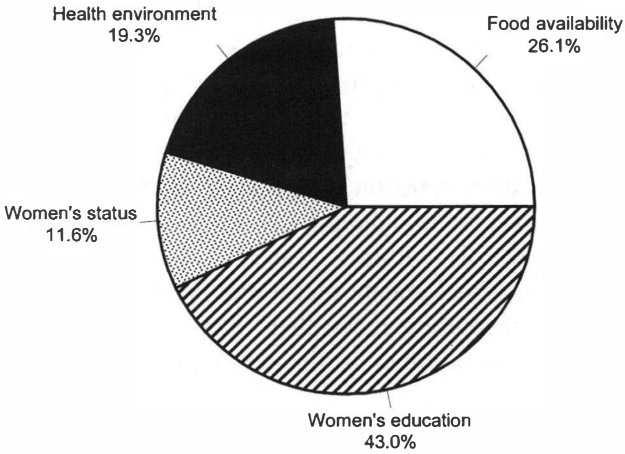

Fig. 3. — Estimated contribution of major determinants to reductions in child malnutrition, 1970-1995 (*source* : SMITH & HADDAD 2000).

consumption. Nutritionists generally agree that if a person takes in enough calories, she or he will also get the necessary protein. But this does not guarantee adequate intake of micronutrients (vitamins, minerals, and trace elements). As much as 80 % of humanity experiences iron deficiency. About 2 billion people suffer from anemia, usually due to inadequate dietary iron, including 48 % of all pregnant women and 56 % of pregnant women in developing countries. In South and Southeast Asia, 76 % of pregnant women and 63 % of preschool children are anemic. Around 50 % of the world's anemic women live in South Asia. Their risk of maternal mortality is 23 % higher than that of non-anemic mothers. Their babies are more likely to be premature, have low birth weights, and die as newborns. The incidence of anemia is also high among South Asian infants and children. Anemia can impair child health and development, limit learning capacity, impair immune systems, and reduce work performance. Even when iron deficiency does not progress to anemia, it can reduce work performance. These effects of iron deficiency result in annual economic losses as high as 2 % of gross domestic product in some developing countries (ACC/SCN & IFPRI 2000, GILLESPIE & HADDAD 2000). Nevertheless, high levels of iron deficiency anemia have persisted over the past two decades, and there are few high priority public health programs aimed at tackling this problem (WHO 1999).

Insufficient intake of vitamin A among children in developing countries is the leading cause of preventable severe visual impairment and blindness and contributes to infections and death. Pregnant women who are vitamin A deficient face increased risk of mortality and mother-to-child HIV transmission. Vitamin A deficiency impairs the immune system and increases the severity of HIV/AIDS, malaria, and other illnesses. The World Health Organization estimates that 100 million to 140 million children are vitamin A deficient, and that 250,000-500,000 of them go blind every year as a result. About half of the children who suffer from vitamin A blindness die within a year of losing their eyesight (WHO 2001). National surveys indicate that trends in the incidence of clinical eye disorders are encouraging, but that vitamin A deficiency remains a serious public health problem in the developing world (ACC/SCN & IFPRI 2000).

Food Supply and Demand to 2020 [4]

IFPRI projects a gap between food production and demand in several parts of the world by 2020. Under the most likely scenario, global demand for cereals will increase by 39 % between 1995 and 2020 ; demand for meat will increase by 58 % ; and demand for roots and tubers will increase by 37 %. These increases in demand will stem from population growth, urbanization, income growth, and associated changes in dietary preferences.

World population will increase by more than 25 % between 2000 and 2020, when it will exceed 7.6 billion. On average, 77 million people, equivalent to the population of Vietnam, will be added each year, virtually all in developing countries. Six countries will account for fully half of this population increase : India, China, Pakistan, Nigeria, Bangladesh, and Indonesia, and India and China alone will account for one-third (U.N. Population Division 2001). Urban population in developing countries is expected to double between 1995 and 2020, when the majority of the developing world's population will live in urban areas (U.N. Population Division 2000). Ninety percent of the population increase between 2000 and 2020 will occur in the rapidly expanding cities and towns. When people move to cities, they tend to shift consumption to foods that require less preparation time, and to more meat, milk, fruit, and vegetables (Garrett 2000).

Prospects for economic growth appear favourable in the developing world, and like urbanization, rising incomes will push people towards more diversified diets. IFPRI projects that total income in the developing world will increase at an average of 4.3 % per year between 1995 and 2020. Per capita incomes in all developing regions will grow. Meeting the food needs of a growing and urbanizing population with rising incomes will have profound implications for global food production and trade. However, it is important to stress that income inequality is likely to persist within and between countries. Poverty is likely to remain entrenched in South Asia and Latin America, and to increase considerably in Africa, where average income per person will remain under a dollar a day, leaving the average African in a state of absolute poverty (table 1). Many millions of impoverished people will be unable to afford the food they need, even if it is available in the market-place.

Table 1

Income Levels and Growth, 1995-2020

Region	Annual Income Growth Rate, 1995-2020	Per Capita Income Level	
		1995	2020
	(percent)	(1995 US$ per person)	
Sub-Saharan Africa[a]	3.40	280	359
Latin America and the Caribbean	3.59	3,590	6,266
West Asia and North Africa	3.83	1,691	2,783
Southeast Asia	4.44	1,225	2,675
South Asia	5.01	350	830
East Asia	5.12	984	2,873
Developed countries	2.18	17,390	28,256
Developing countries	4.32	1,080	2,217
World	2.64	4,807	6,969

Source : IFPRI IMPACT simulations, July 1999.
[a] Excluding South Africa.

Almost all of the projected increase in world demand for both cereals and meat will come from the developing countries. China alone will account for about 25 % of the increase in demand for cereals and 40 % of the added meat demand. Nevertheless, the typical developing-country consumer will still consume less than half the amount of cereals consumed by the typical Northern consumer and slightly more than one-third of the meat products. Per capita demand for cereals and meat products in developing countries will continue to lag far behind that in developed countries, due to lower incomes, significant reliance on roots and tubers as staple crops, and heavier use of cereals for livestock feed in developed countries. Notwithstanding these disparities, a demand-driven livestock revolution is already underway in the developing world, with profound implications for global agriculture, health, livelihoods, and the environment. Between the early 1970s and the mid-1990s, the volume of meat consumed in the developing countries grew almost three times as much as it did in the developed countries. IFPRI projects that in per capita terms, demand for meat in developing countries will rise 40 % between 1995 and 2000. It is crucial that governments and industries prepare for this ongoing livestock revolution in order to meet consumer demand while alleviating stresses on public health and natural resources (DELGADO *et al.* 1999).

One direct consequence of growing meat demand is that demand for cereals for feeding livestock will double in developing countries between 1995 and 2020, whereas demand for cereals for direct human consumption will increase by 40 %. Developing-country demand for maize will overtake demand for rice and wheat, with nearly two-thirds of the maize demand going towards livestock feed.

By 2020, in order to meet this surge in demand, the world's farmers will have to produce 40 % more grain than in 1995. Most of the increased output will have to come from yield gains, as ecologically and economically sound opportunities for expanding cultivated area are limited in most developing countries, and virtually non-existent in many Asian countries. Also, there are competing non-agricultural demands for land. IFPRI forecasts little increase in the global area cultivated with cereals (fig. 4). In both developed and developing countries, though, the rate of increase in cereal yields is slowing. This is due in part to reduced use of inputs such as fertilizer, reflecting low and falling cereal prices since the late 1990s, and partly to low levels of investment in agricultural research and technology. Additional factors include inadequate extension services linking researchers and farmers, insufficient or improper use of inputs, poorly functioning markets and lack of appropriate infrastructure and credit. Without substantial and sustained additional investment in agricultural research and associated factors, it will become more and more difficult to maintain, let alone increase, cereal yields in the longer term. The gap in average cereal yields between the developed and developing countries is slowly beginning to narrow, but it is widening considerably within the developing world. Sub-Saharan Africa is lagging further and further behind other regions, particularly East Asia.

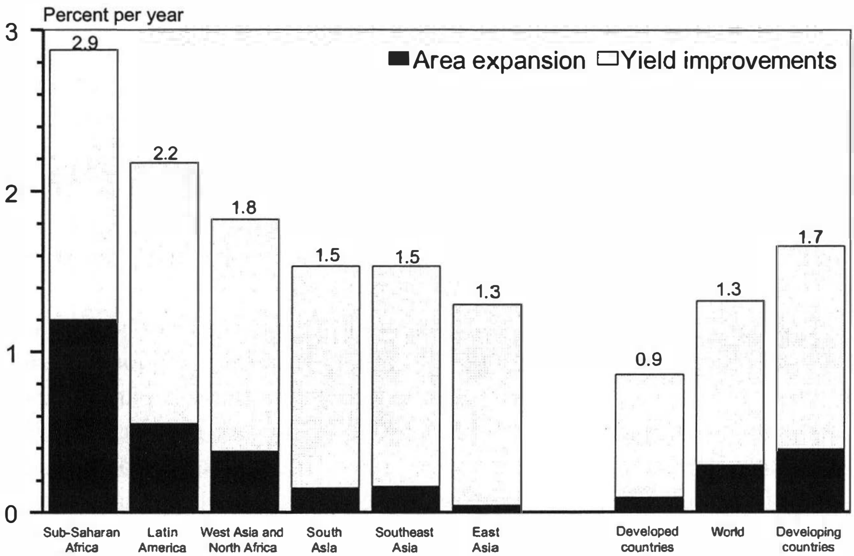

Fig. 4. — Sources of growth in cereal production, 1995-2020 (*source* : IFPRI IMPACT simulations, July 1999).

Food production will increase much faster in the developing world than in the developed world. By 2020, developing countries will account for about 60 % of both cereal and meat production, compared to 54 % for cereal and 50 % for meat in 1995. Despite production increases of about 45 %, developing country cereal output will not keep pace with demand. IFPRI projects that net cereal imports by the developing countries will almost double over the 25-year period to fill in the gap. All developing regions except Latin America are forecast to increase net cereal imports. In South Asia, imports will rise dramatically, due to declining yield growth, problems of salinity and water logging in some important producing areas, and population and income growth. Net meat imports by developing countries will jump eightfold between 1995 and 2020, although trade in meat will remain much smaller than that in cereals.

IFPRI projects that the share of the developing world's cereal demand met through net imports from developed countries will reach 12 % in 2020, up from 10 % in 1995. About 60 % of developing countries' net imports will come from the United States, but its share of the net cereal exports of the developed world is forecast to decline from 80 % in 1995 to 60 % in 2020, due to strong competition from the European Union

(EU), Australia, Eastern Europe, and the newly independent states of the former Soviet Union. The outcomes of global agricultural trade negotiations, changes in U.S. and EU domestic farm subsidies, and controversy over genetically modified food may have a substantial impact on trade patters.

IFPRI projects that real food prices will remain steady or fall slightly between 1995 and 2020. The decline in food prices will slow, as compared with past trends, due to slowing growth in crop yields and strong meat demand.

As a result of increased production and imports, the developing countries will enjoy the per capita food availability increases previously noted in figure 1. Hence, the global food situation and outlook is paradoxical : astonishing advances in agricultural productivity and human ingenuity have not yet translated into a world free of hunger and malnutrition. Dramatic changes in food production, processing, and trade have resulted in a food supply that is more than adequate to meet the minimum requirements of every human being. Since the early 1960s, grain production has doubled and livestock production has tripled, and output will continue to increase over the next two decades. Yet one of every five people in the developing world remains chronically undernourished, and child malnutrition stubbornly persists. Even in the wealthiest countries, such as the United States and the EU, a disturbing number of low-income people depend on government assistance and private charity to meet their food needs.

The situation could worsen with increased policy complacency, greater than anticipated constraints, or deterioration of key factors such as water availability, land quality, human resource development, and technological innovations. With concerted political will – that includes appropriate public investments and policies, and a much greater priority given to food security by governments and international organizations – a food secure world is within reach.

Broad-Based Agricultural Development is Critical to Food Security

It may also seem paradoxical in view of the adequacy of food supplies that productivity gains in developing country agriculture are absolutely essential to achieving universal food security. However, since the centre of gravity of poverty – and therefore food insecurity, since the key issue is access to food – will remain rural during the first three and one-half decades of the 21st century, broad-based agricultural and rural development must be at the centre of any strategy to achieve food security in the developing world. Even when rural poor people are neither farmers nor farm workers, their livelihoods depend on activities that are closely related to agriculture. Low agricultural productivity in developing countries results in high unit costs of food, poverty, food insecurity, poor nutrition, low farmer and farm worker incomes, little demand for goods and services produced by poor non-agricultural rural households, and urban unemployment and underemployment.

IFPRI research has shown that for every new dollar of farm income earned in developing countries, income in the economy as a whole rises by up to $2.60, as growing farm demand generates employment, income, and growth economy-wide (DELGADO *et al.* 1998). Agricultural growth also helps meet rising food demand.

Small farmers in developing countries face many problems. Low soil fertility and lack of access to plant nutrients, along with acid, salinated, and waterlogged soils and drought and pests, contribute to low yields, production risks, and natural resource degradation. Inadequate infrastructure, land tenure biased against poor people, poorly functioning markets, and lack of access to credit and technical assistance add impediments.

Sound public policies are needed to guarantee that agricultural and rural development is indeed broad-based, creating opportunities for small farmers and other poor people. The development of well-functioning and well-integrated markets for agricultural inputs, commodities, and processed goods, along with the supporting institutions and infrastructure (such as roads and storage, especially in rural areas) will contribute enormously to poverty alleviation, food security, and the overall quality of life in developing countries. However, by themselves, markets cannot, and should not, be expected to assure equity. Key public policies and investments include :

- Assuring poor farmers access to yield increasing crop varieties – including drought- and salt-tolerant and pest-resistant varieties – improved livestock, and other yield-increasing and environment-friendly technology ;
- Assuring poor farmers access to productive resources, including land, water, tools, fertilizer, and pest management ;
- Removing institutional barriers to the creation and expansion of small-scale rural credit and savings institutions and making them available to small farmers, traders, transporters, and processing enterprises ;
- Assuring access to extension services and technical assistance ;

- Particular attention to the needs of women farmers, who grow much of the locally produced food in developing countries ;
- Primary education, health care, clean water, safe sanitation, and good nutrition for all.

These investments must be supported by good governance – the rule of law, transparency, sound public administration, and respect for human rights – as well as trade, macroeconomic, and sectoral policies that do not discriminate against agriculture and are favourable to poverty reduction and food security. Policies must also provide incentives for sustainable natural resource management, such as secure property rights for small farmers.

Development efforts must engage low-income people as active participants, not passive recipients. To assure responsive policies, poor people need accountable organizations that articulate their interests. In addition, alliances with nonpoor people can often be effective in advancing the empowerment of poor people (PINSTRUP-ANDERSEN 1993, COHEN 1994).

At present, developing countries are underinvesting in agriculture. On average, they devote 7.5 % of government expenditures to agriculture, and the figure is even lower in Sub-Saharan Africa, where agriculture's contribution to gross domestic output is 30-80 % (FAO 1996, 2000b). While there are no reliable regional data on military spending in Sub-Saharan Africa, some of the region's poorest countries are devoting between 4 and 15 % of gross domestic product to military spending. In South Asia, the regional average is 2.4 % of GDP, and if India is excluded, the figure jumps to more than 3 % (UNDP 2000).

Agricultural research is vital. Public investment in agricultural research that can improve small farmers' productivity in developing countries is especially important for food security. It must join all appropriate scientific tools and methods — including agro-ecology, conventional research methods, and genetic engineering — with better utilization of indigenous knowledge. For example, in India, efforts to intensify hill tribe agriculture and boost incomes combine traditional soil and water conservation techniques with cultivation of new, high value cash crops [5]. It is important that poor farmers have access to the full range of approaches to tackling their problems. Research should focus on productivity gains on small farms, emphasizing staple food crops and livestock. More research must be directed to appropriate technology for sustainable intensification of agriculture in resource-poor areas, where hundreds of millions of poor people live (PENDER & HAZELL 2000).

The private sector is unlikely to undertake much research needed by small farmers in developing countries because expected gains will not cover costs. However, gains to society and to poor people are high. Social rates of return to agricultural research investment exceed 20 % per year, compared to long run real interest rates of 3-5 % for government borrowing (ALSTON *et al.* 2000). Yet low-income developing countries invest less than 0.5 % of the value of farm production in agricultural research, compared to 2 % in higher income countries. Average annual growth rates of public agricultural research expenditures in developing countries fell from 6.4 % in 1971-81 to 3.9 % in 1981-91, and for Sub-Saharan Africa, the decline was from 2.5 % to 0.8 % (table 2) (PARDEY & ALSTON 1995, PARDEY *et al.* 1999).

Table 2

Global Trends in Public Agricultural Research Expenditures

	1971-81	1981-91	1971-91
		(percentages)	
Average annual growth rates :			
Developing countries	6.4	3.9	5.1
Sub-Saharan Africa	2.5	0.8	1.6
China	7.7	4.7	6.3
Asia and Pacific (excluding China)	8.7	6.2	7.3
Latin America and the Caribbean	7.0	0.5	2.7
West Asia and North Africa	4.3	4.1	4.8
Developed countries	2.7	1.7	2.3
Total	4.3	2.9	3.6

Source : PARDEY *et al.* 1999.

It is important to note that the indirect impacts of agricultural research on poverty and food insecurity may be more important than the direct benefits (or losses) from on-farm technological adoption and changes in agricultural employment. As a result of widespread adoption in Asia of high-yielding cereal varieties, developed at international agricultural research centres and national agricultural research institutions, output increased dramatically and unit costs fell. This in turn led to lower food prices, and, over time, increased nonfarm employment opportunities, to the great benefit of poor people, who spend the bulk of their income on food. Lower food prices were not only beneficial to nonfarm poor consumers, but they helped many poor farmers who were net purchasers of food. For farmers who produced more than they consumed, lower prices did not necessarily mean losses where technical advances allowed them to reduce costs of production (Kerr & Kolavilli 1999).

Constraints on Ending Hunger

A number of factors could significantly influence the food outlook over the next few decades :

Trade Liberalization [6]

Many developing countries have liberalized food and agricultural trade since the 1980s. Developed countries have not taken reciprocal measures, maintaining barriers to high value commodities from developing countries such as beef, sugar, peanuts, dairy products, and processed goods. Some developed countries also continue to subsidize their exports. Developing countries must be encouraged to participate effectively in the current round of global agricultural trade negotiations, pursuing better access to industrialized countries' markets. Coalitions with certain groups of higher income countries may help improve their bargaining position. However, without appropriate domestic economic and agricultural policies, developing countries in general and poor people in particular will not capture fully potential benefits from trade liberalization. The distribution of benefits will be determined largely by distribution of productive assets. In addition, many developing countries lack administrative, technical, and infrastructural capacity to comply with global trade rules.

The African share of world agricultural trade continues to decline rapidly. The effect of current trade agreements is likely to be adverse for most African countries. Low-income countries must try to strengthen their bargaining position and pursue changes in both domestic policies and international trade arrangements :

- Domestic policy reforms that remove biases against small farmers and poor people while facilitating access to benefits from more open trade ;
- Elimination of industrialized countries' farm subsidies, export subsidies, and export controls that exacerbate price fluctuations ;

- Technical assistance and financial support for developing-country agriculture from industrialized countries ;
- Strong animal and plant health standards, with technical support from aid donors, to help developing countries produce for developed country markets ;
- Adequate levels of food aid targeted to poor groups in ways that do not displace domestic production.

Falling Aid

Aid to agriculture and rural development shrunk by almost half over 1986-97. The share of aid going to agriculture dropped from 25 to 14 %. Overall development aid fell about 17 % between 1992 and 1997 (FAO 1999). More recently, it appears that overall aid levels have stabilized, and aid to agriculture has increased somewhat (OECD 2001, FAO 2000d). Nevertheless, overall aid remains below the levels of the mid-1990s, and in real terms, aid to agriculture is still well below what was provided fifteen years ago. IFPRI research shows that donors are being short-sighted. Aid to developing country agriculture not only is effective in promoting sustainable development and poverty alleviation, but it leads to increased export opportunities for developed countries as well, including increased agricultural exports, as agricultural growth spurs more general economic growth and demand for food products (Pinstrup-Andersen & Cohen 1998).

Donors have also scrimped on aid to education. Only five of the twenty-one main bilateral donors (Denmark, Finland, Germany, the Netherlands, and Sweden) provide more than 2 % of their aid to basic education. The international community has failed to deliver on the commitment made at the 1990 World Conference on Education for All to universal primary education, for girls and boys alike, by no later than 2000. Nor will the revised goal of universal primary education by 2015 come close to being met at the current rate of progress (Oxfam 2001).

Given the importance of female education and increased food availability to reducing child malnutrition, noted earlier, donors must revise their sectoral aid priorities, in addition to reversing the overall aid decline. Donors must also rethink their 20-year emphasis on reducing government's economic role, which has contributed to developing countries' public disinvestment in agriculture (FAO 1996).

Food aid levels have fluctuated considerably since the mid-1990s. Late in the decade, the United States, which remains the largest donor, expanded food aid substantially, following major reductions in 1994-96 (Cohen 2000). The sharp peaks and valleys stemmed far less from developing country needs for either humanitarian or trade liberalization adjustment assistance than from U.S. domestic market conditions, as the United States continues inflexibly to tie its food aid to U.S. farm products.

Conflict, Refugees and Food Security

Since the end of the Cold War, internal conflicts have proliferated in developing and transition countries, particularly in Africa. Fourteen million refugees have fled these struggles, which have displaced another 20-30 million people within their own countries (UNHCR 2000, USCR 2000). Uprooted people are vulnerable to malnutrition and disease, and need humanitarian assistance to survive. Postconflict reconstruction takes years. Not only does violent conflict cause hunger, but hunger often contributes to conflict, especially when resources are scarce and perceptions of economic injustice are widespread. Conflict prevention and resolution must therefore be integrated into policies and programmes aimed at achieving food security (Messer *et al.* 1998, 2001).

Natural Resource Management

Agricultural growth, poverty alleviation, and environmental sustainability are not necessarily complementary, and achieving all three simultaneously cannot be taken for granted. Much depends on specific social, economic, and agro-ecological circumstances. Nevertheless, a high degree of complementarity is more likely to be achieved when agricultural development is broadly-based and inclusive of small- and medium-sized farms, market-driven, participatory and decentralized, and driven by technological change that enhances productivity but does not degrade the natural resource base. In order to achieve this, agricultural research must pay greater attention to sustainability features of technology, to broader aspects of natural resource management at the watershed and landscape levels, and to problems of resource-poor areas. Polluters or degraders should be subject to taxation or regulation. The performance of public institutions that manage and regulate natural resources must improve, and where possible, government should devolve management decisions to resource users or groups of users. Appropriate policies and investments can break the vicious cycle of poverty, low productivity, and environmental degradation (Hazell 1999).

Low soil fertility and lack of access to reasonably priced fertilizers, along with past and current failures to replenish soil nutrients in many countries, must be rectified through efficient and timely use of organic and inorganic fertilizers and improved soil management. Policies should support an integrated nutrient management approach that seeks to both increase agricultural production and safeguard the environment for future generations. Chemical fertilizer use should be reduced where heavy application is causing environmental harm. Fertilizer subsidies that encourage excessive use should be removed. However, it may still be necessary to subsidize fertilizer in backward regions where current use is low and soil fertility is being mined. Such areas are often home to large, food-insecure populations, especially in Africa. Increased use of fertilizer will help boost production and reduce land degradation (PINSTRUP-ANDERSEN *et al.* 1997, 1999 ; HAZELL 1999).

A new study by IFPRI and the World Resources Institute found that depletion of soil organic matter in developing countries is widespread, leading to significant economic losses and reduced fertility, moisture retention, and soil workability. Degradation also leads to increased carbon dioxide emissions from agricultural land, contributing to global warming. Cropland and pasture management strategies that result in improved soil organic matter content also increase carbon sequestration capacity, and thus help reduce agriculture-induced greenhouse gas emissions (WOOD *et al.* 2000).

Poor people in developing countries tend to depend on annual crops (which generally degrade soils more than perennial crops) and on common property lands (which generally suffer greater degradation than privately managed land). They often cannot afford to invest in land improvements. Degradation and lack of access to high-quality land frequently push poor people into clearing forests and pastures for cultivation, often at the expense of wildlife habitat, contributing to further degradation. Policies should raise the value of forests and pastures, offer incentives for sound management, and help create nonfarm employment opportunities (SCHERR 1999).

Preharvest losses to pests (insects, animals, weeds, and plant diseases) reduce the potential value of farm output by 40 %, while postharvest losses cost another 10 %. In developing countries, losses greatly exceed agricultural aid received (OERKE *et al.* 1994). Developing countries' share of the global pesticide market is expected to increase significantly during the early 21st century. Insecticides now used in developing countries are often older and acutely toxic, and are often banned in developed countries except for export (YUDELMAN *et al.* 1998).

Until recently, developing country governments and aid donors encouraged use of chemical pesticides. Now, consensus is emerging on the need for integrated pest management, emphasizing alternatives to synthetic chemicals, except as a last resort. Alternatives include use of natural predators and biological pesticides, as well as breeding pest-resistant crops (YUDELMAN *et al.* 1998).

Global water supplies are sufficient to meet demand through 2020. But water is poorly distributed across countries, within countries, and between seasons. Competition is increasing among uses. Developing countries are projected to increase water withdrawals 43 % between 1995 and 2020, doubling domestic and industrial uses at the expense of agriculture. Policy reforms can save water, improve use efficiency, and boost crop output per unit of water, while reducing the risk of armed conflict between countries sharing surface or ground water sources. These include establishing secure water rights, decentralizing and privatizing water management, and setting conservation incentives (PINSTRUP-ANDERSEN *et al.* 1997, 1999).

TECHNOLOGY

Technological advances developed through agricultural research and development made substantial contributions to the spectacular increases in food production witnessed during the twentieth century. But rapid changes are taking place in the financing, management, and organization of agricultural research, the proprietary nature of the agricultural sciences, and the nature of the biological sciences themselves. These changes are placing an increasing share of agricultural research and the ownership of new technologies in the private domain, raising concerns about the extent to which agricultural research and development will help eliminate hunger for the world's poor people in the decades to come (ALSTON *et al.* 2001). At the same time, biotechnology, modern information and communication technologies, and energy technologies offer new opportunities that could benefit poor people, their food security, and natural resource management, if policies are in place to assure that poor people can reap these benefits.

GLOBAL CLIMATE CHANGE

Global climate change is leading to higher average temperatures and sea levels and to less stable weather patterns, including more frequent and severe droughts and flooding. These changes will have profound and often negative impacts on developing countries, with many of the poorest countries being most vulnerable. There remains great controversy within the scientific and policy communities over the extent of, and future trends with regard to, this phenomenon. Nevertheless, the United Nations-sponsored Inter-governmental Panel on Climate Change recently reported that anticipated increases in temperatures mean that in the tropics, where some crops are near their maximum temperature tolerance and where dryland agriculture predominates, yields would decrease generally with even minimal increases in temperature. Where there is a large decrease in rainfall, crop yields would be even more adversely affected. Drier soils and heat could also reduce crop production in some parts of the North American "breadbasket" (Agence France Presse 2001).

The Challenges of Urban Food Security

Growth in urban poverty, food insecurity, and malnutrition and a shift in their concentration from rural to urban areas will accompany urbanization, although this shift is likely to occur more gradually than urbanization itself. Despite the growing consequences to urban well-being, policymakers do not yet have solutions that adequately reflect and respond to these challenges, which have long been conceptualized as rural problems. Because urban dwellers must buy most of their food, urban food security depends mostly on whether the household can afford to buy food, given prices and incomes (Garrett 2000, IFAD 2001).

Appropriate policies are needed to improve market efficiency and maintain stable prices, while also concentrating on creating jobs and on increasing the capacity of poor urban dwellers to find and hold more-secure, higher-paying jobs or to expand their own businesses and create new jobs. Targeted income or food programmes and more general social security and unemployment programmes will be necessary to provide for those who are left behind or who cannot work. Programmes may also need to address issues of land and housing security. Urban dwellers often depend indirectly on agriculture for their livelihoods, through employment in food transport, retailing, and processing. Survival strategies may involve maintaining links with a home community in rural areas. Urban agriculture is often important to dietary quality and as a source of income. Access to clean water and safe sanitation are critical for the well-being of urban poor people, and are an essential input into good nutrition. Higher reliance on prepared and processed foods in the cities may be a two-edged sword, as diets include higher intakes of micronutrients and protein, but also more fat and less fiber. Because women in urban areas often work outside the home, they often have less time and more difficulty in caring for their children ; care, too, is vital for good nutrition (GARRETT 2000).

HEALTH

Hungry and undernourished children are likely to miss more school days due to illness, and diet-related chronic diseases – perhaps linked to undernutrition *in utero* – take individuals out of the workforce and absorb resources from primary health services. Compounding the difficulties of malnutrition is the relentless burden of disease. The tragic pandemic of HIV/AIDS, the emergence of obesity as a serious health risk in many developing countries, and the on-going threats from malaria, tuberculosis, and other health problems are all compromising food and nutrition security in developing countries. The result is a global health crisis that appears to infect the poor and undernourished while impoverishing the affected (FLORES & GILLESPIE 2001).

Modern Agricultural Biotechnology and Developing Country Food Security [7]

A thorough discussion of the potential benefits and risks of modern agricultural biotechnology for developing country food security is beyond the scope of this paper. However, in order to link this paper to the main focus of this conference, a few relevant points should be made. Biotechnology, and particularly genetic engineering, is not a silver bullet for achieving food security, but, used in conjunction with traditional knowledge and conventional agricultural research methods, it may be a powerful tool in the fight against poverty that should be made available to poor farmers and consumers. It has the potential to help enhance agricultural productivity in developing countries in a way that further reduces poverty, improves food security and nutrition, and promotes sustainable use of natural resources. Solutions to the problems facing small farmers in developing countries will benefit both farmers and consumers.

Biotechnology may help achieve the productivity gains needed to feed a growing global population, introduce resistance to pests and diseases without costly purchased inputs, heighten crops' tolerance to adverse weather and soil conditions, improve the nutritional value of some foods, and enhance the durability of products during harvesting or shipping. The development of cereal plants capable of capturing nitrogen from the air could contribute greatly to plant nutrition, helping small farmers who often cannot afford fertilizers. By raising productivity in food production, agricultural biotechnology could help further reduce the need to cultivate new lands and help conserve biodiversity and protect fragile ecosystems.

Biotechnology may offer cost-effective solutions to micronutrient malnutrition. However, it should be viewed as complementary to other approaches, such as fortification, supplementation, conventional breeding, and diversifying diets or changing eating habits, and not as a substitute for these.

In order for modern agricultural biotechnology to prove beneficial to poor farmers and consumers in developing countries, there must first be in place an appropriate regulatory system to assure biosafety and food safety. Thorough testing is necessary to ensure the safety of new crop varieties developed through biotechnology. Unless developing countries have policies to assure that small farmers have access to extension services, productive resources, markets, and infrastructure, there is considerable risk that the introduction of agricultural biotechnology could lead to increased inequality of income and wealth, because larger farmers may capture most of the benefits through early adoption of the technology, expanded production, and reduced unit costs. Developing countries need industrial competitiveness policies that will reduce the potential for monopoly and oligopoly practices on the part of the multinational companies that dominate the genetically engineered seed market. Publicly funded research will be needed to develop the technology needed by poor people.

Low-income developing countries that wish to use an agricultural export-led growth strategy will be faced with the choice between adopting modern biotechnology in agriculture or maintaining the possibility of a GM-free food export to the EU and Japan. They could choose to differentiate and label GM foods and non-GM foods, and to the extent that they can manage such a differentiated system, they would be able to capture the benefits from modern agricultural biotechnology for domestic consumption while maintaining an export market for GM-free foods. In view of the tremendous importance of productivity increases in agriculture in low-income developing countries for poor people in both urban and rural areas, it is hard to believe that any low-income developing country would refrain from utilizing appropriate modern biotechnology in agriculture once a reasonable biosafety system is in place. A large share of the food imported by developing countries originates in the United States, and these importing countries must take a position on not only biosafety and food safety, but also whether they wish to insist on product differentiation and labeling in the case of imported food.

Conclusion

There is nothing inevitable about the rather pessimistic forecast regarding world hunger and mismanagement of natural resources that is presented here. It is possible to meet and even exceed the World Food Summit's goal without further damaging the environment. Doing this will require concerted and committed action by governments, citizen groups, and the international community to empower poor people ; mobilize new technological developments, including those in biotechnology, to benefit poor and hungry people in developing countries ; invest in the factors essential for agricultural growth, including agricultural research and human resource development ; and harness the political will to adopt sound anti-poverty, food security, and natural resource management policies. Failing to take these steps will mean continued low economic growth and rapidly increasing food insecurity and malnutrition in many low-income developing countries, environmental deterioration, forgone trading opportunities, widespread conflict, and an unstable world for all.

NOTES

[1] This is IFPRI's definition of food security. While there are many alternative definitions, those most commonly used are quite similar to this.

[2] IFPRI is one of the sixteen Future Harvest international agricultural research centres supported by the Consultative Group on International Agricultural Research.

[3] All IFPRI projections of the world food and nutrition situation are made using the Institute's global food model, the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). It covers 37 countries and country groups and 18 major agricultural commodities, and uses the FAO statistical database (FAOSTAT) for base data. Since each of the 37 countries and country groups produces and/or consumes at least some of each commodity, thousands of supply and demand parameters are specified (income, price, and cross-price elasticities of demand ; production

parameters including crop area and yield growth trends ; price response parameters ; trade distribution parameters ; and so forth). Parameter estimates are drawn from econometric analysis, assessment of past and changing trends, expert judgments, and synthesis of the existing literature. The model itself has been periodically updated. Projections from the July 1999 version are reported in this paper. For further information on the model, see ROSEGRANT, AGCAOILI-SOMBILLA & PEREZ (1995).

[4] This section draws extensively on PINSTRUP-ANDERSEN, PANDYA-LORCH & ROSEGRANT (1999).

[5] The authors are grateful to P. B.R. HAZELL, A. KNOX & P. JAGGER of IFPRI's Environment and Production Technology Division for information on this project.

[6] This section is taken from DIAZ-BONILLA & ROBINSON (1999) & PINSTRUP-ANDERSEN, PANDYA-LORCH & ROSEGRANT (1999, 1997).

[7] This section is taken from PINSTRUP-ANDERSEN & COHEN (2000).

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Seminar
Sustainable Agriculture in the Third World : defining a Role for Transgenic Crops and Research
Brussels, 26-27 March, 2001
pp. 47-48 (2002)

For which Needs can Transgenic Crops offer Responses and in what Conditions ?

by

Claude FAUQUET *

When you consider crop improvement in the last thirty years, it is clear that temperate crops and cereals have benefited most from research and development. An average increase of 2 to 3 % per year is not uncommon, which was the case for wheat, corn and rice in tropical countries. But if you look at *food crops*, the increase was very much less, if at all : cassava recorded a meagre 1 % and banana plantain was zero or negative ! Among those food crops, some are seed propagated like sorghum and millet, but most are vegetatively propagated, like cassava and yam. Transgenic plants can have an impact on all crops, but it is obvious that the biggest impact will be on vegetatively propagated food crops. These crops are difficult or impossible to breed ; therefore genetic engineering can offer a fantastic possibility to integrate useful genes without disturbing the rest of the genome. In addition, the necessary time frame to insert genes is shortened by many years.

Currently, the major targets for transgenic crops are insect and herbicide resistance, but there are many other potential targets such as viruses, bacterial and fungal diseases that can be considered as well. In addition, the new technologies are progressing rapidly and we can foresee now the possibility of improving the food quality and diet of poor people in lesser developed countries (LDCs) by directly improving their food crops.

So far, the efforts in genetic engineering have mostly been on using bacterial or viral genes in plants, but land races and wild relatives of cultivated food crops contain many valuable genes that have been lost via

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breeding. The rapid development of genomics will allow us to revert to those genes and it will then be possible to bring them back into the cultivated genotypes.

Among all those potential targets, cassava certainly combines all the needs and potentials for a rapid and efficient use of biotechnological tools. Cassava is the first food crop in LDCs and the third source of calories in the world for humans. It feeds about 600 million people each day. The productivity of cassava, with 15 % of its potential, is among the lowest ; therefore the possible gain through biotechnology is huge. The biotic constraints on cassava are very high. Gemini viruses are prevalent in Africa and India and are a threat in South America. It is estimated that 50 million tons of cassava are not produced because of viruses in Africa alone.

Cassava is a very poor crop in terms of protein and vitamins, but it is now possible to improve these traits by gene insertion. Protein profiling and vitamin content increase are possible. Furthermore, modification of starch structure and quality can be achieved in a relatively short period of time.

All these arguments could equally be made for other food crops such as banana plantain or sweet potato. Examples and status of research will be provided to illustrate and support these points.

Seminar
Sustainable Agriculture in the Third World :
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pp. 49-66 (2002)

The Case against Agricultural Biotechnology : why are Transgenic Crops incompatible with Sustainable Agriculture in the Third World ?

by

Miguel ALTIERI *

KEYWORDS. — Agroecology ; World Hunger ; Transgenic Crops ; Ecological Impacts ; Sustainable Agriculture.

SUMMARY. — The deployment of transgenic crops is occurring at a rapid pace, reaching about 44.5 million hectares in 2000. Although commercial cultivation is mostly confined to USA, Argentina, Canada and China, biotechnology proponents argue that expansion of such crops to the Third World is essential to feed the poor, reduce environmental degradation and promote sustainable agriculture. Such promises do not match reality.

- Biotechnology is a technology under corporate control, protected by patents and Intellectual Property Rights (IPR), and thus contrary to farmers' millenary traditions of saving and exchanging seeds.
- Hunger is linked to poverty, lack of access to land and maldistribution of food. Biotechnology exacerbates inequalities underlying the causes of hunger.
- Transgenic crops pose a range of potential environmental risks that threaten the sustainability of small farming systems. The ecological effects of engineered crops are not limited to pest resistance and creation of new weeds and pollution of landraces. Transgenic crops can produce environmental toxins that move through the food chain, and also may end up in the soil and water affecting invertebrates, and probably ecological processes such as nutrient cycling. Moreover, large-scale landscape homogenization with transgenic crops will exacerbate the ecological vulnerability already associated with monoculture agriculture..
- There is widespread consensus that yields have not increased with transgenic crops. In the case of Bt corn the economic advantages are not clear, given that the occurrence of the target insect pess is unpredictable.
- Savings in insecticide use are minimal when examined on a per hectare basis, and insignificant when compared to savings derived from Integrated Pest Management

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agriculture further down a misguided route, jointly perceiving agricultural problems as genetic deficiencies of organisms, and treating nature as a commodity while in the process making farmers more dependent on an agribusiness sector that increasingly concentrates power over the food system.

Will Biotechnology benefit Poor Farmers ?

Most biotechnological innovations available today bypass poor farmers : firstly, because these farmers cannot afford the seeds that are protected by patents owned by biotechnology corporations, and secondly, because this modern technology is not adapted to the marginal environments where resource-poor farmers live. An estimated 850 million people live on land threatened by desertification. Another 500 million reside on terrain that is too steep to cultivate. Because of these and other limitations, about two billion people have been untouched by modern agricultural science. Moreover, most of the rural poor live in the tropics, a region that will be most vulnerable to the effects of global warming (CONWAY 1997).

Biotechnology researchers pledge to counter problems associated with food production in such marginal areas by developing GM crops with traits considered desirable for small farmers, such as enhanced competitiveness against weeds, and drought tolerance. However, agricultural biotechnology innovations (*i.e.* Bt crops and herbicide resistant crops) are profit-driven rather than need-driven. The real thrust of the genetic engineering industry is not to make agriculture more productive but to generate profits (BUSCH *et al.* 1990). In the case of herbicide tolerance the goal is to win greater herbicide market-share for a proprietary product, and to boost seed sales at the cost of damaging the usefulness of a key pest management product (Bt) that is relied on as an alternative to insecticides.

Even if biotechnology contributes to increased harvests, poverty will not necessarily decline. Many poor farmers in developing countries do not have access to cash, credit, technical assistance or markets. The so-called Green Revolution of the 1950s and 1960s bypassed such farmers because planting the new high-yield crops, and maintaining them through the use of pesticides and fertilisers, was too costly for impoverished landowners. Data show that in both Asia and Latin America wealthy farmers with larger and better-endowed lands profited from the Green Revolution, whereas farmers with fewer resources often gained little

(LAPPE *et al.* 1998). The 'Gene Revolution' might only end up repeating the mistakes of its predecessor. Genetically modified seeds are under corporate control and patent protection ; consequently, they are very expensive. Since many developing countries still lack the institutional infrastructure and low-interest credit necessary to deliver these new seeds to poor farmers, biotechnology will only exacerbate marginalization.

Moreover, poor farmers do not fit into the profitable marketing niche of private corporations, whose focus is on biotechnological innovations for the commercial-agricultural sectors of industrial and developing nations. The private sector often ignores important crops such as cassava, which is a staple for 500 million people world-wide. The few impoverished landowners who will have access to biotechnology will become dangerously dependent on the annual purchase of genetically modified seeds. These farmers will have to abide by onerous intellectual property agreements not to plant seeds yielded from a harvest of bioengineered plants. In the USA, farmers adopting transgenic soybeans must sign an agreement with Monsanto. If they sow transgenic soybeans the next year, the penalty is about $3,000 per acre and, depending on the acreage, could cost farmers their farms, their livelihood. By controlling germplasm from seed to sale, and by forcing farmers to pay inflated prices for seed-chemical packages, companies are determined to extract the most profit from their investment (KRIMSKY & WRUBEL 1996).

What about Golden Rice ?

Scientists who support biotechnology and disagree with the assertion that most biotechnology research is profit- rather than need-driven, use the newly-developed but not yet commercialized Golden Rice to hide behind a rhetoric of humanitarianism. This experimental rice is rich in beta-carotene, an important nutrient for millions of children, especially in Asia, suffering from Vitamin A deficiency that can lead to blindness.

The suggestion that genetically altered rice is the proper way to address the condition of two million children at risk of Vitamin A deficiency-induced blindness reveals a tremendous naiveté about the real causes of vitamin and micronutrient malnutrition. Vitamin A deficiency cannot really be characterized as a problem, but rather as a symptom. It warns us of broader inadequacies associated with both poverty, and with agricultural change form diverse cropping systems toward rice monoculture promoted by the Green Revolution. People do not exhibit Vitamin A deficiency because rice contains too little Vitamin A, or beta-carotene, but rather because their diet has been reduced to rice and almost nothing else. These people suffer from many other dietary illnesses that cannot be addressed by beta-carotene, but which could be addressed, together with Vitamin A deficiency, by a more varied diet. Golden Rice must be seen as a one-dimensional attempt to fix a problem created by the Green Revolution : the problem of diminished crop and dietary diversity. A magic-bullet solution, which places beta-carotene into rice while leaving poverty, poor diets and extensive monoculture intact, is unlikely to make any durable contribution to well-being. When leafy plants are re-introduced into the diet of poor people, they provide both needed beta-carotene and other missing vitamins and micro-nutrients, providing a meaningful addition to peasant nutrition and subsistence. There is an abundance of wild and cultivated green leafy vegetables rich in vitamins and nutrients within and on the periphery of paddy rice fields, most of which are eliminated when farmers adopt monocultures and associated herbicides (Greenland 1997).

Rice biotechnologists have no understanding of the deeply-rooted cultural traditions that determine food preferences among Asian people, especially the social and even religious significance of white rice. It is highly unlikely that the Golden Rice will replace white rice, which for millennia has played a variety of nutritional, culinary and ceremonial roles. No doubt Golden Rice will clash with traditions associated with white rice, as green or blue French fries would clash with Western food preferences in the USA or Europe.

But even if Golden Rice made it into the bowls of poor Asians, there is no guarantee that it would benefit poor people who don't eat fat-rich or oil-rich foods. Beta-carotene is fat-soluble and its uptake in the intestine depends upon fat or oil in the diet. People suffering protein-related malnutrition and lacking dietary fats and oils cannot store Vitamin A well in the liver, nor transport it to the different body tissues where the vitamin is needed. Moreover, given the low concentration of beta-carotene in the miracle rice (about 1.5 mg/g of dry weight), people would have to eat more then one kilogram of rice per day to obtain a recommended daily allowance dose of Vitamin A.

Does Biotechnology increase Yields ?

A major argument advanced by biotechnology proponents is that transgenic crops will significantly boost crop yields. Data from the USA do not support such claims. US Department of Agriculture Economic Research Service report (USDA 1999) which analysed data collected in 1997 and 1998 for 12 and 18 USA region/crop combinations including Bt corn and cotton, and herbicide tolerant (HT) corn, cotton and soybeans, and their non-engineered counterparts, concluded that yields have not increased with transgenic crops, rather, soybean yields tend to be lower (about six per cent less) when compared with conventional varieties, cotton yields have remained unchanged, and maize yields are higher only under sporadic conditions of high pest-pressure. Despite the fact that there is research in the Third World to genetically engineer bananas, sweet potatoes and cotton, thus far no biotechnological breakthrough for resource-poor farmers has been recorded, and there is no GM crop on the horizon that is expected to outperform local varieties under the heterogeneous environmental conditions facing small farmers.

Some scientists and policy makers suggest that large investments through public-private partnerships can help developing countries acquire the indigenous scientific and institutional capacity to shape biotechnology to suit the needs and circumstances of small farmers. Biotech proponents envision increasing Asian rice yields in 20-25 % over the next decade. But once again, corporate intellectual property rights to genes and gene-cloning technology might play spoiler. For instance, in Brazil its national research institute (EMBRAPA) must negotiate licence agreements with nine different companies before a virus-resistant papaya developed with researchers at Cornell University can be released to poor farmers (PERSLEY & LANTIN 2000). Moreover, emerging precautionary biosafety regulations in countries such as Brazil, Mexico, Kenya, India and others will further seriously limit the rapid spread of the technology.

Environmental Impacts of Agricultural Biotechnology

Biotechnology is being pursued in order to patch up problems (*e.g.* pesticide resistance, pollution, soil degradation, etc.) caused by previous agrochemical technologies promoted by the same companies now leading the biorevolution. Transgenic crops developed for pest control closely follow the paradigm of using a single control mechanism (a pesticide) that has proven to fail over and over again with insects, pathogens and weeds (National Research Council 1996). The touted 'one gene--one pest' approach will also be easily overcome by pests that are continuously adapting to new situations and evolving detoxification mechanisms (Robinson 1996).

Agricultural systems developed with transgenic crops favour monocultures characterized by dangerously high levels of genetic homogeneity, leading to higher vulnerability of agricultural systems to biotic and abiotic stresses (Robinson 1996). By promoting monocultures, it will also undermine ecological methods of farming, such as rotation and polycultures, thus exacerbating the problems of conventional agriculture (Altieri 2000a).

As the new bioengineered seeds replace and contaminate the old traditional varieties and their wild relatives, genetic erosion will accelerate in the Third World (Fowler & Mooney 1990). Thus the push for uniformity will not only destroy the diversity of genetic resources, but will also disrupt the biological complexity that underlies the sustainability of indigenous farming systems (Altieri 1996).

Impacts of Herbicide Resistant Crops

Weed Resistance

The continuous use of herbicides such as bromoxynil and glyphosate (also known as Roundup), which herbicide resistant crops tolerate, can lead to problems (Goldberg 1992). It is well documented that when a single herbicide is used repeatedly on a crop, the chances of herbicide resistance developing in weed populations greatly increases (Holt *et al.* 1993). About 216 cases of pesticide resistance have now been reported in one or more herbicide chemical families (Holt & Le Baron 1990). Triazine herbicides have the most resistant weed species (about 60).

The problem is that given industry pressures to increase herbicide sales, acreages treated with these broad spectrum herbicides will expand, exacerbating the resistance problem. Although glyphosate is considered less prone to causing herbicide resistance in weeds, over time the increased use of the herbicide is bound to result in resistance.

Herbicides kill more than Weeds

Companies affirm that bromoxynil and glyphosate, when properly applied, degrade rapidly in the soil, do not accumulate in groundwater, have no effects on non-target organisms and leave no residue in foods.

There is, however, evidence that bromoxynil causes birth defects in laboratory animals, is toxic to fish and may cause cancer in humans (Goldberg 1992). Because bromoxynil is absorbed dermally, and because it causes birth defects in rodents, it is likely to pose hazards to farmers and farm workers. Similarly, glyphosate has been reported to be toxic to some non-target species in the soil : both to beneficial predators such as spiders, mites, carabid and coccinellid beetles, and to detritivores such as earthworms, as well as to aquatic organisms, including fish (Paoletti & Pimentel 1996). Questions about food safety also arise as this herbicide suffers little metabolic degradation in plants and is known to accumulate in fruits and tubers, and more than 37 million pounds of this herbicide are now used annually in the USA alone. Moreover, research documents that glyphosate seems to act in a similar fashion to antibiotics by altering soil biology in a yet unknown way and thus exerting effects such as :

- Reducing the ability of soybeans and clover to fix nitrogen ;
- Rendering bean plants more vulnerable to disease ;
- Reducing the growth of beneficial soil-dwelling mycorrhizal fungi, which are key for helping plants extract phosphorous from the soil.

Most poor farmers rely on soil biological processes and organic matter for soil fertility, thus altering microbial populations with herbicides can make them more dependent on fertilisers, an expensive outcome.

Creation of 'Superweeds' and Contamination of Landraces

Although there is some concern that transgenic crops themselves might become weeds, a major ecological risk is that large scale releases of transgenic crops may promote transfer of transgenes from crops to other plants, which then could become weeds but also unleash unpredictable ecological effects (Darmancy 1994). Transgenes that confer significant biological advantage may transform wild/weedy plants into new or worse weeds (Rissler & Mellon 1996). The biological process of concern here is introgression (hybridization among distinct plant species), a major problem in biodiverse farming systems within centres of origin where the possibilities of a transgenic variety encounter with sexually compatible wild relatives is very high. Evidence indicates that such genetic exchanges among wild, weed and crop plants already occur.

The fact that interspecific hybridisation and introgression are common to species such as sunflower, maize, sorghum, oilseed rape, rice, wheat and potatoes, provides a basis for expecting gene flow between transgenic crops and wild relatives to create new herbicide resistant weeds ((SNOW & MORAN 1997, LUTMAN 1999). Transgenic crops can also allow transgenes to escape into free-living populations of landraces as recently demonstrated with local maize varieties in Oaxaca, Mexico. The invasion of transgenes into native varieties could provoke a host of negative effects such as shrinking the agricultural gene pool and diluting the natural sustainability of land races. Clearly any threat to local varieties represents a threat to the food security of local farmers and accelerate the loss of native agrobiodiversity that make the traditional system sustainable (JORDAN 2002). It is imperative to maintain pools of genetically diverse material, geographically distinct from any possibility of cross-fertilization or genetic pollution from GM crops. Such islands of agricultural germplasm within traditional agriculture landscapes will act as extant safeguards against the failure of the dominant agricultural system promoted by the gene revolution.

Environmental Risks of Insect Resistant Crops (Bt Crops)

RESISTANCE

According to the biotechnology industry, the promise of transgenic crops inserted with Bt genes is that they will replace synthetic insecticides now used to control insect pests. Most crops have a diversity of insect pests, and therefore insecticides will still have to be applied to control non-Lepidoptera pests, which are not susceptible to the Bt toxin expressed by the crop (GOULD 1994). But biotechnology has a limited role in pest management, even for Lepidoptera. In the USA the economic advantages of growing transgenic corn are not assured because population densities of the European corn borer are unpredictable.

On the other hand, several Lepidoptera species have been reported developing resistance to Bt toxin in both field and laboratory tests, suggesting that major resistance problems are likely to develop in Bt crops which through the continuous expression of the toxin create a strong selection pressure (TABASHNIK 1994). No serious entomologist questions whether resistance will develop or not. The question is how fast ?

In order to delay the inevitable development of insects resistant to Bt crops, bioengineers are preparing resistance management plans, using patchworks of transgenics and non-transgenics (called refuges) to delay the evolution of resistance by providing susceptible insects for mating with resistant insects. Although refuges should cover at least 30 % of the crop area, Monsanto's new plan calls for only 20 % refuges, even when insecticides are to be used. Moreover, the plan offers no details whether the refuges must be planted alongside the transgenic crops, or at some distance away, where studies suggest they would be less effective (MALLET & PORTER 1992). In addition to refuges requiring the difficult goal of regional co-ordination between farmers, it is unrealistic to expect most small and medium sized farmers to devote up to 30-40 % of their crop area to refuges, especially if crops in these areas are to sustain heavy pest damage.

The farmers who face the greatest risk from the development of insect resistance to Bt are neighbouring organic farmers who grow corn and soybeans without agrochemicals. Once resistance appears in insect populations, organic farmers will not be able to use Bt in its microbial insecticide form to control Lepidoptera pests moving in from adjacent neighbouring transgenic fields, thus losing a valuable biorational tool for pest control.

What is ironic is that all the above ecological problems will arise while transgenic maize will not significantly reduce insecticide use in most of the corn growing areas of the US Midwest. During the past six years, the percentage of corn treated with insecticides in the USA has remained at approximately 30 %, despite a significant increase in the hectares of Bt corn planted (OBRYCKI *et al.* 2001).

EFFECTS ON NON-TARGET SPECIES

By keeping pest populations at extremely low levels, Bt crops could potentially starve natural enemies, as predators and parasitic wasps that feed on pests need a small amount of prey to survive in the agro-ecosystem. Among the natural enemies that live exclusively on insects which the transgenic crops are designed to kill (Lepidoptera), egg and larval parasitoids would be most affected because they are totally dependent on live hosts for development and survival, whereas some predators could theoretically thrive on dead or dying prey (SCHULER *et al.* 1999).

Natural enemies could also be affected directly through inter-trophic level effects of the toxin. The potential of Bt toxins moving through arthropod food chains poses serious implications for natural biocontrol in agricultural fields. Recent evidence shows that the Bt toxin can affect beneficial insect predators that feed on insect pests present on Bt crops

(Hilbeck *et al.* 1999). Studies in Switzerland show that mean total mortality of predacious lacewing larvae (Chrysopidae) raised on Bt-fed prey was 62 % compared to 37 % when raised on Bt-free prey. These Bt-prey fed to Chrysopidae also exhibited prolonged development time throughout their immature life stage (Hilbeck *et al.* 1999).

These findings are of concern to small farmers who rely for insect pest control on the rich complex of predators and parasites associated with their mixed cropping systems (Altieri 1994). Inter-trophic level effects of the Bt toxin raise serious concerns about the potential of the disruption of natural pest control. Polyphagous predators that move within and between mixed crops cultivars, will encounter Bt-containing non-target prey throughout the crop season (Hilbeck *et al.* 1999). Disrupted biocontrol mechanisms may result in increased crop losses due to pests, or to the increased use of pesticides by farmers, with consequent health and environmental hazards.

It is also now known that windblown pollen from Bt crops found on natural vegetation surrounding transgenic fields can kill non-target insects. A Cornell study (Losey *et al.* 1999) showed that corn pollen containing Bt toxin can drift several metres downwind and deposit itself on milkweed foliage with potentially deleterious effects on Monarch butterfly populations. These findings open a whole new dimension on the unexpected impacts of transgenic crops on non-target organisms which play key roles in the ecosystem, such as providing alternative food for natural enemies that depend on field margins for their continual existence in agroecosystems (Altieri 1994). But environmental effects are not limited to the interface of crops and insects. Bt toxins can be incorporated into the soil through leaf materials when farmers incorporate transgenic crop residues after harvest. Toxins may persist for 2-3 months, resisting degradation by binding to clay and humic acid soil particles while maintaining toxin activity (Palm *et al.* 1996). Such active Bt toxins that end up and accumulate in the soil and water from transgenic leaf litter may have negative impacts on soil and aquatic invertebrates and nutrient cycling processes (Donnegan & Seidler 1999).

The fact that Bt retains its insecticidal properties, and is protected against microbial degradation by being bound to soil particles and persisting in various soils for at least 234 days, is of serious concern for poor farmers who cannot purchase expensive chemical fertilisers. These farmers instead rely on local residues, organic matter, and soil micro-organisms for soil fertility (key invertebrate, fungal or bacterial species), which can be negatively affected by the soil-bound toxin (Saxena *et al.* 1999).

More Sustainable Alternatives to Biotechnology do Exist

What is Agroecology ?

A growing number of farmers, NGOs and sustainable agriculture advocates propose that instead of the biotechnology capital- and input-intensive approach, developing countries should favour an agro-ecological model that emphasizes biodiversity, nutrient recycling, synergy among crops, animals, soils and other biological components, as well as regeneration and conservation of resources (Altieri 1996).

Agro-ecological approaches rely on indigenous farming knowledge and selected low-input modern technologies to diversify production. The approach incorporates biological principles and local resources into the management of farming systems, thus providing for an environmentally sound and affordable way for smallholders to intensify production in marginal areas (Altieri 2000b).

There are proven agro-ecological alternatives to biotechnology that result in technologies that are cheap, accessible, risk averting, productive in marginal environments, environment and health enhancing, and culturally and socially acceptable. A recent analysis of 208 agro-ecologically based projects and/or initiatives documented clear increases in food production over some 29 million hectares, with nearly 9 million households benefiting from increased food diversity and security. Promoted sustainable agriculture practices led to 50-100 % increases in per hectare food production (about 1.71 tonnes per year per household) in rain-fed areas, typical of small farmers living in marginal environments ; that is an area of about 3.58 million hectares, cultivated by about 4.42 million farmers (Pretty & Hine 2000). Such yield enhancements are a true breakthrough for achieving food security among resource-poor farmers isolated from mainstream agricultural institutions (Uphoff & Altieri 1999). Some of the examples considered in this study include (Pretty 1995) :

- Brazil : 200,000 farmers using green manures/cover crops doubled maize and wheat yields ;
- Guatemala-Honduras : 45,000 farmers using the legume Mucuna as a cover for soil conservation systems tripled maize yields in hillsides ;
- Mexico : 100,000 small organic coffee producers increased production by half ;
- South-east Asia : 100,000 small rice farmers involved in IPM farmers' schools substantially increased yields while eliminating pesticides ;

- Kenya : 200,000 farmers using legume-based agroforestry and organic inputs doubled maize yields.

These examples are but a small sample of the thousands of successful experiences of sustainable agriculture implemented at the local level. Data show that over time agro-ecological systems exhibit more stable levels of total production per unit area than high-input systems, produce economically favourable rates of return, provide a return to labour and other inputs sufficient for a livelihood acceptable to small farmers and their families, and ensure soil protection and conservation and enhance agrobiodiversity. More importantly, these experiences, which emphasize farmer-to-farmer research and grassroots extension approaches, represent countless demonstrations of talent, creativity and scientific capability in rural communities. They point to the fact that human resource development is the cornerstone of any strategy aimed at increasing options for rural people and especially resource-poor farmers.

Conclusions

The ecological effects of engineered crops are not limited to pest resistance and creation of new weeds or virus strains. Transgenic crops can produce environmental toxins that move through the food chain, and also may end up in the soil and water affecting invertebrates and probably ecological processes such as nutrient cycling. Gene flow from transgenic crops to landraces can compromise the genetic integrity of centres of origin and the spread of characteristics of genetically altered grain can dilute the natural sustainability of local races. Moreover, large-scale landscape homogenization with transgenic crops will exacerbate the ecological vulnerability already associated with monoculture agriculture (ALTIERI 2000a). Unquestioned expansion of this technology into developing countries is not desirable. There is strength in the agricultural diversity of many of these countries, and it should not be inhibited or reduced by extensive monoculture, especially when the consequences of doing so results in serious social and environmental problems (THRUPP 1998).

It is through management of this biodiversity that small farmers located in marginal environments in the developing world can produce much of the needed food. The evidence is conclusive : new approaches and technologies spearheaded by farmers, local governments, and NGOs around the world are already making a sufficient contribution to food security at the household, national, and regional levels. A variety of agro-ecological and participatory approaches in many countries show very positive outcomes, even under adverse conditions. Potentials include : raising cereal yields from 50 to 200 %, increasing stability of production through diversification and soil/water management, improving diets and income with appropriate support and spread of these approaches, and contributing to national food security and to exports (UPHOFF & ALTIERI 1999).

Whether the potential and spread of these thousands of local agro-ecological innovations is realized depends on investments, policies and attitude changes on the part of researchers and policy makers. Reluctance to challenge the belief that GM crops can benefit the small farmer and relieve hunger, has led to massive investments in biotechnology to the neglect of other more promising, effectively pro-poor agroecological but less glamorous approaches. Major changes must be made in policies, institutions and research and development to make sure that agro-ecological alternatives are adopted, made equitably and broadly accessible, and multiplied so that their full benefit for sustainable food security can be realised. Existing subsidies and policy incentives for conventional chemical approaches must be dismantled. Corporate control over the food system must also be challenged. It is urgent that governments and international public organisations encourage and support effective partnerships between NGOs, local universities, and farmer organisations in order to assist and empower poor farmers to achieve food security, income generation, and natural resource conservation.

Equitable market opportunities must also be developed emphasizing fair trade and other mechanisms that link farmers and consumers more directly. The ultimate challenge is to increase investment and research in agroecology and scale up projects that have already proven successful to thousands of other farmers. If such initiatives are complemented with true land reform this holds the promise of productivity gains far outweighing the potential of agricultural biotechnology. While industry proponents will often forecast 15, 20, or even 30 % yield gains from biotechnology, smaller farms today produce from 200-1,000 % more per unit area than larger farms, world-wide (ROSSET 1999). Land reforms that bring average land holdings down to their optimum (small) size from the inefficient, unproductive overly large units that characterize much of world agriculture today, could provide the basis for production increases beside which the much ballyhooed promise of biotechnology would pale in comparison. This will generate a meaningful impact on the income, food security and environmental well-being of the world's population, especially of the millions of poor farmers yet untouched by modern agricultural technology.

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Témoignage

par

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Introduction

Venant du Sénégal, pays sahélien et de l'Afrique de l'Ouest, je voudrais me situer dans la problématique de développement global que subit l'ensemble des activités humaines dans sa réalisation. Aussi faudrait-il rappeler que notre sous-région s'active dans des formes d'intégration régionale ouvertes au monde.

L'Afrique subsaharienne se caractérise par un environnement naturel difficile :

- Des terres fragiles, dont la grande majorité est constituée de sable et de désert ;
- Des sécheresses persistantes ;
- L'avancée du désert ;
- Une gestion sauvage des ressources naturelles fragiles.

Des populations laborieuses produisent des aliments depuis des milliers d'années à partir de savoirs et savoir-faire respectueux de l'environnement difficile. Ces paysannes et paysans (agriculteurs, pasteurs, pêcheurs, arboriculteurs, ...) sont montrés du doigt depuis des siècles comme incapables d'innovations pour moderniser leurs activités.

Le contexte de réalisation du développement global

Malgré un environnement naturellement difficile depuis seulement cinquante années, et cela à cause de la volonté des administrations colo-

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niales et d'indépendance, les peuples se mobilisent et se battent pour leur survie.

Nos Etats sont institutionnellement faibles et ne disposent pas de ressources humaines, techniques et financières suffisantes.

Les économies nationales sous ajustement structurel s'écroulent sous le poids des dettes de nos Etats.

Les grandes endémies continuent de briser les efforts des peuples (paludisme, rougeole, maladies cardiovasculaires, sida, ...).

La dégradation des ressources naturelles s'accélère. Certains leaders politiques s'enlisent dans des guerres fratricides pour leur pouvoir personnel.

Les politiques sont définies et négociées encore dans la majorité des pays sans implication effective des bénéficiaires qui en assument les résultats.

Les bailleurs de fonds et leurs entreprises profitent de cet affaiblissement pour piller et manipuler nos Etats et leaders.

Nos Etats sont depuis 1960 des laboratoires de test d'idées, de concepts au nom de la coopération et de la solidarité internationale.

Les enjeux dans la problématique du développement global

En Occident, tout ce qui fait la grandeur et la force des économies a été planifié, organisé et financé par les ressources financières nationales depuis plus d'un siècle : les industries, les activités de production, de conservation, de stockage, de commercialisation, la recherche, la vulgarisation, les voies de communication,...

Quel qu'en soit le prix, même au prix de deux guerres mondiales.

Combien de ressources de nos pays ont été englouties dans ce bien-être de chez vous ?

Au moment où vous semblez être au bout de votre préparation, vous nous invitez à être au départ d'une compétitivité avec les mêmes règles, en faisant quelques minimes arrangements.

Quels sont les principes de cette compétitivité dont on ne parle jamais ?

L'homogénéisation des formes, des produits, des procédures de négoces, de services, du langage,...

Qui décide de la suspension des importations et des exportations des produits alimentaires ? Qui a le pouvoir d'alerter et de faire pression ? Quand la société des consommateurs agit-elle ? Combien de temps se passe-t-il avant que l'Etat apporte un jugement ?

Il est constaté que dans les pays industrialisés dont l'agriculture s'est modernisée — il s'agit de ceux qui ont connu une forte expansion de leurs revenus agricoles grâce aux innovations technologiques, aux options comme la spécialisation, l'expansion, la diversification, les activités à haute valeur ajoutée, les nouvelles technologies, le marketing, l'informatique, et même l'emploi des OGM, etc., – les revenus agricoles sont les plus bas.

Tout simplement, nous vivons deux systèmes de production :

- Des multinationales multifonctionnelles (productrices de semences, d'engrais, de substances phytos, de denrées alimentaires ; propriétaires de centres commerciaux, de services de transit, de transport, d'assurances, de banques, de laboratoires de recherche) ;
- Des exploitations agricoles familiales dont la multifonctionnalité traditionnelle a été combattue et marginalisée et qui, pour survivre, doivent négocier avec le premier groupe.

L'aide alimentaire internationale, certes utile, est un grand marché pour doper les prix réels et favoriser les subventions aux grands.

On paie pour produire, pour stocker, pour détruire en vue d'empêcher qu'il y ait trop de produits sur les marchés, pour faire des dons aux pauvres. Ainsi, les coûts d'implantation comme paysan sont si élevés que les enfants des fermiers n'y pensent plus.

Au nom du libéralisme, les budgets nationaux ne doivent pas trop s'occuper de la haute recherche pour les précautions — casser les monopoles publics proches des mécanismes de contrôle des citoyens pour la liberté des monopoles privés «satellites»...

Après les révolutions vertes qui ont privé le monde de dizaines de millions d'hectares aux Etats-Unis, en Amérique latine, en Asie (pour au moins cent cinquante ans)...

Après les pesticides qui ont pollué les nappes phréatiques à travers le monde et l'environnement en Afrique et dans plusieurs parties du monde...

Avec la farine animale dont les effets resteront longtemps dans notre histoire...

Nous voilà invités aux OGM et je me dois de poser trois questions :

Pour quoi faire ? Pour qui ? Par qui ?

Si j'ai voulu me situer dans un contexte de problématique de développement durable, c'est pour un rappel historique.

Pour nous, pays sénégalais, nos préoccupations ne seront pas réglées par les OGM.

Les défis du développement durable

Pour la reconnaissance et le respect des liens séculaires entre la production et les valeurs qui constituent notre identité culturelle, il faut :

- Définir et mettre en œuvre des politiques agricoles avec et pour les exploitations familiales paysannes qui se développeront en harmonie dans le respect de notre environnement fragile ;
- Appuyer nos instituts de recherche intégrés sur les luttes biologiques, la protection et le développement de nos semences traditionnelles ;
- Développer les capacités de production, de conservation et de transformation de nos produits locaux, en vue d'encourager la sécurité et la souveraineté alimentaire de nos Etats ;
- Protéger nos marchés et subventionner les paysans pour développer l'occupation des espaces par les exploitations familiales qui vivront de leurs revenus ;
- Construire et développer nos marchés régionaux ;
- Revaloriser les savoirs et savoir-faire pour garantir la continuité de l'ensemble de nos produits alimentaires faisant partie de notre patrimoine culturel ;
- Défendre avec les paysans du monde entier notre attachement à la promotion de notre métier et de notre projet de société ;
- Engager les Etats à financer les instituts de recherche pour anticiper sur les folies du brevetage et de l'enrichissement.

En attendant, qu'on me démontre en quoi les OGM aideront à la réalisation de nos défis ! Je voudrais terminer en disant : est durable ce qui est soutenable, et est soutenable ce qui part de ce que savent les gens, ce qu'ils savent faire, veulent faire, peuvent faire pour eux et leur descendance.

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Intensification of Agriculture and Release of Transgenic Crops : Social and Economic Consequences in Third World Countries under the Liberalization and Concentration of the Agribusiness

by

Walter PENGUE *

KEYWORDS. — Argentina ; Transgenic Soybean ; No Tillage ; Glyphosate ; Organic Farming.

SUMMARY. — 2000/2001 has been the period when transgenic crops like RR soybean have been planted all over Argentina. As the first developing country that adopted in such a magnitude the recombinant NDA technology, it is very important to identify the variables that explain why it has been so quickly adopted by farmers. In this paper, we discuss the external and internal markets and the socioeconomic conditions that have led farmers to adopt the technology, the effects of global trade and economy subsidies of developed countries and the impacts on our different scale models. Farmers in Argentina obtain an important discount by producing transgenic crops, especially because low costs of seeds and herbicides offered internal borders by transnational companies. Instead of it, a different scale is necessary for production and the new technological approach is generating losers and winners. We discuss too the first socioeconomic and environmental results of the application of the new technology and the expansion of it on marginal areas of the country and the trends for adoption of transgenic crops in Third World Economies. The current situation and trends for agriculture production in Argentina are also considered, as well as its risks and several productive alternatives for avoiding dependence from global markets, concentration of agricultural business and assuring food security and stability for its own people.

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Introduction

Argentina is the only country of South America that has allowed the commercial release of transgenic crops. In fact, it is the second world country – following USA – in transgenic crops implanted and the first one in technology adoption. Transgenic crops planted are soybean and maize with traits as tolerance to glyphosate or *Lepidoptera*. The rate of adoption of the new herbicide-resistant crop has levels higher than in the USA, and is part of an important complex of agricultural intensification and concentration of the economic model.

Argentina is at the global top ranking in relation with the adoption of the transgenic soybean technology. Even though this year, planted surface with this crop has risen by 100 % (around 9,500,000 has), for international trade, the whole argentine soybean that will be commercialized (25,000,000 metric tons) is transgenic.

From the commercial point of view, the new situation must be analysed taking into account two aspects. Those of the companies and farmers, and on the other hand, the customers. For farmers, RR soybean – under the current intensification of agriculture as unique mode of production – has come to solve one of the main problems in the farm management : weed control, obtaining a virtual simplification, cost reduction in the herbicide price and simple application that has made irresistible the technical package offered. For the private sector of pesticides and seed production, there is the possibility to concentrate and rearrange the business of production and commercialization of insecticides and weed killers to the new biotechnological alternative. To this point, two components of the market were satisfied, with results more that promises, but neither farmers, nor policy makers, officers companies were involved, taking into account the primordial link of this chain : the customer. For the latter, the new RR soybean and foods did not imply any improvement for the diet, neither high levels of quality nor new organoleptic factors, which convert these as necessary. These considerations added to other ones, such as the different impacts over the socioeconomic agricultural structure allowing the concentration in larger firms, the missing of small and medium growers and a changing from a low input technology to a high intensive input technology with effects on the environment, society and the quality of our well-known natural foods.

A Global Market

In a global context, the affairs of agricultural biotechnology represent a colourful blend between old and new modes of international affairs. On the one hand, governments and their emissaries still dominate most international forums, standing for the sovereign right of their countries to use and regulate natural resources. On the other hand, non-state actors have directly or indirectly taken prominent positions at the negotiating tables.

The reinforcement of agrobiotechnology industry over the last few years has led to the formation of a few powerful multinational enterprises with global outreach, and the increasing concentration of a multinational private industry with more power than the own countries, specially in the cases of developing countries, such as Argentina. On the other side and at the same time, small groups of issue-oriented NGOs such as those that protect the developing country farmers' rights, genetic resources and customer rights.

Another critical transnational network that influences the international biotech agenda is made up by the large number of scientists engaged in the many areas of pure and applied biological research, whose dependence on multinational funds is crucial.

The different groups of stakeholders tend to come together in a number of international forums, which include United Nations agencies, international conventions and regional economic organizations. Other political forums such as the G-8 are starting to decide on biotechnology and trade. While many of these entities are limited in their substantive and regulatory mandates, they do, however, represent important platforms for debates, negotiation and orientation, and the needs of future markets.

While economic interests are often invoked to explain contrasts in innovation policies and trade decisions, they fail to account for more significant variations in how societies address new technologies. For example, implementation of the precautionary principle in Europe appears at first glance to stifle industrial growth, indicating that economic factors alone do not explain public policy.

The biotechnology global market is changing. The market was constructed for supply but at the end of the second century, demand pressure and customers rights have transformed the rules. European Union and Japan address to a wide regulatory frame that now includes customers rights and willing, labelling, long-term environment studies, developing countries farmer's rights, limits for property rights and any other questions that have to be reviewed. United States is also changing its position about releasing engineered crops and reviewing its regulatory system on behalf of the public interest, customers rights and new research to bring more transparency and security to a reluctant internal and external customer.

The Situation of Argentina

Facing this international scenery, Argentina, one of the main global producers of transgenic soybean, found itself under a commercial storm without umbrella, while other producers and exporters of this kind of crops – USA, Brazil – have already located themselves, one of them beginning to distinguish the production and diminishing the adoption of RR crops and the other, because – without interrupting Biotechnology research – it has not allowed commercial releasing of transgenic crops.

Just like that, Argentina will have to analyse how and where to follow this new way of technology adoption, and which strategies are more convenient to the country, not only in the present situation but also in the medium and long term. How shall we strengthen our natural advantages, facing a general fall-down of comparative advantages by the adoption of globally widespread technology, which will allow countries that are now our purchasers to become first producers, and in the medium future, our competitors ? How shall we order the agriculture production and diversificate it to the profit of farmers, specially those small and medium producers, each day more indebted ? What are the mechanisms, instruments and policies that will allow to diversify the agricultural production and favour a real agro-ecological sustainable environment ? How to build real competitive advantages that will allow to develop and to take advantage of the few commercial specific spaces of the world market ? How to assure and guarantee the "natural market" that until now Argentina has been for the European market ? How to rotate the production by improving the incomes ? How to continue to use a tool as glyphosate without accelerating the appearance of potential resistance ? And how to avoid that our country falls down in the "monoproduction" of transgenic crops, with all the commercial risks of monocultures and the disadvantages that no differentiated products cause to farmers ? And finally, how to maintain our agriculture, and the people and environment involved, in a global market where the countries that subsidize their production system give continuous support to the goods they produce, creating artificial markets and prices that impact directly over farmers and societies in developing countries.

Since 1997, private companies, which have combined in many cases with the support and expectations of government sector, have established that this kind of biotechnology could offer a real competitive advantage to the country.

These advantages added to the comparative advantages of the country could make Argentina one of the most efficient countries for producing and trading agricultural commodities.

In this way, since the 1996/1997 season, there has been a strong campaign for the commercialization of transgenic crops (e.g. RR soybean) that grew from 20 % to 80 % of the surface implanted in 1998/1999. In five years, there were rapid adoptions of the new technology by growers who will represent during the 2000/2001 season the whole production of argentine soybean as transgenic (fig. 1). Argentina did not generate the new technology, which has been imported by an international company's branch from USA.

But this rapid commercialization of biotechnology in agriculture has not been a smooth one. In Europe, Japan and Brazil consumers, environmentalists, policy makers, scientists, the popular press and other social

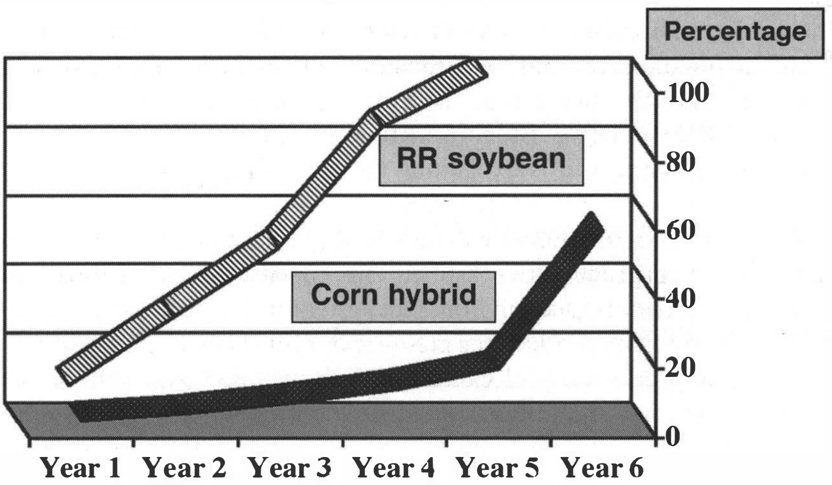


Fig. 1. — Comparison between the adoption rate of Round-up Ready soybean and the successful corn hybrid in the Pampas.

groups have forced governments to review their regulatory systems. Many of their concerns are at odds with the international trading and intellectual rules that are being promoted through institutions such as the WTO and the WIPO.

The general principles of the global trading system as set out under WTO have covered the aspects of commercialization and property rights of biotechnology but have not considered very exhaustively the long-term implications of this matter. There are, however, other issues such as the potential flow of genes from GM crops to their wild relatives. The management of pest resistance, the effects over biodiversity, the impacts of bioprospecting for developing countries, the sustainable conditions of natural resources and the consequences of such application of biotechnology over population health, that falls under the jurisdiction of other treaties and national legislations.

It is this potential regulation and orientation of biotechnology by the legislations that creates the potential for conflict between trade and environment. Differences in perceptions about the character of GM crops, the very few information about this matter from the private sector, and weak implications of governmental agencies in the country, create the current conditions in which the agricultural biotechnology is walking on.

Other countries are watching and monitoring the new demands of the markets (GLICKMAN 1999). "Science follows the market" (SACHS 1999). On the other side, Brazil, the second-world soybean supply country does not produce transgenic crops, and it is gaining a special market position in the commercialization of conventional crops in the world. But, despite this global situation, not only is Argentina not reviewing its regulatory and commercial situation about the commercial release of transgenic crops (*e.g.* RR soybean, Bt corn, RR corn, LLsoybean, RRBtcorn, RRbtsoybean), but also it is expanding the commercialization and offer of engineered crops to Argentine farmers.

A few years ago, traditional cultivation of grains was alternating with fallow seasons to grow cattle pasture. This rotation system allowed to maintain the agronomic and environment system in the long-term. But, in the 1980s, world market prices for grains and oilseeds increased, while at the same time productivity of cattle breeding declined. Agriculture has continued to become more lucrative, since the production of soybean in rotation with wheat or sunflower allows three harvests in two years. Furthermore, the open economy to the global model, the end of hyperinflation due to the fixation of the Argentine peso against the US dollar and the abolition of export levies on agricultural products triggered an investment in new technologies. This new framework favoured the import of machinery and agricultural inputs as pesticides, fertilizers and royalties on seeds at low prices and their use in oilseed production for export market (fig. 2).

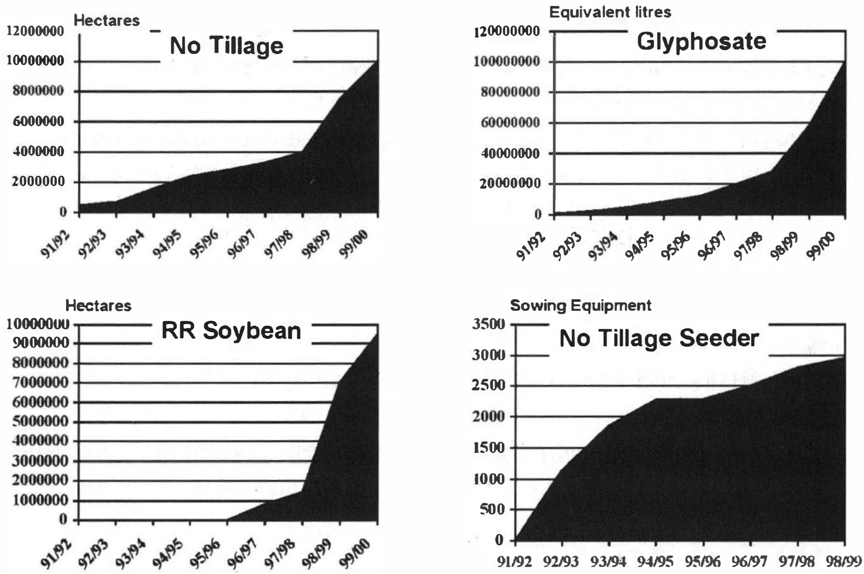


Fig. 2. — Agriculture intensification under the No Tillage Model in Argentina.

The intensification of the production system was followed by a decline in soil fertility and increase of soil erosion. Consequently, fertilizer consumption stepped up from 0.3 million tons in 1990 to 2.5 million tons in 1999. Another step was the continuous increase of No Tillage system that is being supported by herbicide consumption and special machinery for sowing. The model is directly associated with the high consumption of herbicide – such as glyphosate – of which application is being reinforced through a change in the herbicide patron, with the release of transgenic soybean, which is tolerant to this herbicide (package glyphosate + Roundup Ready soybean).

The main factors responsible for the rapid adoption of genetically modified crops are related to :

- Lower herbicide prices. In Argentina, a price of \$ 28/litre goes down now to \$ 3/l, much less expensive than in the USA. Four companies (Monsanto, Atanor, Nidera and Dow) control more than 80 % of the glyphosate market in Argentina, which is mainly imported from USA, EU and China.
- Fewer expenses on labour, fuel and machinery. Direct sowing and more effective herbicide application allow for crop cultivation with less labour and fewer machinery cycles.
- Complete knowledge of the technological package associated to No Tillage + Soybean.
- Seed prices and self-reproduction. In Argentina, farmers don't pay technological fee for seeds and they reproduce the new seeds in their fields. This action is an attempt against the companies and this year the "white bag" (seed with no certificate and fiscalization) is around 300,000 tons (fig. 3).

Risks and Profits of GMOs in Developing Countries

Biotechnology is emerging at a period of worsening inequalities between the developing countries and the industrialized world. The

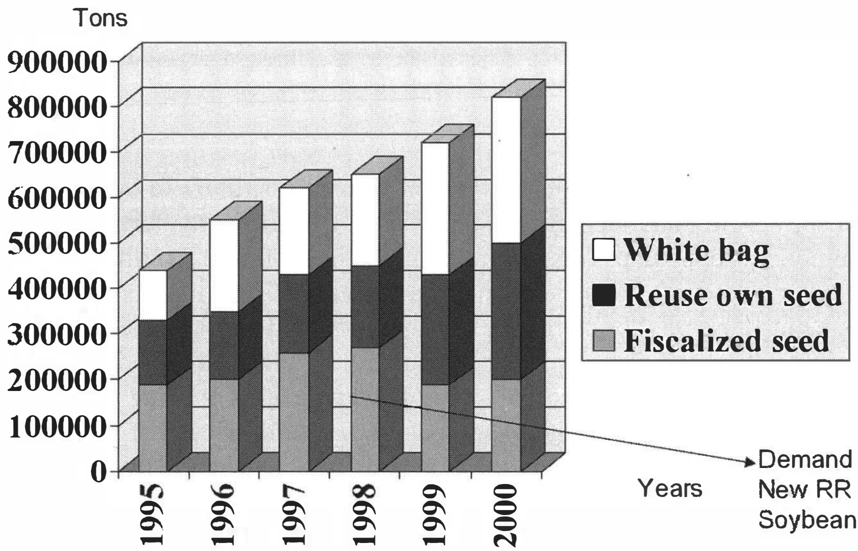


Fig. 3. — Soybean seeds consumed and soybean market in Argentina.

income gap between the fifth of the world's people living in the richest countries and the fifth in the poorest was 74 to 1 in 1997, from 60 to 1 in 1990 and 30 to 1 in 1960 (UNDP 1999). And of the US$ 460 billion spent in R&D worldwide, only one tenth was spent in the developing world where 80 % of the world's population reside (UNESCO 1999). These figures imply that many developing countries are unlikely to benefit from biotechnology.

As many developing countries are interested in the role of biotechnology in improving nutrition and reducing hunger, the majority of current agricultural biotechnology efforts are driven by markets in the developed world : thus much of the research focus is on crops that are staple varieties for animal foods, attributes that minimize labour and comfort farmers (unique herbicides, insecticides) or improve the quality of foods. Many of the crop varieties, traits and environmental or health conditions that could be important for large parts of the developing world are still widely ignored.

A redirection of current agricultural biotechnology efforts would require new incentives for the private sector to support research efforts responsive to the needs of developing countries, as well as increases in public sector support and the independent sector for agriculture research in our countries.

But given the current investment in science and technology in Brazil (0.85 % of GDP) or Argentina (0.3 %), developing countries are very far from the levels of the European Union (1.85), Japan (2.78) or the USA (2.55).

The only producer of GMOs in developing countries is Argentina, but real investment for research of the local or regional problems in the country is around 0 %.

The country imports the technology and all the local seeds' companies pay royalties for it. It seems that the country has to produce herbicide-resistant crops, which are commercialized by multinational companies and insecticide plants that protect them from insects, but with a great cost for the agricultural environment in the medium term (table 1)

Meanwhile, areas planted with GMO crops are growing continuously, as for herbicide-resistant soybean and cotton, IMI corn, and the new Bt maize (fig. 4).

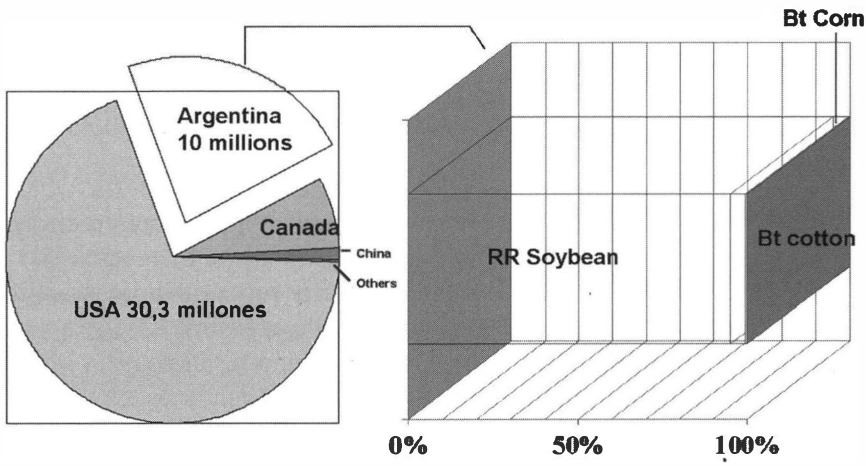
The intensification of agriculture implies for South American countries like Argentina and Brazil (the two main crop growers) two different ways of production :

Table 1

Permission Release by Trait and Crop in Argentina. Some Selected Traits

Trait	Soybean	Maize	Cotton	Rapeseed	Total	Total %
Glyphosate tolerance	14	7	5		26	23,5
Gluphosinate tolerance	6	30	1	7	44	39,6
Bt resistance	1	17	11	1	30	27,0
Bromoxynil tolerance			2		2	1,8
Bt and gluphosinate tolerance		9			9	8,1

Sources : CONABIA 1997, Pengue 1998.



36 % 72 millons ha soybean planted are GMOs.
7 % 140 millons ha corn planted are GMOs.

Source : ISAAA 2000.

Fig. 4. — Global surface planted with transgenic crops and the situation in Argentina.

- Intensive production, under high technology input on common agricultural lands.
- Extensive production, on new lands, gaining and advancing on marginal areas (agricultural border) under high technology input for high yielding crops as soybean.

Three decades ago, soybean was a botanical curiosity. Nowadays, it is the driving force of MERCOSUR. It is the third exportation good (after coffee and sugar) and the first in Argentina. But both countries have followed different goals and different market views. While Argentina has followed the United States and continues with the intensification of GMO production, Brazil has not accepted the production of engineered crops, and conventional crop production has allowed the country to obtain beneficial gains for the commercialization of these crops (table 2).

Table 2

Growing of Surface Planted with Soybean in Argentina and Brazil

	Decades			
Country	**1970**	**1980**	**1990**	**2000**
Argentina Hectares	50,000	2,000,000	5,000,000	8,000,000
Brazil Hectares	1,000,000	6,000,000	12,000,000	13,000,000

The current situation seems to be a bifurcation of the world market. On the one hand, those countries that accept engineered crops and those that do not accept them or insist that those crops and foods have to be labelled.

Soybean and maize are the main crops for Argentina, which, with the United States and Brazil, represent the main exporters of these goods. So, knowing the future situation of markets and the road followed by competitors of Argentina is relevant for the agricultural growers, the economy and the society.

Current Situation and Trends for Agriculture Production in Argentina

Argentina is a "natural" country, free for the first years of this decade from high chemical inputs, such as fertilizers, insecticides or herbicides for its crops (table 3). This is a "market value". But, in the hands of globalization, the country is changing its system of production, following an intensification of agriculture, with high consumption of imported chemicals, new varieties of crops and a type of agriculture biotechnology that implies larger consumption of herbicides, with active imported principles too.

Historically, Argentina has been characterized by its natural conditions, that have done, that indeed following the steps and intensification of the "green revolution", the country has not serious problems with its

Table 3

Some Agriculture Indicators in Selecting Agriculture Economies

	Argentina	USA	France
Insecticides (gr./ha)	*250*	*1,000*	*3,000*
Fertilizer (kg /ha)	*25*	*100*	*300*
Herbicides (gr./ha)	*250*	*900*	*2,000*
Changes in farm *landing (%)*	*18*	*5*	*- 2.5*
Native mammals under danger of extinction (%)	*10*	*11*	*50*
Native birds under danger of extinction (%)	*2*	*8*	*40*
Native reptiles under danger of extinction (%)	*0*	*6*	*38*

Sources : INTA 1995, INRA 1995, USDA 1996, PENGUE 1996.

natural resources. Only in the case of soil, the erosion has been important as a consequence of wrong management and the incorporation of the package for soybean, without a right evaluation of the environmental context. But nowadays, in addition to the problems with soil resource, the entire ecosystem is involved. The "new biorevolution" allows to increase the agricultural cycles, reducing the length of fallow fields and restoration, increasing the impact and pressure over natural resources, the social system and the economy.

As the debate over the effectiveness of the green revolution crops continues, biotechnology and genetic engineering are now being touted for their agricultural potential in developing countries. And once again, the conventional wisdom among officials in international agencies and companies is that what is good for US farmers and industrialized nations will be even better for farmers of developing countries. Indeed, some Third World scientists and governments see biotechnology as a way out of fertilizer and pesticide dependencies that came with the high yielding crops. But this is a very wrong way.

It is true that, by means of agriculture intensification, the country has increased its crop yields, especially in its more important agricultural area, the Pampas (fig. 5), which has allowed the exportation of goods under a commercial point of view in the short time. Meanwhile we export commodities which values go down year by year, the acceleration and globalization of agricultural markets have made our imports of pesticides, fertilizers and seeds rise an important part of our balance gains. Very shortly, because of the millions of dollars flowing out of our countries to

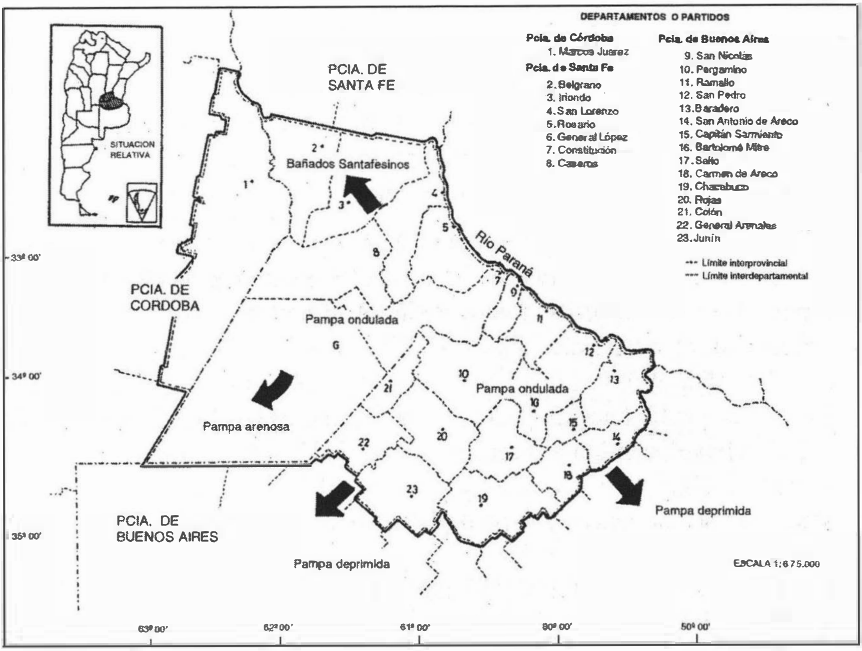


Fig. 5. — The main agricultural productive area of Argentina : Las Pampas.

pay for agricultural supplies, questions began to be raised whether this new agricultural revolution might be helping the developed world companies, as American companies, more than it was helping a developing country as Argentina.

But agriculture intensification has produced environmental, economic and social consequences that have not been evaluated conspicuously in the country. Probably, the new biorevolution could exacerbate the weak conditions of the system : intensification of agriculture, globalization, large farm concentration, low levels of credit for small farmers, dependence on imported supplies, dependence on technology, appropiation of large farms by outside owners, concentration in very few agricultural firms, the seeds and chemicals that we need to produce.

This simplification of agriculture will have effects that will affect the commercial position of Argentina in the meantime : degradation of soils and biodiversity, rural migration, concentration in large farms only producing commodities in a single way of high yielding crops instead of more natural foods that are the willing of the global market, increasing of chemicals over the environment, effects on human health and loss of competitivity in comparison with our competitors.

Obviously, the social and economic consequences of the technology package have not been long. Since 1991 and the start of the period of dollar convertibility, changes in the way of production have led to a number of consequences for the agricultural sector :

- Dependence on imports. Grains and soybean have become the main goods for foreign markets, boosting the dependence on the import of inputs, for this export-oriented mode of agriculture production. Local production of pesticides rises by 16,6 %, while 43,6 % are imported and the other 39,8 % are produced in Argentina with imported drugs.
- Declining profit margins. Most vital for the individual farmer, profit margins have been under pressure. Commodity prices for soybean suffered a decline of 28 % between 1993 and 1999, whereas during the same period the prices for petrol, one of the principal ingredients for production, have risen by 26 %.
- Concentration of holdings. The new technological package offered in a context of profit margins having fallen down by half between 1992 and 1999, it is very difficult to survive for many farmers indebted with bank loans of high interest rates who have to pay back these investments in machinery, chemical inputs and seeds. This situation favoured the concentration of holdings and many farmers (especially small and medium growers who were the train of the Argentine economy) disappeared. Between 1992 and 1999, the number of farms in *las Pampas* declined from 170,000 to 116,000, while the average size of a producer's farm increased from 243 to 357 ha (fig. 6).
- Dumping prices. Argentina, as many developing countries, subsidizes neither its farmers nor the goods it produces, but is being affected by those governments that subsidize the production of commodities in developed countries.

Commoditization or Diversification in Agriculture

The type of biotechnology under the intensification model that is now being offered to the Argentine farmer and the present export-oriented commodity production system is most likely to drive smaller farmers out of business as they are not able to sustain the competition. Probably, big farmers could survive under this technical package if they could maintain the use of glyphosate as a cheap and effective herbicide, the re-use of

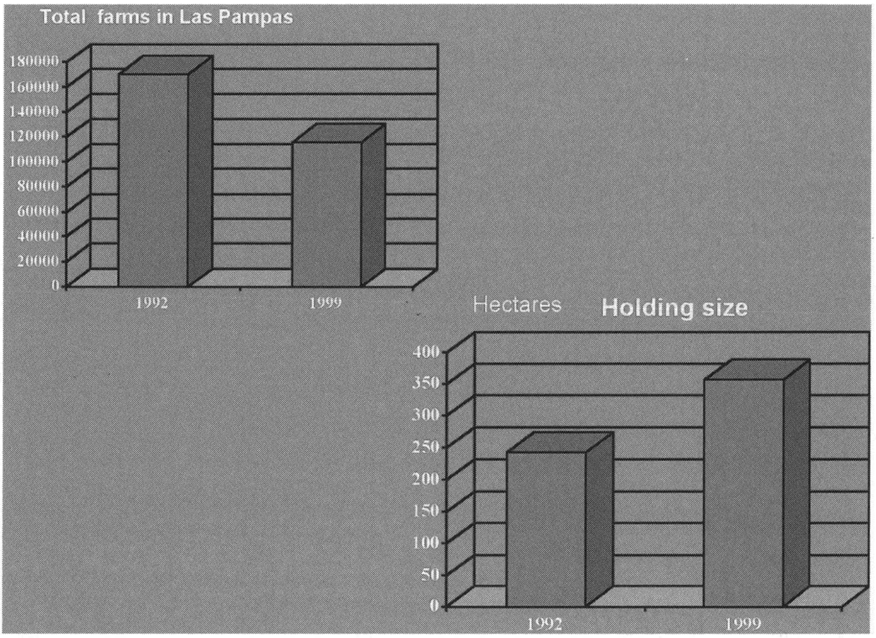


Fig. 6. — Total farms and scale changes in "Las Pampas".

seeds and financial support. These frameworks will favour much more the concentration of agricultural business, under an open market policy that favours a little part of the farmers' distribution gains. But for smaller and medium farms a diversification beyond global commodity markets, either conventional, organic, or low input farming, other crops or rotation with cattle on extensive and natural land makes the return to a real rotation system – recognized for its environment restoration and labour intensive – opening a beneficial window to obtain important profits for medium farmers. However, this would require a drastic turn in Argentine agricultural policy, namely playing a more active role, financing or getting funds to install new projects, new rules for protecting the environment and the social system, extracting mine agriculture, looking for high income markets that account for the high quality of natural and regional goods of developing countries. This must include and take into account subsidizing small-scale farmers, producing other commodities than those of large farms, forcing them to buy, through the bank loans' inputs, seeds or machinery, but also to produce alternative and high-quality goods, which are the real and needed future of the high income economies and which Argentina could have a lot to offer by its comparative advantages and

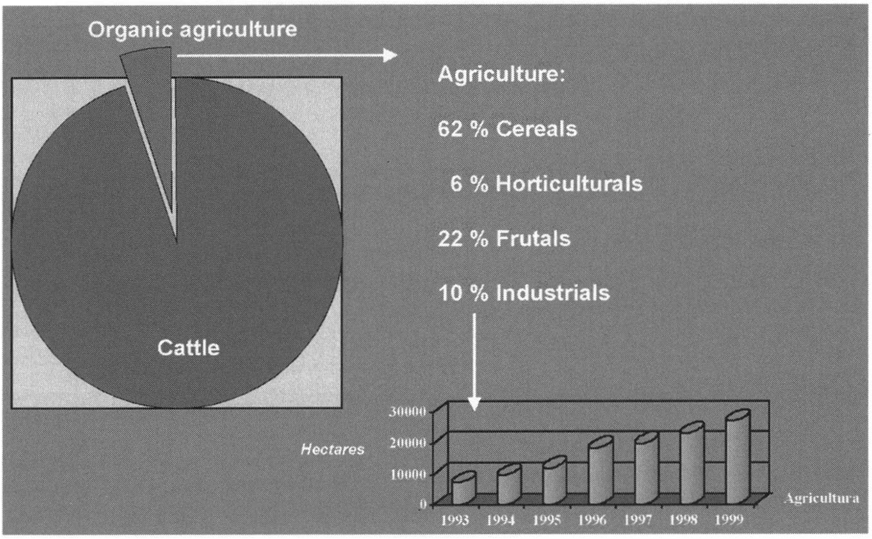


Fig. 7. — Organic agriculture and cattle.

cheaper way of production (fig. 7), avoiding the negative impacts for developing countries of this first wave of biotechnology that was forced to be implemented.

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The Current IPR Framework for Transgenic Crops and its Implications for Developing Countries

by

Geertrui VAN OVERWALLE*

KEYWORDS. — Patents ; Plant Breeder's Rights ; TRIPs ; Convention on Biological Diversity ; Developing Countries.

SUMMARY. — The first chapter of the present contribution deals with the current intellectual property framework for transgenic crops. It focuses on the legislative regime regarding Intellectual Property Rights (IPRs) and not so much on the legal framework regarding biosafety regulations. It looks at the patentability of transgenic plants and plant varieties, rather than focus on property rights on traditional agricultural and ecological knowledge. Last but not least, it highlights the IPR framework from an international perspective, since IPR legislation, and patents in particular, are currently deeply affected by the trend towards globalization. The paper, however, will also offer an overview of the European and the US IPR framework in order to see how the international standards are generally met in developed countries. In the second chapter, some attention is drawn to the effects of the current IPR framework on developing countries. The third and final chapter provides a few scenarios which might offer some guidance to public authorities, the scientific community and the business world in their efforts to create a balanced IPR policy in agricultural research.

1. The Current IPR Framework

1.1. INTERNATIONAL FRAMEWORK

The multilateral trade negotiations in the GATT Uruguay Round, which were concluded in 1993 and resulted in the formation of the World Trade Organization (WTO), encompassed for the first time discussions

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on aspects of intellectual property rights. The result of those negotiations was embodied in the 'Agreement on Trade-Related Aspects of Intellectual Property Rights' (TRIPs Agreement), contained in an Annex to the WTO Agreement [1]*. Membership of the WTO implies adherence to the TRIPs Agreement.

TRIPs is now the key international agreement promoting the harmonization of national and regional IPR regimes. The provisions of the TRIPs Agreement provide a basis for harmonization of IPR laws around the world by providing minimum standards for such laws with regard to the availability, scope and use of IPRs.

TRIPs covers four types of intellectual property rights : patents, geographical indications, undisclosed information (trade secrets) and trademarks. The provisions relating to patents are laid down in articles 27 to 34 of the TRIPs Agreement. According to these provisions, patents *shall* be available for an invention in all fields of technology, provided that the invention is new, involves an inventive step and is capable of industrial application. There shall be no discrimination between nationals and nonnationals, between areas of technology and between locally produced and imported goods (art. 27 (1) TRIPs).

The TRIPs Agreement contains some provisions which are highly relevant to the question of the patentability of (transgenic) crops. TRIPs stipulates that members *may* exclude plants from patentability, but that members *shall* provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof (art. 27 (3) (b) TRIPs). The most likely *sui generis* protection – thought of at the time of the TRIPs negotiations – is the UPOV system, but in theory it could be an alternative system (VAN OVERWALLE 1997b).

1.2. EUROPEAN FRAMEWORK

The current European IPR framework can serve as an illustration of the policy of many developed countries, not to implement the optional provision of the TRIPs agreement excluding plants from patentability. In Europe, like in many other parts of the industrialized world, patents are available for plants. Simultaneously, plant breeder's rights are available for plant varieties.

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* The numbers in brackets [ ] refer to the notes pp. 98-99.

1.2.1. Patents

1.2.1.1. General Background

For the time being, in Europe it is possible to obtain patent protection by separate application to each of the *national* patent offices within Europe (the so-called National Route). Almost every country in the world has its own patent system as well as a patent office or equivalent bureaucracy to screen patent applications and to decide whether patents should be awarded. However, the disadvantage of a national patent is that it only offers protection in one country, and hence it is mostly a *European* patent that is opted for at the European Patent Office (the so-called European Route). On the basis of a single application and examination procedure one can protect an invention in up to nineteen European countries, all contracting states which have ratified the European Patent Convention of 1973 (EPC) [2].

The term 'European patent', however, is misleading from two points of view. It is not a single patent that is valid for the whole of Europe : the application and granting procedures are uniform, after which the patent is broken up into a 'bundle' of national patents which are further subject to national legislation and, more particularly, to national regulations with regard to nullity and infringement. (In contrast, the 'Community patent' will be a single patent extending to all member states of the European Union.) Nor is it a patent granted by the European Union (EU) : European patents have nothing to do with the EU apart from the fact that all EU member states have also signed the EPC. It is on the basis of the EPC that the European Patent Office (EPO) was brought into being, for dealing with European patent applications. It might be repeated that the EPO is not an EU institution either.

Because the recent events of primary interest have taken place in the EPO, national systems are not considered here and the attention is drawn to the European patent system.

1.2.1.2. Eligible Subject Matter

In principle, a European patent shall be granted for an invention which is new, which involves an inventive step and which is susceptible of industrial application (art. 52 (1) EPC). The EPC, however, excludes plant varieties from its field of application : "European patents shall not be granted in respect of plant or animal varieties or essentially biological processes for the production of plants or animals ; this provision does not apply to microbiological processes or the products thereof" (art. 53 (b) EPC).

Since the EPC is somewhat ambiguous as to the exact scope of the exclusion of plant varieties, one has to rely on the case law of EPO in order to get some insight into the limits of the exclusion of plant varieties. According to EPO case law it is now clear that a patent wherein specific plant varieties are not individually claimed, is not excluded from patentability, even though it may embrace plant varieties.

A little explanation might perhaps make the scope of this stance somewhat clearer. The differentiation between plants and varieties of plants as deployed by the EPO is based on the modern biological division of the animal and plant world into groups or taxa : division, subdivision, class, order, family, genus and species, whereby each 'higher' taxon subsumes all 'lower' taxa. The application of these groups to the plant kingdom results in its being classified in a hierarchy with five divisions which, in turn, are divided into subdivisions, classes and orders. Orders are, on the basis of flower structure, further subdivided into families. Families are, in turn, divided into genera and species.

An actual example can perhaps better clarify the contemporary division of the plant kingdom. Let us take the potato (VAN OVERWALLE 1997a, pp. 23-24) :

KINGDOM	Plantae
DIVISION	Spermatophyta (Seed Plants)
SUBDIVISION	Angiospermae (Flowering Plants)
CLASS	Dicotyledoneae
ORDER	Polemoniales
FAMILY	Solanaceae (Nightshade family)
GENUS	*Solanum* (Nightshade)
SPECIES	*Solanum tuberosum* (Potato)
VARIETY	'Bintje', 'Charlotte', 'Lamia', 'Frieslander', 'Solanda', etc.

In terms of the current line of cases from the EPO, no patent protection is possible for the Charlotte *variety* of potatoes, but it is possible to patent (the transgenic) *potato (Solanum tuberosum* L.).

In recent years, the European Commission has given evidence of a clear desire to use the patent mechanism to foster the growth and development of the biotechnology industry and to harmonize member states' legislations on this point. These efforts resulted in the enactment in 1998 of a Directive on the legal protection of biotechnological inventions [3].

As to the patentability of plants, the EU-Biotechnology Directive aligns itself with the relevant EPO case law. Plant varieties shall not be patentable (art. 4 (1) (a) EU Biotechnology Directive) but inventions which concern plants or animals shall be patentable if the technical feasibility of the invention is not confined to a particular plant or animal variety (art. 4 (2) EU Biotechnology Directive).

1.2.1.3. Scope of Rights

Living material's ability to self-replicate throws up the particular question of the generation to which patent protection extends. An example to illustrate this problem : in principle, patent protection can be obtained for a gene containing information on resistance to illness ; if this patented gene is then incorporated into a plant cell, the question arises as to whether the patent protection over the gene also extends to the transgenic plant cell.

According to writers from the breeder's rights camp, patent protection ought *not* to extend to the transgenic plant cell. From the patent lawyers' camp, however, the argument is plead that protection *indeed* ought to extend to the transformed plant cell in question : from the point of view of the satisfactory protection of biotechnological inventions, the contrary is unacceptable, because endless new plant cells, and even whole plants, can be regenerated from the plant cell in question (VAN OVERWALLE 1997a, p. 32). The current EU Biotechnology Directive seems to have adopted the way of thinking of the patent lawyer's camp. The EU Biotechnology Directive does so by stipulating that the protection conferred by a patent on a biological material possessing specific characteristics as a result of the invention shall extend to any biological material derived from that biological material through propagation or multiplication in an identical or divergent form and possessing those same characteristics.

1.2.2. Plant Breeder's Rights

1.2.2.1. General Background

For various reasons, it was felt that the patent system was an inappropriate method of protecting new plant varieties (VAN OVERWALLE 1996, VAN OVERWALLE 1997a). Consequently, special plant-tailored protection systems were created. Special provisions were set out in the 1961 International Convention for the Protection of New Varieties of Plants. This Convention was signed by several European countries and thus created a Union for the Protection of New Varieties of Plants, which is commonly known under its French abbreviation UPOV (*Union pour la Protection des Obtentions Végétales*). The Convention was revised drastically in 1991 [4].

1.2.2.2. Eligible Subject Matter

The Convention is the basis of the national laws on breeder's rights in the contracting states. National laws based on the Convention offer legal protection for a plant variety which is distinct, uniform, stable and novel (Article 5 UPOV Convention).

1.2.2.3. Scope of Rights

A plant breeder's right grants its holder the exclusive right to, and to authorise others, to produce reproductive material of his plant variety for the purpose of sale and to sell this material within a particular territory and for a given period.

The monopoly of the breeder stops short of reproductions or propagations of the variety for pleasure, as many private gardeners might do. On top of that, the plant breeder's rights system contains two other exemptions. First, the *breeder's exemption.* Under the breeder's exemption, a protected variety may be used by a competing company in a breeding programme ; other breeders have the right to use a protected variety for commercial breeding. For example, if a protected flower variety has red and white flowers, a competitioner using purchased seed, could select for a strain that produces only white flowers and receive a certificate for that new variety. Second, the *farmer's exemption,* also called *farmer's privilege.* The farmer's exemption allows farmers to retain seed for planting. Farmed-saved seed is a common practice among major open-pollinated species including wheat, cotton and soybeans. These exemptions have become matters of public discussion.

1.3. United States Framework

The legal scene for the protection of transgenic crops looks somewhat different in the United States. The United States is one of the few countries where plant varieties can be protected and exclusivity can be achieved by use of patents or plant breeder's rights, next to the availability of patent protection for plants. In this respect, the United States can serve as a notable exception.

1.3.1. Patents

The Utility Patent Act (UPA) stipulates that whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor. Contrary to the EPC, the UPA contains no explicit provision excluding plants or plant varieties from patent protection. As a result, the US patent office has been granting UPA patents for plants and plant varieties, as well as for a wide range of genetic engineering techniques ever since 1985.

Patents have been granted for new plant varieties obtained by conventional breeding (*e.g.* a new hybrid corn variety characterized by superior yields, excellent early-season cold tolerance and good grain quality), for mere discoveries (*e.g.* a new and distinct variety of potato which was discovered growing as a small, white flowered aberrant plant in a field of the Butte variety), for in-vitro culture techniques (*e.g.* in-vitro propagation of grape or asexual embryogenesis of callus from cocoa) and for recombinant DNA technology realisations (*e.g. Agrobacterium tumefaciens* mediated gene transfer, electroporation, micro-injection, biolistic transformation) (Van Overwalle 1996, pp. 442-449 ; Van Overwalle 1997a, p. 27).

1.3.2. Plant Breeder's Rights

UPOV like protection for plant varieties became possible in the US through the enactment in 1970 of the Plant Variety Protection Act (PVPA).

2. Resulting Problems for Developing Countries

2.1. Inappropriate IPR Framework

The TRIPs Agreement provides important minimum standards for intellectual property law. The issue of harmonizing international IPR legislation has posed challenges to many developing countries. The latter will have to reconsider their local statutes in the light of the TRIPs Agreement if they wish to become a member of the WTO. This will require fundamental changes to their views on the role of intellectual property and associated statutes. Amendments might be necessary in respect of all major requirements of their current patent system (Van Overwalle 1997b).

2.2. Unbalanced IPR Bargaining Power

Private companies from developed countries own many important IPRs in agriculture. As the development of transgenic crops requires the use of many protected technologies, the private sector usually overcomes this problem by cross-licensing its patents, involving the mutual exchange of access to patented tools and techniques without considerable financial compensation. Many small-scale organizations in developing countries do not have any IPRs to trade and consequently cannot enter into such profitable negotiations.

2.3. Other Effects

The introduction of patented transgenic crops from developed countries with strong IPR regimes in developing countries, has been reported to lead to a growing economic dependency of developing countries from developed countries, as well as to an increase of productivity cost and the loss of biodiversity (local varieties).

3. Defining a Role for Developed Countries

3.1. Legal Basis

In an attempt to offer some solutions to the constraining effects of the strong IPR position of developed countries, one could turn to the Convention on Biological Diversity (CBD) for some guidance [5]. The relationship between TRIPs and the CBD, however, is the subject of a heated discussion. Some argue that both agreements are incompatible, while others see no clear conflict between the two [6]. The claim that there is no conflict between TRIPs and CBD can be clarified to some extent by drawing a conceptual distinction between legal and policy conflicts. Although there might be no conflict from a strictly legal point of view, legal exegesis and reasoning are argued to largely miss the point since many developing countries perceive the TRIPs agreement as a tool for developed countries and feel their interests are being threatened in the absence of a direct violation of their rights.

In this debate the position of the Belgian Federal Council on Sustainable Agriculture can serve as a trendsetting example [7]. This Council took the view that the objectives of the CBD prevail and that IPRs are subservient to the objectives of the CBD.

This point of view has been inspired by art. 16 (5) CBD which stipulates that the contracting parties, recognizing that patents and other intellectual property rights may have an influence on the implementation of the CBD, shall cooperate in this regard, thereby remaining subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to its objectives.

3.2. Practical Scenarios

The CBD and the unique point of view of the Belgian Federal Council on Sustainable Agriculture offer support for some scenarios which may be envisaged to remedy some effects of the dominating IPR position of developed countries. Those scenarios might serve to prime the discussion in civil society at large and in the working groups of the present seminar in particular. They might also serve as a starting point for constructing a balanced policy on the IPR issue in agricultural research by the governments of developed countries.

3.2.1. Free Access to and Transfer of Patented Gene Technology

Governments of developed, technologically rich countries should stimulate their universities, research institutes and private companies to provide the access to and the transfer of gene technology subject to patents, to developing countries free of charge ("free licence") if the technology is only going to be used for local, small-scale commercialization and marketing.

With regard to the contribution of such an approach to biodiversity, it can be argued that transfer of gene technology under advantageous terms can lead to the affordable use of genetic engineering tools and techniques for the adaptation of local crops in developing countries as well as to the conservation of biological diversity : local crops can be genetically engineered to meet the problems within a given community.

3.2.2. Free Use of Transgenic, Patented Saved Seed

Governments of developed countries should also encourage universities, research institutes and private companies to offer their transgenic seeds subject to patents, to developing countries free of charge for small-scale commercialization and distribution on local markets in developing countries and to allow small farmers to retain harvested seed for planting and exchanging.

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Plants for the Future

by

Marc VAN MONTAGU *

SUMMARY. — Plant molecular biologists are convinced that in this 21st century the majority of crops used in the agriculture of the developed and the developing world will be GM crops. The ongoing increase of the world population, which tripled in the last fifty years, puts such an intense stress on our environment, by requiring an ever higher yielding agriculture, wealth creation through industrialization and by introducing a water shortage through an intense urbanization, that the traditional agriculture improvements will no longer be sufficient.

1. Introduction

The World Commission on Environment and Development very rightly asks for Sustainable Development : “A development which meets the needs of the present without compromising the ability of future generations to meet their own needs”.

At the 2002 Johannesburg meeting, the need for sustainable development and the importance of fighting underdevelopment have been well stressed. For obtaining this progress, science and technology will play a major role. This was the statement of ICSU, the International Council for Science, and that is surely my opinion. Thorough sociological and economic changes in the developing countries will be needed, but these can only be achieved if science and technology can put value on agriculture and create the necessary sustainable industry. Plant molecular biology can bring here the new tools to realize them.

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The attention to underdevelopment is rather recent. The Brazilian MD and nutritionist Josué de Castro coined the term in 1946, in his revolutionary book "Geografia da fom ? Geography of hunger". He became the first President of FAO in 1953, and died in exile in Paris in 1973. He made the World aware of the extreme poverty and famine that was increasing all over the tropical areas. Even now, half of the world, or 3 billion people live with less than 2 $ a day and famine gets close to one billion. The World realized that actions were needed. Attention to an improved agriculture came with the CGIAR (Consultative Group of International Agriculture Research) in 1971. From the work of Norman Borlaugh (Green Revolution) till the appeal of Gordon Conway, President of the Rockefeller Foundation, "The Doubly Green Revolution" (Pinguin Books 1997), enormous efforts were made to develop a higher yielding agriculture. Inventive breeding, mechanization, capacity building of extension services for the most remote areas in all countries, all possible aspects of the then available science and technology were used.

But even when it was possible to double the yield and bring substantial relief, it became clear that further doubling or tripling would be needed. Most of all, it was realized that with this high input agriculture (requiring high inputs of fertilizer, pesticides and water), it would be difficult to reach a sustainable agriculture.

Recent progress in Plant Molecular Biology has brought a unique opportunity for developing new tools and new approaches for constructing the plants the Third World so badly needs. But the step between innovative research and a new crop on the market is very long. To make sure that this will happen, we not only need the substantial financial support from the public sector. We will have to rethink the characteristics of fundamental and applied research and favour a strong and dynamic interaction between both sciences.

Till now, the molecular progress has occurred in the faculties of science. The agriculture faculties were very slow to integrate this knowledge. They were indeed so much confronted with the urgent tasks of improving the rural economy in developing countries by introducing modern agronomic practices, that this evolving science was not seen as a priority. In recent years, this trend has been changing. The appearance of textbook which demonstrate how important the crosstalk between fundamental and applied research is, is very welcomed.

The second edition of Maarten Chrispeels' book "Plants, Genes and Crop Biotechnology" is an outstanding example of how information exchange between these two disciplines should work, so that new prototype plants can soon be constructed.

2. Present Agriculture

The high-yielding agriculture of the US and Europe resulting in a doubling of the production during the second half of the last century, was based on the introduction of hybrid corn and, since the early fifties, an intensive use of fertilizers and pesticides. Since then, crop breeding has favoured the selection of the elite cultivars under high-input conditions.

Also the Green Revolution, which urgently needed to double the food production in the developing countries, had to rely on high-yielding cultivars that became available in the "rich" world. This resulted in favouring a large-scale and non-sustainable "industrial" agriculture.

The high-yielding dwarf varieties that made the success of the Green Revolution, also required a high input of fertilizers and pesticides.

Over the years, it became clear that this industrial agriculture causes quite some problems for the environment. The "dead zone" in the Gulf of Mexico has reached now 22,000 km^2 (cf. *Science*, **297** (2002) : 1119). The Baltic Sea, in the summer of 2002, was again infected by toxic micro algae and cyanobacterias.

Another environmental problem was soil erosion. Increasing reports, which demonstrate the important loss of fertile top soils due to intense tillage, become available. Gordon Conway clearly states that for the relief of poverty, it will be essential to develop a sustainable agriculture geared towards subsistence farmers and not only to introduce our industrial agriculture in the Third World. To do so completely, new approaches in crop development will be needed.

Another concern with our present agriculture is that the improved cultivars, even when they double yield in a country like India, bringing basic food security, actually did not alleviate poverty.

3. What can Biotechnology do ?

Agriculture biotechnology can contribute on many levels. Thanks to the emerging knowledge of plant genomes and the regulation of their gene expression, a rapid progress will be seen in the construction of high-yielding varieties of the different local cultivars of the staple in the southern hemisphere. That can bring food security to most of these countries. In this way they will be less dependent from the goodwill of developed countries to supply food and escape the political pressure sometimes attached to the willingness to make food aid available.

Good progress is also in view for the quality of food. In high-poverty areas, the population is often dependent on one single crop. This can result in an amine acid unbalanced shortage of vitamins, micronutrients such as iron or other minerals.

Different bio-fortification programmes like golden rice (enhanced vitamin A content) or folate increase are now in full progress.

In this century we will also see the cultivation of GM plants for industrial purposes. Insect-tolerant cotton is already grown over many million hectares. But completely novel plants can form the bases of a sustainable industry and a valuable agriculture. Many fine chemicals, now synthesized from petroleum products, can be made in plants. Particularly novel chiral products can bring high value to chemical industry.

It will also be possible to enhance the production of the more classic bulk products like sugars, fatty acids, waxes, speciality oils, latexes, not forgetting wood. Already now, President Bush declared that the US should be less dependent on petroleum and that research that can lead to better alcohol production should be stimulated. There is no doubt that plant biotechnology will be the basis of the development of a sustainable, less polluting industry.

It is ironic that green movement is so adamantly against plant biotechnology since it becomes increasingly clear that plant biotechnology will bring crucial contributions in the field of environmental sciences. In the first place, it will bring the basic tools for constructing a non-polluting agriculture. Studies on drought stress and water uptake by plants, improved non-tillage agriculture, reconstitution of soil fertility all point out that novel plants that help preserve the water supply are a possibility.

Over the last forty years, the increase in the use of water and of nitrogen and phosphorous fertilizers has increased tremendously (cf. David Tilman e.a., *Nature*, **418** (2002) : 672).

Our present crop plants take up only 30-50 % of the applied nitrogen and phosphorus. This reduces the water quality, causes eutrophication that can lead to dominance of weed species. These disastrous effects can be overcome by tailoring plants to fit the soil.

The molecular cloning of membrane transporters for nitrate, ammonia, phosphate, sulphate and potassium bring the possibility of manipulating mineral uptake by crop plants.

Basic research allows us to understand the complexity of regulated networks, as well as the crosstalk between the assimilation pathways of carbon, nitrogen, phosphorus and sulphur that integrate environmental nutrient availability with the nutrient status of the plant. Multiple potassium transporters that mediate the uptake and movement of K^+ have been identified in the model plant *Arabidopsis thaliana.*

Although sensors, signalling molecules and signal transduction components involved in nutrient assimilation responses are largely unknown; researchers are confident that with metabolite profiling and mRNA display they have the tools to identify these "missing links". It has been shown that increasing organic anion exudation (*e.g.* citrate) enhances phosphate acquisition. Creation of sinks and pathway engineering will be the approach to obtain the most favourable fluxes from inorganic and organic high-value compounds.

In summary, plant biotechnology will bring the tools to obtain :

- A more valuable and environmentally friendlier agriculture ;
- A sustainable industry based on renewable resources ;
- Environmental engineering.

4. The task

Adam Smith, the champion of free enterprise, very rightly stated : "No society can surely be flourishing and happy, of which for greater part of the members are poor and miserable" (The Wealth of Nations 1776).

Fighting the vicious circle of hunger and poverty is the most urgent task facing our societies. Otherwise, neither world equilibrium nor peace will be possible.

For poverty alleviation it will be essential to create value for agriculture. When a subsistence farmer gets 1.5 ton of corn per hectare, the American farmer reaches 20. The same for wheat and rice: a ten times lower yield largely due to low-quality grain and biotic and abiotic stresses. Yield improvement for these subsistence farmers will come through two parallel approaches.

Promoting in less developed countries a private seed industry with access to value enhancing technologies can stimulate initiatives and entrepreneurship to set up breeding for improved local varieties, produce healthy-quality seeds. This by itself can already help to ensure food production and stimulate rural economy. Meanwhile, the ongoing innovative molecular plant research should integrate agronomy knowledge and experience present in the centres for Tropical Agriculture. The plant genome data, that are now coming available, offer an unprecedented potential for crop improvement. An efficient use of the structural and functional genomics, together with the new tools from proteomics and metabolomics, will bring fast progress in our knowledge of plant biology. It will bring the information needed for the genetic engineering of new input traits in plants such as biotic and abiotic stresses.

Insect resistance, through the engineering of altered *Bacillus thuringensis* "insecticidal protein" genes, has already many years of successful applications. More genes encoding VIP proteins (*Syngenta*) are now introduced. Nematode resistance will be of high importance for many tropical crops, including bananas.

Viral resistance papaya and cassava is available for some cultivars but the field introduction is delayed due to complex and expensive administrative hurdles and the opposition of well-intentioned but ill-advised NGOs.

Severe fungal diseases like Black Sikatoga in bananas could be stopped by using GM bananas. This thanks to the persistent work of R. Swennen at the Leuven University (Belgium).

Better adaptation towards drought-salinity cold could already be obtained under laboratory conditions by expressing protective osmolites like trehalose. Hopefully field trials will soon confirm the validity of the concept.

Important physical traits such as maturity, plant architecture, pod shattering, and shelf life are all under study and positive results will be very welcomed by developing countries.

Great hope is of course put in improving output treats such as content and quality of starch, proteins, fatty acids and speciality chemicals.

5. What is needed to make these Novel Plants ?

In the first place, research, more research for understanding plant growth and development in molecular terms. The agrobacterium mediated gene transfer developed now more than twenty years ago, made this type of research possible.

In the last ten years, tremendous progress was made in the molecular and cell biology of plants. We now urgently need a better integration of this fundamental research with the knowledge of the agronomists, plant breeders and agriculture economists, representing applied research.

It is important to realize that the innovation in agriculture and these "plants for the future" will not be made by universities. Their task is research and capacity building. They can bring tools and suggest approaches. They can bring "state of the art" technology. But constructing, be it a prototype for a novel plant, requires a lot of repetitive work far removed from the competitive research expected from the universities.

Prototype development is also at least ten times more expensive than fundamental research. In the developed world, and particularly in the United States, this concept is well understood. Prototype products are made by "start-up" companies. Small dynamic enterprises, some with a limited life span as they are bought up by major industries when successful, bring together the right expertise of science and product research.

For tropical agriculture it is unlikely that analogous start-up activities will develop. The financial return on investment will be too low during a too long period. Which structure could replace them ? If there is no private money available, governmental and international institution money will have to take on this task. The CGIAR institutes are well positioned to play here a crucial part. We may expect that major plant research institutes will try, stimulated by the EU 6th framework programme of the DG-Science and Technology to take up their role as technology providers for the CGIAR centres.

Our own institution IPBO in Belgium, the genomic centre John Innes in the UK, the CIRAD in France, ETH in Zurich - Switzerland (former Potrykus lab), Wageningen in the Netherlands, they all have the expertise and the tradition to interact with overseas institutions. It should however be clear, as stated above, that this will only deliver candidate novel plants. Notwithstanding the help of the National Agriculture Research institutions (NARs), it will be essential that private seed companies develop to supply and distribute the plants adapted to the different regions.

Surely, the established agro-industry has also a major role to play in turning these novel plants into successful products and in commercializing them.

For financing the prototype development, European authorities will need to see if they can develop tax incentives so that, here also, we would see a better financial climate for charities and foundations. We notice indeed the goodwill of many wealthy individuals to help poverty and underdevelopment by the introduction of new technologies.

Since major effort is needed, we can only hope that tax exemptions can become as stimulating as they are in the US.

6. The Public Perception

Plant biotechnology, and in particular GMO plants, received a very bad press in Europe and it is estimated that here 70 to 80 % of the population is opposed to GM food and even GM feed. For scientists, this is totally incomprehensible since, till now, the slightest detrimental effect on the health of humans or animals has never been demonstrated with the plants currently commercialized. Also no ecological problems were observed.

All the cases of gene spreading highlighted by the press were well expected through what is known about pollen flow but it never turned into an environmental problem. On the contrary, biotechnology techniques developed tell us, for the first time, how gene spreading and variety development occur. It is also bringing the tools for enhancing the biodiversity in agriculture, while classic breeding strongly favours the use of monocultures.

The concept according to which this laboratory technology is unnatural is a problem of semantics. None of the plants or animals we use in agriculture and husbandry are natural. They are all the product of many thousand years of crossing and selection. Since last century laboratory crosses and mutation breeding (irradiation of seeds in nuclear reactors) have often been the source of new genes currently used in our bread wheat in many other staple foods.

This worldwide action of some pressure groups to identify science and technology development with aggressive actions of multinationals and "capitalistic exploitation" is an interesting sociological observation. It is of the greatest importance that scientists understand the fears of society and that they listen well to realize where rational and science-based arguments can help to progress in the dialogue and where emotions through fear take over.

These dialogues should be increased on a large scale worldwide till a climate of trust and confidence is reached. The European authorities understand these needs very well, so one can predict that in the coming years the respective governments will help such debates in mutual respect to change the climate.

Meanwhile research and networking between the key institutions will have it made possible that the prototypes of the "plants for the future" can be taken into product development. This to the benefit of the billion poor and the 80 % of the world population that will be living in the less-developed part of our planet.

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Transgenic Plants for (Sub)Tropical Smallholders

by

Rony SWENNEN *

KEYWORDS. — Banana ; Benefit Sharing ; Biosafety ; Capacity Building ; Cartagena Protocol ; Convention on Biological Diversity ; Farming Systems ; Genetic Modification ; Participatory Varietal Selection ; Technology Transfer.

SUMMARY. — Most (sub)tropical smallholders have fields with a very complicated pattern. This is the result of a low risk strategy that involves maximal exploitation of plant variability both at the varietal and at the species level. With a high biodiversity and long fallowing, inputs are kept at a low level. By increasing population growth such farming systems cannot produce enough food and therefore evolve into high input systems with very low biodiversity. Most breeding efforts are targeted on these latter systems or deliver packages where farmers have to adapt to the crop developed instead of the other way round. It is essential that breeders understand farmers' conditions and breed high yielding stress-resistant varieties for low input farming systems so that farmers keep control of their situation and maximum flexibility is guaranteed. This implies that breeding should focus local crops and varieties and that farming systems are not altered. Biotechnological tools for the rapid genetic modification of smallholders' crops are available and plants of interest are ready for field testing. However, most tropical countries lack an adequate legal system to process applications for field testing. In addition plant distribution to smallholders is hampered by intellectual property rights which should be waved for smallholders' crops. The case of banana is illustrative.

Introduction

In most tropical and subtropical countries, a majority of the economically active population are farmers growing crops on small fields for food and market. These smallholders contribute much to the agricultural development and economic growth of their country (MELLOR 1987). They operate under different farming conditions which are the outcome of the avail-

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able technology in combination with numerous other factors such as population pressure, soil and climatic conditions, existing ecology, economic conditions, culture, history, etc. (RUTHENBERG 1976). Yields in smallholdings are low and insufficient to meet the needs of the fast growing population in the developing world. New technologies in plant breeding, such as genetic modification, offer prospects to produce new varieties with resistance to many stresses, such as pests and diseases, drought stress, etc. at a much faster pace than ever before. These new varieties have the potential to increase both production and productivity but need to be integrated into existing farming systems, and should be built on an in-depth know-how of the farmer's needs and indigenous knowledge. However, the production of transgenic crops and biosafety testing are hampered tremendously by the lack of adequate legal environments in developing countries and access by the developing countries to patented technologies.

Farming Systems

Under conditions of low population pressure, farmers cultivate their crops after a rather long fallow whereby the natural vegetation re-establishes itself and evolves into a climax vegetation (JURION & HENRY 1969, RUTHENBERG 1976). During this period, soil fertility is largely increased due to the effects of the deeper tree and bush roots which ensure that nutrients leached by rain are brought up from the subsoil. The fallen leaves enrich the surface both with nutrients and organic matter (VANLAUWE 1996, VANLAUWE *et al.* 1995). The fallow vegetation covering the soil and the comparatively cool temperatures of the covered soil facilitate the regeneration of the soil. The deposited organic matter changes the soil structure, thereby improving soil aeration and drainage (SALAU *et al.* 1992) that results in a reduced soil erosion. In addition, the soil pH increases during fallowing and, due to an increased soil aggregation, aluminium toxicity is reduced and phosphorus availability increased (TOSSAH 2000, NZIGUHEBA *et al.* 1998, NZIGUHEBA 2001). Non-symbiotic nitrogen fixation can be subtantial.

Smallholders clear these fallows and then install their crops that yield heavily in the first year of cultivation. Since these cleared soils are initially very fertile, farmers cultivate many different crops (OKIGBO & GREENLAND 1976, BEETS 1982). They fully exploit the variability of the soil and plant fertile demanding crops on the richest spots and less demanding crops on the less fertile spots (*e.g.* cassava). They also plant early maturing crops (*e.g.* maize) in combination with late maturing crops (*e.g.* banana) ; deep-rooting plants (*e.g.* papaya) are mixed with shallow-rooting plants (*e.g.* rice) ; tall plants are mixed with small plants. In short, smallholders grow many different crops in mixed associations, thereby exploiting maximally variations in light, soil and water.

Individual farmers value diversity because of heterogeneous soils and production conditions, risk factors, market demand and consumption (BELLON 1996). Diversity within a crop species is also appreciated because of the different products and the possibility to exploit the different soils of, for example, a hillside (BRUSH & MENG 1998).

Farmers also rely on diversity of neighbouring farms to provide new seed (LOUETTE *et al.* 1997). Diversity within cultivated species, which are crop populations and called landraces, usually have a reduced geographic range and are adapted to local conditions (BRUSH 1995). Moreover, mixed cropping covers the soil very well and thus, weeding is kept to a minimum. Other advantages are, for example the spread of labour peaks, the harvesting over an extended period and the production of many different products. Most importantly the high biodiversity on the farm, in fact the *in situ* conservation of genetic resources (BRUSH 1991), guarantees that risks are restricted to a minimum. Farmers maintain local crop varieties in part because they perform better than other varieties in marginal environments (BRUSH 1995). Farmers may also perceive a risk advantage if these varieties are more stable over time than non-local varieties. Diversity itself may provide yield stability and harvest security in the face of pests, diseases, competition and unfavourable environments (CLAWSON 1985).

With population growing at a very high speed, the demand for food and cash crops increases and, consequently, more land is brought into culture. The fallow period shortens, which results in a lower soil fertility after clearing and land preparation. The level of organic matter in the soil decreases, which reduces yield stability (WILSON *et al.* 1985, SWENNEN 1990). Farmers therefore have to abandon the cultivation of fertile-demanding crops and replace them by less demanding crops such as cassava. Also the importance of annual/biannual crops such as maize increases. Because the biodiversity of crops decreases, more pests and pathogens occur, forcing farmers to apply pesticides. In addition, due to land shortage, farmers farm their land much longer, thereby further increasing disease and pest pressure. The lower soil fertility is compensated with fertilizers. Moreover, the longer cultivation of just a few crops results in less soil cover, thereby increasing weeding efforts. In short, high population pressure results finally in the cultivation of one to just a few food crops which will yield well only in combination with heavy inputs. The same applies to cash crops that are routinely cultivated in single stands (*i.e.* monoculture). Modern crop varieties have precisely been bred to perform well under these conditions and diverse, local populations of crops are being replaced by modern varieties because they secure high yields. Because of this genetic erosion, diversity within individual farms is thus threatened, but also between farms, because modern crop varieties have been bred for broad adaptation. Consequently, a handful of "mega-crops" supplant locally important crops and now feed most of the world's population. Farmers loose control of the production system as they become subject to market and political systems (Chambers 1999). Local knowledge and crop diversity is thus lost because of the diffusion of improved, exotic technology.

Smallholders who grow many different crops in mixed associations usually grow crops which have been selected by many generations of farmers. To these crops, the concept of Farmers' Right (FR) apply. Smallholders who grow a crop under low fertility conditions tend to grow fertilizer-responsive crops, which have been produced under different breeding schemes. The same applies to farmers growing cash crops. Such crops depend on Breeders' Rights (BR) and farmers will thus have to pay a supplement for this intellectual property protection when buying seed material. In this context, it is important to stress that farmers' rights and breeders' rights can apply to the same crop. At the first glance, this might be confusing, but a close look shows that both rights are applicable to different varieties of a same crop. Indeed, farms growing maize show that FR are applicable to those maize varieties grown by farmers in mixed association while BR are rather applicable to the maize variety grown under monocrop conditions, the latter usually cultivated with many external inputs.

Genetic Improvement of Tropical Crops

There are numerous complementing strategies to improve the living conditions of the smallholders in the tropics (Manyong & Degand 1995, Tshiunza 1996). Genetic improvement of crops certainly offers much prospects but needs to be placed in a holistic approach, thereby valuing, among others, the indigenous knowledge and relying on an understanding of smallholders (Swennen 1992, Chambers 1999). For example, it is important to know that many farmers grow cassava because of its crop security and robustness under low-fertility conditions but farmers would rather prefer yam. However, yam needs highly fertile soils, needs staking and is less flexible in planting. Also cassava varieties grown near roads are rather monocropped and of the bitter type, while cassava varieties grown in distant fields are grown in association with other crops.

The predicted increase of the world's population to 8 billion people by 2025 (Harris 1996) will require a dramatically increase of yields in developing nations yields. Technologies such as fertilizer, pesticides, etc. will have to contribute ; yet the most environmentally safe and sustainable approach is the production and delivery of stress resistant high-yielding varieties to become part of the existing farming systems. Until recently, new varieties were produced by either cross breeding or mutation induction. With the rapid progress in molecular biology, the genetic modification of (sub)tropical crops needs to be envisaged because genetic improvement can be accelerated and much better focused. An illustrative case is the banana (*Musa* spp.).

The Case of the Banana Crop

Bananas (dessert and cooking types, plantains and beer types) are grown in more than one hundred and twenty countries throughout the tropics. Around one third of the production comes from each of the African, Asia-Pacific and Latin American and Caribbean regions (Sharrock & Frison 1998). Only 13 % are exported. Bananas, especially cooking types, provide an important staple food crop for some 400 million people, while for another 600 million people, they are considered an important additional food source. Bananas are the fourth most important food crop in the developing world after rice, wheat and maize in terms of gross value of production.

Bananas are one of the first domesticated crops (De Langhe & de Maret 1999) and are being cultivated in Africa since nearly 3,000 years (Mbida *et al.* 2001). Its popularity among smallholders is due to the year-round production of a food rich in energy, vitamins and minerals ; the supply of many different products (snack foods, drinks, leaves for wrapping, male buds as vegetables, stems and leaves as fodder and handicrafts made from banana fibre) (Swennen & Vuylsteke 1991) ; the low cost of production (Johnston 1958) and even spread of labour over the year and the adaptibility of the crop to a wide range of environments.

and farming communities and to agriculture in general. Since the produced transgenic plantains will be made freely available to farmers who will be allowed to pass them on, all ingredients for crop evolution have been respected (HARRIS & HILLMAN 1989), *i.e.* genetic diversity (is increased), farmer knowledge and selection (farming systems and local varieties are not affected, CBD article 18(4)), and exchange of crop varieties. This approach clearly deviates from classical approaches with which local knowledge and crop diversity is lost because of the diffusion of improved, exotic varieties and which mostly goes hand in hand with higher inputs to secure higher yields. Consequently, The Convention on Biological Diversity (article 1 and 18(1) : the conservation of biological diversity) is respected as it requires the conservation of genetic resources *in situ.*

Conclusion and Outstanding Issues

The predicted increase of the world's population to 8 billion people by 2025 (HARRIS 1996) will require developing nations to increase yields substantially but the means for achieving this are rarely available locally. "The production increases required to meet expected population thus inevitably results in the direct competition between local and exotic knowledge, inputs, and crops. Previously, this competition has provoked erosion or the loss of genetic variability in crop populations" (BRUSH 2000). "Sources of change that can be expected and must be tolerated include the introduction of new crops and crop varieties" (BRUSH 2000). Bananas offer a unique opportunity in that newly produced varieties will not only increase the biodiversity on the farm but also do not change the farming system nor reduce the indigenous knowledge. This approach fulfills the request of the Convention that wants to conserve the domesticated and cultivated species (article 2) and the traditional knowledge (article 8). Farmers can then select, under their conditions, the best transgenic lines, *i.e.* participatory varietal selection.

The second generation of transgenic bananas and their testing, however, highlights some problems that need to be avoided in the future. The genes of agronomic interest are owned by the industry and it took much effort by one single Advanced Research Institute (ARI) before these genes could be used for plantain and cooking bananas. As the genetic modification of many tropical and subtropical crops offers much prospects for faster plant improvement, a mechanism should be put in place whereby an authority at the global level will interact with the industry to negotiate access of protected technologies for developing countries. The International Agricultural Research Centres (IARCs) should play an important role in this because they already facilitate access to biotechnology through technologies they develop themselves and therefore could act as a honest brooker. Negotiations should be built upon article 1 and 19(2) of the CBD (fair and equitable sharing of the benefits arising out of the utilization of genetic resources) and article 16 (access and transfer of technology on a fair and equitable basis) (Convention of Biological Diversity 1994). However, in the case of food production by smallholders, it is absolutely necessary that technologies are royalty-free and that produced transgenic plants are allowed to be harvested and resown and distributed from farmer to farmer without any financial return to the industry.

Disease-resistant transgenic plantains exist since about eight years but have not been tested in the field to confirm their field resistance and evaluate its biosafety. This clearly highlightens that legal and political conditions are not in place in developing countries to evaluate biotechnologies that can contribute to alleviate poverty and increase food security. There is therefore an urgent need for capacity building in biotechnology in developing countries, both through participation in biotechnological research and legal issues. The first meeting on the implementation of the Cartagena protocol (Montpellier, December 2000) identified training and capacity building as one of the top priorities.

Among the trained personnel, the best should be selected for the roster of experts for the importing developing country. Such a roster of experts is requested by the Cartagena Protocol. Developed countries also are requested by the Protocol to establish a roster of experts and the names of experts should be made public. So far governments have nominated only 211 experts from 35 countries. These two groups, *i.e.* roster of experts both of the importing and exporting country, should work hand in hand to develop biosafety mechanisms that are as strict in the developing as in the developed world. This is abolutely necessary for those who develop the technology/plants because nowadays it is not clear whether developing countries have a promotional, permissive, precautionary or preventive policy for LMOs (Paalberg 2000). The transfer of technology (CBD article 18/2) and biosafety evaluations in a developing country would be much facilitated if the roster of experts of an importing developing country and an exporting country would work together when it comes to the import of LMO's and this in partnership with the producer of the LMO.

The non-field testing of transgenic plantains produced for smallholders also indicate the need that the signatories to the Cartagena Protocol should ratify it as soon as possible. Indeed, so far only 2 out of about 80 countries have ratified the Protocol and this certainly slows down its implementation.

Current progress in genetic modification of crops will accelerate plant breeding in general but needs to be applied to the food crops of the smallholders in the developing world. Indeed, there the greatest needs for food production exist. Also several crops will especially benefit from the possibilities of genetic modification because they are sterile, such as yam and banana, or produce few seeds, such as sweet potato. Also breeding of polyploid crops is expected to benefit because such conventional breeding schemes progress slowly. In some crops, such as banana, genetic modification is the only option when it comes to breeding for virus resistance because no natural germplasm is known to be virus-resistant. With the declining resource base, biodiversity in smallholders' field is declining resulting in more pests and diseases and imbalanced food supplies. Therefore, genetic modification for disease resistance (*e.g.* banana) or higher protein content (*e.g.* sorghum) is certainly warranted. A deteriorating soil also results in increased drought stress and aluminium toxicity adversely affecting root development. Therefore, genetic modification for tolerance to drought, aluminium but also for increased rooting (Blomme *et al.* 2000) should be envisaged as this will all result in reduced inputs. The produced transgenic lines should then be integrated into the existing breeding programmes so that several hybrids of local germplasm can be delivered to the smallholders.

Finally, all this work should be conducted in full partnership with the South and this explains why at the Laboratory of Tropical Crop Improvement more than one hundred people from the South were trained in these and related techniques over the past ten years.

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Agricultural Research and the Path towards Sustainability : an Agenda from the South

by

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KEYWORDS. — Genetic Engineering ; Family Farming ; Biotechnologies ; Sustainability ; Brazil ; Agriculture.

SUMMARY. — Genetic engineering and its current applications to agriculture have been pointed out as an alternative to farm crisis in the South. This paper aims to discuss the ability of GE technologies to respond to economic, social and environmental problems faced by Brazilian farmers, enhancing the sustainability of the Brazilian food system. The uncertainties surrounding the release into the environment of transgenic crops, the risks to human health associated with the introduction of GMOs in our food system, together with the high level of corporate control underlying this technological package, fully justify the use of the precautionary principle in the case of GE plants and animals. A new research agenda, based on a systemic and ecological approach, and socially oriented towards the strenghtening of family farming is now under construction in the country, engaging different sectors of Brazilian civil society.

1. Introduction

Genetic engineering consists of a set of techniques directed towards isolating, modifying, multiplying and recombining genes that belong to different organisms. These procedures allow geneticists to transfer genes between species belonging to different kingdoms – between different plants and animals, for example – which would not be able to cross "naturally". This kind of intervention has made possible the handling of genes in a radically new way, very different from conventional breeding.

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The application of genetic engineering techniques to agriculture has been pointed out by many researchers working on the development of agricultural technologies as a solution to the problems faced by farmers, especially in the developing countries. The incorporation of new features into plants and animals, such as nutritional qualities and resistance to diseases, and to extreme climatic conditions, post-harvest durability and so on, has been advertised as a new way of overcoming the limits imposed by nature to the design of profitable and competitive agricultural systems.

This paper aims to briefly discuss the ability of genetic engineering techniques to respond to the economic, social and environmental problems currently faced by farmers in the South. In the first part, we will try to briefly recover the history of social resistance against the impacts of modern agriculture that has arisen in Southern Brazil since the 1980s. The strengthening of family farming, the construction of an ecological agriculture, and the resistance to genetic engineered crops are today central points in the agenda of the different organizations engaged in the construction of an alternative project of development to agriculture in this region. The case of Southern Brazil is taken here as an example of the reasons that make farmers in the South believe that Genetically Manipulated Organisms (GMOs) will not solve the complex problems in which they are currently involved.

The second part of our comments will focus on the relationship between the applications of genetic engineering techniques to agriculture and the search for sustainability. After making a few remarks on the capability of genetic engineered varieties, in their current stage of development, to enhance the sustainability of farm systems in the South, we will try to propose a few points that could, from our perspective, compose a first draft of a research agenda towards sustainability from the perspective of family farmers.

2. Family Farming and the Struggle for Sustainability : the Case of Southern Brazil

Brazilian agriculture is, perhaps, one of the best examples of the relationship between environmental degradation and social inequality, as land distribution patterns have been highly concentrated along the country's history. In 1996, 80.6 % of the 4.8 million existing farms in Brazil were under 50 ha, occupying a total area of 42 million ha, 12.2 % of the whole agricultural territory. In contrast, 1 % of the farms had a size of

1,000 ha or more, occupying 45.1 % of the total land area used for agricultural purposes [1]*. According to IPEA [2], 32 million people in Brazil were below the poverty line in 1990 ; 52 % of them lived in rural areas.

Family farming keeps 14 million workers busy, *i.e.* 60 % of the total labour force in agriculture in the country. It also represents 75 % of agricultural concerns, 25 % of tilled areas, and responds to 35 % of the Brazilian agricultural production volume [3].

The agricultural development model, based on the technological package of the Green Revolution, has generated a wide range of economic, social and environmental impacts that have been affecting particularly family farmers over the last three decades.

The modernization wave of the 1960s and 1970s, facilitated by credit and price policies, and by the establishment of a research extension system organized on a national basis, gave way, as in many other Third World countries, to the crisis of the 1980s. Credit and price subsidies were cut, specially in the case of small enterprises, and farmers became more aware of the unsustainable forms of organization of their agricultural activities, strongly dependent on external inputs purchased from large-seed and pesticide companies.

Southern Brazil was the first region in the country to adopt the modern technologies proposed by the Green Revolution. Grain monocultures (specially soybeans), oriented towards external markets, particularly to Europe, were one of the main forces in the reorganization of farm systems in the area.

The concentration of land, the migration of thousands of small farmers to the cities, the monopoly of market opportunities in the hands of big enterprises, and the degradation of natural resources, were some of the results of the changes produced during the 1970s. Farm systems based on family labour did not disappear, but became extremely fragile in a context of market instability and reorganization of agricultural policies.

From the beginning of the 1980s, it has been possible to register, though in the farming setting of Southern Brazil, the structuring of different social organizations and production initiatives opposing, under different aspects, the so-called "modern agriculture". The concentration of land and capital, and the degradation of natural resources, were at the root of these different forms of resistance.

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* The numbers in brackets [ ] refer to the notes pp. 131-132.

Family farmers, organized in labour unions, civil associations, small cooperatives and different social movements, started to react against the different processes of exclusion brought about by the advent of "modern agriculture". The landless movement, the struggle of people displaced by the construction of large dams, the mobilization of small farmers against the cut of subsidies, and the involvement of different groups of family farmers in the design of alternative agricultural systems were part of the first wave of protests.

By the 1990s, this reaction had generated the basic lines of an alternative project of development to agriculture in the area. The democratization of land, the protection of family farming, and the promotion of ecological agriculture, became a set of principles supported by a wide range of organizations working in the countryside.

This utopia, under gestation, with its ambiguities and contradictions, points not to a more democratic and socially including version of modern agriculture, but to the construction of an "alternative", "ecological", or "agro-ecological" agriculture, based on family farming and on new forms of distribution of the economic results generated in the process of food production and consumption. Technologies are not seen here, therefore, as a neutral element, but as part of a complex web of economic and social relations, through which production, marketing and consumption of food is organized.

Nowadays, the reaction against "conventional agriculture" includes not only the resistance to the technological package internationalized by the Green Revolution but, more recently, to the incorporation of GMOs to agriculture. In some places, this resistance is expressed by the organization of groups of family farmers who, challenging the monopoly of the large-seed companies, go back to the practice of producing their own corn or bean seeds, both by recovering landrace varieties, and by crossing the hybrid seeds now existing in the market. In other places, it is being shown by the formation of associations of family farmers, involved in the production, marketing, and industrialization of an extensive diversity of ecological products. It may also be represented by the organization of small cooperatives, engaged in the spreading of productive and organizational practices, which try to counteract those approaches proposed by the agribusinesses and corporate cooperatives.

To these farmers, the advances of biotechnology are not an adequate response to the set of problems they face everyday. The economic instabilities generated by the liberalization of markets, the fragility of farm systems due to their dependence upon external inputs, the lack of control of producers over the marketing of their products, will not be addressed by the genetic engineered varieties now being released in the market. They will not empower farmers in the redesign of farm systems, but, on the contrary, make them more dependent on the big corporations both in capital and knowledge.

The organizations of family farmers in Southern Brazil, as well as the NGOs dedicated to technical advising in ecological agriculture, like the *Centro Ecológico*, which we represent, strive today for an alternative project of development for the region, capable of reconstructing the social, economic and ecological relations established within the food system as a whole. The limits faced in this task will not be overcome by punctual technological solutions. What we need is the participation of farmers, scientists and extension agents, in the construction of sustainable, not only profitable, agro-ecosystems, which we believe we can build with the genetic resources we already have in our hands.

3. Biotechnologies and Sustainability in Agriculture

The use of GMOs in agriculture cannot be well evaluated if we do not take into account the social and biological complexity of farming systems. Sustainability in agriculture is the result of complex interactions. Positive and negative impacts of these interactions can only be assessed over time.

The release of genetic engineered varieties into the market has been surrounded by several promises. The minimization of the environmental impact of the "chemical technologies" generated by the Green Revolution, through the incorporation of new characteristics into plants and animals, is one of them. GMOs would also help eliminate world hunger, minimizing crop failures and making agriculture possible in extreme ecological conditions. But, can we really say that ?

Big investments have been made in the generation of these new products. The funds invested by the biotech corporations in research and development of new varieties need to be recovered as quickly as possible. Pressure exerted by the large economic groups on the governments of the developing countries in order to authorize the release of transgenic varieties on a commercial scale has intensified. In the specific case of seeds, transgenics are already a reality in Latin American countries such as Argentina.

At a global level, the commercial exploitation of genetic resources has also been facilitated by international agreements such as the TRIPS (Trade Related Intellectual Property Rights). Several aspects related to the patenting of living beings and the rights of property are being discussed nowadays in the sphere of the WTO (World Trade Organization) and within the *Codex Alimentarius.* The removal of the legal barriers to the patenting and marketing of genetic engineered plants and animals seems to be very close.

Although the quantity of genetic engineering products already in the market is very small, compared to the volume of funds invested in biotechnological research, one cannot deny that a series of conditions needed for the generalization of these new technologies are already present in the political and economic setting of the early 21st century. We are now at a very delicate point of this navigation route. From this point on, we probably will have to deal with a wide series of unplanned impacts and consequences.

Farmers and consumers are not so convinced that GMOs will actually help build a more sustainable food system, at least in our country. Several aspects related to the complex mechanisms that govern animal and human nutrition are still unknown to geneticists, who manipulate genes in the laboratories. Impacts resulting from the introduction of GMOs in different ecosystems remain unforeseen. These uncertainties have not prevented companies from patenting a whole series of products that are now being released for marketing in several countries. The power of the big enterprises in the food system increases every day.

The new technological innovation frontier represented by biotechnology is not, for sure, the only element behind the more and more centralized structure of the great transnational corporations. However, the movement of concentration of transnational conglomerates, involving not only the seed and chemical input industries, but also sectors like pharmaceutical industry and food processing itself is very visible. Biotechnologies seem to be creating the technological base for this new arrangement in corporate power.

The knowledge that has been accumulated by the different social actors involved in the building of an alternative project of development for agriculture in Southern Brazil, concerning not only genetic engineering itself, but also the fragile economic, social and environmental conditions of our ecosystems, which face today a situation that is very similar to the conditions faced by farmers in other countries in the South, enables us to affirm that transgenic crops can not be seen, today, as a step forward towards sustainability. We understand, on the contrary, that the introduction of GMOs in agriculture will enhance the instability of our farm systems because :

- These systems are already facing a serious crisis, as a result of the social, economic, and environmental impacts generated by the Green Revolution, and the effects of IMF agreements, and trade liberalization issues ;
- Genetic engineering technologies are currently dominated by a small number of corporations, capable of imposing to farmers a whole set of constraints, such as the use of patent protecting technologies, such as the Terminator ;
- Transgenic crops represent a closed technological package, which cannot be adapted by farmers to the social and environmental features of their local agro-ecosystems ;
- Genetic engineered varieties have not proved to be more efficient than traditional ones in our agricultural settings.

Moreover, the risks to the environment and to human health associated with the release of GMOs in agro-ecosystems, fully justify the use of the precautionary principle in this case. What we need now is the formulation and implementation of a new research agenda towards sustainability, deeply rooted at the grassroot level and deeply oriented towards the experiences accumulated by farmers during the past decades.

As we understand, an agricultural research agenda towards sustainability should contemplate the following points :

- Priority for small farmers ;
- Systemic and interdisciplinary approach ;
- Public accountability ;
- Flexible access to research funds in order to bring research closer to farmers and to the control of grassroot organizations ;
- Respect to the farmer's rights over traditional varieties.
- No patent of living organisms.

These are the principles that currently inform our practice at the local level.

NOTES

[1] Cordeiro, Angela. Sustainable Agriculture in the Global Age – Lessons from Brazilian Agriculture. Stockholm, Swedish Society for Nature Conservation, 2000.

[2] IPEA. 1993. O Mapa da Frome : subsídios à formulação de uma política de segurança alimentar.
[3] Folha da Embrapa - Jan/Feb 1999, Year VII, No. 37

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Sustainable Agriculture and Transgenic Crops in Developing Countries

by

Oscar Zamora* & Domingo Porte*

1. Introduction

The Philippines have a unique socio-political climate. Recent developments have shown, for the second time, that organized groups of the middle forces and professionals, NGOs/CSOs, peasants and other members of the basic sector, can accomplish a peaceful change in government by active participation in mobilizations and other related activities.

Among developing countries, opposition to modern biotechnology is probably one of the strongest in the Philippines. So far, there has only been one field test of transgenic crops in the country (that of BT corn in a 350 m^2 area) and it has faced stiff opposition from various sectors. Very recently, the new President Gloria Macapagal-Arroyo has committed "not to support the Estrada government's policy of promoting the use of GMOs because there has been growing objection from civil society to this risky crops and products" (*Philippine Standard*, 14 February 2001). She further ordered the new Secretary of Agriculture Leonardo Q. Montemayor to conduct a series of multi-stakeholder discussions and come up with recommendations regarding this issue.

A multi-stakeholder round-table consultation was held last 6 March 2001 by the Secretary of Agriculture to discuss the elements of a policy formulation concerning GMOs in the Philippines. Present in the consultation were representatives from both the proponent and oppositors from the scientific/academic community, NGOs/CSOs, POs/FOs, government

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agencies, industries, consumer groups and international organizations (IRRI). Most of those present were actively involved in the debate for years and have their own programmes on the GMO issue (see box 1 for the activities on GMOs by the group MASIPAG). After the deliberations, the Secretary of Agriculture concluded that :

- The draft administrative order for the commercialization of GM crops would not be approved and will have to undergo re-examination ;
- GM foods should undergo strict regulation including toxicological studies ;
- Local government units should have the right to disallow GMO open field trials ;
- There are important questions of access and control associated with GMOs that must be addressed and that will affect small farmers ;
- We, as a country, should not press ahead with GM crops if there is no market for them ;
- The labelling policy for GMOs to be enacted should recognize the question of choice that is very important for both consumers and farmers.

BOX 1 – MASIPAG ACTIVITIES ON GMOS

The Farmer Scientist Partnership for Development (MASIPAG), Inc. is a farmer-led network of peasant organizations, concerned scientists and support non-governmental organizations (NGO) formed in 1985 as a response to the problems created by the Green Revolution. Since its founding, the network has grown in scope and in coverage in the Philippines. MASIPAG now involves 456 farmers' organizations with membership reaching to around 30,000 individual farmers.

From its inception, MASIPAG was envisioned to be farmer-led and farmer-driven in all its activities with the concerned scientists and NGOs/CSOs serving the backstopping and support role. In the first phase of implementation, there were involved in developing seeds breeding seeds that are adapted to farmers' local conditions, e.g. without external MASIPAG strives to enable small farmers to produce safe food with decent yields and at the same time maintaining a safe environment.

As of today, MASIPAG farmers have brought back 668 traditional cultivars, and their farmers had bred or selected 538 locally adapted seeds. Adaptability trial farms are now going on in 115 agro-ecological zones throughout the Philippines. Initial activities were focused on rice but have now expanded to corn and vegetables ; fruit, wood trees, agroforestry species and root crops are important components in an integrated and diverse farming system to create a diverse food source in the farm.

In the new millennium, farmers and consumers are faced with challenges much threatening than the Green Revolution – Genetic Engineering. In response to this pernicious threat in furthering sustainable agriculture that MASIPAG has been espousing, it has actively engaged in the following activities :

- Production of resource materials in collaboration with other like-minded institutions, on genetic engineering (e.g. GMO manual) and its products (e.g. BB rice, Golden rice, BT rice and corn), translating and producing them into local languages ;
- Information on dissemination activities by organizing symposia, seminars and fora in the different provinces all over the country ;
- Lobbying and campaigns at the local government level to produce resolutions rejecting GMOs and their field-testing ;
- Press releases to oppose field testing and other GMO activities. These are circulated in mass media and the internet through the MASIPAG News and Views ;
- Lobbying in the Philippines Congress and Senate regarding bills on plant variety protection, GMO moratorium, labelling, etc. ;
- Building strong alliances with other NGOs/CSOs, national farmers' formations, academe and the church and coordinating the activities of the anti-GMO campaign ;
- Organizing local mass mobilizations ;
- Promotion of viable and sustainable alternatives to GMOs through MASIPAG's practical work with the grassroots.

2. Understanding the Opposition to the Gene Technology

Debates about the potentials, risks and benefits of genetic engineering have been going on for more than a decade and it remains highly polarized. Most stakeholders, whether food consumers, scientists, farmers, environmental activists, politicians, or even governments, are either strongly in favour of technologies or strongly opposed to them. One thing is clear at the moment : there is lack of consensus among the various parties regarding genetic engineering, and this is a cause for concern.

As the debates are raging on, eyes and rhetoric are fixed on the next generation of GM products : bananas that vaccinate, apples that enlarge breasts, potato crisps that fight cancer, milkshakes that cure obesity, rice fortified with vitamins and minerals, soybean oils with the taste and health benefits of olive oil, corn stripped of artery-clogging fats and spiked with extra nutrients – all these are almost ready to come off the production line. And beyond that, in the third wave, GM crops will replace factories and be used for producing pharmaceuticals and fuels.

Those who opposed technology are quick to point out that proponents are suffering from historical amnesia. Often cited are : the promotion and sale of pesticides in the 1950s with the same exact rhetoric, the nuclear power of the 1960s and 1970s, food colouring and other additives which were eventually withdrawn from the market after their ill-effects were found later, and the FDA banned tryptophan, a genetically engineered dietary supplement that killed 37 people, permanently disabled about 1,500 and poisoned more than 5,000 before it was recalled.

On the more pragmatic side, the opposition claims that technology and its products will affect the position of developing countries both as exporter of agricultural products and as importer of the agricultural inputs of production (e.g. agricultural chemicals, seeds and planting materials, and technology). It will also change the relationship between the farmer and the corporations, *i.e.* the farmer is transformed into a free supplier of raw materials, displaced as competitor and made totally dependent on the vital inputs of production. Hence, most stakeholders, whether food consumers, scientists, farmers, environmental activists, politicians, or even governments, are either strongly in favour of technologies or strongly opposed to them. The debate over their potentials, benefits, risks and implications to society has intensified as the products have moved from the laboratory to the field and from research to commercial application.

In all these debates, the proponents of genetic engineering view the farmers as passive targets, end-users of the technology, beneficiaries or clients. On the other side of the fence, there are groups and individuals opposing genetic engineering, almost all of them had years of experience in actual grass-roots development work. For these individuals and groups, it is a reality that poor and resource-poor farmers cannot afford expensive "modern" technologies that could increase their yields. What they need are readily available, cheap, and preferably free means to improve yields and sustainability of their farming systems. They also need to have control over their means of production, including knowledge, information, technologies, and especially the land they till. Many have worked hard to demystify the science and the technology that have brutalized the farmers. And here comes genetic engineering, so detached, alien and beyond farmers' control. This is probably the reason why, for these groups and individuals, using food insecurity, nutrition problems, and environmental degradation in the countryside as a justification by the proponents for genetic engineering betrays ***insensitivity, ignorance and lack of understanding*** of the farmers' socio-economic and political milieu.

3. Possibilities for Transgenics in Developing Countries ?

An industry-driven technology like genetic engineering can only succeed if it is acceptable to the consumers. Hence, the growing use of GMO crops would ultimately be a societal decision.

Developing countries are not homogenous. Impacts, risks and acceptability of any technology will vary not only from country to country and from sector to sector of a nation's economy, they will also differ for the various segments of their population. Even the farming sector in many developing countries varies. In the Philippines, farmers may be broadly classified into four groups : the commercial farmers, semi-commercial farmers, subsistence farmers and the landless farm workers. Technologies appropriate for one group are not necessarily applicable to the other groups. Hence, possibilities for transgenic crops in developing countries should be considered under varying contexts. However, history has shown us that risks are likely to emerge when universal technologies, such as genetic engineering, are applied under varying social, economic, political or cultural settings.

However, by assuming that transgenic crops may be "acceptable" to some sectors in developing countries, some questions need to be addressed :

3.1. Does technology provide solutions to real problems ?

Before any meaningful solution to any problem can be formulated, it is necessary that the real problem should first be correctly identified. A concrete example can be cited in the case of rice in the Philippines.

A couple of years ago, a study was conducted by the Swiss Federal Institute of Technology (ETH) in cooperation with the University of the Philippines, Los Baños - College of Agriculture (UPLB-CA), entitled "Public acceptance of genetically engineered food in developing countries : the case of the Philippines". The study investigated the perception of the problems in the Philippine rice economy and the potential of genetic engineering for solving them. A total of 65 respondents from 46 different organizations or institutions, who are all active in the debate on genetic engineering, answered the questionnaire. The respondents can be classified into the following groups : NGOs, including consumer organizations (28 %) ; government institutions (23 %) ; business sector (12 %) ; international research institutions, IRRI (9 %) ; academe (8 %) ; legislators (6 %) ; media (6 %) ; international foundations (5 %) ; international NGOs (3 %). Respondents were asked to assess the importance of the problems of the Philippine rice economy according to a scale 1 (being least important) to 5 (being most important). The same scale was used to assess the potential of genetic engineering for solving the problems.

A total of 19 problems (table 1) were listed and were found important to the Philippine rice economy. Market conditions (4.48), lack of irrigation facilities (4.46), inadequacy of post-harvest facilities (4.33), problem of indebtedness due to high input costs (4.25), weak support services (4.21), typhoon (4.20), inefficient transport network (4.19) and unequal land distribution (4.13), were perceived to be the most serious. Note that five out of the eight most important problems are related to market and infrastructure conditions – problems that cannot be solved by providing farmers with golden, BT- and BB- resistant rice.

The potential of genetic engineering for solving these problems listed is the highest in controlling plant diseases (3.95) and pest infestation (3.83), improving food quality (3.62), reduced use of pesticides (3.58), stabilizing fluctuating yield (3.56) and developing drought tolerance (3.36).

Note that there is a mismatch in the perceived problems and the potential of genetic engineering in solving them, *i.e.* the potential of genetic engineering is the highest in problems that were perceived to be minor problems. If the perception is correct, it appears that the amount of money being invested in rice genetic engineering is disproportionate to its importance (at least in the case of rice in the Philippines as this study shows).

3.2. Assuming the problem is real, are there any known alternative, conventional, environmentally benign, and more sustainable approaches to solve the problem ?

The onus on proving that there are no known alternatives to solving the problems addressed by genetic engineering should rest on the proponents. In many consultations, the proponents find this difficult, particularly in agricultural applications. For every agricultural problem addressed by genetic engineering there are alternatives. For example in the case of BT corn, farmers claim that "detasseling" (or the removal of

Table 1

Perception of the Most Important Problems in the Philippine Rice Economy and the Potential of Genetic Engineering for Solving them

Problems	Most Important Problems in the Philippine Rice Economy		Potential of Genetic Engineering for Solving the Problems	
	(Rank)	(Score)	(Rank)	(Score)
Market conditions	1	4.48	16	1.88
Irrigation facilities	2	4.46	13	2.12
Post-harvest facilities	3	4.33	12	2.16
Indebtedness (due to high input costs)	4	4.25	11	2.28
Weak support services	5	4.21	17	1.84
Typhoon	6	4.20	15	1.95
Inefficient transport network	7	4.19	18	1.83
Unequal land distribution	8	4.13	19	1.39
Drought	9	4.08	6	3.38
High use of pesticides	10	4.00	4	3.58
Reduced soil fertility	11	4.00	8	3.33
Little investment in R&D	12	3.93	10	2.34
Pest infestation	13	3.86	2	3.83
Fluctuating yield	14	3.86	5	3.56
Flood	15	3.83	9	2.82
Soil erosion	16	3.80	14	2.05
Plant diseases	17	3.71	1	3.95
Small numbers of variety	18	3.33	7	3.04
Poor eating quality	19	3.28	3	3.82

80- 90 % of the tassles in a field) can effectively control corn borer. The tassles are then fed to cattle or water buffaloes that provide additional income to the farmers or are composted to serve as biofertilizer. This is just one of the many examples. Farmers have tremendous wealth of wisdom and they always have alternatives to address field problems if and when they occur. Their alternatives are invariably cheaper or even free, environmentally safer and less risky.

3.3. Are transgenics valuable enough to mankind to make it reasonable to expose the environment or the consumers to even the slightest risk ?

Science and the technology it generates should be used for the benefit of the majority. Genetic engineering is a double-edged sword. Benefits that can be derived should outweigh whatever negative consequences it may cause. Technology will have such tremendous impact on everybody's life that it is improper to leave decisions regarding it to science and technology committees and simple cost benefit analysis.

4. Important Requisites for the Involvement of all Stakeholders in Defining and Orienting Agricultural Research Programmes on Genetic Engineering

Debates between proponents and detractors of transgenic crops are important ; otherwise, we miss the opportunity to set sensible limits to the technologies. Also, there is a need for scientifically reliable and socially credible institutions' safety programmes ; otherwise, farmers and consumers are unlikely to accept the technology and its products. For these engagements to be meaningful and useful, however, there are some requisites.

- The proponents must accept that GMOs are offered to developing countries because of the big market rather than help the starving poor and protect the environment. Hiding behind the altruistic motive of "feeding the hungry poor of developing countries" is misleading if not insulting for the peoples of developing countries.
- The proponents must admit that the issue of transgenic crops is social, economic, ethical and political in nature as much as technical and scientific. These issues are beyond the capability of existing regulatory bodies and committees to resolve.
- The proponents should accept accountability for any harmful damage that the technology and its products can do to human health, environment and biodiversity. Hence, there is a need for a regulatory regime that includes liability ensuring that the proponents take responsibility if and when things go wrong. At the very least, they should accept mandatory labelling to enable traceability and provide to the consumers informed choice, rather than hide behind the veil of the unsci-

entific "substantial equivalence". It appears odd that while the proponents profess that there is nothing wrong with technology, many of them refuse mandatory labelling.

- The proponents should stop defending what they know and admit that not enough is known yet in this technology, particularly in prediction of the ecological long-term effects of releasing GMOs into the environment. Science has a lot to offer, but reckless science, *i.e.* when the technology and its products precede science, is dangerous. By admitting that there are still some un-assessable risks in genetic engineering, we can muster science to its potential to make it really useful for people.
- There is a need for meaningful and democratic (as against token) participation in the decision-making process as regard transgenic crops. Many consultations held on the issue in developing countries have been described as "consultations for promotion" of the new technology. This has led many NGOs/CSOs to conclude that they were invited only to deodorize the stink created by the new technology.
- Mutual respect for each other's views (proponents and oppositions). Nobody knows everything and everybody knows something. Many consultations on the issue have been emotionally charged, especially if they involve people who have been in the debate for a long time. Heckling and name-calling is common even in formal legislative meetings and public hearings. Disagreements are common and can even be healthy as surely there can be disagreement without being disagreeable.
- Respect for local laws and ordinances. These fiats are carefully crafted pieces of legislation to reflect the socio-political, economic, moral/ethical standards, spirituality and traditions of the local people. They should not be subverted even if there is a promise of short-term economic gains.

5. Research for Whom and Who Benefits ?

Science and the technology it generates is a very powerful tool that should be harnessed for the benefit of the majority. If it is not carefully applied in a society, it can intensify existing socio-economic inequities – a pernicious problem in developing countries.

5.1. Prioritization of Research

All research institutions are mandated to prioritize research because of the usual limitation in funding. However, this does not mean that they alone have the right to determine what research priorities (even only in broad terms) are established. What is interesting and exciting to scientists (who do not even do actual farming) are not necessarily what is needed and useful to the farmers. It is very disturbing that every time farmers use a new variety or technologies, they have to adjust their farms to suit the specific variety or technologies. Is it not possible to develop varieties and technologies to suit the conditions in farmers' fields ? Meaningful prioritization in research can best be achieved by combining the best that science can offer and the intuitive wisdom of the experienced practitioners – the farmers. Outputs of research should be identifiable with farmers, under their control, affordable and not alien to them.

The Philippines are one developing country that made considerable effort to be involved in biotechnology. In 1979, it set up the National Institute of Biotechnology and Applied Microbiology (BIOTECH). It focused on four interdisciplinary research programmes : biofuels, nitrogen fixation, food fermentation and tissue culture – programmes that are useful for resource-poor farmers of the country. However, as it turns out, the technology ended up in the hands of only one type of farmer : the one who can pay for it. The production of fuel from biomass has limited usefulness for small farmers because the initial capital requirements are too high and not affordable to them. An effective bio-pesticide that was developed by the Institute became too expensive because of a monopoly situation that was created as its production and distribution were handed over to one company.

5.2. Funding Concerns

The availability of funding is always a problem. Funds for universities are almost non-existent. As an example, 98 % of the annual budget of the University of the Philippines at Los Baños (UPLB), the prime agriculture university in Southeast Asia and home base of probably 60 % of agricultural scientists in the Philippines, go to maintenance and operating expenses, and staff salary. Whatever small, funds available are usually tied to utility, short-term productivity gains (*i.e.* genetic engineering), usually in response to globalization and liberalization of agriculture. Indeed, even research money is invested to where it will grow fast. The result is over-investment of financial, human and other resources in genetic engineering. The current over-emphasis on genetic engineering has shifted work away from broader, more holistic or integrative alternatives, including approaches that can contribute to alternative solutions to present social problems.

Because of these problems, the usual role of universities serving society as providers of research outputs, *i.e.* independent of market forces, and as source of expertise, *i.e.* independent of vested interest, is getting a thing of the past. Most available funding in universities prioritize research being relevant to the industry and having high potential for commercialization.

In the absence of public funds and in the quest for relevance, many scientists go into collaborative research with the industry. This is now becoming a norm in many public institutions. Sad to say but the "tyranny of the funding agency" does exist ! The problem here is that the agenda of private institutions is not necessarily compatible with public interests and many scientists (knowingly or unknowingly) adopt the firm's profit goals as if they are his/her own. This problem is very pervasive in the field of genetic engineering, where there is substantial money to be made in patents and royalties. What is unimaginable, and somewhat bordering on the obscene, is when public researchers in their public positions, using public funds and public facilities, apply for patents on their outputs.

6. Role of Development Co-operation

The role of development co-operation in furthering a pro-farmer and pro-environment research agenda in developing countries cannot be overemphasized. To do this effectively, it is necessary for development cooperation institutions to :

- *Diversify its choice of partners* : many public and quasi-public (e.g. the CGIAR) institutions tend to work on the development of so-called universal technologies such as the genetic engineering in its approach to providing solutions to agricultural problems. This is not only unscientific but also dangerous since it should be recognized that diversity exists in the farming milieu in developing countries.
- *Clear position on (perceived or real) threats to sustainable agriculture* : some of the threats that have been identified in many seminars, workshops, fora and conferences in developing countries are patent of

life forms and processes, reckless globalization and liberalization, environmental degradation, food insecurity and poverty, and genetic engineering itself.

- *Support, and work in partnership with groups working on the following areas* :
  - Research and development activities on sustainable agriculture approaches to solving problems in agriculture in developing countries.
  - Documentation, promotion, popularization and dissemination of farmer-developed and adapted technologies in lieu of the genetic engineering approach to problem-solving in the farm. Included also are case and process documentation of successful initiatives on sustainable agriculture.
  - Policy and impact studies of agricultural trade liberalization, genetic engineering and patenting on crops important in developing countries.
- Facilitate and provide a venue for discussions of strategic issues relevant to sustainable agriculture.

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Closing Speech

by

Eddy BOUTMANS *

Mister Chairman,
Ladies and Gentlemen,

I am very pleased to have the honour of closing this two-day seminar. I have to say that I have been reported on the high level of the presentations and of the discussions in the three working groups.

I very explicitly want to welcome the presence of several representatives of farmers' associations from developing countries. We have to take into account their call for an increased participation in research programmes.

De fundamentele maatschappelijke keuzes kunnen niet zomaar overgelaten worden aan de wetten van de vrije markt — laat staan die van de multinationals — of de wetenschap ; er is een open debat nodig met het zogenaamde middenveld, de civiele maatschappij, en uiteindelijk is het aan de politici om een eindbeslissing te nemen.

Sedert enkele jaren leeft bij de publieke opinie een groeiende ongerustheid over de sociale en ecologische impact van ons productie- en consumptiemodel. En de landbouw, het onderwerp van dit seminarie, staat daarbij in het centrum van het debat.

De landen uit het Zuiden zijn wellicht nog meer dan de andere betrokken partij : ongeveer één inwoner op vier leeft er van de landbouw ; ongeveer 800 miljoen mensen zijn er slachtoffer van chronische ondervoeding.

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In de jaren '60 was er de Groene Revolutie. Dankzij de verspreiding van plantenvariëteiten met hoog rendement, voornamelijk van graan en rijst, was er een sterke verhoging van de productie, waardoor landen zoals India erin geslaagd zijn om zelfvoorzienend te worden op het vlak van voeding. Maar deze revolutie had een niet te onderschatten sociale en ecologische kostprijs : het gebruik van deze gevoelige en veeleisende variëteiten vereiste ook meer productiemiddelen, inzonderheid pesticiden en herbiciden.

Voor de aankoop hiervan was men afhankelijk van het buitenland ; zo heeft de Groene Revolutie bijgedragen tot het marginaliseren van de kleine boer en de toenemende ongelijkheid ; ze had eveneens zeer ernstige leefmilieuproblemen voor gevolg.

Zonder de positieve effecten van deze landbouwrevolutie te ontkennen, blijkt nu toch dat ze niet past in de logica van duurzame ontwikkeling.

Met de komst van de moderne biotechnologie en de techniek voor de invoering van genetisch gemodificeerde gewassen rijst ook een groot aantal vragen die het kader van wetenschap en economie ruim overschrijden : de vraag naar sociale en ethische aspecten, en naar aspecten op het vlak van leefmilieu.

Deze technieken, waarvan de mogelijkheden tijdens dit seminarie uitgebreid aan bod kwamen, laten toe om binnen een bepaald organisme een aantal nuttige erfelijke kenmerken te combineren. Kenmerken die het organisme oorspronkelijk niet bezit en die afkomstig kunnen zijn van soorten die er in de stamboom van de levende wezens ver van verwijderd zijn. Deze technieken openen perspectieven die zowel sensationeel als onrustwekkend zijn : de mogelijkheid om de genetische barrière te doorbreken, waardoor in de natuur kruisingen tussen individuen die behoren tot verschillende soorten uitgesloten zijn ; de mogelijkheid om door de techniek van klonering een genetisch perfecte kopie van een individu te maken, uitgaande van één enkele van zijn cellen. In de landbouw kunnen genetisch gemodificeerde gewassen zich op grote schaal en op een totaal oncontroleerbare manier in het milieu verspreiden.

Depuis quelques années, des interrogations croissantes se sont élevées sur les risques liés à ces techniques ; risques dont certains sont établis et d'autres font l'objet de débats passionnés entre experts :

- Risques agricoles, avec la dissémination incontrôlée dans l'environnement de gènes de résistance, aux pesticides notamment ; ou la multiplication de phénomènes de résistance chez les ravageurs des cultures ou les organismes pathogènes ;

– Risques environnementaux pour la biodiversité ;
– Risques potentiels pour la santé humaine.

La majorité des pays du Sud se trouvent particulièrement mal armés pour affronter et gérer les risques connus et potentiels associés aux organismes transgéniques. L'impact environnemental doit y être considéré avec d'autant plus de prudence que ces pays abritent la plupart des centres d'origine des espèces vivantes, parmi lesquelles les espèces cultivées.

L'application des biotechnologies modernes aux animaux et à l'homme pose de graves problèmes éthiques, liés aux possibilités qui sont désormais données à l'homme de générer des clones à partir d'un individu, ou de modifier volontairement le patrimoine génétique d'un homme, d'une femme ou d'un animal.

Derrière l'avènement de ces technologies se profile la logique très préoccupante d'un petit nombre de grands groupes agro-industriels, dont la technologie dite TERMINATOR, basée sur le transfert d'un gène empêchant l'embryogenèse et donc toute reproduction, constitue l'expression la plus préoccupante. Logique monopolistique qui, à terme, pourrait mener à une dépendance forte des paysans du Sud par rapport à quelques grands groupes transnationaux.

Corollaire de l'avènement des biotechnologies, s'est ouvert un débat sur la question fondamentale du brevetage du vivant : dans ce domaine aussi, les pays du Sud se trouvent bien désarmés pour protéger les savoirs et pratiques culturales traditionnels ainsi que les variétés locales de plantes cultivées. Les risques d'une multiplication des pratiques dites de «bio-piraterie», aux dépens des populations et pays du Sud, sont bien réels. On ne peut tolérer que la logique du marché vienne remettre en cause la liberté séculaire des agriculteurs de conduire eux-mêmes la reproduction, la sélection et le croisement de leurs variétés : après tout, c'est au travail de ces générations d'agriculteurs, à travers le monde et à travers les siècles, que nous devons la diversité des produits qui aboutissent dans nos assiettes.

Enfin, toutes ces questions s'inscrivent dans le contexte plus général de la remise en cause de nos modèles de production agricole intensive et de consommation dont les crises à répétition de ces dernières années ont montré les limites et les défauts, tant pour les producteurs que pour les consommateurs.

Loin de fermer les yeux sur les progrès potentiels que recèlent les biotechnologies modernes, j'ai fait le choix de promouvoir un débat serein, transparent et ouvert sur les questions que je viens de soulever : le séminaire qui se clôture maintenant est la première expression de ce choix. Il a permis de confronter, de manière constructive, les avis des différentes parties sur la question. Il a surtout permis de resituer les biotechnologies modernes dans l'éventail très large de mesures à mettre en place pour promouvoir un développement agricole durable. Les discussions de ces deux jours nous ont clairement rappelé que dans ce domaine, il n'existe pas de formule miracle ou de solution technique unique. Le développement durable d'un terroir agricole nécessite généralement la mise en œuvre de systèmes de production complexes faisant appel à une combinaison de techniques et variétés végétales ou animales diversifiées.

La mise en place, au début de cette année, d'un Forum National sur la Recherche Agricole Internationale pour le Développement, est un autre aboutissement de notre volonté de promouvoir le dialogue et la participation. Ce forum, qui regroupe des représentants des universités et centres de recherche, des ONG et des groupements d'agriculteurs, a pour mission de contribuer à l'orientation de stratégies de financement de la recherche agricole pour le développement et de stimuler la concertation et les synergies des différents protagonistes dans ce domaine. La Coopération belge au Développement consacrera cette année 240 millions de francs au financement de programmes de recherche à destination des pays du Sud : dorénavant, toutes les parties impliquées pourront émettre leurs suggestions et recommandations quant à l'orientation de ces financements, par l'intermédiaire de leurs représentants au sein du Forum National sur la Recherche Agricole. Quant à la sélection des programmes de recherche, j'ai demandé une évaluation indépendante des propositions et demandes de financement reçues des grands instituts internationaux de recherche agricole. Cette évaluation sera réalisée par un groupe d'experts internationaux, sur base de critères transparents : la pertinence des thèmes de recherche pour la promotion d'un développement équitable socialement et écologiquement durable, recevra une attention particulière.

Mais il ne s'agit pas non plus que nous scientifiques, dirigeants d'entreprises ou hommes politiques du Nord, décidions ici de ce qui est bon ou mauvais pour les pays du Sud : ces pratiques paternalistes relèvent d'une époque révolue et les représentants des organisations paysannes ont eu la bonne idée de nous le rappeler au cours de ce séminaire. La Coopération belge au Développement se donne pour mission de contribuer à l'information et au renforcement des capacités des pays partenaires. Il s'agit de renforcer leur capacité d'engager un débat sur ces questions, de les doter des moyens de choisir librement et de manière participative les voies les plus appropriées du développement de leur agriculture et de transposer ces choix dans un cadre juridique adéquat. Il s'agit également de les impliquer activement dans l'établissement de l'agenda de la recherche agricole internationale pour le développement, notamment dans le domaine des biotechnologies modernes.

Concrètement, la Coopération belge se consacrera en priorité à :

- La promotion des programmes de recherche, menés par des institutions publiques indépendantes, en particulier sur les impacts des organismes transgéniques, par des tests strictement contrôlés et sur le long terme visant à évaluer leurs impacts écologiques et sanitaires.
- La promotion de programmes de recherche sur des techniques alternatives, adaptées aux contextes du Sud.
- Le financement de programmes de conservation des variété locales impliquant largement les utilisateurs de ces variétés.
- L'appui à la mise en place de mécanismes internationaux d'échanges d'informations et d'expériences comme le *Clearing House* sur la biodiversité, auquel l'Institut Royal des Sciences Naturelles, financé à cette fin par la Coopération belge, apporte une contribution scientifique substantielle.
- Une contribution active à la mise en place de mécanismes de régulation et de contrôle aux niveaux national, régional et international s'inscrivant dans le cadre de la Convention sur la Biodiversité et du Protocole sur la Biosécurité. Dans ce domaine, la contribution volontaire de la Belgique au Programme des Nations Unies pour l'Environnement, portée à 120 millions de francs en 2000 et 2001, apporte un soutien indispensable à cette institution qui joue le rôle de chef de file au niveau international pour les questions d'environnement.

In het Noorden wordt de intellectuele eigendom van wetenschappelijke instellingen en bedrijven beschermd door de octrooiwetgeving. Dit is ook nodig en verantwoord door de hoge kost van het wetenschappelijk onderzoek. Onder meer dank zij deze bescherming blijft de maatschappij investeren in de nieuwsgierigheid van de wetenschapper. Maar patentering heeft ook het pervers effect dat soms broodnodige kennis ontoegankelijk is voor de derdewereldlanden. De producten die uit deze kennis voortvloeien zijn voor hen dan ook onbetaalbaar. Heden ten dage stellen we dit vast in de strijd die farmaceutische ondernemingen voeren tegen de Zuid-Afrikaanse regering om de prijs van de geneesmiddelen tegen AIDS. Dit kan ook de voorbode zijn voor soortgelijke geschillen over vitale diergeneesmiddelen of voedselveiligheid.

Vandaar dat ik mij hier en nu speciaal richt tot onze universiteiten, wetenschappelijke instellingen en farmaceutische bedrijven om een eerlijk evenwicht te zoeken tussen bescherming van hun kennis, onder meer via patentering, en het ter beschikking stellen ervan in het belang van de bevolking in het Zuiden.

Op 29 januari 2000 heeft de Internationale Gemeenschap het protocol van Cartageno goedgekeurd. Dit protocol, door België op 24 mei van hetzelfde jaar ondertekend, verschaft een passend juridisch kader voor overbrenging, behandeling, gebruik en verspreiding in het milieu van de Genetisch Gemodificeerde Organismen. Dit protocol kan evenwel slechts effectief toegepast worden in de landen van het Zuiden, mits een versterking van de lokale capaciteit en expertise, de promotie van adequate informatie- en communicatiestrategieën, de omzetting van de principes van het protocol van Cartageno in de nationale wetgeving en het op punt zetten van controle- en opvolgsystemen.

Ook op dit terrein wil de Belgische Ontwikkelingssamenwerking actief deelnemen aan de financiering en promotie van programma's voor capaciteitsversterking.

Maar tezelfdertijd willen wij zeer strikt het voorzorgsprincipe bewaken. We zullen elke medewerking weigeren aan programma's voor de verspreiding op grote schaal van transgene organismen in de landen van het Zuiden, zolang uit effectenstudies niet onweerlegbaar blijkt dat ze onschadelijk zijn voor mens en milieu.

In dergelijke gevoelige domeinen moet de verspreiding van nieuwe technologieën niet enkel voorbereid en voorafgegaan worden door een studie naar de impact, maar ook door een democratisch debat en de invoering van een goed werkend regulerings- en controlemechanisme. En niet omgekeerd. In de sector van de landbouw, meer nog dan in om het even welke sector, moet men erop letten de wagen niet voor het paard te spannen.

Ik ben ervan overtuigd dat dit seminarie een substantiële bijdrage geboden heeft aan het debat over de plaats van de moderne biotechnologie en van de transgene organismen in de verdere ontwikkeling van de landbouw. Ik hecht eraan persoonlijk de sprekers en deelnemers te bedanken voor hun uiteenzettingen en tussenkomsten, even rijk als gevarieerd, en voor de constructieve ideeën die deze twee dagen naar boven gekomen zijn. Dit seminarie zal niet zonder gevolg blijven : de conclusies zullen zorgvuldig worden bestudeerd en zullen mee een leidraad vormen voor de verdere landbouwpolitiek van de Belgische Ontwikkelingssamenwerking.

Pour terminer, je tiens à remercier tout particulièrement les organisateurs de ce séminaire.

Tot slot houd ik eraan de Federale Raad voor Duurzame Ontwikkeling ; le *Conseil inter-universitaire de la Communauté française de Belgique*, de Vlaamse Interuniversitaire Raad en de Koninklijke Academie voor Overzeese Wetenschappen van harte te danken voor de organisatie van dit seminarie.

Seminar
Sustainable Agriculture in the Third World : defining a Role for Transgenic Crops and Research
Brussels, 26-27 March, 2001
pp. 153-155 (2002)

Synopsis of Decisions and Recommendations

by

Eric TOLLENS* & Thierry KESTELOOT**

1. Sustainable agriculture in the Third World is a very large issue which involves many aspects. Agronomic research, and particularly biotechnological research, is only one of the many levers that could be used for solving the existing problems (food insecurity, poverty, ...). During the seminar, a strong accent was put on a demand-driven approach on Third World countries, with a great involvement and important participation of farmers' legal associations in the process of technological development. The demand-driven bottom-up approach must also put problems back in their context and hierarchize them (*i.e.* define priorities). Problems must be solved by considering the political and socio-economic context ; a demand for an integrated (technical, economic, social, liberating, environment-respectful) approach is the most recurrent.
2. Molecular biotechnology might contribute to solving specific problems that would be difficult, perhaps impossible, to solve differently. But biotechnology itself is not always the best solution. Biotechnological research must be assessed in comparison with other research / solution(s), it must be chosen only if it seems to be the less expensive and most sustainable solution considering the socio-economic aspects.
3. The Third World is insistently sending us the message according to which the possibilities, limits, risks, dangers and insecurities of

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modern biotechnology are not well known. In this regard, much emphasis is laid upon the need for a capacity building of the South by the North.

4. Research on biotechnologies, which is turned towards the South and financed by the North, must always start from the South and try to provide a local capacity building and a technological transfer. Research must be at the service of local needs in order to develop in those countries an adapted legal framework and to sustain the society debate on the introduction of biotechnologies.
5. Capacity building always includes the precautionary principle and risk analysis, which must be locally implemented. More research must be carried out to know how a good risk analysis can be implemented in the South, what institutions are necessary to this end, how the risks must be assessed. The needs on this matter are important.
6. Similarly, research on biotechnologies, publicly financed in the North and directed to the South, must rather aim at reducing the dependence from the South towards the North in the field of technological solutions at the national and local levels as well as at the farmers' level. Thus, small farmers of the South must be capable of making their own technological choice – a technology can never be imposed.
7. Publicly financed agricultural research must provide public and free access to its activities and results. The appropriation of benefits resulting from research by the private sector must be prohibited. Structural solutions must also be found to allow free access to both biological knowledge and technology, which are currently protected by patents in favour of public research turned towards the Third World countries and towards more sustainability.
8. Publicly financed research in the field of biotechnology must take the social implications into account, including the application and implementation of the precautionary principle and an adapted risk analysis. The responsibility for the risks related to specific technologies must be formally established, set in its legal framework and made operational.
9. Biotechnological public research must always be submitted to a general control regarding the criteria of sustainability, food security, struggle against poverty, preservation / improvement of natural resources, environment, autonomy and sovereignty of local actors /

cultures. The criteria used must be defined always in a wider than purely technical dimension, the agronomists must be subject to a society control.

10. Biotechnological research financed by the North must not take as a starting point what is here possible and technically desirable. Both the needs and implication of the South, including the participation of local farmers' associations, are of vital importance. The South must always decide on the orientation of technological development which is turned towards itself, even if it appears in the North or is financed by the North. Cooperation to development may contribute to a more structured and steady participation of farmers in the South as far as technological development is concerned.

11. The priorities of publicly financed agricultural research for the South must be directed towards agricultural systems / products in which private and multinational companies have none or little interest, in particular (resource-poor) small family firms, orphan crops (eg. cassava, bananas, "plantains", vegetables, specific indigenous plants, ...). There is also a greater need for a socio-economic research on these agricultural systems / plants.

12. In a long-term sustainability perspective, one must avoid choosing a specific technological solution which entails a lock-in danger. Therfore, one must choose integrated applications with various components / actions rather than a one-component solution.

13. The recommendations and guide lines stated above must be defended by the Belgian cooperation to development in the international fora concerned : National Agricultural Research Systems (NARS), NARS fora, CGIAR, international and regional fora (FAO, CEAR, ...).

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Synopsis van besluiten en aanbevelingen

door

Eric Tollens* & Thierry Kesteloot**

1. De problematiek van duurzame landbouw in de Derde Wereld is zeer ruim en heeft vele aspecten. Landbouwkundig onderzoek, en in het bijzonder biotechnologisch onderzoek, is maar één van de vele hefbomen die zou kunnen gebruikt worden om problemen op te lossen (voedselonzekerheid, armoede,...). In het seminarie werd sterk aangedrongen op een *demand-driven* benadering vanuit de ontwikkelingslanden zelf, en met grote betrokkenheid en inspraak van legitieme boerenbewegingen in het technologie-ontwikkelingsproces. De *demand-driven bottom-up*-benadering moet ook de problemen in hun context plaatsen en ze hiërarchiseren (prioriteiten vastleggen). Het oplossen van problemen moet gebeuren, rekening houdend met de politieke en sociaal-economische context, en een geïntegreerde benadering (technisch, economisch, sociaal, emancipatorisch, milieukundig) is het meest aangewezen.
2. Moleculaire biotechnologie kan wellicht bepaalde problemen helpen oplossen die anders niet of zeer moeilijk kunnen opgelost worden. Maar biotechnologie is per se niet steeds de beste oplossing. Biotechnologisch onderzoek moet geëvalueerd worden naast ander(e) onderzoek/oplossingen, en enkel indien dit de beste kostenbesparende en duurzame oplossing blijkt, moet hiervoor gekozen worden, rekening houdend met sociaal-economische en maatschappelijke aspecten.

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3. Vanuit de Derde Wereld komt zeer sterk de boodschap dat men niet goed weet wat de mogelijkheden zijn van moderne biotechnologie, haar beperkingen, risico's, gevaren en onzekerheden. Men dringt sterk aan op capaciteitsopbouw dienaangaande in het Zuiden door het Noorden.

4. Onderzoek betreffende biotechnologieën gericht op het Zuiden en gefinancierd door het Noorden moet steeds vertrekken vanuit het Zuiden en moet aan lokale capaciteitsopbouw en technologietransfer doen. Het onderzoek moet ook ten dienste staan van de lokale noden om een aangepast juridisch kader in deze landen te kunnen uitwerken en om het maatschappelijk debat betreffende de invoering van biotechnologieën te kunnen voeden.

5. Capaciteitsopbouw is steeds inclusief het voorzorgsprincipe en risico-analyse, die lokaal moeten toegepast worden. Meer onderzoek moet gebeuren naar hoe een goede risico-analyse in het Zuiden moet gebeuren, welke instellingen hiervoor nodig zijn, hoe de risico's moeten ingeschat en geëvalueerd worden. De noden op dit vlak zijn zeer groot.

6. In dezelfde gedachtegang moet publiek gefinancierd onderzoek rond biotechnologieën in het Noorden gericht op het Zuiden eerder de afhankelijkheid van het Zuiden van het Noorden voor technologische oplossingen verminderen, zowel op nationaal als lokaal niveau, als op het niveau van de boeren. Aldus moeten kleine boeren uit het Zuiden steeds in staat zijn zelf hun technologische keuzes te maken ; een technologie mag nooit opgedrongen worden.

7. Publiek gefinancierd landbouwkundig onderzoek moet publieke en gratis toegang tot dit onderzoek en zijn resultaten verzekeren. Privé-toeëigening van de voordelen van dit onderzoek moet verboden worden. Ook moeten structurele oplossingen gevonden worden om kennis en technologie dienaangaande die nu onder patentbescherming staat vrij toegankelijk te maken voor het publiek gefinancierde onderzoek ten bate van ontwikkelingslanden en gericht op meer duurzaamheid.

8. Publiek gefinancierd onderzoek betreffende biotechnologie moet de maatschappelijke implicaties omvatten, inclusief de toepassing en uitwerking van het voorzorgsprincipe en aangepaste risico-analyse. Aansprakelijkheid i.v.m. risico's verbonden aan specifieke techno-

logieën moet uitdrukkelijk bepaald worden, in zijn juridisch kader gesitueerd worden en geoperationaliseerd worden.

9. Publiek gefinancierd biotechnologisch onderzoek moet steeds een algemene toetsing aan de criteria van duurzaamheid, voedselzekerheid, armoedebestrijding, behoud/verbetering van de natuurlijke hulpbronnen/milieu, autonomie en souvereiniteit van lokale actoren/culturen ondergaan. De gebruikte criteria moeten geëxpliciteerd worden, moeten steeds ruimer zijn dan louter technisch/landbouwkundige en moeten onderworpen zijn aan een maatschappelijke toetsing.
10. Biotechnologisch onderzoek gefinancierd door het Noorden mag niet vertrekken vanuit het oogpunt van wat hier technisch mogelijk en wenselijk is. De noden van het Zuiden, de betrokkenheid van het Zuiden, inclusief inspraak van lokale boerenorganisaties, staan centraal. Het Zuiden moet steeds de technologie-ontwikkeling die op haar gericht is sturen, ook als deze in het Noorden gebeurt en/of door het Noorden wordt gefinancierd. Ontwikkelingssamenwerking kan in het Zuiden helpen bij het structureren en tot expressie brengen van boereninspraak m.b.t. technologie-ontwikkeling.

11. Prioriteiten voor publiek gefinancierd landbouwkundig onderzoek voor het Zuiden moeten gericht zijn op landbouwsystemen/gewassen waarvoor privé-maatschappijen en multinationale ondernemingen geen of weinig belangstelling vertonen, o.a. kleine familiale (*resource-poor*) landbouwbedrijven en de zogenaamde *orphan crops* (b.v. maniok, bananen en plantanen, groenten, specifieke inheemse gewassen,...). Er is ook meer nood aan socio-economisch onderzoek aangaande deze landbouwsys-temen/gewassen.

12. Met het oog op langetermijnduurzaamheid moet vermeden worden dat gekozen wordt voor één specifieke technologische oplossing die een *lock-in* gevaar inhoudt. Aldus zijn geïntegreerde toepassingen met meerdere componenten/acties te verkiezen boven enkele-componentoplossingen.

13. De hierboven geformuleerde aanbevelingen en richtlijnen moeten door de Belgische ontwikkelingssamenwerking bepleit worden in de fora die kunnen relevant zijn : nationale landbouwonderzoekssystemen (NARS), NARS-fora, CGIAR, regionale en internationale fora (FAO, GFAR,....).

Seminar
*Sustainable Agriculture in the Third World :
defining a Role for Transgenic Crops and Research*
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Synopsis de décisions et de recommandations

par

Eric TOLLENS* & Thierry KESTELOOT**

1. La problématique d'une agriculture durable dans le Tiers-Monde est très large et revêt beaucoup d'aspects. La recherche agronomique, et en particulier la recherche biotechnologique, ne sont qu'un des nombreux leviers qui pourraient être utilisés pour résoudre les problèmes existants (insécurité alimentaire, pauvreté,...). Au cours du séminaire, on a fortement insisté sur une approche axée sur la demande (*demand-driven*) des pays du Tiers-Monde, avec une grande implication et une participation importante de la part d'associations légitimes d'agriculteurs dans le processus de développement technologique. L'approche *demand-driven bottom-up* doit aussi replacer les problèmes dans leur contexte et les hiérarchiser (c'est-à-dire établir des priorités). La résolution des problèmes doit se faire en tenant compte du contexte politique et socio-économique ; une demande pour une approche intégrée (technique, économique, sociale, émancipatrice, respectueuse de l'environnement) est celle qui revient le plus.

2. La biotechnologie moléculaire pourrait aider à résoudre des problèmes déterminés qu'il serait très difficile, voire impossible, de résoudre autrement. Mais la biotechnologie n'est pas toujours la meilleure solution en soi. La recherche biotechnologique doit être évaluée au regard d'autre(s) recherche(s)/solution(s), elle ne doit être choisie que si elle semble représenter la solution la moins coûteuse et la plus durable compte tenu des aspects socio-économiques.

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3. Le Tiers-Monde nous envoie avec insistance le message selon lequel les possibilités, les limites, les risques, les dangers et les insécurités de la biotechnologie moderne ne sont pas bien connus. On insiste aussi beaucoup sur la nécessité d'une *capacity building* en la matière du Sud par le Nord.

4. La recherche concernant les biotechnologies, orientée vers le Sud et financée par le Nord, doit toujours partir du Sud et chercher à assurer une *capacity building* locale et un transfert technologique. La recherche doit être au service des besoins locaux afin de permettre l'élaboration dans ces pays d'un cadre juridique adapté et d'alimenter le débat de société sur l'introduction des biotechnologies.

5. La *capacity building* comprend toujours le principe de précaution et l'analyse des risques, qui doivent être mis en œuvre localement. On doit se livrer à plus de recherches sur la question de savoir comment mettre en œuvre une bonne analyse des risques au Sud, quelles institutions sont nécessaires pour ce faire, comment les risques doivent être évalués. Les besoins en cette matière sont importants.

6. Dans le même ordre d'idées, la recherche en matière de biotechnologies, financée publiquement au Nord et orientée vers le Sud, doit plutôt viser à diminuer la dépendance en matière de solutions technologiques du Sud vis-à-vis du Nord, aussi bien aux niveaux national et local qu'au niveau des agriculteurs. Ainsi, les petits agriculteurs du Sud doivent être en mesure de faire leurs propres choix technologiques — une technologie ne peut jamais être imposée.

7. La recherche agricole financée publiquement doit assurer un accès public et gratuit à ses activités et à ses résultats. L'appropriation par le privé des avantages issus de la recherche doit être interdite. Des solutions structurelles doivent également être trouvées afin de permettre un libre accès au profit de la recherche publique tournée vers les pays du Tiers-Monde et vers plus de durabilité, au savoir et à la technologie en matière biologique actuellement protégés par des brevets.

8. La recherche financée publiquement et qui concerne la biotechnologie doit englober les implications sociales, y compris l'application et la mise en œuvre du principe de précaution et une analyse des risques adaptée. La responsabilité en ce qui concerne les risques liés à des technologies spécifiques doit être formellement déterminée, située dans son cadre juridique et rendue opérationnelle.

9. La recherche publique biotechnologique doit toujours subir un contrôle général par rapport aux critères de durabilité, de sécurité alimentaire, de lutte contre la pauvreté, de maintien et d'amélioration des ressources naturelles, de l'environnement, d'autonomie et de souveraineté des acteurs locaux et des cultures locales. Les critères utilisés doivent être explicités, toujours dans une dimension plus large que purement technique ; les agronomes doivent être soumis à un contrôle de la société.

10. La recherche biotechnologique financée par le Nord ne doit pas partir du point de vue de ce qui est possible et techniquement souhaitable ici. Les besoins, l'implication du Sud, y compris la participation d'organisations d'agriculteurs locales, sont centraux. Le Sud doit toujours décider de l'orientation du développement technologique qui est dirigé vers lui, même s'il apparaît au Nord ou qu'il est financé par le Nord. La Coopération au développement peut aider la participation des agriculteurs au Sud en matière de développement technologique à se structurer et à s'affirmer.

11. Les priorités de la recherche agricole pour le Sud financée publiquement doivent être orientées vers des systèmes agricoles et des produits pour lesquels les sociétés privées et les multinationales montrent peu ou pas d'intérêt : entre autres petites entreprises familiales (*resource-poor*), *orphan crops* (par exemple, le manioc, les bananes, les «bananes plantain», les légumes, des plantes indigènes spécifiques,...). Il y a aussi un plus grand besoin quant à une recherche socio-économique concernant ces systèmes agricoles et les plantes.

12. Dans une perspective de durabilité, on doit éviter de choisir une solution technologique spécifique qui porte en elle un danger de *lock-in* (exclusion des autres solutions). Par conséquent, il faut choisir des applications intégrées avec plusieurs composantes de préférence à une solution à composante unique.

13. Les recommandations et lignes directrices formulées ci-dessus doivent être défendues par la Coopération au développement belge devant les forums internationaux concernés : Systèmes nationaux de recherche agricole (NARS), NARS-forums, CGIAR, forums internationaux et régionaux (FAO, GFAR,...).