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Foreword

Asia remains to be home to the highest number of the world's poor. The challenge to Asian governments to provide adequate food to its growing population has become greater amidst the context of shrinking land resources, declining water supply, deteriorating environmental resources, and yield plateaus. While biotechnology is recognized as a harbinger of opportunities to meet the challenges of regional and global food security, many speculate on the risks and potential hazards it may bring on the population.

Biotechnology has become a general concern especially in the region where the need for an efficient and environmentally friendly food production system has been more pronounced given its expanding population. The potentials of biotechnology in contributing to sustainable food production and agricultural development cannot be overemphasized. It is for this reason that the SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA) has made biotechnology a major component of its recently launched Seventh Five-year Plan. SEARCA's objective is to look deeply into the issues of biotechnology and its impact on the region's agriculture and environment, including biosafety policy and regulatory infrastructure.

SEARCA recognizes the concerns about the associated risks in biotechnology, specifically the release of genetically altered organisms in the environment and the consumption of genetically modified foods. If these concerns are not addressed in due time, these will continue to limit the potential application of biotechnology in agriculture. For instance, in 1999, about 40 million hectares were already grown to genetically modified crops elsewhere. In Asia, however, no country had grown transgenic crops in commercial scale, except China. In Southeast Asia, in fact, only Thailand, Indonesia, and, recently, the Philippines had conducted experimental field trials of transgenic crops.

The slow introduction and adoption of transgenic crop technology in the region is attributable to, among other reasons, the general fear among the populace. The unfavorable perception of biotechnology in Europe has likewise contributed to a generally conservative approach adopted by Southeast Asian governments with regard to the introduction and use of transgenic crops.

The imperative now is to have a much more concerted country effort to fully explore and exploit the biotechnology revolution, given all the necessary precautions and risk-assessments based on hard science. Therefore, regional response initiatives are in order to assess research and development capability, human resource capacity, as well as institutional management policies, infrastructure, and strategies such as those dealing with intellectual property rights and biosafety.

SEARCA, for its part, convened a high-level conference and workshop focusing on the regional "enabling environment" for biotechnology – the technical, legal, regulatory, and social infrastructure that would make possible the effective and safe utilization of agricultural biotechnology in Southeast Asia. This move is supportive of the Center's thrust of enhancing sustainable agriculture in the region through quality research and education in all areas relevant to agriculture --- science and technology, policy, human resource development, and other institutional concerns.

The proceedings of the conference/ workshop contain the discussions on pressing issues, as mentioned above, regarding the region's agricultural biotechnology, particularly on crop biotechnology. It likewise contains the group's recommendations on how to harness the benefits of this modern technology, yet at the same time, calling for a more sober and science-based assessment of the risks associated with it. Hopefully, various stakeholders will review the recommendations and take positive steps toward a productive and safe use of biotechnology for the region's agriculture.

RUBEN L. VILLAREAL
SEARCA Director

EXECUTIVE SUMMARY

SEAMEO SEARCA, being the lead regional and inter-governmental institution for graduate research and education, headed by its Director Ruben L. Villareal, convened this conference-workshop to identify and understand regional needs, priorities, policies, constraints, and status of agricultural biotechnology research and development, especially among SEARCA member countries, and to develop approaches of regional collaborative programs on agricultural biotechnology. This conference-workshop was co-sponsored by the United Nations Food and Agriculture Organization (FAO) and the Asia and Pacific Seed Association (APSA).

Agriculture remains to be a very significant part of the economies of Southeast Asian countries and provides the livelihood of a great number of people. Although the region as a whole has made significant progress in recent years in increasing average capita incomes, rural communities who depend mostly on agriculture remain poor amidst shrinking land, water, and forest resources, declining environmental resources and yield. Thus, any technology that will further increase productivity in agriculture and will conserve environment will be most welcome.

Modern biotechnology is one of the strategic technologies adopted by many Southeast Asian countries which has the potential to contribute significantly to increasing agricultural productivity and sustainability. It has already produced commercial products such as genetically modified (GM) crops (e.g., corn, cotton, soybean, potato) with enhanced agronomic traits such as insect resistance and herbicide tolerance, resulting in higher yield and better quality produce. Hectarage planted to these GM crops increased from 1.7 million ha in 1996 to 39.9 million ha in 1999, with 16 percent of total hectarage found in developing countries.

Concerns

A study of the Southeast Asian regional situation revealed that biosafety guidelines are in place and operational in most of Southeast Asia except in Lao and Cambodia. The ASEAN, through its various committees has developed guidelines to harmonize biosafety regulations for agricultural products derived from biotechnology. The Codex Alimentarius is recognized by WTO members as the reference for food safety. The Codex requires science-based evaluation of biotechnology-derived foods. The Cartagena Protocol on Biosafety, adopted during the fifth conference of the parties to the Convention on Biological Diversity in May 2000, works on the basis of precautionary principle and provides global rules to control transboundary movements, transfer, and handling of GMOs.

Concerns about intellectual property rights (IPRs) and their protection have arisen from the tremendous private sector investment in agricultural biotechnology in the past two decades. Thus, managing agribiotechnology IPR is needed to effectively deal with biotech creations, their distribution and applications, their interaction with industry, and assistance to the biotechnologist. In most Southeast Asian countries, laws which protect IPs, such as copyright, patent, trademark, among others, are in place. However, offices or personnel involved may need to be upgraded as they may not be adequately prepared to evaluate biotech applications. Efforts to enact Plant Varietal Protection (PVP) laws are underway. However, patenting of life forms except microorganisms is not allowed in most Southeast Asian countries.

Even as adoption of modern biotechnology products increases, concerns regarding their biosafety to human health and environment and safety as food or feed and intellectual property rights are shared by private, government, and civil society sectors. However, since there is no such thing as zero-risk technology, studies on risks associated with biotechnology, those inherent to the technology and those that transcend it, and their management should be carefully conducted.

Agricultural Biotechnology---What Is in It for Developing Countries?

According to private sector perspective, agricultural biotechnology provides:

1) Opportunity to increase production where it is needed, not more production from outside or redistribution of products, by increasing crop yields (e.g., improved tolerance to biotic and abiotic stresses, increased yield stability), and by increasing farm management efficiencies; and

2) Opportunity to improve product quality traits such as higher nutritional quality (e.g., vitamins, protein) and environment-friendly (e.g. uses less chemical pesticides or herbicides, produces less pollutants, biodegradable plastic polymers).

Furthermore, the contention of international agricultural research organizations (IARO) is that agricultural biotechnology can enhance farmer competitiveness for sustained food security and globalization. To assist in this regard, IAROs can:

1) Provide options and advice on various information and technologies (including biotechnology);

2) Provide opportunities to improve national capacity and enhance accessibility to new knowledge and expertise; and

3) Promote partnerships among all stakeholders involved in R&D.

However, an NGO, the Third World Network disagreed on the use of modern biotechnology in agriculture and stated that it is absolutely essential for developing countries to make the right production and consumption choices. It further argued that agro-ecological farming systems can be productive and sustainable.

Agricultural Biotechnology: Status of R&D and Commercialization of Agribiotech Products in Southeast Asian and other Asian Countries

R&D in agricultural biotechnology in Southeast Asian countries are at various stages of development. Field trials of GM crops have been conducted in Thailand (i.e., corn with insect resistance and/or herbicide tolerance, tomato with delayed ripening trait), Philippines (i.e., corn with insect resistance or Bt corn) and Indonesia (Bt corn).

Importation of GM crops for testing in contained facilities and field testing are regulated by plant quarantine and biosafety regulations in individual Southeast Asian countries. Thailand has issued a decree allowing importation of 40 species of GM crops only for experimentation in contained facility or limited field trials but not for commercialization. Allowed as well are processed GM foods and those used in the food, feed, and other industries.

Among countries in Asia and Oceania, China, and Australia have extensive commercial plantings of cotton with insect resistance (Bt cotton), 80,000 ha in Australia in 1998 and 300,000 ha in China in 1999. Only recently, India allowed multilocation field trials of Bt cotton. Japan, on the other hand, has approved GM products (i.e., corn, soybean, potato, cotton) for food and feed since 1997 and has passed labeling guidelines for GM products.

Making Agricultural Biotechnology Work for Developing Countries

Developing countries have faced similar constraints in biotechnology R&D leading to commercialization. These are in the areas of 1) funding, 2) capabilities, both infrastructure and human resources, and 3) public awareness. Whereas Singapore and the Malaysian governments have invested heavily in funding research programs and manpower and infrastructure building in agribiotech since the mid-1980s, other SEA governments have failed in this regard. In addition, the 1997 Asian financial crisis led to cutdowns in R&D investments not only in agribiotech but in other areas as well.

In general, Southeast Asian countries lack biotechnology-trained personnel with only 1-2 persons per 10,000 population compared to 20 in Australia, 40 in the USA and 60 in Japan.

The lack af awareness and understanding of modern biotechnology and its products and the active campaign of those who oppose the use of this new technology are also hampering progress in realizing benefits from this technology.

The challenge, therefore, is for developing countries such as those in Southeast Asia to access and mobilize biotechnology for their national objectives.

Based on the various inputs to the conference-workshop, the following areas of concerns for stakeholders and follow-up activities were highlighted:

1) Greater capacity building to conduct biotechnology R & D. Networking R&D programs such as the Asian Rice Biotechnology Network and the Asian Maize Biotechnology Network and collaborative projects between developing and developed countries significantly contribute to manpower training and effective technology transfer.

2) Promotion of public awareness and understanding of modern biotechnology.

3) Increasing assessment and management studies of risks associated with biotechnology.

4) Promotion of greater public sector investment in agricultural research, in general, and agricultural biotechnology, in particular.

5) Encouragement of private sector investment in biotechnology for developing country agriculture.

6) Promotion of greater official development assistance (ODA) funding for agricultural biotechnology to international agricultural research organizations which provide new information and technologies and training to the national research systems (NARS).

7) Promotion of awareness and training in managing intellectual property rights among researchers, administration officials, and policymakers.

It was emphasized that it is the obligation of technology innovators, producers, and of government to assure the public of the safety of agricultural biotechnology products and their effect on environment. Further, biotechnology, biodiversity, and sustainable agriculture are complementary, synergistic, and interdependent. Contradictions and controversies result from nonscientific and misapplication of biotechnology.

WORKSHOP OUTPUT

What is Agricultural Biotechnology to Developing Countries in Southeast Asia?

- ♦ Biotechnology is officially recognized by these countries to provide tools for sustainable agricultural development.

- ♦ Biotechnology includes many tools--- fermentation, tissue culture, markers, diagnostics, and genetically modified organisms among them.

- ♦ However, each country should define its own priorities based on its needs using cost-benefit analysis, comparing various methods of attaining similar objectives, and involving all stakeholders in determining biotechnology priorities. Depending upon the tool, biotechnology can provide the following opportunities to attain sustainable agriculture.

- ♦ Opportunities to:

    - ◊ Reduce soil erosion through a technology that reduces or totally eliminates tillage;
    - ◊ Reduce or eliminate the use of chemical pesticide or other inputs that upset the environment; and
    - ◊ Increase yield, productivity, and incomes of farmers through a number of means such as

        - * Reduction of other production input such as water and fertilizer;
        - * Ensuring crop yields despite the vagaries of stress environments;
        - * Offering a farm-level method of adding value to farm produce;
        - * Adding new value such as higher value trait; and
        - * Shortening cropping cycle.

- ♦ However, particularly pertaining to GMOs, each country must address the following concerns:

    - ◊ Biosafety issues;
    - ◊ Public perception and public awareness;
    - ◊ Agreement with other countries on the approach to regulation;
    - ◊ Socioeconomic issues; and
    - ◊ Ethical issues.

RECOMMENDATIONS

What are Required for the Effective Development and Use of Biotechnology in the Southeast Asian Region?

- **Capacity Building, aimed at providing an enabling environment**

  ⇒ Policy, consisting of articulated direction by political leaders
  ⇒ Institutions, referring to those engaged in research, regulation, communication and transfer of technology
  ⇒ Resources, including financial support and the scientific support of scientists, technicians, management level and support staff
  ⇒ Regulatory framework, regulating the movement of GMOs but not research itself.

- **International cooperation contributes significantly to the successful development and application of agricultural biotechnology in developing countries through**

  ⇒ Information and communication technology (ICT), and
  ⇒ Centers of expertise approach, nodes or clusters that can work together on a common area or serve as contact point in a particular area.

- **Information sharing and policy dialog for all stakeholders at national and regional levels**

- **Use of technology, technology should reach farmers and farmer cooperatives and eventually consumers**

- **Intellectual property is important as it is the gateway to access to the technology. While biosafety issues are already being addressed quite adequately, addressing IP issues lags behind.**

Recommendations for SEARCA

- Training of researchers for the all the competencies needed.
- Exchange of experts in policymaking, IPR, biosafety, information sharing, and ICT.
- Establishment of database on agricultural biotechnology information in the region and database on resource persons.
- Establishment of a pooled or linked website within the region to serve as electronic means for exchanging ideas and information.

Searching For the Role of Agricultural Biotechnology In Sustainable Agricultural Development of the Region[1]

Dr. Ruben L. Villareal[2]

Asia has greatly benefited from science and technology innovations that accompanied the green revolution. Yet, the sad fact is that it remains home to the highest number of the world's poor. It continues to face the difficult and continuing challenge of providing adequate food for its growing populations amidst shrinking land resources, declining water supply, deteriorating environmental resources, and yield plateaus.

There is an increasing consensus not only in the scientific community, but in government and private sectors as well, that green revolution technologies need to be augmented with "gene revolution" technologies or modern biotechnologies to effectively improve agricultural productivity and address the problem of feeding six billion people, 60 percent of whom are in Asia. These new technologies have already produced commercial products, including transgenic or genetically modified crops, with enhanced agronomic traits resulting in higher yield and better quality produce. In the past three years, we have seen a tremendous increase in hectarage planted to these genetically modified or GM crops from 1.7 million hectares (ha) in 1996 to 11 million ha in 1997, 27.8 million ha in 1998, and 39.9 million hectares in 1999. The figure is expected to increase in the year 2000. Eighteen percent of the total hectarage in 1999 was in developing countries, up from 4.4 percent in 1997 and 16 percent in 1998. In 1999, China had 300,000 has planted to GM crops, In contrast, only limited field trials of GM crops had been conducted in Indonesia, Thailand, Malaysia, India, Japan, and the Philippines. In fact, in the Philippines, we just completed the first 500 sq m field trial of the Bt corn.

However, there are also growing concerns about the risks of this new technology. In Europe, there is a lively, and at times, heated debates as to the benefits of the application of biotechnology in food and agriculture. I attended very recently a memorial lecture in honor of Dr. Chandler at Cornell. Even at Cornell, there are many active groups against the proliferation or the planting of the GM crops. Consumers are demanding food labeling, so they will have information as to the kind of food that they take, further fueling the speculation that biotechnology-derived foods may unexpectedly cause allergens and other ill-effects to unsuspecting food consumers.

As much as we would like to explore and maximize the benefits that can be derived from agri-biotech, we also have to listen to the valid concerns being raised against biotechnology. While we would do everything we could to increase our agricultural productivity and efficiency, we would not do this without being assured of the safety of the technologies and their sustainability to protect and conserve our rich agricultural and natural resource-base in the region.

The needed balancing between the promises and concerns regarding GM products is the very reason for the gathering of minds that we are having within the next

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[1] Opening Remarks, Regional Conference on Agricultural Biotechnology

[2] Director, SEAMEO SEARCA

two days. SEAMEO SEARCA, as the lead regional and international governmental institution for academic education and research, has the mission to enhance sustainable agriculture in the region through quality research and education in all areas relevant to agriculture, from science and technology to policy and institutional concerns. One of the 14 regional centers under SEAMEO is SEARCA and earlier my director explained to you the mechanics by which we operate. With the co-sponsorship of the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Seed Association (APSA), we convened this conference workshop focusing on crop biotechnology. We hope that at the end of our meeting, we can come up with some answers to questions such as:

1) How can biotechnology have an impact on food production of developing countries?

2) Is biotechnology compatible with sustainable agriculture?

3) What is the enabling environment for the effective development and application of agricultural biotechnology in the region?

By the way, I consider this joint activity a rekindling of our relationship with FAO. This is the first activity during my term as SEARCA Director and during the term of R.B. Singh as the Assistant Director General of FAO to work together on this very important activity. And this is my second joint activity with APSA. Sometime in May, we had an excellent activity on Project LINK, which we co-sponsored also with the Asia Vegetable Research and Development Center office here in Bangkok. In this meeting, we have with us top level practitioners, administrators, policymakers and leading experts in various aspects of agricultural biotechnology from all over the world. Together we will discuss global and regional trends in agri-biotech R&D, biosafety and food safety, intellectual property rights, risk assessment and communication, public information and education, and the socioeconomic aspects of agricultural biotechnology. Let me close these remarks with a quotation from Dr. Norman Borlaug, 1970 Nobel Prize Laureate, and Father of the Green Revolution, who said in 1997:

"I am now convinced that what began as a biotechnology bandwagon some 15 years ago has developed some invaluable new scientific methodologies and products which need active financial and organizational support to bring them to fruition in food and fiber production systems."

We recognize that a lot more need to be done to successfully bring these new technologies to the farmers and consumers of the developing countries especially in this region, apply them, and reap benefits from them. We truly hope this conference will be able to significantly contribute toward this end.

MOBILIZING BIOTECHNOLOGY FOR DEVELOPING COUNTRY AGRICULTURE

Emil Q. Javier[1]

The paper briefly described modern agricultural biotechnology and its components: genomics, bioinformatics, transformation, molecular breeding, diagnostics, and vaccine technology. Among the components applied in agriculture, development of genetically modified (GM) crops with specific desirable traits is the most commercially advanced with 39.9 million hectares grown to such GM crops worldwide and sales estimated at US$2.1 – 2.3 billion in 1999. Based on the premise that modern biotechnology could be a powerful tool for improving productivity and sustainability of agriculture in developing countries, five major concerns and issues were discussed and recommended to be the foci for collective regional action. These are 1) managing risks associated with biotechnology; 2) promoting public sector investment in agricultural research; 3) private sector investments in biotechnolo9gy for agriculture in developing countries; 4) official development assistance (ODA) for agricultural biotechnology; and 5) managing intellectual property.

Introduction

Agriculture constitutes a very significant part of the economies of the countries in Southeast Asia and provides the livelihood of the greatest number of people. However, although the region as a whole has made significant progress in recent years in increasing average per capita incomes, rural communities, for the most part, remain poor (Lipton 1999). Thus, any means, any intervention that will further lift productivity in agriculture will be a positive step toward alleviating poverty.

Moreover, there is increasing realization that man, through his mere presence and increasing numbers, is putting intolerable pressure on the environment and the natural resources he is exploiting to meet his needs. The major sources of environment pressure are the rural industries of farming, fishing, and forestry. Thus, similarly, any technology that will save land, water, and forest resources, any technology which will diminish the need for environment-polluting farm inputs, will help conserve the environment and should be most welcome.

One such means, which has the potential to contribute to agricultural productivity and sustainability, and at the same time dramatically alter the course of agriculture, is modern biotechnology.

Biotechnology is defined as the use of biological processes for the development of products such as foods, enzymes, drugs, and vaccines. Biotechnology is the new label for a process that humans have used for thousands of years to ferment foods such as beer, wine, bread, and cheese (Vogt and Parish 1999).

Modern biotechnology narrowly refers to biological applications based on the new science of molecular biology. With the new knowledge in molecular sciences, it is now possible to identify specific genes; understand their function in the whole organism;

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[1] Chair, Technical Advisory Committee (TAC), CGIAR and Member, National Academy of Science and Technology (NAST), Philippines.

clone, move, and transfer the genes across natural species barriers; and make the genes express their products in specific tissues at specific growth stages in the recipient organisms.

In classical or conventional plant breeding, gene transfers are limited to between varieties of the same species; occasionally, between species within the same genus; and rarely, between species belonging to different genera. Transferring novel genes between plant families, much less from bacteria to plants, were impossible. But now with modern biotechnology, these very wide genetic introgressions are possible.

In one sense, modern biotechnology is merely a continuation of the old. The essential unity of the genetics of all living organisms had been there all along. We simply discovered the secrets of what the discrete units of inheritance are made of, how they function, and how we can manipulate them with more precision compared with the random, statistical methods we have deployed in the past.

Status of Commercialization of Biotech-derived Products

Modern biotechnology consists of at least six components (Persley and Doyle 1999), namely:

- Genomics: the molecular characterization of species;
- Bioinformatics: the assembly of data from genomic analysis into accessible forms;
- Transformation: the introduction of novel genes into crops, forest, livestock, and fish species;
- Molecular breeding: identification and evaluation of desirable traits in breeding programs with the aid of molecular genetic markers;
- Diagnostics: the use of molecular characterization to provide more accurate and quicker identification of pathogens; and
- Vaccine technology: development of recombinant DNA vaccines for control of diseases.

Rapid scientific progress is being made on all these fronts. The genomic characterization of the major crop commodities are underway. The first that should be completely mapped will be rice, which has a relatively small-sized genome. A Japanese-led consortium at Tsukuba is expected to complete the rice genomic map in a couple of years. This process has been greatly facilitated by the private sector initiatives using massive computing in the characterization of the human genome. However, to be useful, these genomic maps should be accompanied by information indicating gene function (functional genomics). This will still take some time.

Marker-assisted breeding is in progress in many countries, including all the CGIAR crop centers. For example, the Asian Rice Biotechnology Network using molecular markers has succeeded in pyramiding bacterial blight resistance genes in a number of popular varieties. Many diagnostic kits have been developed to detect presence of specific races of plant pathogens. Recombinant DNA vaccine work is in progress for the control of East Coast fever in ruminants. Just to mention a few.

Among the modern biotechnology components applied in agriculture, the development of genetically modified crops with specific desirable traits (transgenic crops) has been the most commercially advanced. This has been going on for almost 20 years, although it was only in the past five years when commercial release and adoption of transgenic crops have dramatically increased. Between 1996 and 1999, the global area planted to transgenic crops increased from 1.7 million hectares to 39.9 million hectares (James 1999). Sales were estimated to have risen from $75 million in 1995 to $2.1-$2.3 billion in 1999.

The following major observations characterize this initial phase of commercialization of biotechnology-derived crop varieties:

a) Most of the early technology adopters were commercial farms in developed countries with the US and Canada accounting for 72 percent and 10 percent, respectively, of the area planted.
b) All the subject crops are crops widely grown in developed countries, i.e., soybean, corn, cotton, and canola.
c) The almost exclusive foci of trait improvement were herbicide tolerance and insect (Bt) resistance.

The above observations are pivotal to the rest of this paper because they call attention to and explain to a large extent the opposition and unease which genetically modified crops have elicited from significant sectors of society as well as highlight the challenges and opportunities for us in Southeast Asia and the rest of the developing world as far as exploiting the benefits of modern biotechnology for food and agriculture.

An essential feature of modern agricultural biotechnology is its increasing proprietary nature. Unlike the agricultural sciences in the past which have come out of publicly supported laboratories, the new biotechnologies are locked into patents, and other private intellectual property rights.

In order to recover their massive investments, the private companies must create value added for which there is effective demand – i.e., from farmers, consumers, food manufacturers and traders, among others, who are willing and have the capacity to pay. Thus, it should not come as a surprise that their initial targets are commodities grown by commercial producers in developed countries.

Among the possible target traits, crop protection against weeds and insect pests were obvious priorities in as much as commercial growers expend lots of money on herbicides and insecticides to control these pests. Moreover, these Western farmers are fully aware of the health hazard they expose themselves to and the pollution they cause in their own environments with excessive use of pesticides.

Were the initial priorities high levels of essential vitamins and minerals in food crops, public perception would have been different, although for people in Europe and the United States who have adequate nutrition, these may still not be attractive enough. It would be better if the breeding objectives were low cholesterol, low sodium, high antioxidant, and “lite” farm produce.

One of the purposes of a keynote address is to prepare the stage for accomplishing the objectives of the conference. I have decided to depart from the topic assigned to me and instead dwell on how we mobilize biotechnology for agriculture in a developing country. I have selected five concerns/issues which, in my judgment, could very well be the foci for collective regional action.

I proceed from the basic premise that modern biotechnology could be a powerful tool for improving the productivity and sustainability of agriculture in developing countries. However, as with all other innovations and changes involving complex systems, there will always be trade-offs; there will always be unintended unwanted consequences that accompany the gains. It is a matter of weighing the risks against the benefits, of avoiding or mitigating the unwanted consequences, and of intelligently deciding which aspects of change to accept and which to reject.

Managing Risks Associated with Biotechnology

We are all aware that there are strong, discordant voices against the desirability of genetically modified crops. Although there are some who absolutely reject modern science, by and large, those who have reservations do not necessarily object to modern biotechnology per se. Potential recombinant DNA vaccines against HIV, cancer, malaria and other serious human diseases are acceptable to all. The use of molecular markers to assist in plant breeding and for systematizing the management of biodiversity in plant genebanks are perceived as benign. In other words, of the six major components of modern biotechnology, opposition actually centers on the release and use of transgenic plants into which novel genes from unrelated species have been inserted.

It is useful, at this point, to recognize that the objections to the use of transgenic crops can be differentiated into two – those risks inherent to the technology and those that transcend it (Leisinger 1999).

The risks inherent to genetically modified organisms include the danger of unintentionally introducing allergens and other anti-nutrition factors in our foods; the possibility of the newly introduced genes escaping to other organisms by outcrossing thus creating superweeds: and, in the case of insect-repelling genes, the possibility of killing beneficial non-target pests. Moreover, antibiotic resistance has been used as a marker for selecting genetically modified plants. There is fear that the gene might be transferred to bacteria that cause disease in man.

In the developed countries where legislation and regulatory institutions are in place, there are elaborate steps or protocols to precisely avoid or mitigate those dangers. There are standard tests for known specific allergens and anti-nutrition factors. At the molecular level, there are now DNA sequence tests which identify gene combinations that have the potential to generate allergenic substances.

The possibility of introduced genes "escaping" in the wild through outcrossing between the genetically manipulated transgenic plants with wild relatives cannot be ruled out. Obviously, if there are no known interfertile relatives, as in the case of corn in most parts of the world, the risk is miniscule. Moreover, it depends on what genes may be "escaping" into the wild. A weedy rice plant which, by chance, acquired the novel beta carotene gene from daffodil is clearly no threat to anybody including the insects who feed on them.

And even when such outcrossings do occur, the chances that these rare hybrid plants surviving and flourishing over their competitors in the wild are extremely low unless the gene confers a selection advantage for hybrid plants possessing the new gene. However, experience to date indicate that varieties bred and selected by man for specific purposes are less weedy and generally lose their ability to compete in the wild.

The so-called superweeds that may come out of outcrossing herbicide-resistant transgenic plants with weed relatives will be superweeds only in cultivated fields as long as the specific herbicide is used. In the wild where no herbicides are sprayed, there is no reason such rare hybrid plants should outcompete other plants which do not possess the herbicide-resistance gene. In any case, there is a ready field management expedient: switch to other modes of weed control such as cultivation and use of other herbicides.

The risk of genetically modified insect-inhibiting plants affecting non-target pests is no worse than the current practice of broad-spectrum insecticides decimating both harmful and beneficial insects. In fact, on the contrary, the transgenic plants like the Bt crops tend to be more specific and discriminating.

With regard to the concern about the use of antibiotic resistance genes, the British Royal Society noted that the widespread use of antibiotics as feed additives for animals, and as over-the-counter and prescribed medicines for humans, carry a greater risk of creating antibiotic resistant bacteria than transfer of marker genes from genetically modified plants (Anon 1999). Indeed, a large number of bacteria present in the gut already carry resistance to several antibiotics, including kanamycin and ampicillin. Nevertheless, the British Royal Society considers the presence of antibiotic resistance marker genes in genetically modified crops unacceptable and encourages the development and use of alternative marker systems.

However, what is more urgent is the real possibility that insects may quickly build up resistance to the new genes rendering the utility of the improved varieties very short-lived. It is clearly in the interest of the plant breeders and the private seed companies which developed the new varieties to manage the deployment of their genetically modified resistant varieties in such a way that insect-resistance buildup is discouraged by, for example, creation of insect refuges amid fields sown to Bt crops.

These remarks were not meant to dismiss the concerns for food safety and biosafety inherent with biotech-derived foods and organisms. It is the obligation of the technology innovators, the producers, and the government to assure the public of the safety of the novel food and drugs they offer as well as their benign effect on the environment. However, hazard identification and risk assessment ought to be scientifically based and on a case-by-case basis i.e., regulating the end product rather than the process (Juma and Gupta 1999). Risk assessment should consider the characteristics of the organism being assessed, intended use of the organism, and features of the recipient environment.

It is very important that we set in place the appropriate legislation and regulatory mechanisms to govern biotechnology not only as a matter of good science and sound governance but also to forestall and anticipate the debate on biotech products raging in the West.

On the other hand, technology-transcending risks as opposed to technology-inherent risks, emanate from the political and social context in which a technology is used (Leisinger 1999). Included under this category are differential access to the new technology leading to a further widening of the economic gap between developed countries (technology users) versus the developing countries (non-users); further disparity in income between rich and poor farmers within the same communities, and the further loss of biodiversity should the new transgenic varieties become too successful and displace other varieties.

However, in the case of technology-transcending risks relating to access, the solution is not to ban the use of the new technology by everybody, but by developing technologies tailor-made for the needs of the poor and by instituting measures so that the poor producers will likewise have ready, affordable access to the new technology.

As Leisinger (1999) contends, technology-transcending risks mostly materialize because a gap opens between human scientific technical ability and human willingness to shoulder moral and political responsibility.

This differentiation between technology-inherent risks and technology-transcending risks is very germane to our conference today because we have to aggressively address both concerns if we were to succeed in exploiting the potential of modern biotechnology to advance our respective national purposes now, and not much later.

Promoting Public Sector Investment in Agricultural Research

Although our topic in this conference is narrowly agricultural biotechnology, the broader issue of declining public support for agricultural research in general ought to be of greater concern to all of us. In both developed and developing countries, agriculture as a sector is increasingly being marginalized and its share of public expenditure progressively declining. Agricultural support services, including research, are being phased out with the expectation that the private sector will take over the slack.

This is not a very serious problem in the developed economies because they have well-developed agriculture-based private sectors with strong research base. In fact, in the US and Europe private sector investments in biotechnology already dwarf public sector investments.

But this is not the case in most developing countries where private sector research in agriculture is practically non-existent. Without the public research institutions, the small farmers are really left on their own.

For us in Southeast Asia, there could very well be a momentary surge of public support for agricultural biotechnology but this will not do us much good in the long run without a sustained effort for complimentary agricultural research in conventional plant breeding, integrated pest management, integrated natural resources management, postharvest handling and processing, in rural social sciences and rural policy research.

So even as we fight for our share of public funds for agricultural biotechnology, we have to keep pressing as well for support for the rest of the agricultural education and research system.

Private Sector Investments in Biotechnology for Agriculture in a Developing Country

Since modern biotechnology in all of its dimensions is still at its infancy, large investments are still needed to push the frontiers of knowledge. Given the urgency and the prospects for recovering investments, biotechnology for the understanding and control of debilitating human diseases and genetic disorders naturally attract the greater bulk of global investments, both public and private. Nevertheless, agricultural biotechnology has been receiving a healthy share of private sector investments.

However, with the effective lobby against genetically modified crops in Europe, the new life science companies are retreating from their commitments to agricultural biotechnology. There is a real danger that private sector investments in agricultural biotechnology will slow down.

Moreover, as shown by the data on release and adoption of transgenic crops, the private sector investments in agriculture had been exclusively on commodities and traits for commercial growers in developed countries.

Thus, the challenge is two-fold: 1) encouraging global private sector investment in agricultural biotechnology in general, and 2) diverting some of those investments to address commodities and traits of relevance to the needs of developing countries.

We should therefore, as a first measure, discard the notion that the private sector companies investing in agricultural biotechnology are enemies. All of us workers in agricultural science are allies and ought to work together to arrest the marginalization of agriculture in the priorities of the governments both in developed and developing countries.

Intellectual priority rights are necessary evils. Foreign and domestic companies will hesitate to invest in research and development without guarantee of recognition and protection of their IPR. We have to lobby to set into place the appropriate legislation on intellectual property rights in our respective countries. We must comply with the minimum requirements set by the international conventions but must, in doing so, safeguard the interests of the farmers, particularly the small subsistence farmers and local entrepreneurs.

The small unorganized subsistence farmers in developing countries are not an attractive target market for multinational biotech companies. They are dismissed as not worth the effort. However, if we disaggregate the activities private companies have to undertake to develop such markets and engage the public research agencies and the domestic private sector to take on some of these activities where they have competence, the attitude of these big biotech companies may change.

There are at least five sets of activities in the research, development, and marketing chain: basic research, strategic research, applied research, adaptive research, and marketing. The private companies have a great comparative advantage in strategic and applied research. On the other hand, national research institutions and domestic private companies have local expertise and have people deployed in the countryside and should be more effective in carrying the adaptive research and local marketing functions. Since the private seed companies will be exploiting principally the research spillovers from their major operations elsewhere, the marginal costs to them in strategic and applied research will be minimal. It should be possible to explore such co-development and similar partnership arrangements.

The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) had been brokering such partnerships between private biotech companies and some developing countries. They have a number of very successful experiences, which demonstrate that such partnerships are possible. In the joint ventures they have brokered, the developing countries typically contribute adapted germplasm and the external private sector provide the proprietary gene that enhance the product (James and Krattiger 1999). For now, the private biotech companies provide their technology for free but as the partners gain experience and confidence their relationships can mature to a more business-like basis.

ODA Support for Agricultural Biotechnology

The network of international agricultural research centers (IARCs) of the Consultative Group for International Agricultural Research (CGIAR) has been the principal source of improved germplasm and biotechnology training, information, and materials for many developing countries. The IARCs rely heavily on official development assistance (ODA) funds provided by international bodies like the World Bank, FAO, and UNDP; the regional development banks like the Asian Development Bank, as well as by the OECD countries.

For the most part, the IARCs are not engaged in basic biotechnology research. They rely on the universities, advanced research laboratories, and the private sector for their information and material requirements and specialize in applying biotechnology information and techniques to meet the agriculture needs of developing countries.

They work on the three principal cereals – rice, maize, and wheat. However, they also work on pearl millet and sorghum; pigeon pea and beans; and roots and tubers like sweet potato, cassava, and yam which poor people in developing countries eat. The IARCs working closely with their national counterparts try to increase the yields of these crops as well as improve their nutritional quality.

Their target traits include resistance to pests and diseases as well as tolerance to drought and to adverse soil and climatic conditions, which are the common problems of marginal farmers in developing countries.

The CGIAR centers' budget for biotechnology is less than 10 percent of the total $340 million CG system research budget. They can use more if additional official development assistance (ODA) support were forthcoming. It will be a terrible loss to the developing countries should the IARCs be phased out for lack of political support.

Unfortunately, there are disturbing signs of flagging donor interest in international public agricultural research. We in the developing countries, who have been benefiting from CGIAR research, should demonstrate our solidarity and support for the IARCs so that the co-sponsors like the World Bank, FAO, UNDP, the regional banks and the OECD countries will maintain, if not raise, their support for public international agricultural research, including biotechnology. With the anti-biotechnology lobby groups attaining ascendancy in Europe, this demonstration of political support for the research activities of the CGIAR from the developing countries will be most timely.

Managing Intellectual Property

Agricultural research managers in developing countries are accustomed to managing people, funds, facilities, and infrastructure and even the political goodwill of their respective institutions. The management of intellectual capital is a relatively recent phenomenon brought about by the massive entry of the private sector in the hitherto public domain of agricultural science. Information and genetic materials that used to be freely received or shared now must be paid for, leased, exchanged, inventoried, and protected.

Cohen (1999) identified five management tasks at the institute level which require close attention from research managers:

1) Clarifying institutional roles – legal and regulatory frameworks; institutional policies for assembling intellectual property; rights and obligations of scientists, of research partners, of recipients
2) Identifying intellectual property – inventory of intellectual property used in the institution
3) Securing ownership – disclosure of intellectual property generated by researchers; registration of intellectual property rights
4) Managing intellectual property – liaison with suppliers, enforcement of IPR
5) Technology transfer and marketing – liaison with technology users, licenses and material transfer agreements, remuneration strategy

Managing the institution's intellectual property portfolio is a complex and demanding challenge for which most research managers are not prepared and properly trained. However, the appropriate institutional mechanisms need to be installed, staff need to be made aware of their obligations and rights under the new regime of intellectual ownership and the management must be able to deal with their various publics to gain access to other institutions' technology and to be compensated for their own. This is one subject area where our developing country agricultural research institutions can benefit from external assistance and a collective regional effort.

Conclusion

Modern biotechnology has great potential to contribute to agricultural productivity and sustainability. The biological processes which underpin the growth and development of crops, fish, forest trees, livestock, and microorganisms can be manipulated through their genomes. With the new science of molecular biology, it is now possible to identify specific genes; understand their functions in the whole organism; clone, move, and transfer the genes across natural species barriers; and make the genes express their products in specific tissues at specific growth stages in the recipient organisms. This new tool allows man to perform many manipulations of the factors of biological production which were impossible before. In conjunction with other conventional tools of science, many essential operations can be performed with more precision, quicker and eventually cheaper.

However, as with all other innovations and changes involving complex systems, there will always be trade-offs, there will always be unwanted consequences that come with the gains. It is a matter of weighing the risks against the benefits, of avoiding or mitigating the unwanted consequences and intelligently deciding which aspects of change to accept and which to reject.

There are risks associated with biotechnology – risks inherent to the technology and those that transcend it.

The risks inherent to biotechnology include the danger of unintentionally introducing allergens and other anti-nutrition factors in our foods, introducing and/or creating novel genes which can, in turn, create and let loose in the environment unwanted and harmful organisms.

Technology-transcending risks as opposed to technology-inherent risks emanate from the political and social context in which a technology is used. Differential access to biotechnology may engender serious economic gaps between users and non-users and further loss of diversity.

A clear distinction between these two sets of risks is important as they call for different responses.

Technology-inherent risks are susceptible to scientific analyses and technological corrections. Protocols for assessing food safety and biosafety are in place for many organisms or products. If they are not yet available, further research can be conducted.

Technology-transcended risks, on the other hand, have their roots in social, economic, and political inequalities or differences. Their solutions must, for the most part, be sought from the same realms of human activity.

The transcendent risk of unequal access to biotechnology is a very real dilemma to developing countries. Much of the new biotechnology are proprietary and are not exactly relevant to the needs of the poor in developing countries.

The challenge therefore to developing countries is how to access and mobilize biotechnology for their national purposes. In addition to acquiring the actual capacity to conduct biotechnology research and development themselves, five areas of concern were highlighted as requiring national attention and possible foci for regional cooperation, namely:

- Managing risks associated with biotechnology;
- Promoting public sector investment in agricultural research;
- Private sector investments in biotechnology for developing country agriculture;
- ODA support for agriculture biotechnology; and
- Managing intellectual property.

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Agricultural Biotechnology in Southeast Asia

Proceedings of the Regional Conference
On Agricultural Biotechnology

"Biotechnology Research and Policy: Needs and Priorities in the Context of Southeast Asia's Agricultural Objectives"

Table of Contents

Country Papers

Appendices

Regional Development in Agricultural Biotechnology: Capacity Building in the 21st Century

Sutat Sriwatanapongse[1]

The paper briefly reviewed global trends in agricultural biotechnology research and applications, including commercialized products. Two major issues were cited to affect biotechnology in agriculture, food, medicine and natural resource management: intellectual property rights and biosafety. Almost all ASEAN countries, except Indochina, have their own biosafety guidelines which are in general, based on those from developed countries such as the USA, Japan and Australia. Field testing of genetically modified (GM) crops has been done in China, Japan, Thailand, Philippines and Indonesia. However, only China has allowed commercialization of GM crops. Further, two major problems in biotechnology R & D in the region were identified: shortage of skilled manpower in biotechnology (and other areas as well) and linkages between research and commercial sectors. Capacity building has been addressed in the region through various networks including the Asia-Pacific International Molecular Biology Network (IMBN), the Asian Rice Biotechnology Network, the Asian Maize Biotechnology Network and the Papaya Biotechnology Network. It was recommended that international and regional organizations in the region help developing countries in capacity building.

Green Revolution had saved the world food crisis during the late 1960s and early 1970s. During that period, the global population was about 3.7 billion. At present, world population is approximately 7 billion and it is anticipated to reach 10 billion by 2050 (Falvey 1996). The majority of this population will be in developing, resource poor countries. The increased demand for food will therefore come from these countries. While demand for food increases, the potential for meeting that demand decreases (Altman 1995). The adverse factors are ecological and socioeconomic. The per capita availability of land and water steadily goes down, while biotic and abiotic stresses limiting crop production are increasing. It is challenging how agriculturists and policymakers could make a more rapid growth in food production to cope with the rapid increase of world population.

Food security has become an important issue in the 21st century. Modern agriculture may not be able to guarantee for food sufficiency. During the period of the Green Revolution, traditional technologies had been used together with naturally rich resources in the production of food. With natural resource deterioration, it is necessary that advanced technologies such as biotechnology should be applied in order to improve productivity. Advanced biotechnology -- genetic engineering -- allows the transfer of a desirable gene from one distant species to another. It has become an effective means of genetic transformation that could not be realized through traditional breeding. It is a way to precisely engineer an organism to perform as one wishes to increase productivity and quality of the products.

Biotechnology is, in fact, not new but has been used for centuries. It involves any technique that uses living organisms, or parts thereof, to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses. Fermentation

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[1]Director, Thailand Biodiversity Center

and plant tissue culture are probably considered as old biotechnology that has helped produce foods and alcoholic beverages. These technologies are still useful, especially with the combination of modern science such as molecular biology, biochemistry, molecular genetics, and electronics. Genes in all living organisms could be discovered through the "Genome Research" and their functions known. At present, the "Human Genome" and "Rice Genome" are considered to be the largest operation, with the involvement of many national programs. It is anticipated that many applications could be made from knowledge coming out from genome research. This includes the application in agriculture through agricultural biotechnology.

This paper will give some background of the agricultural biotechnology development in the Southeast Asian region. Capacity building to cope with a rapid technology development, together with problems and issues such as biosafety and intellectual property, will be discussed.

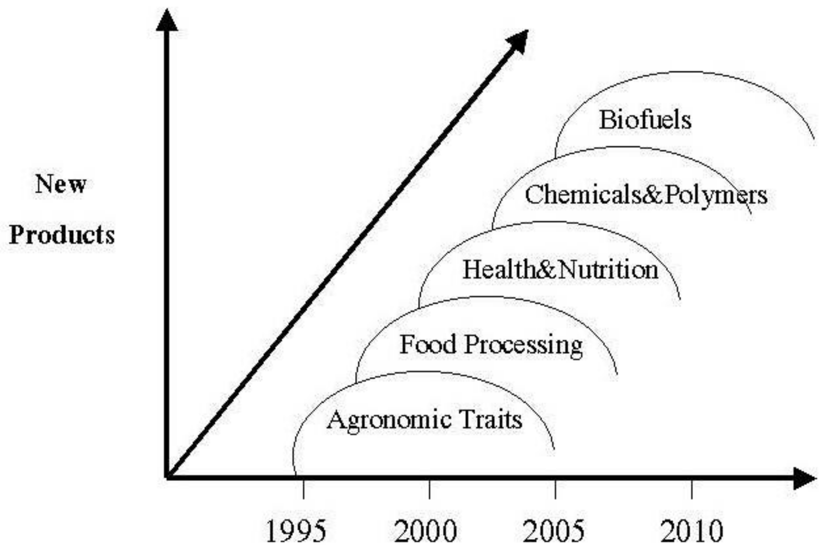
Agricultural Biotechnology

Biotechnology has been recognized as an important tool in improving a broad spectrum of industry, human health, and environment. Traditional biotechnology includes fermentation, tissue culture for plant propagation, vaccine production, bioinsecticides, and biofertilizers as well as other uses of microorganisms for various purposes. Modern or advanced biotechnology has been rapidly developed using DNA technology. It includes genotypic manipulation by using molecular aided selection and genotypic modification through genetic engineering.

Agricultural biotechnology covers broad areas of research and development leading to the improvement of microorganisms, plants and animals. Present fermentation industry uses improved strains of microorganisms, traditionally improved or genetically modified. The application in plant and animal improvement follows a similar process. DNA technology could be used in various ways, from the identification of individuals to the genotypic manipulation and modification.

Plant biotechnology promises to deliver new products and new industries (Fraley 1994). Figure 1 illustrates that many new products are expected to be developed in certain time periods. It is anticipated that biotechnology will lead to new opportunities to develop foods with different functional compositions as well as fruits and vegetables with better storage properties and flavor. We could expect to see plants as micro-factories producing some pharmaceutical products, biodegradable plastics, and biofuels. Through the application of genetic engineering technology, it could be possible to produce those target products.

Figure 1. Potential new products developed in certain periods (Fraley 1994)



Modern technologies in animal breeding represent a dramatic change that is, nuclear transfer, cloning, sexing, and transgenic biology may generate dramatic shifts in the phenotypes of animals (Powell 1995). These changes may bring new benefits to agricultural development regardless of potential problems they may pose. Recombinant DNA technology has been used in improving growth rate, meat and milk production, sanitation, feed quality, and others.

Genome Research

Advanced biotechnology allows the genetic study of life forms deep into the molecular level. At present, the US is the world leader in the Human Genome Project, which is projected to be completed in 2005 (Wilairat 1999). The International Rice Genome Sequencing Project (IRGSP) was launched in 1998 with 10 participating countries, namely: Japan, US, Canada, UK, France, Korea, China, Taiwan, India and Thailand (Vanavichit 1999). Brazil has decided to join the group in 2000 and that added up to 11 countries in the consortium. Besides rice genome, other crop species such as tomato, and animals such as shrimp, are under the early phase of genomic research. The information from genome research, when completed, could lead to the development of many valuable useful products such as pharmaceutical products, new treatments for diseases (human, plant and animal diseases), new plant varieties and animal breeds, as well as new food products.

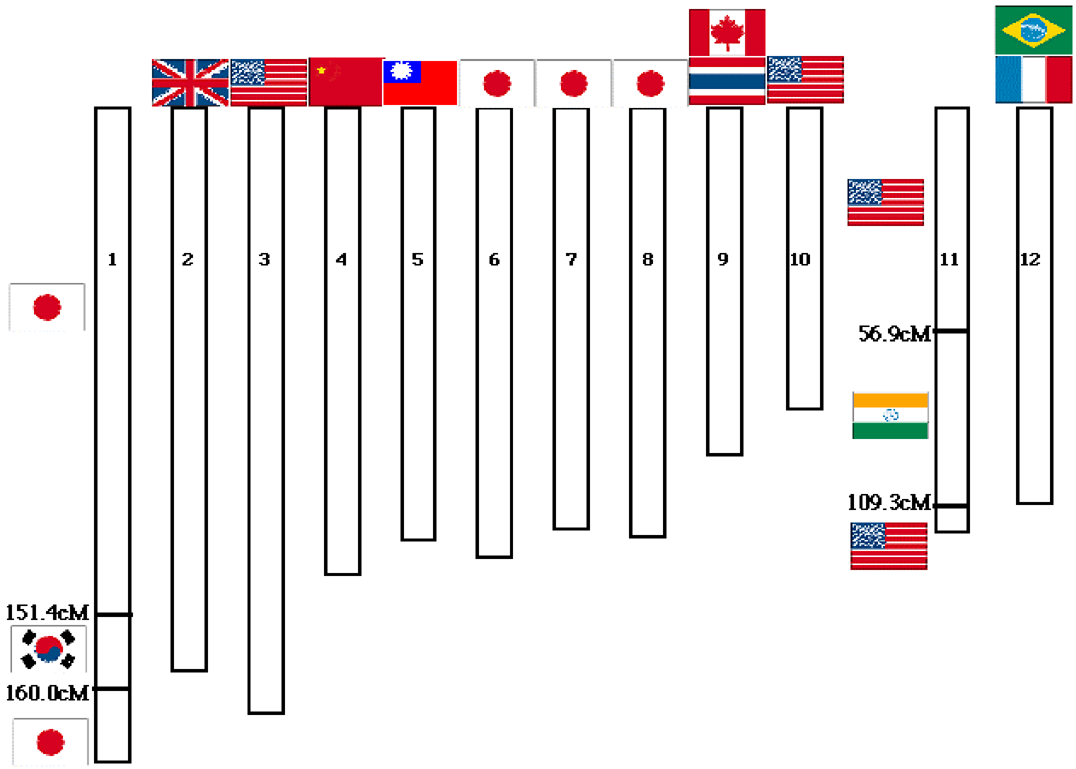


Figure 2. Rice Genome Research Consortium of 11 Participating Countries.

The Rice Genome Consortium has agreed to sequence the Japonica rice, Nipponbare. Each country has selected certain chromosome for sequencing as illustrated in Figure 2. It was also agreed that each country should contribute at least 1 kb annually (Vanavichit 1999). The Japanese Rice Genome Project (RGP) in Tsukuba has been working on genome mapping using this rice for quite some time (Sasaki 1996). Recently, Monsanto company announced that it has been engaged in rice genome sequencing for a number of years in a collaborative project with an US university. The first “working draft” of the rice genome will be delivered to the Ministry of Agriculture, Forestry and Fisheries (MAFF) of the Government of Japan on behalf of the IRGSP. Then IRGSP will make it available to its members. The sharing of the company’s data will help advance the work of the IRGSP member by four to eight years (Monsanto Press Release 4 April 2000).

Recent work indicates that the grass genomes – wheat, rye, barley, maize, sorghum, millet, and rice -- have similar genetic maps over large blocks of the chromosomes (Vanavichit 1999). These synthenic relations are important in applying knowledge from rice genome sequencing. It is anticipated that there will be many new areas for research and development that are related to crop improvement after the completion of the rice genome research.

Modern biotechnology—genetic engineering

Modern biotechnology means the application of:

a. *In vitro* nucleic acid techniques, including recombinant DNA and direct injection of nucleic acid into cells or organelles, or

b. Fusion of cells beyond the taxonomic family, that overcome natural physical reproductive or recombination barriers and that are not techniques used in traditional breeding and selection (UNEP Biosafety Protocol Official Text 23 February 2000). So modern biotechnology is, in fact, the genetic engineering technology that results in the production of "**genetically modified organisms –GMOs.**" In fact, molecular genetics could be used in two ways in plant breeding:

   i) **Molecular marker assisted selection (MAS).** Once the trait is physically identified, a molecular marker for that trait or gene could be developed and used in selection. The resulting "improved variety" will be a normal plant variety.

   ii) **Genetic engineering.** This technology involves the gene modification within the species or the gene transformation across the species, family, and genus. The resulting transgenic organisms are of the genetically modified organisms or GMOs.

Commercialization of Transgenic Crops

Between 1996 and 1999, 12 countries, 8 industrial and 4 developing, have contributed to more than twenty-fold the increase in the global area of transgenic crops (James 1999). In 1999, the area increased from 12.1 million hectares to 39.9 million hectares, an increase of 44 percent (Table 1). Seven transgenic crops were grown commercially in 12 countries in 1999, three of which were Portugal, Rumania, and Ukraine, grew transgenic crops for the first time. Table 2 shows the distribution of the seven crops and Table 3 the dominant transgenic crops in 1999.

Three crops still dominate GM plants in the field—maize, soybeans, and cotton. The trait most widely spread by the private sector is herbicide resistance (Table 3). Insect resistance via a gene to express Bt toxin is the second main trait inserted. Lipton (2000) reviews the role of genetically modified plants and stressed the importance of benefit to poor farmers. Presently available commercial varieties of GM crops mainly involve input trait technology such as insect and disease resistance and herbicide tolerance. More research and development is now emphasizing the output traits such as yield, quality, nutritional content, and special chemicals. Agronomic characteristics such as salt tolerance, drought tolerance, and other desirable plant types are under development. If these desirable traits are inserted into cultivated crops, poor farmers will benefit from this technology because of less input used, resulting in low production cost. More important is the reduction in chemical usage leading to a more sustainable agriculture.

Table 1. Global Area of Transgenic Crops in 1996, 1997, 1998 and 1999.

	Hectares (million)	**Acres (million)**
1996	1.7	4.3
1997	11.0	27.5
1998	27.8	69.5
1999	39.9	98.6

Source : Clive James, 1999.

Table 2. Global Area of Transgenic Crops in 1998&1999: By Crop (million hectares).

Crop	1998	%	1999	%	Increase	(Ratio)
Soybean	14.5	52	21.6	54	7.1	(0.5)
Corn	8.3	30	11.1	28	2.8	(0.3)
Cotton	2.5	9	3.7	9	1.2	(0.5)
Canola	2.4	9	3.4	9	1.0	(0.4)
Potato	< 0.1	<1	<0.1	<1	<0.1	(--)
Squash	0.0	0	<0.1	<1	(--)	(--)
Papaya	0.0	0	<0.1	<1	(--)	(--)
Total	**27.8**	**100**	**39.9**	**100**	**12.1**	**(0.4)**

Source : Clive James, 1999.

Table 3. Dominant Transgenic Crops, 1999.

Crop	**Million Hectares**	**% Transgenic**
Herbicide tolerant Soybean	21.6	54
Bt Maize	7.5	19
Herbicide tolerant Canola	3.5	9
Bt/Herbicide tolerant Corn	2.1	5
Herbicide tolerant Cotton	1.6	4
Herbicide tolerant Corn	1.5	4
Bt Cotton	1.3	3
Bt/Herbicide tolerant	0.8	2
Total	**39.9**	**100**

Source: Clive James, 1999.

Problems and Issues

Gene technology is an extremely powerful tool in agriculture, food medicine and natural resource management. However, its applications is one of the most controversial subject with at least two important issues: biosafety and intellectual property. It is very important to have a better understanding of these issues.

Intellectual Property Rights

Intellectual property rights (IPRs), as legal instruments, are of increasing importance in encouraging industrial development and economic growth. There have been efforts in the movement toward unified, global intellectual property rights among developed countries. At the same time, developing countries are resisting, both formally in international fora and informally through less-than-aggressive administration of their own intellectual property rights (IPR) legislation . As a result, considerable international tension and animosity exist between most developing countries and many developed countries.

At present, intellectual property issues are attracting the interest of people at all levels in Asia. Researchers are becoming more aware of the issue. They realize the importance of protecting their inventions and, at the same time, are aware of the potential consequences of using proprietary technologies. In fact, the patenting of life forms are not yet allowed in most developing countries. Few countries in Asia, Thailand included, have come up with the Plant Variety Protection (PVP) system. Thailand just completed its PVP Act and, with the parliament's approval, its implementation is under way. The key elements in the PVP Act are to have the protection of new varieties as well as the old, traditional varieties, and the wild plant species.

Biosafety

The application of biotechnology in agriculture and food has been around for a long time. However, recent developments in applying advanced biotechnology, genetic engineering, in agriculture and food production have drawn public attention on safety, or biosafety of the new biotechnologies and their products. Thus biosafety concern is quite new to many countries and is not widely known even among the academe and certain regulatory agencies. The issue of biosafety could lead to world trade conflict if some important aspects such as labelling cannot be resolved. There are at present several issues related to biotechnology and some of these are:

- health and safety concerns;
- ethical questions regarding introduction of traits from one species to another;
- the possibility of resistance developing in weeds, insects, and diseases;
- the potential for biotechnology to limit farmers' approaches to crop management; and
- the impacts on biodiversity so that a wide variety of species is maintained.

Biosafety Development in Asia

Almost all countries, except a few such as Indochina, have their own Biosafety Guidelines (Sriwatanapongse 1999a). These guidelines are relatively well harmonized because they were developed based on the biosafety guidelines from developed countries such as the US, Japan, and Australia. The United Nations Environment Program (UNEP) has been also actively involved in this by holding regional meetings. The Asian Regional Biosafety meeting was held in New Delhi, India in January 1999 where capacity building of developing countries were discussed.

In Asia, field testing of GM plants has been done in China, Japan, Thailand, the Philippines, and Indonesia, while commercialization has been made only in China (James and Krattiger 1996). In order to have a systematic field testing of GM plants, Thailand established the "Biotechnology Product Development Center" where agricultural biotechnology products will be subjected to a systematic testing up to commercialization under the highest standards of safety evaluation.

Capacity Building

Developing countries have faced similar constraints in biotechnology research and development leading to commercialization. The two major problems identified lay in the area of capabilities and linkages between the research and commercial sectors. Most countries face a shortage of skilled personnel in biotechnology as well as in other areas. In Thailand research manpower has been estimated to be only about 2 per 10,000 population compared to 2 in Indonesia, 1 in Malaysia, 20 in Australia, 26 in Korea, 23 in Taiwan, 60 in Japan and 40 in the US in the same period (UNDP Human Development Report 1997). There is a need for a critical mass of scientists to carry out research work. Another limitation is financial support with only 0.2-0.3 percent of the GNP coming from the government budget and a very small share from the private sector. During the 7th National Economic and Social Development Plan the budget for R&D was set for 0.5 percent of the GNP and 0.25 percent should come from the private sector. Other developing countries in the region have more or less the same level of financial situation.

Capacity building in biotechnology in Asia-Pacific has been assessed (Sasson 1993, Tzotzos and Skryabin 2000, Sriwatanapongse 1999). Almost all countries in this region have prepared to cope with a rapid development in biotechnology. Each country has come up with its infrastructure and human resource development as well as reasonable financial support. Capacity building has been made also through various networking, few of which will be discussed.

IMBN--International Molecular Biology Network

The Asia-Pacific International Molecular Biology Network (IMBN) was established in 1997 on the premise that molecular biology and biotechnology can contribute greatly to the benefit of mankind (Yuthavong 1999). The Network intends to facilitate development in molecular biology and biotechnology through cooperation and collaboration with various organizations. The Network shall have the following program areas:

- To encourage scientists and supporting institutes to conduct research and to provide training, educational, and skills enhancement opportunities in molecular biology and genetic engineering;
- To help coordinate the conduct of research and development activities in laboratories designated by supporting institutions as Asia-Pacific IMBN laboratories (IMBL);
- To cooperate with industry to identify areas of common interest for promoting the work of scientists and institutions working with the Network.

ARBN – Asian Rice Biotechnology Network

It has been recognized by rice-growing countries in Asia that biotechnology could provide powerful new tools for rice improvement. Universities and rice research institutes across the region are receiving funding to improve their capacity and capabilities that will enable them to conduct basic and applied research in this field. The International Rice Research Institute (IRRI) in Los Baños, Laguna, Philippines shares this enthusiasm for rice biotechnology. Since circa 1988, it has devoted about $2 million annually to research programs in tissue culture; wide hybridization; genetic engineering; DNA marker technology; and DNA fingerprinting of pests, diseases, and rice germplasm. The ARBN was initiated by IRRI in 1993 to provide a vehicle for collaborative research in these areas with universities and rice research institutes of the national agricultural research systems (NARS) of Asia.

The objectives of ARBN are:

- To promote manpower and infrastructure development for biotechnology at selected NARS institutes through joint research activities and training coordinated by IRRI, and

- To generate biotechnology tools and products for use by NARS through research and infrastructure development at IRRI.

DNA marker technology and genetic engineering are key innovations that would lead to the improvement of rice research and development. ARBN has been set up to provide a comprehensive mechanism for NARS and IRRI to work together in these two important areas.

ARBN was established with funds provided by the Asian Development Bangk (ADB) and the German Government's Bundesministerium fur Technische Zusammenarbeit (BMZ). ADB prefers to support research and infrastructure development at NARS with additional funding for training and shuttle research by NARS scientists at IRRI. BMZ has been supporting research and development at IRRI in developing biotechnological products that will be of direct use to NARS.

There are three types of membership:

- Full member: China , Indonesia, Pakistan , Philippines and Thailand
- Associate member : Vietnam, Bangladesh and Sri Lanka
- Supporting member : Japan and Germany

The ARBN Steering Committee (SC) assists IRRI in guiding the work. SC consists of five senior biotechnologists from member countries and one from IRRI (Deputy Director General for Research). A chairperson is elected among representatives of member countries who take turns every two years. One of the IRRI ARBN staff acts as its Coordinator. There are 7-8 resource persons from supporting countries and donors joining the SC meeting held annually. The task is to review progress and approve workplans, to discuss general operational matters, and to make decisions concerning strategy and funding. The ARBN coordinator manages the day-to-day work with responsibility in maintaining strong links among stakeholders in the Network (donors, steering committee, and NARS and IRRI scientists).

There is a diversity of collaborative mechanisms under ARBN. Some ARBN activities are conducted at NARS principally by NARS staff, and some are conducted at IRRI by IRRI staff. These research activities are supported by training activities at IRRI and in-country. The ARBN Training and Shuttle Research Laboratories accommodates 10-15 trainees and is located within the Biotechnology User Laboratories at IRRI, giving NARS scientists the opportunity to learn a wide range of techniques and use instruments that may not be available at their own institutes. In addition, ARBN enables NARS scientists to conduct research activities in collaboration with IRRI scientists at IRRI and in-country-the so-called **"Shuttle Research."**

AMBIONET --Asian Maize Biotechnology Network

CIMMYT (International Maize and Wheat Improvement Center) established the AMBIONET with similar objectives as the IRRI ARBN. Experience shows that, through training and region-wide collaboration, national programs can achieve the critical mass of scientific human capital needed to sustain effective agricultural research. The network functions through collaborative research and a range of training and information sharing activities. AMBIONET has been in operation since April 1998 with financial support from the Asian Development Bank (ADB).

General Goals of AMBIONET are:

- Increase the scientific capacity of the region's maize biotechnology Programs so as to ensure higher, more stable, and more sustainable maize productivity for farmers in Asia, and thereby help meet the region's rapidly growing demand for maize.
- Develop sustainable, environment-friendly and natural resource-conserving maize production systems.

General Objectives:

- Empowering national programs to effectively use modern biotechnology for maize improvement.
- Strengthening the ability of national programs to identify and overcome the key production constraints faced by maize farmers in the region.
- Generating and distributing improved maize cultivars, and implementing improved crop management strategies, in collaboration with existing national program personnel, and by using existing facilities and other resources more effectively, avoiding duplication of effort.
- Ensuring the long-term sustainability of integrated maize and biotechnology research programs in participating countries.

Membership and organization are:

- Member countries are China, India, Indonesia, the Philippines, and Thailand.
- The Steering Committee consists of a representative from each member country and one of them is elected as the chair. The committee provides guidance on the programs and activities of the network and meet once a year.
- CIMMYT has appointed one staff as the Network Activity Director and one as a coordinator. Both of them are in the Steering Committee.

AMBIONET emphasizes the development of molecular markers for specific traits and use them in selection of plants – the so-called "MAS or molecular marker aided selection." The resulting variety from this technique of improvement will be the same as those developed using traditional breeding. However, genetic engineering that will lead to the production of transgenic plant varieties will be carried out at a later stage.

Papaya Biotechnology Network of the Southeast Asia

ISAAA (International Service for the Acquisition of Agri-Biotech Application) has supported the establishment of this network in 1998. The objectives are similar to those of ARBN and AMBIONET in emphasizing the capacity and capability building among member countries. It may have only one distinct feature in terms of greater involvement of private sector, forming a so-called "**partnership arrangement**". More emphasis has been placed on dealing with biosafety and IPR issues.

Member countries are Malaysia, Indonesia, the Philippines, Thailand, and Vietnam. ISAAA has been playing a key role in technology transfer with the following objectives (James 1999):

- To facilitate the transfer and adoption of proprietary agri-biotechnology applications to increase the productivity of food and feed in Asia, within the context of sound and sustainable strategy.

- To build national capacity in agri-biotechnology in member countries and facilitate its sharing within Asia through networking.
- Build institutional capacity in regulatory oversight that will ensure the safe testing and adoption of biotechnology products and to address the policy issues of biosafety, food safety, biodiversity, and intellectual property rights related to plant genetic resources.
- To foster a significant effort in human resource development through product-specific training that will ensure the long-term sustainability of activities.

Papaya networking has been used as a pilot project in partnership arrangement. ISAAA has played a role in negotiating with private companies who own needed proprietary technologies. In this case there are two: the delayed ripening gene of Zeneca and PRSV (papaya ringspot virus) resistance gene of Monsanto.

The principles in the arrangement of the Network are:

- The company would give the member country a license-free use of technology.
- The technology could be used only for papaya transformation.
- Commercialization of products could be made only within the country and among member countries.

Future Development

In reviewing the capacity and capability of developing countries in technological development, it is quite clear that the chance to catch up with developed countries is slim. The lack of human and financial resources coupled with poor infrastructure and research environment have caused a great delay in development. At present, it is not possible for a research team in developing countries to compete with researchers in developed countries in technology development. It may take a long while to be able to do so. Therefore, careful strategies should be made in each country. The following suggestions could be made:

1. Building up public education and awareness. It is important to convince the government, public and private agencies, including all stakeholders, to believe that biotechnology is a key in the country's development.
2. Establish a national policy on biotechnology. This will allow for a clear direction for implementation.
3. Establish an infrastructure for a more effective implementation. It may be necessary to improve the present system of working through the reorganization of the government agencies.
4. Encourage partnership arrangement. With scarce resources partnership arrangement through networking with other agencies in the country and outside, as well as with the private sector is an ideal approach.

At present, there are many international and regional organizations that may help developing countries in capacity building. For example, UN agencies, CGIAR Centers

(IRRI, CIMMYT, etc.), ISAAA and SEAMEO SEARCA are among those potential contributors.

Concluding Remarks

Biotechnology – one of many tools of agricultural research and development -- could contribute to food security by helping in the promotion of sustainable agriculture centered on smallholder farmers in developing countries (Serageldin 1999). Agricultural biotechnology, especially genetic engineering, will play an important role in improving agricultural productivity, food, fiber, pharmaceutical, and other industrial products. At the same time, it has been under debate with opposing factions making strong claims of promise and peril. The concerns on biosafety as well as on intellectual property cannot be ignored. Effective regulatory mechanisms and safeguards need to be universal so that the impact of agricultural biotechnology is both productive and benign.

There has been widespread public unease about biotech products. In Europe consumers demand to have choice to eat genetically modified foods or not. In the US, foods derived from GMOs seem to be acceptable to consumers. In fact, the genetic modification of plants does not differ to such an extent from conventional plant breeding. Foods derived from these plants are substantially equivalent to those developed by traditional means. The development will make a substantial contribution to food security and truly benefits the poor. There is a moral imperative to make GM crops readily available to developing countries that want them to help combat world hunger and poverty.

There may be plenty of food at present but not for everybody. An excerpt cited by Dr. C.S. Prakash 1999 said, **"A man who has food has several problems. A man without food has only one problem."** As former US President John F. Kennedy said, "We should not let our fears hold us back from pursuing our hopes." So let us continue to move forward thoughtfully with biotechnology in agriculture, with appropriate measures (Glickman 1999).

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Biotechnology, Biodiversity, and Sustainable Agriculture: A Contradiction?

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This paper describes (1) the status of the use of biotechnology for conservation and utilization of biodiversity and interaction among them, (2) the status of use of biotechnology for sustainable agriculture, (3) how real are the contradictions among biotechnology, biodiversity and sustainable agriculture , (4) issues and efforts in resolving the concerns and contradictions, and (5) the way ahead. The author cited that it is not the science of biotechnology which is a subject of controversy, but the mode and nature of its applications, through techniques and technologies which could stir controversies. Biotechnology contributes to sustainable agriculture by reducing dependence on agro-chemicals, particularly pesticides, through the deployment of genes conferring resistance or tolerance to biotic and abiotic stresses. Discussing some concerns about risks posed by some aspects of biotechnology, the author stressed that the contradictions and risks surrounding the development and applications of biotechnology should be resolved scientifically and transparently for which individual countries should have the necessary research, technology assessment, impact monitoring, technology refinement, and adjustment capacities.

Introduction

The Convention on Biological Diversity (CBD) defined biotechnology as "any technology application that uses biological systems, living organisms, or derivatives there of, to make or modify products or processes for specific use." In a broad sense, the definition covers many of the tools and techniques, which have been commonly used in agriculture and food production, processing, and utilization. In a narrow sense, however, it encompasses DNA techniques, molecular biology, and reproductive technological applications dealing primarily with gene splicing and recombination, and genomics. In the present context, the narrow sense definition of biotechnology has been considered.

Biotechnology is already underpinning the sustainable development of agriculture, forestry, and fisheries, as well as the food and other primary product- related industries. It has tremendous potential for impacting global food security, human and animal health, environmental health, and overall livelihood of mankind (Serageldin 1999).

However, as in the case of any complex technology impacting wide range of processes and developments, the gains from modern biotechnology are accompanied with certain negative effects and concerns. The nature and extent of the positive and negative impacts will depend on the choice of the technique, place and mode of application of the technique, ultimate use of the product, concerned policies and regulatory measures, including risk assessment and management ability, and finally on the need, priority, aspiration and capacity of individual countries. What is applicable for

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commercial commodities in USA, Europe, and Japan may not be true for food-deficit low-income and other developing countries. We must know whose priorities ad agenda are we pursuing.

Science is always truth seeking, beautiful, and caring. The science of biotechnology is no exception. Molecular biology researches have beautifully been disentangling the thread of life which are being carefully rearranged to serve the humanity by thwarting diseases, poverty, and hunger. It is the application part of the science which, at times, generates contradictions, and not the science *per se*.

Modern biotechnology includes the following interdependent components: genomics, bioinformatics, transformation, molecular breeding, diagnostics, and vaccine technology. While there is general appreciation of the potential and impact of each of the components, controversies generally surround the transformation component resulting in Genetically Modified Organisms (GMOs), which may pose certain risks inherent to the technology. Other contradictions, socioeconomic in nature, are technology-transcending (Leisinger 2000). **Therefore, it is not the science of biotechnology which is a subject of controversy, but it is the mode and nature of its application, through techniques and technologies, which could stir contradictions.**

Biotechnology, especially as it deals with living organisms, with its veritable manifestations, has been a subject of extensive public debate. As regards biotechnology in relation to biodiversity and sustainable agriculture, the three are complementary, synergistic and interdependent, and not contradictory to each other.

Biodiversity is fundamental to both biotechnology and sustainable agriculture. Judicious, rational, and science- and need-based exploitation of genetic resources through biotechnological techniques should lead to sustainable agriculture. The controversy arises only when non-scientific, hasty, profit-motivated, inhuman and unethical applications of biotechnology, and use of biodiversity are contemplated. Scares like 'terminator gene' and the 'negative' application of gene use restriction technologies (GURTs) are seen as moves toward monopolistic control of the thread of life by a few global companies.

It has to be pointed out that the issues of food safety and biosafety could be matters of real contradiction. Horizontal gene transfer through genetic engineering is a possibility, posing threat to biodiversity and sustainability. However, with the scientific assessment of the risk and adoption of preventive and corrective measures, the risks (contradictions) could be avoided or at least minimized. With the overwhelming evidence of high synteny among genomes of highly diverse organisms, such as flies and mammals, the risk from horizontal gene transfer gets diluted. As new results and understandings build up, which is happening exponentially, the risks and contradictions must be assessed critically and continually on a case-to-case basis.

This paper briefly describes 1) the status of the use of biotechnology for conservation and use of biodiversity and interaction among them; 2) the status of use of biotechnology for sustainable agriculture; 3) how real are the contradictions among biotechnology, biodiversity, and sustainable agriculture; 4) issues and efforts in resolving the concerns and contradictions; and 5) the way ahead.

Biotechnology and Genetic Resources

The genetic resources (and the full spectrum of genetic diversity contained in them) of plants, animals, and microbes constitute the raw material for all biotechnology–based research, technology development, and creation of new products. The molecular tools of biotechnology have accelerated precision breeding by identifying, isolating, cloning, and transferring desired genes from one species to another, from microbe to man, rendering the concept of Mendelian population as an obsolete concept. All the processes of genetic resources, namely: collection, conservation, evaluation, and utilization have been eminently impacted by biotechnology.

DNA libraries are a major supplement to germplasm conservation, let alone various *in vitro* conserved materials. *In vitro* conservation of plant species, which are asexually propagated or are infertile or produce recalcitrant seeds, is a common and important approach. Cryopreservation of semen, embryos, and even somatic cloning have greatly strengthened traditional conservation strategies in animals.

As regards evaluation, detecting single nucleotide polymorphism, identifying functions of specific genes and assigning functions to otherwise unknown genes is the ultimate in this field. Regarding germplasm use, besides distant hybridization, the production of transgenics (Table 1) and marker-aided selections have greatly enhanced the pace and precision of breeding activities. Today, nearly 40 million hectares are planted to transgenics, 33 million hectares of which fall in North America.

Table 1. Transgenic crops – the traits modified and their use

Crops	Genetic Modification	Purpose
Tomatoes, peas, peppers, Tropical fruits, broccoli, Raspberries, melons	Controlled ripening	Allows shipping of vine ripened tomatoes; improves shelf life, quality
Tomatoes, potatoes, corn, rice, lettuce, coffee, cabbage family, apples	Insect resistance	Reduces insecticide use and crop loss
Peppers, tomatoes, cucumbers	Fungal resistance	Reduces fungicide use and crop loss
Potatoes, tomatoes, cantaloupe, squash, cucumbers, corn, oilseed rape (canola), soybeans, grapes	Viral resistance	Reduces diseases caused by plant viruses and, since insects carry viruses, reduces use of insecticides and crop loss
Soybeans, tomatoes, corn, cotton, oilseed rape (canola), wheat	Herbicide tolerance	Improves weed control
Corn, sunflower, soybeans, rice	Improved nutrition	Increases amount of essential amino acids, vitamins or other nutrients in the host plants
Oilseed rape (canola), peanuts	Heat stability	Improves processing quality; permits new food uses for healthier oils

Source: Food Marketing Institute, The Hale Group/Decision Resources, Inc., Food Processing and Biotechnology Magazines, 2000.

Genomics - the science of deciphering the structure and function of a genome in totality - has emerged as the single most powerful discipline for detailed analysis of organization, expression, and interaction of an organism at the genome level. The structural (nucleotide sequences) and functional genomics have greatly expanded scientific understanding of biodiversity. In the year 2000, 141 projects of sequencing of a number of microbes, plants, and animals are underway and several of these are expected to be completed by the year 2003. The complete sequence of *Arabidopsis thaliana*, yeast, nematode, and fruitfly are already known and are helping gene transfer and understanding of evolution and gene functions in a big way. The recent declarations on the "working drafts" of the full genomes of rice (by Monsanto) and of human (by the Human Genome Project and Celera) are landmarks in the understanding of biodiversity and its use. The "working draft" of the rice genome will provide the data to the International Rice Genome Sequencing Project (IRGSP), enabling it to complete the genome sooner and at a lower cost.

Genomic analyses have revealed the conservation of gene sequences across life forms. The high synteny of rice genome with that of corn, wheat, other graminaceous plants, and also with other plants opens unlimited opportunities for developing products and technologies, not only in rice but also in other crops. The development in rice is particularly important for South, Southeast, and East Asia as the countries of these sub-regions produce and consume about 90 percent of the world's rice – the most important crop. The genomics will provide insight into the genetic control of complex processes and traits, thus paving the way for their improvement.

Biotechnology and Sustainable Agriculture

Biotechnology has been contributing to sustainable agriculture through the following ways:

- Increased resistance against biotic stresses (insect pests and diseases);
- Increased resistance against abiotic stresses (drought, cold, flooding, and problem soils);
- Bioremediation of polluted soils and biodetectors for monitoring pollution;
- Increased productivity and quality;
- Enhanced nitrogen fixation and increased nutrient uptake and use efficiency;
- Improved fermentation technology;
- Improved technologies for generating biomass-derived energy;
- Generation of high nutrient levels in nutrient-deficient staple crops such as rice.

Biotechnology contributes to sustainable agriculture by reducing the dependence on agro-chemicals, particularly pesticides, through the deployment of genes conferring tolerance or resistance to biotic and abiotic stresses. Carefully selected genes from related or unrelated genetic resources are integrated in otherwise desirable genotypes. Systematic pyramiding of genes allows integration of desirable genes in one genotype for different traits, such as tolerance to stresses, productivity, and nutritional quality.

Technology, including new varieties and breeds, is an essential element of sustainable agriculture. However, it is not the only element of sustainable agriculture.

Non-technological aspects such as governmental policy and will, institutional and infrastructural support, technology sharing and transfer mechanisms, and peoples attitude and awareness are equally, if not more important, in providing the needed conditions for absorption and successful exploitation of the technology toward sustainable agriculture.

Contradictions and Suggested Solutions

There are concerns about risks posed by some aspects of biotechnology. In the context of biodiversity and sustainable agriculture, the technology-inherent concerns are: 1) depletion of biodiversity and poor access to tailored genetic resources, 2) adverse environmental effect, and 3) negative effects on human health. The technology-transcending concern of widening of inequity and poor access to the new and emerging technologies and products on part of developing countries and resource-poor people and the majority of small farmers is a major contradiction.

It is feared that a handful of selected GMOs may replace diverse traditional cultures, causing increased genetic vulnerability. This concern is not different from the one caused by the Green Revolution varieties which had displaced indigenous varieties. In fact, biotechnology could be used for increasing biodiversity primarily through the channeling of genes from wild and weedy relatives into cultivated forms. A GMO developed for a specific purpose could fit a new niche. Thus, it will not only provide an ecological diversification but also a better option for management of risks.

Studies, however, are needed to study the impact of release of new improved genotypes in open populations on the gene and genotype frequency in the long term. There are good prospects of development of single-line (apomictic) hybrid varieties through the use of biotechnology. Besides socioeconomic implications (farmers can save seed for replanting of the hybrid), large-scale planting of apomictic hybrids can cause genetic erosion and enhance genetic vulnerability.

Horizontal gene transfer to unwanted sources, leading, for example, to the development of more aggressive weeds or wild relatives with increased resistance to environmental stresses or diseases would cause both genetic erosion and ecological imbalance. The extreme case of GM Bt corn pollen having lethal effects on the larvae of monarch butterflies if it lands on milkweed, the plant upon which they feed, had received wide attention. The loss of fish diversity associated with the escape of cultured transgenic fish and its mating with its wild counterpart appears to be a real threat. But, efficacies of such studies need to be ascertained more realistically before reaching definite conclusions. Multidisciplinary studies, involving genetics, agronomy, soil, microbiology, entomology, pathology, virology, among others, are needed to establish benchmark data and for continuous monitoring of the impact of such releases. Some caution that in the risk assessment process the “bar” should not be higher for genetically improved plants, and the protocols must cover all plants regardless of the process (Cook 2000).

Biotechnology and its application must always avoid accentuation of poverty and socioeconomic inequalities as these are strong cause for environmental degradation, political instability, and social unrests, which lead to greater unsustainability. The current trend of biotechnology development has generally been pro-rich as most of the biotechnological research and its application is in the hands of private sectors of developed countries, thus widening the gap between the rich and the poor. This trend is certainly not sustainable. This contradiction can be resolved if the pro-poor features of biotechnology are promoted. The public sector in developing countries must have the responsibility and capacity for the promotion of pro-poor features of modern biotechnology.

Some of the contradictions have arisen due to biotechnology garnering unduly high proportions of national resources for research and technology development at the cost of some of the conventional but vital programmes. Biotechnology must be seen only as an important tool to produce new products and services, which hitherto were generally considered difficult, if not impossible, in addressing challenges of food security and poverty alleviation. Biotechnology must not be seen as a panacea in itself, but only as an important and unique component integrated with overall national research and development infrastructures, institutions, policies, and programs.

The contradictions and risks surrounding the development and application of biotechnology should be resolved scientifically and transparently for which individual countries should have the necessary research, technology assessment, impact monitoring, technology refinement, and adjustment capacities.

Issues and Resolves

Biosafety and Risk Management

Biosafety means the safe and environmentally sustainable use of all biological products and applications for human health, biodiversity and environmental sustainability in support of improved global food security and livelihood. It involves assessing and monitoring the effects of possible gene flow, competitiveness, and the effects on other organisms as well as possible destructive effects of the products on the health of humans and animals. Biosafety policies and measures would thus have serious implications for the use of biotechnology for sustainable agriculture, food security, and biodiversity. For this purpose, each country, developed and developing, must have adequate and effective biosafety rules, regulations and legislations, capacity for detailed risk assessment and management, and mechanisms and instruments for monitoring the use and compliance of biosafety measures.

Introduction or import of GMOs and other genetically engineered products either through private or public sector channels should adequately be covered under legislation and handled with great care because of the threat of introducing completely new organism or genetic material. With the increasing focus on international transfers of GMOs, assessment of risk associated with the horizontal transfer of the ‘new’ gene in non-target species and development of resistance in pests and possible side effects on beneficial organisms should be undertaken most comprehensively and in a transparent manner. Given the wide implications of the biosafety concerns of biotechnology-led transformation of food and agriculture, FAO, and several other international organizations have been addressing the issue rather actively.

The signing of the CBD Biosafety Protocol in January 2000 in Canada is a landmark in the field of sustainable use of biotechnology and biodiversity management. The objective of the Protocol is to contribute to the safe transfer, handling, and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focussing on transboundary movements.

Recognizing that GMOs carry special or additional risks, the Protocol provides for their international regulation and establishes an internationally binding framework of minimum standards, which, together with national biosafety regulations, would provide the necessary biosafety net. The Precautionary Principle contained in the Protocol seeks that in the absence of scientific certainty, Parties should err on the side of caution.

In order to effectively implement the Biosafety Protocol, the following must be ensured by the concerned country: 1) full knowledge that GMOs will be crossing national boundaries and 2) capacity to assess the risks and take decisions regarding improving or banning the GMOs with or without conditions. While exporting Party is obliged to provide risk assessment, the importing Party must evaluate the risk assessment in order to make an informed, scientific decision. Therefore, the countries must have effective biosafety regulation, scientific capacity, and monitoring and enforcement capability.

The OECD, in collaboration with UNEP and UNIDO, coordinates a program of the harmonization of regulatory aspects of biotechnology and emphasizes the scientific evaluation of possible risks, which avoiding non-tariff barriers to biotech products. The Office International des Epizooties (OIE) is a global clearing house of occurrence and control of animal diseases and harmonizes regulations for trade in animals and animal products among Member Countries. The OIE Standards Commission publishes the Manual of Standards for Diagnostic Tests and Vaccines, including those genetically engineered.

Under the World Trade Organization (WTO), GMO related biosafety is covered by the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which recognizes international standards, guidelines, and recommendations, for instance, for food safety the standards and guidelines of Codex Alimentarius Commission are adhered to. The SPS Agreement is supplemented with the WTO Agreement on Technical Barriers to trade (TBT Agreement) which covers a large number of technical measures that seek to protect consumers from economic fraud and human, animal, and plant health problems not covered under the former.

As regards FAO, FAO/WHO Codex Alimentarius Commission is to protect the health of consumers and to coordinate and harmonize all international food standards and guidelines, including those related to foods derived from biotechnological applications. Scientific evidence and risk-analysis, in consort with other legitimate factors relevant to the health protection of consumers and promotion of fair practices in food trade are the basis of formulation and implementation of the food safety codes.

The *ad hoc* Intergovernmental Task Force on Foods Derived from Biotechnology was established by the Commission last year to assist in realizing the objectives of the CAC. In its First Session in Chiba, Japan, March 2000, it stressed the importance of a progressive and science-based exchange of views to reach a consensus in this area. The recent FAO/WHO Expert Consultation on Biotechnology had reaffirmed its support for technical assistance to developing countries regarding approaches to the safety assessment of foods and food components produced by genetic modification. The Task Force sought elaboration of two major texts: 1) general principles for risk analysis of foods derived from biotechnology and 2) specific guidance on the risk assessments of such foods. The Task Force also called for a list of available analytical methods to detect biotech-derived foods, a working paper on "traceability" and an information paper on "familiarity".

FAO's International Plant Protection Convention (IPPC) under its global mandate to prevent the introduction and spread of pests of plants and plant products, and promotion of their effective control, is concerned with evaluating the potential "pest" characteristics (including weediness) of GMOs. The Interim Commission on Phytosanitary Measures (ICPM) in October 1999 gave high priority to standard setting in relation to GMOs, in particular to risk assessment and testing and release of GMOs.

The draft Code of Conduct on Biotechnology, being finalized under the auspices of FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA), includes biosafety as one of its four modules. Once negotiated, these will become biosafety protocol of the Convention on Biological Diversity (CBD). Concerned regional and international fishery organizations have adopted, in principle, codes of practice on the use of introduced species and GMOs. The FAO's Code of Conduct for Responsible Fisheries includes general principles for environmental assessment, constrained use, advanced notification, and the application of the Precautionary Approach. In close collaboration with OIE, FAO has been providing assistance to developing countries to improve their capacities in the effective application of international standards and agreement of the development and exchange of genetically modified fish species.

Access to Biotechnological Inventions, Products, and Information

Intellectual Property Rights (IPRs). The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) under the World Trade Organization (WTO) requires countries to grant patents for "inventions, whether products or process, in all fields of technology provided that they are new, involve in inventive step, and are capable of industrial applications." Under this agreement, most processes and many products, barring diagnostic, therapeutic and surgical methods for humans and animals and of plants and animals other than micro-organisms, are patentable.

The Intellectual Property Right (IPR) provisions promote inventions and their disclosers. These have particularly been stimulatory to the private sector, mostly in developed countries, to invest in research and development of biotechnology and have their results patented. The global market for agricultural biotechnology products is projected to increase to US$ 20 billion by 2010 from about US$ 0.5 billion in 1996. Private investment in agricultural research in the Organization of Economic Co-operation and Development (OECD) is now in excess of US$7 billion and accounts for about half the world's entire agricultural research investment. As expected, most privately-funded biotechnology research is targeted to those commodities, areas and markets where the economic benefits are maximum. Food staples and livelihood commodities of poorer people, often referred to as orphan crops and commodities, are generally excluded from the priorities of the private sector. Further, under the existing arrangements and current trend, the developing countries are required to pay to use a patented biotechnology produce and procedure. And several of the low-income food-deficit countries which may find it difficult to pay would be deprived of the new opportunity to meet even their essential needs.

It is also disturbing to note that there is a tendency to seek broad patents of generic nature. With no provisions for exemption to researchers, this trend will be counter productive to the original belief that the property rights regimes will stimulate inventions. The patent seekers should self-impose restraints from obtaining broad-based patents. Or else, the over-regulation of biotechnology could further widen the technology and income gaps between the rich and the poor.

For a different reason, public sector research institutions are now increasingly seeking protection of their biotechnological products and processes. Their protection regimes are designed essentially to protect their discoveries from being misused and for ensuring their availability to all stakeholders and bonafide users, especially the poor and small holders. Thus, as a whole, there will be different types of IPRs which must be internationally harmonized to facilitate effective sharing of the inventions. FAO Commission on Genetic Resources for Food and Agriculture advocates a judicious balanced blend of Farmers and Community Rights and Plant Breeders Rights encompassing farmers' privileges and researchers exemption. Most developing countries have included or are likely to include these elements in their national legislations on plant breeders rights and intellectual property rights. Several countries are making provisions for exclusion of "traitor" or "terminator" technologies. For instance, India's draft legislation on this subject has explicit provisions against the development, introduction, and use of "terminator" technology.

Recognizing that the IPRs are critical for growth of the biotechnology industry, realizing that under the TRIPS agreement it will be difficult to introduce new technologies originating elsewhere, and appreciating that IPR related issues are complex, with implications for trade, research priorities, technical investment, and access to biotechnology outputs, individual countries must have national debates involving various stakeholders to evolve a truly national view and perspective. The process will allow a critical assessment of the various issues, the national priority, existing and needed national capacity, and national goals and aspirations while preparing the national legislation. In view of the fast pace of developments in biotechnology research and application, each country may institute a national forum to internalise the dynamics of "gene revolution" in national plan and strategies.

Securing Benefits for Developing Countries. Several of the products and findings of biotechnology applications need to be exploited widely in the developing countries. Production and distribution of vitro-cultured disease free plantlets are already benefiting small farmers in developing countries. The virus resistant papaya transgenics developed in Hawaii are being shared with developing countries. Some of the international associations and agencies such as International Service for the Acquisition of Agro-Biotech Applications (ISAAA) are already assisting in sharing biotechnology products and techniques between developing and developed countries.

Regional and international initiatives such as those by the Consultative Group on International Agricultural Research (CGIAR), FAO supported regional biotechnology and research institutions and associations such as Asia Pacific Association of Agricultural Research Institution (APAARI) and the Global Forum for Agricultural Research (GFAR), should be further strengthened to undertake collaborative activities. Several countries lack basic research and technology development resources and infrastructure to even absorb introduced technologies, let alone the generation of new knowledge and technologies (Singh 1994). Such countries must give high priority to develop the minimum facilities. FAO and other UN agencies and donors should assist developing countries in building capacity for harnessing the latest developments in the field of biotechnology.

Monopolistic Control of Seeds and Other Products. The recent trends of mergers and takeovers between breeding (seed) companies, seed traders, chemical and food companies, health-related companies, and genetic engineering companies must be taken note of in context of the availability of and access on the part of small and resource-poor farmers, who are the majority, to desired seeds, genetic vulnerability, and household food security. Just 10 internationals have now cornered nearly 50 percent of the world's seed market. Given the stringencies of patent legislations, including the abolition of farmers' privileges of using saved seeds and the fear of "terminator seeds," individual governments must constitute their own product marketing rules, regulations, and legislations. It is a kind of *sui generis* system to meet their specific needs, containing effective checks and balances within the umbrella of international agreements. Countries may need antitrust enforcement policies for consumers protection when competition among industries is shifted because a particular multinational has acquired control of a market.

Access to Information. The information explosion in the field of biotechnology is being assimilated in various databases, but the information is not always available freely due to restrictions imposed by patent regimes. However, the recent decision of Monsanto and Celera regarding the sharing of the "working drafts" of full genomes of rice and human beings, respectively, is a major paradigm shift. Free access to information at all levels is fundamental to the rapid improvement of crop, livestock, forestry, and fish species. This is particularly important for the developing countries which are not in a position to generate new technologies, but are in a position to use them. Increasing databases on risks and possible negative effects of biotechnology should be available for consensus building and to enable the people at large to make informed choices. The Code of Conduct on Biotechnology for Genetic Resources for Food and Agriculture aims to ensure that informatics would not become a divider between the "haves" and "have nots."

Partnership between 'Seed Rich' and 'Gene Rich'

Molecular biology and genetical engineering research and development call for high-level investment of financial and human resources. Most developing countries are unable to commit the needed financial support. The costly biotechniques and products are thus out of the reach of the majority of poor institutions and people in the developing world. Private sector research and biotech development has therefore tended to be confined to well-endowed countries, communities, and commodities. It is unlikely that the private sector will serve a large number of resource-poor farmers in marginal and non-congenial settings. The public sector will therefore be required to develop technologies for such deprived people. However, the problems to be solved under such settings are rather complex and need advanced technologies for their redress. For instance, a poor rice farmer in rainfed areas needs technologies which will minimize his risks from too much or too little water, toxic soils, and low fertility and a large number of serious pests and diseases. To meet these challenges, the public sector will need advanced technologies which are often being developed by the private sector and are proprietary.

The marginal areas inhabited primarily by poor farmers and other people who are not poor in everything. Genetic resources evolved through ages and local knowledge accumulated and enriched over generations in such difficult habitats are unique and invaluable. A good part of genetic resources and the associated information and knowledge is conserved in public sector and national and international organizations, especially the CGIAR Centres. These unique resources are needed both by the public and private organizations and institutions to advance the frontiers of biotechnology, emphasizing the importance of synergistic collaboration between the two sectors. Recent developments and prospects of the genomics have further heightened the need and scope of effective complementarity and cooperation between the public and private sectors.

Both the public and private sectors will need ‘free’ access to the new tools and vast genetic resources for discovering new traits and the control of the intricate processes. One good example is the discovery and sharing of the ***Xa21*** gene, conferring resistance to ***Xanthomonas*** in rice. A rice germplasm collection from Mali (Africa), the development of near-isogenic lines by the International Rice Research Institute (IRRI) and the isolation and cloning of the gene by a “private” system, and patented in USA were integrated to produce the desired product, which is available to various developing countries at zero royalty.

In forging the public and private sector collaboration, the profit-making motive of the private sectors to recover the cost and for further invest, and the public sector’s access to the new technologies and their use in a non-commercial manner should be rationalized. The public-private linkage in the genomics of rice and human is a major step towards accelerated research for identifying new genes and traits. The essentialities for sustaining this partnership could be satisfied through creating flexible proprietary rights arrangements. A material transfer arrangement (MTA) being advocated by the CGIAR system and supported by several national programs takes into account the needs and capacities of low-income subsistence farming settings, developing countries, and developed countries. Under such agreements, data and materials are freely available for research and there are provisions ensuring that recipients cannot obtain any form of intellectual property protection on the genetic stocks per se.

It is gratifying that the international community is continually providing guidance and mechanisms for equitable and judicious sharing of genetic materials and biotechnological products. The FAO’s Code of Conduct on Biotechnology for Genetic

Resources for Food and Agriculture, the public sector-supported Genome Project and the International Rice Genome Sequencing Project and the private sector initiatives of Celera, Monsanto, and the like and the recently formed International Functional Genomics Working Group are geared to strengthen research, technology development, and information, technique and material sharing.

The cutting-edge discoveries in biotechnology, especially genomics, have increased the emphasis and scale of research collaboration between public and private sectors. Both in developed and developing countries, leading public sector institutions are seeking alliances with research wings of private companies. For instance, the University of Berkeley, California, U.S.A, is collaborating with Novartis in genomics research and Monsanto is collaborating with the Indian Institute of Sciences, (Bangalore) in molecular biology and genetic engineering. In the recent weeks, the collaboration of Monsanto with the International Rice Genome Sequencing Project in sharing the first "working draft" of the entire rice genome and the collaboration between Celera and the global human genome project for sharing the "working draft" of the entire human genome, are landmarks in private and public sector partnerships. This partnership must provide for equitability and benefit sharing mechanisms to the needs of all stakeholders, the gene-rich and the seed-rich and the rich and the poor. Such partnerships should particularly emphasise environmental sustainability, including biodiversity conservation, the needs of consumers and the aspirations of small farmers.

Ethical Aspects. Although all the contradictions must be resolved scientifically, the ethical and moral issues assume another dimension. These concerns are rooted in the fact that biotechnology is seen by some to 'interfere with the workings of nature and creation.' These concerns must be clearly balanced with the aspects of providing food to the hungry and dignity to the destitute. Mahatma Gandhi said to a hungry person that God can appear before him only in the form of bread. If biotechnology is the resort to grant the bread to the hungry, the ethic may demand the use of science. Mahatma also said nature has provided enough for everyone's needs but not for their greeds. The use of biotechnology to satisfy the greed of the greedy should clearly be discouraged, particularly when it raises ethical and moral concerns.

Some developing countries are suffering economically due to the substitution of their high-value export products such as food additives, flavors, vegetable oils and fats, and medicinal products with genetically engineered products (e.g., copra-quality oil rapeseed) by some developed countries. This phenomenon is not new. Think of the substitution of jute fibre and products by synthetic fibres causing economic and, indirectly, food security hardships to Bangladesh and other jute-producing and jute-exporting countries. Such contradictions could be settled through bilateral and multilateral negotiations on market sharing and pricing arrangements. Public awareness of the comparative values of naturally occurring conventional products versus engineered nonconventional products would also mitigate the problems.

Many of the ethics-related issues, such as 'patents on life forms,' cloning of mammalian species often referred to as "playing God'' are being debated in the context of IPR legislation and religious and cultural settings. These issues are more than just scientific issues. Public awareness; people's perception; and cultural backgrounds of the various scientific, socioeconomic, ethical, and moral issues will decide the nature and mode of use of modern biotechnology.

The Way Ahead

During the past 40 years, the global food production had more than kept pace with the increase in world population. Between 1960 and 1990, world cereal production doubled and per capita food production increased by 37 percent. Various predictions suggest that toward 2020, the trend will be maintained. However, it will be at a slower rate and per capita availability of food is estimated to increase around seven percent.

Despite the above trend of food production outpacing the population growth, a recent FAO technical interim report, titled “Agriculture: Towards 2015/2030,” estimates that from the current level of about 790 million in 1995/97, there could still be about 575 million people suffering from chronic undernourishment in 2015. The number is expected to decline to 400 million in 2030. It may be recalled that the World Food Summit in November 1996 had targeted to halve the number of malnourished persons to 400 million by 2015. Thus, the current pace for meeting the target has so far been slow and the world might have to wait for another 15 years, until 2030 against 2015, before the numbers of undernourished are reduced by half.

World production of cereals, the principal source of food supplies, is projected to increase by almost one billion tons by 2030 from the current level of 1.84 billion tons. This increase even exceeds that of the past three decades. The dependence of the developing countries on imports of cereals is expected to rise from 107 million tons (net imports) in 1995/97 to 270 million tons in 2030.

The scenario in the Asia-Pacific Region is expected to be still of greater concern. While in the world as a whole the numbers of malnourished have declined, in the Asia-Pacific Region these had increased by three million, from 512 in 1990/92 to 515 million in 1995/97. The Region’s dependence on cereals imports had increased from 33 million tons in 1965 to 80 million tons in 1998.

The Asia-Pacific Region, as the rest of the world, had witnessed the Green Revolution triggered through the semi-dwarf, lodging resistant, input-responsive, and period-bound varieties of rice, wheat, and other crops developed and widely adapted in the mid-60s and onward. The impact of the Green Revolution was most felt in this region and many doomsday predictions of mass hunger deaths were belied. The revolution brought unprecedented increases in productivity, production, irrigation, fertilizer use, food price deadline, rural prosperity, and food availability. Between 1995 and 1999, in the Asia-Pacific Region, cereal production and yield increased from 371 million tons to 987 million tons, and 1391kg/ha to 3258 kg/ha, respectively. Despite high population rise, the per capita calories intake increased from 2,039 kilo calories in 1965 to 2,693 kilo calories in 1998.

Primarily because of the high population pressure (57 percent of the world population) and the low access to the production resources (availability of arable land to an Asian farmer is one-sixth of that to a farmer in the rest of the world), the Asia-Pacific region accounts for nearly two-thirds of the world's malnourished. Of the world's about 200 million malnourished children, nearly 100 million dwell in South Asia alone.

Notwithstanding the outstanding role and impact of the Green Revolution in food security, rural income growth, and the much needed confidence of the politicians, policymakers and people in science-led growth and transformation of agriculture, there are several adverse impacts. The often cited weaknesses of the Green Revolution are:

- Bypassing the vast rainfed and dryland areas and commodities, thus exacerbating inequity;
- Environmental degradation and depletion of soil and water resources and quality caused due to inefficient and excessive use of irrigation, fertilizers, and other agrochemicals, and build up of pesticide resistance in major pests; and
- Loss of land races and overall erosion of biodiversity leading to greater genetic vulnerability.

Given the high present and projected population concentration, with agriculture being the backbone of national economy and main employer of the masses and having almost closed the option for horizontal expansion of cropped area in most developing countries of the region, the way ahead must be based on sustainable intensification of agriculture.

The Green Revolution path of agricultural intensification during the past over 30 years was certainly the most effective path to overcome the problems of widespread food insecurity and hunger. But, as already mentioned, it had its own pitfalls. Moreover, the Green Revolution varieties were developed using conventional Mendelian approaches whose impact is plateuing off, yield ceilings have been attained in the high yielding varieties (HYVs), and the approach had limited success in designing crops tolerant to complex stresses, such as drought. Convergence and integration of multiple desirable traits is a slow and highly uncertain process under the conventional approaches. The future path of intensification must avoid these pitfalls and limitations.

The way ahead must therefore seek the development of highly productive, efficient, resistant (to biotic and abiotic stresses) remunerative, quality-rich genotypes suitable both for congenial (irrigated) and non-congenial (rainfed/dryland) settings, which when blended with time-tested traditional technologies and appropriate policies, and synergized with modern information technology, should promote congruence of enhanced productivity, sustained and healthy ecology and environment, referred to as ecotechnologies (Swaminathan 2000).

On an average, in the recent years, the global, regional, and national level (in most countries) food production and availability had looked promising. And if everyone had full physical and economic access to the food, today there would not be hungry and malnourished person in the world. But, as noted, the averages conceal turbulent variations. Almost one-fifth of the population of the developing world is malnourished, ranging from less than 10 percent to over 40 percent from country to country. This paradox is linked with the inability of the poor to buy food. It is estimated that 1.3 billion people in the developing countries live in abject poverty, earning a dollar a day or less per person. No technological development should accentuate this paradox. Instead, the way ahead is to develop and promote pro-poor technologies which may enhance the income of poor people, improve their purchasing capacity and food self-reliance and augment the production of their commodities and agro-ecological settings, altogether to improve their food security (Persley 2000).

Food security should mean not only calories and protein adequacy and balance, but also adequacy of vitamins and especially vitamin A, zinc, iron, and iodine as well as balance of micronutrients to counter deficiency disorders prevalent in poor people. An estimated 180 million children, mostly in developing countries, suffer from the vitamin A deficiency that leads to two million deaths annually. Future food security strategies must address the issues of nutritional adequacy along with the issues of food security. In this context, the development of the "Golden Rice" holds great promise for Asian people where rice is the predominant food alongside widespread vitamin A and iron deficiency, especially among children and women. Golden Rice is a genetically transformed rice in which the transgenes enable the rice plant to modify certain metabolic pathways in its cells to produce the precursors to vitamin A, which otherwise was not possible.

It is fortuitous that as we have entered the new millennium and were seeking a technological breakthrough which may spearhead agricultural production in the next 30 years at a pace faster than that during the past 30 years (the Green Revolution era), modern biotechnology with multiple and far reaching potential has appeared on the horizon. As mentioned earlier, it is already being used for and has the potential to enhance yield levels, increase input use efficiency, reduce risk and depress effects of biotic and abiotic stresses, and enhance nutritional quality leading to increased food security, nutritional adequacy, poverty alleviation, environmental protection, and sustainable agriculture. Often referred to use 'Gene Revolution' or 'Bio-Revolution,' if judiciously harnessed, blended with traditional and conventional technologies and supported by appropriate policies, biotechnology can lead to Ever Green Revolution – synergizing the accelerated pace of growth and sustainable development.

The way ahead must map out the ways to optimize the benefits and minimize the negative effects of biotechnology on a case by case basis. Biotechnology should be kept in a balanced perspective by integrating it within the national research and technology development framework and using it as an adjunct to – and not as a substitute for conventional technologies in solving problems identified through national priority setting mechanisms. Priority setting should also take into account national development policies, private sector interests, market possibilities, public perception, and consumers views. Accordingly, various stakeholders, public sector, private sector, industries, NGOs, and civil societies should be involved in the formulation and implementation of national biotechnology policies, strategies, plans, and programs.

The technology-inherent as well as technology–transcending risks must be critically and scientifically assessed in a transparent manner. Capacities and measures should be in place to manage the risks, minimize the negative effects, and promote the positive impacts. Each country must have the necessary infrastructure, human resource, financial support, and policy for meeting the challenges and capturing the novel opportunities. Competence will particularly be needed in the formulation of country–specific rules and regulations on biosafety and intellectual property rights management regimes, along with commensurate financial, institutional, information, and human resources for their effective implementation.

The multiplicity of cooperation and management of development and application of biotechnology would seek a new way of governing the technology. The development of the "Golden Rice" amply substantiates this need. The inventors of the "Golden Rice" are professor Ingo Potrykus of the Institute for Plant Sciences, Swiss Federal Institute of Technology, Zurich, Switzerland, and Dr. Peter Beyer of the Centre of Applied Biosciences, University of Freiburg, Germany. The "Golden Rice" technology was developed with funding from the Rockefeller Foundation, the Swiss Federal Institute of Technology, the European Union, and the Swiss Federal Office for Education and Science, all costing about 100 million dollars. Other partners involved are Greenovation, which will help distribute this technology and is an offshoot of Freiburg University, and Zeneca Agrochemicals of AstraZeneca, which has bought the commercial rights to "Golden Rice" from Greenovation. Zeneca then licenses "non-commercial" rights back to the inventors and undertakes to help them improve the grain, deal with patenting issues, and guide Golden Rice through the costly testing and regulatory process.

The inventors of "Golden Rice" are supposed to distribute the rice free to government-run breeding centres and agriculture institutes, particularly in India, China, Thailand, and other rice-dependent Asian nations. However, some nearly 70 patents are involved in the development of the "Golden Rice." And, the discoverers of this rice are already frustrated with the veritable restrictions in taking the product to the malnourished who suffer from the vitamin A deficiency. Furthermore, other contradictions are also being voiced around "Golden Rice." These complexities clearly demonstrate that it is not enough to have a technology developed, but it is equally important, if not more, to have the nontechnological aspects, the enabling mechanisms, in place to allow a technology to perform. Such complexities are generally expected to be associated with biotechnological developments. Hence, the efforts at various levels must address concerns about "governing biotechnology," not just solving specific technical problems (Juma 1999).

The Asia-Pacific countries and regional programs of international organizations and institutions in the region must take cognizance of the commonality and unique features of the region while formulating their regional programs. For instance, more than 90 percent of the world's rice – the anchor of food security – is produced and consumed in the Asia–Pacific region. Therefore, it is most encouraging that, led by Japan, several Asian countries, supported by the Rockefeller Global Rice Biotech project, IRRI, and USA are engaged in analyzing rice genome. Due to strategic reasons, as mentioned earlier, Monsanto and other private companies have also supported rice genomics work. Similar initiatives are also needed for other commodities, whose more than 70 percent of the global production is confined to this region. These include jute, rubber, coconut, oil palm, mango, and a large number tropical fruits and vegetables, buffalo, aquaculture and several forestry and agro-forestry species.

Another unique feature of the Asia-Pacific region is high concentration of small farmers. While the region accounts for 73 percent of the World's farming households, its per caput availability of land is nearly one-sixth of that in the rest of the world. Therefore, the application of biotechnology in the developing Asia-Pacific region should be geared to improve the commodities and production systems linked with small farmers. Further, intellectual property right regimes should have provisions not to deny the access of resource-poor small farmers to needed biotechniques and products.

In the Asia-Pacific region, there is great inter-country diversity in the preparedness for judiciously harnessing modern biotechnology. On one hand, there are countries like Australia, Japan, New Zealand, and the Republic of Korea which have comprehensive research and regulatory mechanisms and provisions for rational development and application of biotechnology. On the other hand, most of the low-income food-deficit countries, although keen to use the new technology, are rather ill-prepared for capturing the opportunity. Then there are a good number of countries such as China, India, Malaysia, Thailand which have fairly elaborate technical capacity, but would need to strengthen their biosafety and other regulatory institutions and mechanisms to effectively manage biotechnology.

Thus, there is ample scope for cooperation and collaboration among the countries of the region to share and learn from their experiences, technologies, expertise, management strategy, and policy. It must, however, be recognized that ultimately it is the responsibility of individual nations to formulate and create their own country-specific policies, regulatory measures and other institutions to harness the technology.

FAO and other concerned international organizations should assist the developing countries in building and strengthening their scientific, regulatory (legislations and standards) and policy capacities. These organizations should constitute the global information clearing houses and undertake collection, collation, and exchange of value added information, knowledge, and experience. These should also provide neutral forums fora for global debate on the various issues and sometimes differing perspectives related with the use, or even no use, of biotechnology for comprehensive food security and nutritional adequacy, poverty alleviation, and environmental sustainability (FAO 2000). The proposed establishment of Asia-Pacific Bionet could provide such a forum.

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Agricultural Biotechnology: What is in it for Developing Countries? - A Perspective from a Nongovernment Organization

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Although many biotechnology applications have a positive role to play in the context of sustainable agriculture and development, the author disagreed on the use of modern biotechnology or genetic engineering based on issues of biosafety, bioethics, cultural appropriateness, preservation of local and indigenous systems and effects on the livelihood of millions of small farmers. The importance of making the right production and consumption choices by developing countries was emphasized. Expansion of organic and other forms of ecological farming was noted not only in developing countries but in the North also with western holistic scientific knowledge complementing traditional knowledge and improving existing practices. Agricultural policy and research must be farmer-driven and must recognize and understand the critical role of farmers' knowledge and traditional production models, their integration in the ecosystem and the role they play in maintaining local resources. Further, the Cartagena Protocol on Biosafety was discussed as it relates to developing countries.

The term 'biotechnology' describes a vast number of applications and many of these applications have a positive role to play in the context of sustainable agriculture and sustainable development. However, the field of modern biotechnology or genetic engineering biotechnology is a departure from conventional biotechnology, and one that has received considerable attention and concern, from scientists, governments, and the public.

Genetic Engineering Biotechnology

Genetic engineering is a significant departure from traditional methods, and introduces significant differences. Genes can be transferred between distant species that would never interbreed in nature. Reproduction is bypassed altogether as genetic engineers can transfer genes horizontally (as opposed to vertically, from parent to offspring) often making use of artificially constructed vectors.

The constructs are designed specifically to overcome species barriers and natural mechanisms that prevent foreign genetic material from inserting themselves into the genomes. Most of the constructs have never existed in nature.

Genetic engineering introduces new genes and new combinations of artificially constructed genetic material. The artificial constructs are derived from the genetic material of pathogenic viruses and other genetic parasites.

Invasive methods are used to introduce these constructs into cells, resulting in a random insertion of foreign genes into the genome.

Some scientists have begun to question whether current genetic engineering technology is really "technology". The term "technology" is derived from the Greek word

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‘tekhne,’ which is connected with handicraft or the arts. The term is associated with predictability, control, and reproducibility. But genetic engineering is hit or miss and not at all precise as it depends on the random insertion of the artificial vector carrying the foreign genes into the genome.

This is the root of the problem. Many genetically engineered (GE) seeds and crops are already undergoing field trials and some have been commercialized, but there is no evidence of the long-term stability of the GE inserts in terms of structure or location in the plant genome.

Genetic engineering can give rise to unpredictable, random effects, including toxins and allergens. There is also potential for the generation of new viruses and bacteria that cause disease and mutations, including cancer in mammalian cells. In the United States, there have been reports by farmers of inconsistent performance of GE crops, which has led to a decline in their overall yield.

The actual and potential hazards of GE organisms to human and animal health, the environment, and biological diversity are well known and well documented. Some of these are openly acknowledged by governments and regulators in the North.

More worrying is the suppression of scientific evidence and opinions of potential dangers of genetic engineering. A lawsuit against the US Food and Drug Administration has revealed that it ignored the warnings of its own scientists who cautioned that genetic engineering introduces new risks. The lawsuit has also revealed that the first commercialized GE organism, the Flavr Savr tomato, did not pass the required toxicological tests.

Risk Assessment

Wading through all these potholes and pitfalls, what becomes abundantly clear is that present scientific knowledge is inadequate, and a reliable and adequate risk assessment framework is virtually impossible. For instance, knowledge about the complex interactions in the ecological system is lacking, but this knowledge is crucial because releases of GE organisms into the environment cannot be recalled and may cause irreversible changes in the ecosystem.

The term “risk” is often confused with probability. But risk is the probability or likelihood that something will take place multiplied by the effects that arise if that event does indeed take place. In other words, something may have a small chance of happening, but if the consequences of it happening are catastrophic, the risk is immense. But both these components (probability and adverse effects) are not known.

This understanding of risk and the scientific application of the Precautionary Principle must be factored into any assessment of the potential utility of any GE crop or application. There should be a cost-benefit analysis conducted to see if there is even a need for the GE organism, and if there are safer or sustainable alternatives.

Agricultural Genetic Engineering Biotechnology for Developing Countries?

It is absolutely essential for developing countries to make the right production and consumption choices. What is at stake for developing countries is food security; access to safe, nutritious, and culturally appropriate food, the health and diversity of their ecosystems, the preservation of local and indigenous knowledge systems, and the livelihood of millions of small farmers.

Technology is only one part of the solution toward achieving all this.

The proponents of genetic engineering biotechnology insist that more food production, particularly in developing countries themselves, is necessary to adequately feed people, now and in the future – the "Green Revolution" went some way toward increasing food production, but with declining yields and a growing realization of the environmental and health impacts of chemical and intensive farming, the so-called "Gene Revolution" is now necessary.

Yet, out of the estimated 786 million hungry people in the world, roughly two-thirds of them live in Asia, where the Green Revolution seeds did contribute initially to the greatest production success. Technological fixes alone cannot ensure that the hungry are fed. It is precisely because people are poor and have no access to land that millions are hungry.

The need for the so-called second generation of "functional" GE organisms such as the much touted "Golden Rice," also fails to convince by much the same reasoning. In the final report of a 10-year FAO project to reduce Vitamin A deficiency, John Lupien, Director of the Food and Nutrition Division of the FAO, concluded that "a single nutrient approach towards a nutrition-related public health problem is usually… neither feasible nor desirable."

There are plenty of cheap, alternative sources of Vitamin A or pro-Vitamin A such as green vegetables and unpolished rice, which would also provide for other nutritional needs. Yet those suffering from Vitamin A deficiency are being offered a technological fix which has cost US$100 million so far and which might never be commercialized as is tied up with 70 major patents.

In fact, the "Golden Rice" uses standard first generation technology and is potentially even more hazardous to human health and biodiversity than the herbicide-tolerant Bt crops. Professor Bevan Moseley, molecular geneticist and the current Chair of the Working Group on Novel Foods in the European Union's Scientific Committee on Food, has expressed concern about the so-called "functional foods" as they will pose an even greater health risk due to the increased complexity of the gene constructs.

Sustainable Agriculture in Developing Countries

Agricultural research has been strongly directed by the commercial self-interests of agro-industry. In general, the research has been focused on single technological fixes that fail to take into account the complexity and diversity of the ecosystem. Current agricultural research is geared toward increasing the profits of agro-industry by increasing their ownership and control over agriculture production, for example, through patented GE seeds. For the farmer, this means higher input costs and greater dependency on the companies and their technology.

But despite the aggressive push by agro-industry to market their chemical inputs, hybrid seeds, and genetically engineered seeds and crops, and despite the lack of funds that has been directed to support research into sustainable ecological agriculture, an estimated 12.5 million hectares of land worldwide are under agro-ecological farm systems.

Millions of farmers in developing countries are practicing traditional and indigenous methods of farming. Organic and other forms of ecological farming are also rapidly expanding in the North. In many cases, western holistic scientific knowledge is complementing traditional knowledge and improving existing practices.

Successive studies have shown the productivity and sustainability of traditional small farm agriculture based on agro-ecological principles. Agro-ecological farming systems that emphasize diversity, synergy, recycling and integration, combined with social processes that emphasize community participation and empowerment, are seeing significant yield increases.

Not only does yield increase and stabilize, other ecological benefits, such as improved natural pest regulation mechanisms and soil and water restoration and conservation, are also reaped. These results are a breakthrough for achieving food security, and ensuring environmental protection in developing countries, and for protecting the livelihood of millions of small farmers.

Significantly, a landmark study by the National Research Council in the US has found that “alternative farmers often produce high per-acre yields with significant reductions in costs per unit of crop harvested” despite the fact that “many federal policies discourage adoption of alternative practices.”

Agricultural policy and research must be farmer-driven, and must better recognize and understand the critical role of farmers’ knowledge in traditional production models, their integration in the ecosystem, and the role they play in the maintenance of local resources. Existing research in the fields of holistic agricultural systems that are rooted in the scientific discipline of agroecology must be mainstreamed.

Agricultural research over the past 20 years has been grossly imbalanced in favor of genetic engineering. This must be redressed immediately. Only then can real scientific, technological, and policy choices be made.

The Cartagena Protocol on Biosafety and What It Means for Developing Countries

Scientific concerns about the actual and potential risks and hazards of genetic engineering led the international community, under the auspices of the United Nations, to begin negotiations for a Biosafety Protocol. The Protocol has now been adopted. When it was opened for signature at the 5th Conference of the Parties to the Convention on Biological Diversity in Nairobi in May, 68 countries signed the Protocol. Most of these countries are developing countries.

Almost all developing countries had consolidated themselves into a negotiating bloc (known as the Like-Minded Group) during the course of the Protocol negotiations.

Developing countries had consistently negotiated for a strong Protocol, and for, inter alia, the application of the Precautionary Principle, socioeconomic considerations to be taken into account and the inclusion of a liability and redress regime.

Developing countries face an even greater environment risk from GE organisms than countries in the North as most of the centers of crop origin and diversification are located in the South. The growing consumer rejection of GE organisms in the North (particularly in Europe, and now spreading to North America) means that, increasingly, markets are being sought in developing countries for GE organisms and their products. Many developing countries fear becoming dumping grounds for GE seeds and food that are being rejected in the North.

The Protocol is very significant because for the first time, GE organisms are regulated by international law, a recognition of the fact that GE organisms are distinct and inherently different, and carry special risks and hazards. It is also significant for the reaffirmation of the Precautionary Principle which is operationalized in the decision-making procedures in the Protocol. The Protocol puts in place procedures that regulate the international transboundary movement of GE organisms, allowing the potential importing country to make an informed decision, based on risk assessment and the Precautionary Principle, before permitting import.

Parties to the Protocol, and developing countries in particular, now need to build capacity in a number of key areas: comprehensive national and regional biosafety laws, scientific capacity for risk assessment and risk management, and monitoring and implementation capabilities. Most developing countries do not as yet have national biosafety legislation, adequate scientific biosafety capacity, or the infrastructure to monitor and enforce biosafety adequately.

The Biosafety Protocol was a heavily negotiated text, given the fact that the main exporters of GE organisms were ruthless in protecting the interests of the biotech industry in their countries. There are some serious deficiencies in the Protocol. Nevertheless, the Protocol merely sets minimum standards that Parties are obliged to implement nationally. Parties may take action that is 'more protective of the conservation and sustainable use of biological diversity than that called for in the Protocol.' Comprehensive national biosafety legislation must strive to fill the gaps in biosafety regulation based on the highest standards of biosafety and the Precautionary Principle.

Agricultural Biotechnology: What is in it for Developing Countries? – A Perspective from the Private Sector

Paul S. Teng[1]

This paper attempts to present the industry perspective on what agricultural biotechnology can contribute to developing countries. Key topics discussed are: (1) why private sector is interested in biotechnology, (2) adding value to current products and creating value through new products, (3) consumer acceptance and concerns, (4) producer acceptance of product stewardship, (5) need for clear regulatory framework and (6) sharing of proprietary technology. Identified as the major applications of biotechnology in agriculture are (1) the use of molecular markers in studying genetic diversity of plants, insect pests and pathogens, varietal identification, marker-aided selection and as diagnostic tools and (2) genetic engineering to transfer specific useful traits. Moreover, the author emphasized the great potential of biotechnology to address food security problem of developing countries to increase production where it is needed.

Biotechnology has in a very short time produced applications of benefit to farmers in both industrialized and developing countries. Of the 40 million hectares of biotechnology-produced crops globally in 1999 (James 2000), most area is undeniably in the industrialized countries according to the International Service for Acquisition of Agribiotech Applications (ISAAA), leading some to ask the extent to which the developing world may benefit, and also, whether resource-poor farmers will be among the beneficiaires. Furthermore, the relative roles of the private versus the public sectors, in the research and development of cash versus subsistence crops, has increasingly been discussed. It is notable that the program of the international meeting at which this paper was presented focused on topics in agricultural biotechnology as seen from three different perspectives—the public sector, the NGOs and private sector – reflecting multisectoral views that are not altogether congruent with each other. This paper will attempt to present the industry perspective although this is difficult as there is not a single industry perspective, such as there is no single NGO perspective or a single public sector perspective.

Some of the key topics that will be discussed include 1) why the private sector is interested in biotechnology, 2) adding value to current products, 3) consumer acceptance and concerns, 4) producer acceptance and product stewardship, 5) clear regulatory frameworks and 6) the sharing of proprietary technologies.

Private Sector Interest in Biotechnology

In general, business or industry is interested in biotechnology because there is a need for it. Industry attempts to meet societal needs while in the process, makes money and helps people. A second compelling reason for private sector interest in biotechnology is that with the fast and modern advances in molecular sciences and information technology (IT), there is a real potential to capture value through traits improvement in crop germplasm. Third, companies aim to capture more of the market share through farmers' choice. All companies believe that if a product performs better than others, farmers will choose to buy that product. Fourth, biotechnology has the potential to shorten and increase the precision of the time of product delivery, thus,

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increasing its competitiveness. This is important in a modern context, as happened with IT and communication technology where the North American region is recognizably the leader in global competition.

At the farmer level, where a main concern is profitability, biotechnology products have been shown to reduce production costs while making farming schedules such as weed control more flexible, and subsequently, making higher profits for farmers than their counterparts who do not use biotechnology products.

Potential Benefits of Agricultural Biotechnology

Among the major applications of biotechnology in agriculture are 1) the use of molecular markers to study genetic diversity, 2) marker-aided selection to speed up the incorporation of major genes for specific traits, 3) diagnostic tools and genetic engineering to transfer specific genes where the current gene pool cannot provide the genes necessary for important traits. Recently, the coevolution of blast and rice in mixed culture systems was studied in the Yunnan Plateau, China, using molecular markers. This study could not have been done 30 years ago simply because the science was not developed yet and neither were the tools (Zhu et al. 2000).

Biotechnology offers great potential to address the problem of food security in developing countries, a problem which may be considered as consisting of food access (distribution) and food supply (production). Addressing food distribution to solve food security is affected by innumerable social and economic factors. What can be done through R&D is to increase food production where it is needed, and thereby benefit the resource poor farmers such as those who reside in marginal rainfed regions in large parts of Asia. Distribution is not the answer to solving food security problems. Distribution, as in buying food from the North and supplying to the South, creates and promotes dependency, and in fact, dis-empowers more farmers. To empower farmers, they should be provided with technologies that significantly increase crop yields under difficult environmental conditions such as less water and less fertilizer to enable them to earn more income to buy things that they need. Through biotechnology, crop yields can be improved per unit land. Improvement of crop tolerance to herbicides will also lead to more efficient land use, less tillage, and thus less soil erosion.

The success of the green revolution has always been cited as a major contribution of R&D. However, half of the rice lands in the world are rainfed. These are marginal farms with very low yields. These are not the farms which will grow surpluses to feed people in the cities and urban areas. These are marginal lands where population is increasing very fast. It is estimated that global demand for rice in 2020 will be 820 million (M) tons, an additional 220 M relative to the situation in 1993. Present food production could not possibly meet this demand unless new technologies are utilized. This is where biotechnology could have a major impact. The use of biotechnology to increase production in the irrigated areas and to make marginal areas more productive will contribute to producing foods to meet the demands of growing populations.

Adding Value to Current Products; Creating Value through New Products

Most companies believe in improvement of current technology and products through biotechnology. Results have been obtained in the pharmaceutical industry with insulin, interferon, and vaccines. Industry also seeks to generate new technologies and products based on sound science in response to farmers' changing needs.

Parallel to the use of sound science for generating new technologies and products, the development of regulatory processes should also be done using sound scientific principles, at the same time recognizing social concerns. Industry supports transparent processes by governments to regulate biotechnology so that consumers are assured of its applications. Data regarding regulatory processes such as field trials, biosafety and food safety tests are available in databases and can easily be accessed in the internet. However, regulatory processes should also not be too overly restrictive as this can be a disincentive to industry and may, in the future, be suppressive to public sector institutions with products which may greatly benefit poor farmers growing subsistence food crops.

The private sector sees three mechanisms by which biotechnology can be applied to add value to products: 1) biotechnology-derived traits, driven largely by developments in molecular sciences, genomics, and IT; 2) conventional traits enhanced through genomics and other biotechnology techniques; and 3) technologies to improve production efficiency. If improved seeds such as hybrid seeds can be produced more efficiently through a biotechnology process than at present, this can bring down costs to farmers and consequently lead to more profit for the farmer.

Traits that have been added by biotechnology to commercial crop varieties have generally elicited a strong, positive response from farmers, especially those in North America. These traits include herbicide tolerance, insect resistance (Bt), both Bt and herbicide tolerance and virus resistance (Table 1). Of the 40 million ha grown to GM crops in 1999 (James 2000), 28.1 percent were planted to soybean, corn and cotton with herbicide tolerance, 8.9 percent to corn, cotton and potato with insect resistance, 2.9 percent to both herbicide tolerance and Bt resistance in corn and cotton and less than 0.1 percent to virus resistance. More products are in the pipeline. From agronomic traits, a shift to quality traits is anticipated (Table 2 and Figure 1). From the private sector's perspective, it was easiest to engineer agronomic traits first as these traits were thought to be what farmers needed most.

Table 1. Traits of dominant GM crops in 1999 (James 2000)

Crop/Trait	Ha (millions)	%
Herbicide tolerant soybean	21.6	54
Bt maize	7.5	19
Herbicide tolerant canola	3.5	9
Bt/herbicide tolerant corn	2.1	5
Herbicide tolerant cotton	1.6	4
Herbicide tolerant corn	1.5	4
Bt cotton	1.3	3
Bt/herbicide tolerant cotton	0.8	2
Total	**39.9**	**100**

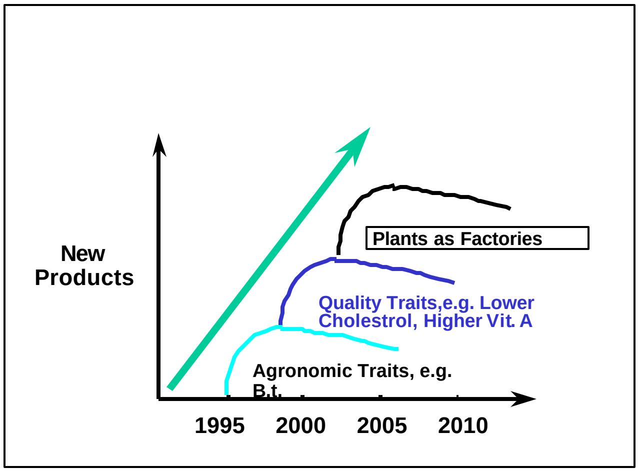

Figure 1. GM products will evolve from the current crop protection traits to products with quality traits.

Figure 2 and Table 2 illustrate the long process that a genetically modified product is subject to before it is commercialized. It was previously the view in industry that registering a pesticide was a long protracted process, requiring much effort in documenting safety. With genetically modified crops or GMCs, the process takes even longer time. As an example, it took approximately 20 years from product concept to the final release of Roundup Ready soybeans. Even the most optimistic industry sources consider timelines of about 10 years for any product to get into the market as reasonably common. During the development period, there are many oversight points regulated by public sector (Fig. 2). If such oversight processes are weak or inadequate, they should be strengthened. NGOs can assist in improving the process by pointing out weaknesses for further remedy or research to generate the knowledge base. The private sector is fully supportive of strong regulatory frameworks for GM crops based on science. Without science-based regulatory processes, it would be difficult for society to use biotechnology's potential to help resolve serious social issues such as those of food security.

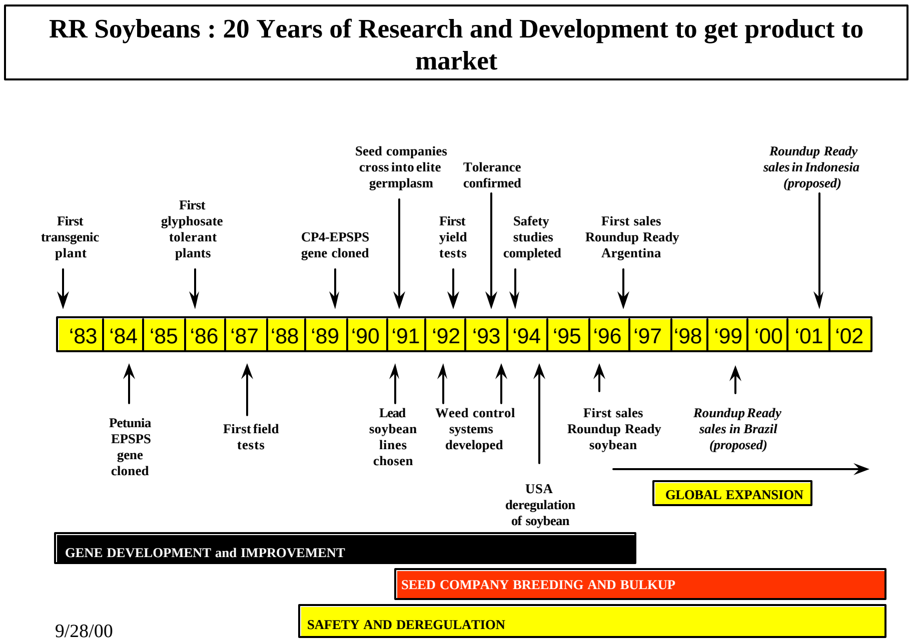

Figure 2. Roundup Ready soybeans: 20 years of research and development to commercialization

Table 2. Biotech Trait Development Process

YEARS	ACTIVITIES	TECHNOLOGIES
1	*Gene Discovery*	*Genomics*
2	*Transgenic Development*	*Transformation*
3-4	*Efficacy Evaluation*	*Molecular Biology*
	Variety Development	*Applied Genetics*
4-5	*Safety/Environmental Impact*	*Reg. Science*
5-6	*Variety Selection/Registration*	*Breeding*
7	*Seed Bulk-up*	*Breeding*
8	*Product Launch*	*Prod Dev./Marketing*

Consumer Acceptance and Concerns

Public knowledge, attitudes, and perception of GM products are very important factors which determine ultimately whether GM crops will become an important contribution to the world's food supply.

Balancing information and news on biotechnology and GM food has been a real challenge in some parts of the world. How does one separate emotion from science? Most of the big life science companies did not appreciate the many challenges facing them. When they started commercializing GM products, they all believed in the value of the product and were confident of public acceptance. Looking back, this may be viewed as a failure on the part of many companies to anticipate public sentiments about the safety of their food supply.

Another important issue concerning public acceptance of GM crops is the availability of processes or regulatory frameworks for assuring food safety. Many surveys have shown that people want to know how food safety is assured. It is interesting to note that most common food products that are currently eaten have not been subjected to the same rigor of testing that is done now for GM foods. If so, many of today's common foods would not have been approved. The testing of GM foods is a science-based process that includes actual and potential information, risk assessment for the presence of allergens or toxins, what genes are transferred, what proteins are produced, among others. The question then is how the current process for assuring food safety be improved. Information from surveys such as those conducted in Malaysia in February this year have shown that the general awareness about GM foods is very low. Although it is high among the people who want to know, it is very low among the general population. Eighty to ninety percent of the people sampled are not aware of what the issues are. In countries like Singapore, Malaysia, Thailand, and Philippines, there has been increasing recognition in the media of GM foods as an issue. But these same surveys do not pick up increased concern on GM food or biotechnologies by the general population. In fact, surveys showed that people are more concerned about prices of food and health, especially cholesterol.

It is important that public concerns be recognized and properly addressed. Some of these concerns are about environment such as regulation of field releases; outcrossing and effects on nontarget organisms; and food safety such as the safety assessment process, regulation, presence of allergen or toxin, nutritional value, and the presence of antibiotic resistance marker. Being aware of the issues helps the scientist understand and generate data to address them. Right now, science addresses these concerns very well. There are elements of risks. But the benefits far outweigh the risks. There is certainly a large level of speculative fear associated with discussing the topic of GM food. The more emotion is separated from science and the fear from reality, the better for all. According to the Vatican Pontifical Academy, "If you know about biotechnology, you don't fear it". It is therefore important to demystify the process of GM crop production so that the public has the opportunity to understand it. Efforts like those by IRRI and Kasetsart University, involving farmers, NGOs, scientists, and media together, are laudable.

Producer Acceptance and Product Stewardship

On top of regulatory requirements, producers of GM crops assure the biosafety and food safety of their products through product stewardship. What product stewardship implies is providing the subsequent after-sales support to ensure that the product is properly used. This includes resistance management schemes especially for the insect-protected products (Bt corn, Bt cotton), and detection techniques, among others. The public sector may not be as strong as the private sector in such follow through. Thus, international organizations like the FAO can play an important role here, especially in developing and strengthening public sector capability in product stewardship.

There has been about 25,000 field trials in 45 countries on 60 crop species without a single accident having occurred ecologically. This is an impeccable record of government-supervised field trials. Globally, there has been a 1500 percent increase in area grown to GM crops in the past two years, from 3 million hectares in 1998 to almost 40 million in 1999, an amazing story in technology adoption. In China today, there are over two million smallholders farming Bt cotton in just one province. This occurred only after one year of introduction. Farmers like Bt cotton because, they say, it improves income, reduces their exposure to insecticides, and assures them of getting a good harvest of cotton at the end of the season. A US Department of Agriculture study done by some universities has also shown that farmers are the main beneficiaries of the now available products from GM technologies. Consumer benefits are the least even through prices are maintained. This perhaps has contributed to opposition in some countries to GM crops because to consumers, the benefits of the technology have not been obvious with this current set of products. In the near future, another set of products which focuses more on nutritional traits may more clearly demonstrate to the general public the benefits of biotechnology.

Clear Regulatory Framework

Private companies cannot operate unless the regulatory framework for their products is clear. This explains why biotech companies have not gone into countries such as Vietnam where there is no regulatory framework yet for intellectual property (IP) protection and as well as for biosafety and food safety. Suffice to say that industry recognizes the limitations of regulatory frameworks and the need for it to work within the existing framework.

This paper will not discuss the Cartegena Biosafety Protocol although it is important to note that for the first time, there is actually an international agreement which represents the first global affirmation of the potential and value of biotechnology. The Protocol further establishes a global framework for informed decision making. Moreover, this protocol preserves the rights and obligations as established under the World Trade Organization (WTO) and allows companies to continue development, application, and trade of biotechnology products.

Within Asia, several countries have biosafety regulations in place (Table 3). Although a group of West European countries has decided to delay any kind of biotech approvals for GM field trials, there is still substantial biotech research going on in these countries. Interestingly, three European countries planted GM crops in 1999 for the first time. Within the last six months, three East European countries also approved GM plantings.

Technology Sharing

Much of the new agricultural biotechnologies have been generated by the private sector and thus, most of the new tools and genetic materials are protected by intellectual property rights. For example, insect resistant plants are covered by various IP protection, from patents, trademark to plant variety protection (Table 4). The "golden rice" is covered by as many as 70 IPs which belong to 32 patent holders, leading Dr I. Potrykus to say that "only if you start to give away your material do you realize how much stands in the way." The recent years have seen an increasing trend in technology sharing between the private sector and public sector. Only recently, Monsanto announced that the genome map of rice which it had contracted to a laboratory at the University of Washington in Seattle would be turned over to the International Rice Genome Sequencing Project (IRGSP), a ten-country public sector consortium led by Japan. This database would then be shared with the public sector through the IRGSP.

Table 3. Status of regulatory frameworks and field testing of GM crops

Country	Regulations in place?	Approval for any crop?	Approval for rice?	Trait
Australia	Yes	Yes	No	
China	Yes	Yes	Yes	SB (PIN II, Cp/Ti, Bt)
EU	Yes	Yes	No	
India	Yes	Yes	No	
Indonesia	Yes	Yes	No	
Japan	Yes	Yes	Yes	RSV, R, low allergen
Malaysia	Yes	Yes	No	
Mexico	Yes	Yes	No	
Philippines	Yes	Yes	No	
Taiwan	Yes	Yes	No	
Thailand	Yes	Yes	No	
USA	Yes	Yes	Yes	Herbicide tolerance; XA21, maize Ac Element, phaseolin and legumin genes

Table 4. Proprietary ownership of technology: Insect resistant plants (S. Dryden 1998)

Subject	Component	IPR
Plant variety	Germplasm	PVP
Selectable marker gene	Promoter	Patent
	Coding sequence	Patent
Trait	Promoter	Patent
	Coding sequence	Patent
Transformation technology	Ti-plasmid	Patent
Gene expression technology	Transcription initiation	Patent
	Translation initiation	Patent
	Codon usage	

The different types of technology sharing are: (1) donation of proprietary technology and processes, (2) royalty sharing, and 3) joint ventures between government and the private sector to accelerate production of certain GM crops or products. It is important to recognize that there are fundamental differences in the approach to supporting biotechnology R&D of market crops and subsistence crops by the public and private sectors, respectively. In the North American experience, the government has tended to spend less on the R&D of crops in which the private sector is investing. There is also trend to devolve R&D to the private sector in other countries, such as the United Kingdom. Arising from this devolution are key questions such as: What are the R & D priorities in each country? Where should the public sector invest the dwindling R&D funds it has? These are tough questions for scientists because the answers require information beyond the realm of science.

Although the private and public sectors may have differences in their methods, approaches, expectations, and clientele, they can work toward common goals and beneficiaries through cooperation and not confrontation, to provide tools for farmer empowerment, not dependency, and to allow farmers to practice sustainable systems, not transient ones.

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Agricultural Biotechnology: What is in it for Developing Countries? - The Role of International Research and Development Centers

William G. Padolina[1]

Agricultural biotechnology can be used as a tool to enhance productivity thus enhancing farmer competitiveness. The role of international agricultural research organizations (IAROs) in this regard is envisioned as follows: (1) the IAROs must provide information and various technologies, including biotechnologies, to farmers to solve a particular problem. (2) IAROs should provide opportunities to improve national capacity in science, technology management and policy studies such as on managing intellectual property, biosafety, bioprospecting and related issues. (3) IAROs are in the best position to support and/or manage networks or partnerships on various topics such as training on technical aspects, harmonization of policies and guidelines affecting the conduct of biotechnology. (4) Collections of about 600,000 accessions of crops, forage and agroforestry species are now held by CGIAR centers in trust for the benefit of the international community. These continue to be a source of materials for varietal improvement of national programs. Long -term continuing support for genetic resources conservation must be assured. (5) Results of research studies undertaken by IAROs must be shared with the NARS to encourage institution of proper interventions.

Modern biotechnology, specifically applied to agriculture, has produced useful tools for improving productivity in the farm. However, using these tools requires relatively large investments, which are often intimidating to developing countries. Fairly well-equipped laboratories and highly trained researchers are needed for the practice of modern biotechnology. In addition, problems that have emerged are of such complexity that teamwork is a necessary element in the success of the research activities. All these require substantial investments of resources, often with no guarantee of a quick return.

The role of agricultural biotechnology in poverty elimination has been the subject of many debates. There is clear evidence that modern biotechnology provides the tools that may overcome many of the technical road blocks that limit the application of conventional biological techniques in agricultural research, especially in the area of varietal improvement. Since the discovery of recombinant DNA technology by Cohen and Boyer in 1973 and many other advances in molecular biology, researchers have used and improved on these techniques. The great strides achieved in biological research attest to the precision and rapidity of these techniques. However, it is still a fact that modern biotechnology research is an expensive undertaking. As such, most of the research activities have been supported by rich countries and big corporations.

Be that as it may, the goal of any research activity in agricultural biotechnology research is still a product or a process that can be used by the farmers in the field. Notwithstanding the sophisticated laboratories and the high level of training required of researchers, the end products are similar to those generated by the conventional means such as a seed, planting material, diagnostic kit or process. These product forms hide the tremendous amount of investment and testing to get to the point of application in the farmers' fields.

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The array of new tools and new experimental techniques are a result of greater understanding of biological processes at the molecular level. Thus, the researcher acquires precise tools that significantly reduce uncertainties in the experiment and accelerate the pace at which new data is generated, thus reducing the time to get to a useful product. Hence, many feel that the gains in precision and time are worth the investment.

Modern biotechnology when applied to agriculture is expected to provide better products, which will help alleviate hunger and want in a timely fashion. It is the precision and rapidity of approach which agricultural biotechnology offers that makes it a powerful tool to address the problems of productivity and sustainability. At some point in the research and development process, these products are brought to the farmers' fields for testing. The farmers try it out under field conditions and provide valuable feedback to the researchers.

Biotechnology in the Context of Poverty Alleviation

National programs aimed at poverty elimination need, among others, highly trained people who can help assess the potentials of new processes and technologies. Each country must have the internal capacity to identify and absorb emerging technologies that they consider most useful for their development programs.

In many countries, agriculture is often thought of as a low-tech activity that need not be or cannot be competitive. However, recent developments show that agriculture deals increasingly with many tradeable items that must compete and contend with the vagaries of the global market. Also, there is a growing realization that agriculture is a knowledge intensive activity and must be managed as such if it were to be competitive.

In developing countries, poverty elimination provides the context within which biotechnology can be developed. But it is clear that we are on the crossroads. Modern biotechnology is a very powerful tool for agricultural research, a production enhancing innovation. This tool is precise, rapid, and of wide application. It can be used to improve life forms and understand how they behave or react to the environment. Genetic material can be moved across unrelated species. The genome of organisms can be decoded, mapped, and related to phenotype.

Modern biotechnology is made more potent as a tool when combined with information technology. Thus, the field of bioinformatics is rapidly developing as an interphase between biotechnology and information technology. We do not know what other synergies can be derived between biotechnology and other emerging technologies in the near future. But such synergies are sure to happen.

The Challenge--- Rough Road Ahead

Even as we gather momentum to apply this production-enhancing innovation, we face many hurdles that we have to overcome.

There is a perception that the world already produces enough food for all and that food insecurity is not a result of global shortage of supply but of a distribution and marketing problem. On the basis of this observation, many argue that we do not need productivity-enhancing technologies anymore.

New products, new life forms created by the application of the tools of modern biotechnology are perceived to have yet unknown effects on the environment and human health. The genetically modified organisms are now subject to very rigid biosafety tests before they are released to the environment.

Furthermore, the massive investments in modern biotechnology have caused the application of intellectual property rights protection on most of the discoveries, which are in the possession of the private sector. Thus, limited access to vital scientific information owned by the private sector is now a subject of intense discussion. For example, the increasing barriers towards the accessibility of genetic resources, which were once considered the common heritage of mankind, has affected public perception, especially farmers' perception about the usefulness of biotechnology. Corporations have to recover costs if they are to sustain their research and development activities. New technologies and products generated by these corporations are protected and released only under certain conditions. Thus, the resource-poor farmer has difficulty in gaining access to improved varieties of various crops, some of which are transgenic which have been released for commercial applications.

The Changing Role of International Agricultural Research Centers- Toward Enhancing Competitiveness

While we cannot predict what shape and form the regime of trade liberalization and globalization will take, we must strive to make farming profitable and competitive. The massive influx of food products, especially from developed countries, has caused a lot of disequilibrium among farmers of developing countries who do not have the wherewithal to compete. These farmers do not have easy access to technology, finance, marketing, and the policy environment to engender efficiency in their productive operations. Thus, developing country farmers are often not competitive and are marginalized in the global market.

It is in the context of enhancing farmer competitiveness that agricultural biotechnology can be used as a tool to enhance productivity. International agricultural research organizations (IARO) cannot be expected to provide the silver bullet to rescue developing country farmers from the throes of poverty. This is a complex undertaking that cannot be assumed by the IAROs alone. Poverty elimination has to be a global undertaking, with many actors in the stage committed to a convergence of purpose. The IAROs can be one vital cog in the wheel of progress if they play their roles properly as discussed in the next paragraphs.

Honest Broker. As a general approach, IAROs must be organized to be able to deal with the different and complex situations existing in the national agricultural research system (NARS). IAROs are most effective if they can provide valuable advice to developing countries. They can offer a menu of options and leave it up to the nations to decide. The international centers focus on the production of international public goods that are shared on a non-exclusive and on a non-competitive basis.

To be able to assist developing countries, the IARO must be an honest broker of information and technologies. They must make known to potential users all the options available to solve a particular problem. Agricultural biotechnology must be seen simply as one of the tools that can be used. Other approaches, even using traditional breeding techniques should also be offered. It is the duty of IAROs to make available as many options as can be handled.

Human Resource Development. The knowledge-intensive emerging technologies, of which modern biotechnology is one, need people who are trained to handle the new features of such tools. Thus, IAROs may provide some opportunities to improve national capacity in the science, technology management, and policy studies. The national research systems need assistance also in capacity building to enhance the capabilty to manage intellectual property, biosafety, bioprospecting, and related issues.

IAROs can enhance accessibility to new knowledge and expertise to the NARS, especially in the following areas:

- Development and dissemination of tools and protocols for biotechnology research.
- Training and information networking.
- Technology management and policy formulation especially in biosafety, genetic conservation and use, intellectual property rights.

The graduate studies scholarships and various research consortia being promoted by SEARCA are good examples of capacity building.

Networking. The magnitude of today's challenges that lend themselves to the application of biotechnology requires the combined efforts of research institutions. IAROs are organized to manage these partnerships well and reduce transaction costs, enhance flexibility, and augment resources and competencies. The role of IRRI in the Asian Rice Biotechnology Network is a good example of this effort. Networks can include advanced research institutions in molecular biology, particularly those in the developed countries. Furthermore, IAROs can provide technical and policy support to the NARS as they prepare to participate in international meetings that involve harmonization of policies and guidelines affecting the conduct of biotechnology.

A very important partner in this effort is the private sector. In the field of biotechnology, they have much to share and a network that includes private sector under mutually beneficial terms would be a great advantage to research.

Genetic Resources Conservation. Among the IAROs, the CGIAR centers have gathered enormous quantities of collections of crops, forage and agroforestry species. The collections numbering about 600,0000 accessions are held in trust for the benefit of the international community. Many national programmes have obtained materials from these collections and used them for their varietal improvement programs. These collections are available freely and free-of-charge to both public and private sector. However, these materials are shared on the condition that no intellectual property protection be obtained on the material *per se*. The collections and the work done at the centres to characterize, evaluate and enhance the material have been considered valuable contributions to research in food and agriculture. Therefore, it is important that long-term continuing support for genetic resources conservation must be assured.

Policy Research. International research centres undertake policy and socioeconomic research on the impact of biotechnology and information technology, especially among the poor countries. These studies are intended to understand how policy distortions, institutional deficiencies, and ill-defined public goods create barriers to the diffusion and adoption of new technologies. Policy studies may cover the following:

- legal and policy issues on food, agriculture and resource use, IPR, risk assessment;
- improved use of technological advances responsive to the goal of poverty elimination capitalizing on biotechnology, precision farming, geographical information systems, participatory breeding, and extension techniques.

The results of these studies must be shared with the NARS so that proper interventions can be instituted.

Concluding Statements

Thus, in this era of expanding knowledge and faced with the challenges to apply new tools towards the elimination of poverty, a strong partnership is needed among all sectors involved in research and development. The international agricultural research organizations have the comparative advantage to promote these partnerships. It has been suggested that these partnerships should be widened and diversified to include academic institutions, private foundations, corporations, small and medium enterprises, professional organizations, NGOs, peoples' organizations, farmers and others.

To ensure the effective delivery of new technologies to the resource-poor farmers, international agricultural research organizations and other research institutions, public or private, must now work together and explore new modes of institutional governance and institutional arrangements that should be transparent, flexible, mutually beneficial and efficient.

Communicating Biotechnology: Conquering the Fear of the Unknown

Julie Howden[1]

The ASEAN biosafety regulations and developments including the Cartagena Biosafety Protocol as they relate to communication of biotechnology to the public are briefly discussed. According to AFIC studies, although there are ASEAN biosafety guidelines in addition to country-specific guidelines, most ASEAN consumers are not aware of these. Consumers are confused because of (a) scarcity of scientifically correct and balanced information; (b) general unfamiliarity of the public with even conventional methods of crop production, much less, biotechnology-assisted crop production; (c) fear of new technologies, and (d) differences in global acceptance of biotechnology. The author further discussed the theories on risk communication and their implications for education program in biotechnology. These include trust determination and risk perception.

Communication is a topic that is frequently overlooked, yet is vitally important to biotechnology. The success of this technology will depend on its acceptability to consumers. Consumer acceptance will depend largely on how well the science is communicated.

This paper will provide: 1) a brief overview of the ASEAN biosafety regulations and developments and highlight a few points which are relevant to the topic of this paper; 2) risk communication theory; 3) some of the research that Asian Food Information Center (AFIC) has done on Asian consumer attitudes toward genetically modified (GM) foods; and 4) some implications for communication programs.

Food Safety and Biosafety Regulations

Our research shows that one of the key issues for consumers is whether or not these GM foods are safe and biosafety regulations have a lot to do with that perception.

There have been significant developments in the whole area of risk assessment, including Codex and the Cartagena Biosafety protocol. There are ASEAN biosafety guidelines in addition to country-specific guidelines. Yet most Asian consumers do not know this. They have no perception at all that these foods are regulated, which makes them uneasy and keen to source additional information.

Codex is the reference for food safety issues evolving from the World Trade Organization (WTO) and is based on scientific principles and transparency. There have been two Food and Agriculture Organization/World Health Organization consultative meetings on biotechnology. The recommendations coming out of these meetings included: 1) establishment of comprehensive and enforceable food regulations by national authorities; 2) that nations seek to keep pace with technological developments in this area; 3) the adoption of appropriate strategies in the evaluation of food derived from biotechnology, and 4) that safety assessments should be based on sound science.

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Another recommendation is that consumers must be provided with sound science-based information on biotechnology and safety assessment.

One key point that came out of the Montreal meeting, which resulted in the Cartagena Protocol held in May this year, was that there is a need to avoid any confusion between food safety and labeling issues. Another key point was that labeling is not intended to replace a safety evaluation. There is a lot of misperception about this. Codex has labeling regulations under discussion. And while there is agreement on the definitions for labeling, there has been no agreement reached on how labeling will be approached.

ASEAN also has guidelines on the risk assessment of agriculture-related GMOs. These are legally non-binding and have no precedence on national legislation. However, they provide a very good framework for science-based risk assessment. They also have attachments with a step-by-step checklist to guide regulators and risk managers on the assessment of product. But they exclude compensation and liability issues. They do not discuss labeling. And there were no socioeconomic or religious factors discussed in the document. Individual countries also have their own biosafety regulations.

The need for public awareness campaigns was discussed during the 21^{st} **MAMF** meeting. The importance of biotechnology was noted during this meeting and the need to communicate with the public about biotechnology was identified. There was an ad-hoc task force meeting in Jakarta in March of this year looking at ASEAN public awareness programs. Ten countries attended that meeting and the group identified target groups, strategies, and programs.

Why Are Consumers Confused?

If all of this work is underway, in terms of risk assessment, regulations, and public awareness campaigns, why are consumers confused? There are several reasons for this.

Our research shows that the number one source of information on biotechnology in every market in Asia is the media. And unfortunately, a lot of information that is printed is controversial. It is often not based on the science, contains very emotive language, and can be extremely misleading. This is not the media's fault. The fault lies in the lack of good risk communication by the scientists and regulators involved in this area.

A search in the Internet shows that 90-95 percent of information on biotechnology or genetically modified foods there is extremely negative. It uses very emotive biased terms and a lot of it is not based on the science. There seems to be a scarcity of information out there that is scientifically correct and balanced.

The general public is not familiar with even conventional methods of crop production. They do not know about genes. They know nothing about genetics. In AFIC's research on consumer knowledge and attitudes toward biotechnology in Asian countries, questions relating to knowledge of genetics in agriculture were asked. For example, one question asked: "Is this statement true or false? *A genetically modified soy plant contains genes but normal soy plants do not*." Most people in Asia will agree with that statement and believe that conventional plants do not have genes but genetically modified ones do.

Of greater concern is that when we asked them if eating a product, which had been genetically modified, would also change their genetic makeup, about 30 percent agreed. Significantly more did not know if this was true or false. So, as you can see, there is a lot of work to be done in terms of educating people.

Added to this is the fear of new technologies. Throughout history, people have been afraid of new technology. When the first telephone was introduced, people thought that they would be electrocuted, so they did not use it. People believed initially that immunization would make them would grow horns or take on the characteristics of animals.

There is also a lot of confusion over the differences in global consumers' acceptance of biotechnology. People in Asia have looked at the dispute between Europe and US, and asked what's going on? Why isn't Europe accepting this? Is this a safety issue or a trade dispute?

The polarization of supporters and opponents has generated a lot of noise and confusion. The terminology used by the different sides adds to this. For example, an opponent to biotechnology uses terms such as “artificial,” “genetically engineered,” “manipulation,” and “tampering.” On the other hand, a supporter tends to use a totally different terminology.

AFIC’s research shows that in Asia, people see genetic modification/food biotechnology as a means by which foods are processed. So essentially, there's very little awareness of what biotechnology is about. When the terminology is explained to them by a simple description, they are not particularly negative but they still have many misconceptions, particularly the belief that perhaps the technology will involve the use of additional chemicals and additives in the food supply.

Risk Communication Theory

There are two main theories that are related to communication in situations where there is a perceived risk and the findings have implications for education programs on biotechnology. The first of these is **trust determination**. The extent to which someone will listen to your message will largely depend on how much they trust you. A lack of trust can lead to distortion of the message you are trying to convey. The level at which somebody trusts you depends on your level of empathy with them and your credibility. Can they relate to you or are you standing there as a scientist or a government regulator spouting a lot of scientific information that they do not understand? Are you expressing any empathy with them, do you understand their real concerns? Credibility relates to the extent to which the audience believes the communicator to be honest. For example, there is a lot of resistance to accepting information from the industry. Despite their level of expertise, they are not deemed as credible as other sources of information. The perceived credibility of government varies by country, being high in countries such as Singapore but low in many parts of Europe.

The second theory is on **risk perception**. Depending on how much risk an individual perceives there to be, they can become quite frustrated. And as scientists, what often happens is you relay information about what you perceive to be the real risks. You've done the research, you know the evidence, you are very learned. As an “expert” in the area, you convey what you believe to be the issues and the real concerns. Unfortunately, the consumer often does not understand the terminology being used and, in many cases, has concerns different from those of the “experts.” Many of the consumer concerns that have been picked up in our research are quite different from what the “experts” see as the issues in biotechnology.

In risk communication, you need to respond to consumer concerns. This means listening to what consumers are saying and answering their concerns.

Over the past 12 months, print media coverage on biotechnology has risen significantly. In terms of a percentage of the total print media coverage of food, food safety and related issues, biotechnology has gone from about 20 percent up to 50 percent. This means that there is a lot of “noise” out there and a lot of conflicting information. This causes confusion and acts as a block to communication efforts. To cut through the noise, messages need to be clear, simple, and concise - or they will be lost.

Risk communicators need to be aware that science alone is not necessarily going to be enough. In a situation such as biotechnology, which is highly emotive, people are concerned. Science alone is not going to win the day. Communication programs need to be carefully planned and executed and involve professional communicators.

Once people form beliefs, they are difficult or even impossible to change. One of the problems in Europe was that the activist groups put out a lot of misinformation that was not addressed by scientists. People can hear something once and they might form an opinion about it. If it comes from a credible source, that opinion might be quite a solid opinion. If somebody then tells them an opposing opinion, they will tend to stay neutral, once again depending on the credibility of the source. Research shows that four pieces of information repeated four times from a credible party lead to the formation of a belief. This means that inaccurate or unscientific messages that are not countered will lead to the establishment of beliefs. Parties involved in education programs around biotechnology must be aware of the need to counter misinformation in a timely manner before it develops into a belief.

The goal of any party in the communication of science must be to communicate in ways that serve both public understanding and the goals of communicators. Biotechnology is a very complex subject and is very difficult to communicate, particularly given the lack of information in the community. Joint programs and consistent messages from all parties involved in the communication process offer the best opportunity for improving consumer understanding. ASEAN programs should be coordinated regionally for maximum effectiveness. Programs such as this conference can provide opportunities to discuss issues, debate programs, and debate various approaches.

Biotechnology will evolve in much the same way as did the Green Revolution and other technologies if the education process is executed effectively. It has started off as a very emotional issue with little awareness or understanding. It is now progressing (or will progress, hopefully in Asia) toward improved consumer understanding and the addressing of the real issues and informed opinions. It will progress from being perceived as a local situation to one with a global perspective, particularly with the trade issues going on. It will progress from looking at safety issues to one of consumer choice, as the biosafety regulations and labelling issues are sorted out.

James Watson, co-discoverer of the DNA structure stated:
"I'm worried about a lot of things, but not modified food.
To argue that you don't know what is going to occur is true about everything in life. People will never get married, never have children, never do anything.”

A lot of concerns people have expressed through our research was related to the long- term health effects of modern biotechnology products. But you can argue just about anything and this quote puts it all in perspective.

Biotechnology and Biosafety in ASEAN

Linda S. Posadas[1]

Work undertaken by the Association of South East Asian Nations (ASEAN) in the area of biotechnology and biosafety is reported, with special emphasis on the developments in the last three years. An increasing interest on the issues involved, including its bearing on public policy and the need to address them regionally, are manifested in the decision of the ASEAN Ministers for Agriculture and Food (AMAF) to adopt a set of harmonized guidelines in agriculture-related genetically modified organisms (GMOs). The methodology to build consensus among the ten member countries of ASEAN is also described. Programs lined up for implementation and future challenges that the region must address are also discussed.

Introduction

The ASEAN Secretariat welcomes the opportunity to participate in the SEAMEO SEARCA Regional Conference on Agricultural Biotechnology. SEAMEO's concerns have been very close to those of ASEAN. We serve the same member countries, and it is but fitting that the two regional organizations cooperate with each other in reaching similar goals for the region.

Not being sure that everyone in the Conference would know what ASEAN is. This presentation has been structured to begin with a brief introduction of the organization, starting with some general matters such as its history and its vision, and then proceed to focus on the topic of concern in this Conference, which is agricultural biotechnology. The presentation will end with a summary of steps being planned by ASEAN in this area, and a discussion of other related issues that the region must address in the near future.

Introducing ASEAN

Adopted in 1967 on the occasion of ASEAN's 30th anniversary, the ASEAN logo represents a stable, peaceful, united, and dynamic ASEAN. The colours of the logo – blue, red, white and yellow – represent the main colours of the crests of all the ASEAN countries.

The blue represents peace and stability. Red depicts courage and dynamism, white shows purity, and yellow symbolizes prosperity. The ten stalks of rice padi represent the dream of ASEAN's Founding Fathers for an ASEAN comprising all the ten countries in Southeast Asia bound together in friendship and solidarity, cooperating voluntarily for the common good, with peace, as well as economic, social and cultural development as its primary purposes.

This dream was enshrined in the ASEAN Declaration, signed in Bangkok in 1967 by 5 founding members, namely Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The Declaration states that:

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"The Association represents the collective will of the nations of Southeast Asia to bind themselves together in friendship and cooperation, and through joint efforts and sacrifice, secure for their peoples and posterity the blessings of peace, freedom, and prosperity."

Since then, ASEAN has grown into the full 10 member countries, with Brunei Darussalam joining in 1984, Viet Nam in 1995, and Lao PDR and Myanmar in 1997. Cambodia was the last to join, having been admitted to membership only in 1999. The five-year period 1995-1999 marked the fastest rate of expansion during which 4 countries were added to the membership.

The goals of peace, and economic, social and cultural development led to the pursuit of cooperation activities in these areas. These are the political security , economic, and functional areas. For example, in economic cooperation, ASEAN bodies have been established in the sectors of agriculture, trade, transport, energy, tourism, etc., to spearhead regional cooperation in their respective areas of concern. Social and cultural development activities are generally grouped together under the term "functional" cooperation. Science and technology is also included as a functional cooperation area.

ASEAN Vision 2020

In 1997, as it anticipated the dawning of the 21st century, ASEAN's leaders issued ASEAN Vision 2020, which encapsulates the three main long-term goals, succinctly stated as:

"… a concert of Southeast Asian nations, outward looking, living in peace, stability, and prosperity, bonded together in partnership in dynamic development, and in a community of caring societies."

It is essentially a re-affirmation of the original goals in the Bangkok Declaration. The attainment of the goals of political and security cooperation is captured in the phrase "a concert of Southeast Asian nations"; the goals of economic development in the phrase "partnership in dynamic development" while the social and cultural concerns are captured in the term "a community of caring societies."

Hanoi Plan of Action, 1999-2004

To realize the goals of ASEAN Vision 2020, a series of action plans will be adopted and implemented. The first of these is the Hanoi Plan of Action, covering the six-year time frame 1999-2004, which would identify 10 priority program areas. Of relevance to the theme of this conference are the programs in food, agriculture and forestry, in environment, and in science and technology.

By bearing in mind the factors of: 1) ASEAN's overall goals of economic, social and cultural development, 2) the general economic situation among the member countries, where agriculture still remains an important part of the development agenda, and 3) the sweep of globalization riding on liberalization efforts in trade, investment and capital market, and on the easier flow of information, it is easy to understand why

ASEAN would decide to pursue cooperation in biotechnology, especially its applications in agriculture and the environment. And in so doing, ASEAN also has to grapple with related issues on biosafety.

ASEAN Bodies Concerned with Biotechnology and Biosafety

There are 3 ASEAN sectoral bodies that deal with biotechnology and biosafety issues, each one with its own mandate, structure and mechanisms to handle the technical and policy aspects of the matter. The first of these is the ASEAN Ministers for Agriculture and Food (AMAF) who tackle the issues from the twin perspectives of the promotion of trade in ASEAN food products and food safety. Implementation of cooperation programs in food, agriculture and forestry is handled by the Senior Officials Meeting on Food, Agriculture and Forestry (SOM-AMAF). The SOM-AMAF has organized, among its many technical working groups and subsidiary bodies, a Task Force on the Harmonization of Regulations for Agricultural Products Derived from Biotechnology.

The second ASEAN body with interest in biotechnology and biosafety is the ASEAN Committee on Science and Technology (COST), which approaches it from the perspective of research and technology development and its utilization. For the purpose of overseeing overall conceptualization, implementation, monitoring and evaluation of joint Research & Development and training programmes in biotechnology, it has established a Sub-Committee on Biotechnology.

The third is the ASEAN Senior Officials on Environment (ASOEN) who deal with it from the perspective of environmental protection. ASOEN has a Working Group on Nature Conservation and Biodiversity to look at the matter in the context of international conventions and protocols within their purview, such as the Convention of Biological Diversity, and the Cartagena Protocol on Biosafety.

A quick look at some of the major program areas of SOM-AMAF, COST and ASOEN could give a better sense of the mandates of these three ASEAN bodies, and why their work in the area of biotechnology and biosafety are complementary to each other. AMAF's domain are the food, agriculture and forestry sectors, and some of its major programs are in food security, facilitation of intra- and extra-ASEAN trade in agriculture, fishery and forest products, agricultural rural community human resources development, and strengthening of ASEAN common position and joint approaches in addressing relevant regional and international issues. For example, in crops, the emphasis on trade issues is evident in SOM-AMAF's work on harmonization of phytosanitary measures and harmonization of maximum residue limits of pesticides for vegetables. In livestock, they are developing ASEAN standards for animal vaccines. Insofar as it is concerned with improving agricultural productivity through R&D and technology transfer, then it has an interface with the activities of COST.

COST looks at the broader, overall development of science and technology capability within the region through joint R&D, human resource development, regional networking of Science & Technology infrastructure and programs, and promotion of technology transfer. However, these activities have to be implemented in specific, identified economically significant sectors and disciplines, such as food science and technology, marine science, non-conventional energy, and biotechnology among others.

In particular, for the Sub-Committee on Biotechnology, the priority areas for the period 2001-2004 are in food and horticultural crops, improvement of livestock production, value-addition to natural products, and bioinformatics. From this list, the interface with SOM-AMAF can be easily recognized.

On the other hand, ASOEN's concerns are in the introduction of policy measures and institutional development. These promote the integration of environmental factors into national and regional development planning, establishment of long-term goals on environmental quality and work towards harmonization of environmental quality standards, and joint actions to address common environmental problems in the region, such as haze. ASOEN's work on promoting cleaner production techniques through the introduction and adoption of technology, or promoting technology solutions to environmental problems has an interface with the work of COST.

Moving on to specific ASEAN programmes and actions in biotechnology and biosafety, COST was the pioneer, having started joint R&D and training in biotechnology back in the 1980's. Since 1983, when the Working Group on Biotechnology (later renamed as the Sub-Committee on Biotechnology in 1989) was established, joint projects with some of ASEAN's Dialogue Partners have been pursued. These partners include the European Union, Australia and Japan in the earlier days, and more recently, India, Korea and China. These activities have contributed to the development of the infrastructure in the ASEAN member countries as well as to the training of staff.

While COST has been steadfastly pursuing joint R&D and human resource development in biotechnology since the early 1980s, the involvement of SOM-AMF and ASOEN is quite recent. This is to be expected, in view of the nature of their mandates being more in the realm of trade promotion, policy development and crafting of joint positions and approaches in the context of international agreements. SOM-AMAF's and ASOEN's involvement in biotechnology and biosafety were initiated only in the late 1990s. SOM-AMAF's involvement began when it agreed to take up Singapore's initiative on the harmonization of regulations for agricultural products derived from biotechnology in 1997. In the same year, ASOEN also agreed to develop a common protocol on access to genetic resources and related intellectual property rights. This was because by this time, genetic modification technology had moved out of the research laboratories and into agribusiness which has started marketing products derived from genetically modified organisms. Likewise, the search for genetic resources that might have relevant desirable properties for horticultural crops, for example, had also intensified, so that the issues of access and ownership of intellectual property rights were being intensely debated over around the world.

Recent Initiatives

The initiatives launched in 1997 progressed during the following year, with consultations among various stakeholders conducted by way of an ASEAN Workshop on Regulations for Agricultural Products Derived from Biotechnology, hosted by Singapore. This Workshop became the venue where baseline data on the various national regulations being imposed by the ASEAN member countries were established, as well as where the views of the private sector and civil society groups were heard.

Information reported by the ASEAN member states during the Workshop as to the status of biosafety regulation in their respective countries revealed that although a few member countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) have developed some guidelines of R&D and field releases of genetically modified organisms, none has a comprehensive legal framework to address commercial and consumers' concerns. The key weakness of the guidelines in these countries is that they do not have the force of law, and the standard S&T infrastructure for most operational procedures in risk assessment and risk management is weak. Much work remains to be done in ASEAN in the area of building up the institutional and legal framework, as well as developing the scientific and technical capacity to implement the framework.

The Workshop was followed at the official level by the creation of the Task Force on Harmonization of Regulations for Agricultural Products Derived from Biotechnology (ATFHRAPB) to attend to the drafting of harmonized guidelines.

In the same year, ASOEN also convened its first Workshop to draft a Framework Agreement on Access to Biological and Genetic Resources, held in Manila.

By 1999, SOM-AMAF started activities on public awareness of the GMO issue, with a seminar in Jakarta, again involving the participation of government, private sector, and national government organization (NGO) representatives. The drafted guidelines were also ready by this time, and the Task Force met to review the draft.

The SOM-AMAF laid down some principles to form the basis of the guidelines. These mainly defined the scope of the guidelines to cover the release of agriculture-related GMOs only, not their products. It also excluded questions of liability and compensation, labeling, and socio-economic issues. Furthermore, they also defined the framework within which the Guidelines will operate: as a statement of ASEAN's common understanding and approach to scientific evaluations of applications from various parties for the release of agriculture-related GMOs. They also agreed to go by the Food and Agriculture Organization (FAO) definition of substantial equivalence.

By October 1999, much of the work of the Task Force was completed, as the guidelines were ready for presentation to the ASEAN Ministers for Agriculture and Food, who subsequently adopted the Guidelines, now renamed as ASEAN Guidelines on Risk Assessment of Agriculture-Related GMOs, to better reflect its scope and framework. A significant condition stated in the adoption of the Guidelines is that they are legally non-binding and would not take precedence over national legislation. This condition has its roots in the very nature of ASEAN as an organization, which, in the words of the current Secretary-General of ASEAN, is "not meant to be a supranational entity acting independently of its members." [2]

Even more activities are being pursued this year, with SOM-AMAF continuing its work on creating public awareness on GMOs. ASOEN is also continuing with the refinement of its Draft Framework Agreement on Access to Genetic Resources.

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[2] Rodolfo C. Severino, Jr., "What ASEAN Is and What It Stands For", Remarks at the Research Institute for Asia and the Pacific, University of Sydney, Australia, 22 October 1998, *ASEAN Rises to the Challenge, A Selection of Speeches*, The ASEAN Secretariat, Jakarta, November 1999, pp. 83-100.

The ASEAN Ministerial Meeting on Environment held this year in Bandar Seri Begawan, Brunei, with respect to the Convention on Biological Diversity (CBD), also agreed to share information and promote better understanding on the position of member countries on specific issues under the CBD, especially on GMOs. In support of this decision of the ASEAN Ministers for Environment, Malaysia organized a regional workshop on Biosafety of GMOs.

ASEAN participation in the global debate on GMOs further intensified with the private sector weighing in, when the ASEAN Chambers of Commerce and Industry (ASEAN-CCI), an ASEAN-affiliated NGO since 1981, called for labeling of GMO foods and the development of science-based standards for testing the safety of GM food products , during a meeting with the US Business Council.

In the meantime, the Sub-Committee on Biotechnology continues its work, and is now preparing to conduct a workshop with China on Transgenic Plants, to discuss possible joint R&D and training activities. With the increasing calls for science-based standards for risk assessment and risk management of GM food products, COST is well aware of the urgent need to develop in ASEAN the technical expertise and facilities to undertake the task, and its important role in implementing such S&T infrastructure development and training programs.

Harmonized Guidelines on Risk Assessment of Agriculture-related GMOs

In summary, what is clearly a solid accomplishment out of the activities in the last three years is the adoption of harmonized Guidelines on Risk Assessment of Agriculture-Related GMOs. The guidelines are posted on the website of the ASEAN Secretariat at http://www.aseansec.org under the area of cooperation in food, agriculture, and forestry. They provide a common understanding of, and approach to, science-based evaluation of applications for the release of agriculture-related GMOs. The Guidelines also describe procedures for notification, assessment, approval, and registration of release of agriculture-related GMOs. A risk assessment questionnaire forms part of the Guidelines, to facilitate provision of required information by the parties proposing to introduce agriculture-related GMOs into the region. The questionnaire was developed by drawing upon the experience of ASEAN's dialogue partners Australia, Canada, and USA in the development of risk assessment tools.

Administratively, the guidelines call for the establishment of a National Authority on Genetic Modification in each member country, to oversee the implementation of the guidelines. Obviously, the implementation of the guidelines would have a bearing on the activities of researchers in GMOs, insofar as following the prescribed procedures for notification, assessment, and approval of the release of GMOs are concerned.

How has harmonization been arrived at? ASEAN followed its usual process of consensus building, essentially taking the following steps:

- Experts from the Ministries of Agriculture and the national biotechnology regulatory agencies in the member countries were mobilized to collect and jointly review baseline information on pertinent national regulations and guidelines and discuss the relevant technical issues;

- Consultations with other stakeholders, such as NGOs and business groups were conducted, to obtain their views on the technical and policy issues;
- A lead country, in this case, Singapore, was requested to draft the guidelines;
- The draft guidelines were presented to the member countries for review by an appropriately mandated body, in this case the ATFHRAPB;
- Further review and consensus building was conducted at the level of Senior Officials; and finally
- Adoption by the relevant sectoral ASEAN Ministers (AMAF).

This is a procedure that works well for ASEAN and ensures that the views of all stakeholders are duly sought.

After the adoption of the harmonized Guidelines, SOM-AMAF will proceed with the public awareness programme on GMOs. The public awareness program is designed to meet the following needs:

- To raise awareness among the ASEAN public comprising different age groups and educational and social backgrounds, including members of the press, on the utilization of GMOs and its implications;
- To provide clear and simple information to the public so as not to frighten them with too many technicalities;
- To clear the misconceptions and negative images such as references to "Frankenfood", surrounding GMOs as initiated and disseminated by certain interest groups;
- To generate resources to develop publicity and educational tools in various media formats to launch the program.

The relevant national bodies have embarked on the publication of brochures in the format of FAQs on GMOs, to help clarify the issues to the general public in a simple and layman-friendly manner. The Environment Ministers are expected to sign the Framework Agreement on Access to Genetic Resources when the document is finalized, and COST will continue with its R&D and human resource development activities to strengthen capability in the member countries to deal with GMOs.

The Next Step

Beyond these short-term activities, ASEAN would have to look at other issues and prepare to take action on them. Among these, clearly, are those that were excluded from the scope of the harmonized Guidelines, such as labeling of GMO foods. This is already the subject of a raging global debate to which the South East Asian scientific community must strengthen and contribute its expertise to the clarification of the technical issues, as well as to the design and implementation of the science-based assessments that will facilitate sound decision-making. As the subject has become more and more politically-charged, it is also important that the national decision-makers engage civil society in dialogue to ensure that the latter's views are taken into account in policy formulation. This approach helps build public trust in government regulatory mechanisms.

Specifically for COST, as the driver of ASEAN regional cooperation in science and technology, it must accelerate the pace of capacity building in biotechnology, with special attention to the newer member countries that are at a much lower level of development in the area of high technologies. In particular, it should work with SOM-AMAF in building up technical expertise at the national level on science-based risk assessment and risk management of GMOs.

In the case of ASOEN, it is posed to develop regional institutional mechanisms to address biodiversity concerns, including the upgrading of regulatory agencies' capacity to regulate biosafety, and establish biosafety clearing house mechanisms.

Conclusion

The adoption of the ASEAN harmonized guidelines on risk assessment of agriculture-related GMOs is but a first step in the region's efforts to keep at par with global developments in agricultural biotechnology. Because of the implications of biotechnology and its applications on trade, environment, human health, as well as on legal, religious and ethical matters, it is imperative that ASEAN prepare itself to address these issues. Aside from strengthening the legal and institutional framework to address biosafety concerns, capacity building in risk assessment and risk management, enhancing information sharing and networking, and building public awareness of biotechnology and its products are concerns that have to be addressed in an integrated and coordinated way, and on a sustained basis. ASEAN welcomes cooperation with other entities and organizations to get going in some of these activities.

Managing Technology Transfer in Agricultural Biotechnology

Tetsuo Matsumoto[1]

This paper describes strategies for managing technology transfer in agricultural technologies including biotechnology adopted by the International Cooperation Center for Agricultural Education (ICCAE). ICCAE is a Japanese international center for human resource development with the major objective to help resolve agricultural issues in developing countries through agricultural research and education via international cooperation. These strategies include: strengthening higher education and research system in agriculture in developing countries, formulation and development of consortium and networks among universities/research institutions in and outside Japan, training of young researchers from cooperating countries, development and implementation of technology transfer projects, and development and utilization of human resource database.

The challenge to developing countries such as most of SouthEast Asia, is to access and mobilize biotechnology for their own objectives. Japanese agencies and institutions have been involved in activities to assist developing countries in this regard. This paper describes the strategies adopted by the International Cooperation Center for Agricultural Education (ICCAE) based in Nagoya University, Japan in managing transfer of agricultural technologies including biotechnology.

Creation of Biotechnology Industry in Japan

In July 1999, Ministry of Education, Science, Sports, and Culture (MOE); the Ministry of International Trade and Industry; Ministry of Health and Welfare; Ministry of Agriculture, Forestry, and Fisheries (MAFF); and Science and Technology Authority, released their joint action plan for industrialization of biotechnology in Japan. They recognized that 1) biotechnology is the technology that would change human life in the 21st century by overcoming food and environmental issues, 2) biotechnology would influence the global competitive power of the industry and offer new business opportunities with high quality of job sites, and 3) competition on patenting genes would become intensified and a delay in becoming a major player in this area would mean losing a foothold in the industry.

The joint action plan for industrialization of biotechnology and its development includes the following :

1. Improvement of foundation for creation of biotech industry.

   a) Accelerated promotion of basic and fundamental study on genome analysis. As the country's leader in the rice genome project, Japan aims to complete analyzing all genomic sequences of rice by 2008 and officially announce the data to the public; determine the locations of about 20,000

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of cDNA sequences on the genomes by 2003; and isolate useful genes from rice by new methods, like micro array and elucidate their functions.

b) Enhancement of intellectual foundation and promotion of network. Towards this goal, the agricultural gene bank will be updated and revitalized in order to establish an efficient system of collection, classification/identification, storage, and supply of biological gene resources and linking of databases among national institutes and universities and opening these to the public.

2. Promotion of technology development and enhancement of industrialization support.

   a) Promotion of technology development for practical use. This aims to contribute to overcoming environment, energy and food problems using biotechnology. Technology development in research areas of genetics, molecular biology and microbiology that are expected to create new businesses, could be promoted by gathering research power from non-government services and by working closely with national institutes and universities.

   b) Expansion of fund support for industrialization of biotechnologies.

3. Establishment and strengthening of social aspects of biotechnology.

   a) Build up of appropriate research development systems conducive to original basic research. Basic research results are easily industrialized in biotechnology area. The new action plan has emphasized the need to promote original basic researches by increasing competitive research funds for basic research in universities and national institutes.

   b) Establishment of effective technology transfer system

   c) Securing biosafety and rationalization of regulation. This will entail updating and improving safety guidelines on recombinant DNA technology considering the past and immediate experiences on the development and commercialization of genetically modified organisms (GMOs). The ministries should mutually utilize the results of the studies on biosafety and promote their release to the public.

   d) Protection of intellectual properties

4. Promotion of public acceptance.

   The public should be informed of the value of research and development to generate technologies, research results and technologies developed, and the contributions of biotechnology to society through meetings, symposia, and multimedia.

The ICCAE

There are five international cooperation centers in five main areas: Primary Education in Hiroshima University established in 1996; Agricultural Education in Nagoya University in April 1999; Medicine at the University of Tokyo in April 2000; Technology and Sociology to be opened in 2001 and 2002, respectively.

ICCAE is the international center for human resource development to resolve agricultural issues in developing countries through agricultural research and education via international cooperation. It cooperates with international organizations and Japanese universities and organizations to develop cooperative work towards overcoming agricultural problems from the farmer level, as in extension studies, to the biotechnology level.

ICCAE has two divisions: one for project development and the other, for network-cooperation development. Activities under the Division for Project Development include development of project proposals for human resource development, analyses and evaluation of Japan International Cooperation Agency (JICA), university and non government organization (NGO) developmental projects in agriculture, dispatch of experts overseas and training of young researchers from cooperating countries. ICCAE is now involved in the following studies: 1) strengthening of higher education system at the Faculty of Agriculture, Namibia University in Africa; 2) development of a human development center at the African Institute for Capacity Development based in Jomo Kenyatta University of Agriculture and Technology, in cooperation with seven other universities in Kenya, Tanzania, and Uganda; 3) developing an agricultural curriculum for high schools in Paraguay; 4) development of a higher education and research system at the Royal University of Agriculture in Cambodia; and 5) transfer of biotechnology to the Southeast Asian countries.

The Division of Network Cooperation Development is in charge of 1) development of coordination method and utilization of database; 2) development of project management ; 3) formulation of consortiums and networks with universities and institutes in and outside of Japan and 4) training of experts. ICCAE has more than 2000 researchers in its database who can be tapped to work overseas as experts for various projects.

As a center of all universities in the agricultural area, ICCAE which is directly under the Ministry of Education (MOE), communicates and collaborates with all Japanese universities, JICA and MAFF including the Japan International Research Center for Agricultural Sciences (JIRCAS) for international cooperative studies. ICCAE provides data on human resources to MOE as well as universities, JICA, MAFF and international research institutes, and discusses candidates for the projects from which MOE or others, selects.

Further, ICCAE has a visiting fellowship system to invite researchers from overseas for cooperative study. For the year 2000, ICCAE is inviting three researchers from China, Cambodia and SEAMEO SEARCA in the Philippines. ICCAE hopes to develop consortium or cooperative linkages with various organizations worldwide.

Current Project of ICCAE on Technology Transfer of Biotechnology

With increasing population and decreasing agricultural lands, utilization of marginal lands such as saline areas for food production is an important area of research and biotechnology application for developing countries. Through modern biotechnology, it may be possible to transfer genes conferring salt tolerance to major crops such as rice. In cooperation with Japanese universities, ICCAE is in search of young researchers from Vietnam to study the transfer of the salt tolerance genes to a rice variety for the Mekong Delta. Researchers from various universities and institutes such as Canto University, Cuu Long Delta Rice Institute, Hanoi Agricultural University, Center of Biotechnology in Hanoi National University are now being considered for this project.

Key Issues to Succeed

One key issue to succeed in this technology transfer scheme is that the home institution of the successful candidate should be adequate to enable the returning researcher to teach as well as conduct research. This will also, to a large extent, minimize the possibility of immigration of the researcher to Japan or other industrialized country.

However, in cases where the home institutions lack certain facilities for experiments or analyses, it is envisioned that the researcher can make brief visits to Japan or perhaps Singapore for such purposes considering the high cost of the purchase and maintenance of certain biotechnology equipment.

Another key issue is the improvement and updating of regulations on biosafety, food safety, intellectual property rights and other relevant regulations in Southeast Asian countries to enable safe and acceptable movement of GMOs and technology transfer.

ICCAE is working with universities, institutes and authorities in and outside Japan to transfer biotechnology to Asia and assist in the updating of various regulations covering biotechnology and its products.

IPR In Southeast Asian Biotechnology

Frederic H. Erbisch[1]

The paper briefly reviewed the different protections given to intellectual properties (IP): copyright, patent, trademark, plant variety protection. With the advent of biotechnology development, concerns about patenting and licensing have increased. These concerns include: ability to exchange research materials, privatization of blocks of technology which may result in reduced availability of new biotechnologies, the costs associated with products utilizing biotechnology, implied licensing of all biotechnologies, and the impacts of IPs on the developing country's food supply and economy. The paper likewise briefly reviewed the IP protection available in Southeast Asia. It noted that most countries have adequate copyright and trademark laws in place. Although many countries have patent laws, their patent officers may not be able to effectively evaluate biotechnology patent applications. Plant variety protection laws or their equivalent are in various stages of development. Management of IPs at the local or institutional level was discussed. The need for an education/awareness program for researchers, administrators, and other concerns on research and intellectual property policies were emphasized.

Introduction

In the mid-1800's the United States government established the Land Grant system through which support was to be provided in agriculture and in engineering. Through this system colleges were established to provide this support. Michigan State University was the first such Land Grant college to be established wherein the college extensive agriculture research programs and outreach services were developed. Generally, new and improved crops and technical advances were given at no charge to the farmer, and as a result, a Land Grant philosophy was developed. This philosophy stated that whatever was developed was to be given at no charge to the farmer. Essentially this philosophy was followed until recently when industry became commercially interested in high tech agriculture/plant biology developments. These developments are often protectable through patenting and trademarking. When so protected, these developments are restricted in use by the owner allowing the owner to commercialize them. Consequently, the farmer must pay for such developments in order to use them.

These protectable developments are termed intellectual properties and their use is defined under the term "intellectual property rights" (IPR). Intellectual property protection is generally obtained through a governmental agency such as the United States Patent and Trademark Office. Such protection is available only in those countries where application is made and protection granted.

This trend in protecting intellectual properties in the agrisciences is affecting the entire world. It is making researchers more aware of the potential value of their work, it is resulting in a major reorganization of the agribusiness industry, and causing concern for farmers and governments in the availability and cost for agriproducts. This paper will discuss these impacts from the basis of intellectual property management, and particularly its impact in Southeast Asia.

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Intellectual Properties

Intellectual properties are ideas. When these ideas are reduced to tangible forms they, if new and novel, can be protected. This protection is such that the owner of the intellectual property is able to restrict its use with maximum restriction being that no one is allowed to manufacture, grow or sell the intellectual property. These forms of protection include copyright, trademark, plant variety, and patent. A brief description of each protection form, its cost, and use in agriculture will be given using experience from the United States.

Copyright protection is given for a number of things including written works, music, dance, photographs, paintings, and computer programs. Copyright protection is given when the creation is completed. There is no cost associated with obtaining this protection. The creator should appropriately mark the creation if the copyright is to be enforced (it is not necessary to do so, but is helpful if violations of the protection occur). Marking can be done by writing the word “copyright” followed by the name of the owner and the year when the copyright was granted. The copyright can be registered with the U.S. Copyright Office by completing a simple form and submitting with it a nominal fee of $20.00 US Dollars. The agency will assign the copywritten creation a number, which should be attached to the creation. Copyright protection, which prevents anyone from copying the creation without the creator’s permission, extends during the creator’s lifetime plus seventy-five years

Trademark protection is provided for logos, symbols, and short phrases. Trademark protection is only granted after application, review, and acceptance by the trademark office. The initial cost for a trademark is less than $2,500 US Dollars. In order to keep the trademark protected it is necessary to use it commercially and to pay periodic maintenance fees. Trademark protection prevents anyone else or any company from using the protected mark for their product or product line without permission of the owner. The agency in the United States handling trademarks is the U.S. Patent and Trademark Office.

Plant variety protection is given to sexually reproducing plants which are different from any other plant. In most cases, this protection is given to crop plants. An application must be prepared which details the particulars of the new variety, and if the office granting such protection agrees that the variety is new and unique, protection is granted. In general, this protection prevents anyone from growing or selling the variety without the owner’s permission. In the United States the cost of obtaining plant variety protection from the U.S. Department of Agriculture is approximately $3,000 US Dollars. The protection extends for 20 years for herbaceous plants and 25 years for woody plants.

Patents are granted for those creations which are new or novel, are unique, and have a use. These creations can range from mechanical devices, new chemicals or other new compositions, and genetic materials to methods and/or processes for accomplishing certain tasks. The protection granted by the U.S. Patent and Trademark Office is 20 years from the date of filing a patent application. The cost of obtaining patent protection can be very expensive. Costs may range from $5,000 US Dollars to many thousands of dollars more with the average cost ranging from $15,000 to $20,000.

All of these methods of protecting materials are used in agriculture. Some are more obvious than others, some are not usually noticed because one is so accustomed to seeing it. Examples of the use of each are provided. Three packages of Danvers carrot seed were purchased. Each package was prepared by a different seed company; NK Lawn & Garden Co., Lake Valley Seed Company, and W. Atlee Burpee & Co. The name of each company was trademarked as noted by a trademark symbol by the name and/or logo, so each was distinct and could not be confused with the other. The directions on the back of the packets described how to plant the seeds and although each gave the same planting instructions these instructions were presented quite differently. Each indicated their directions were copyrighted. Each company provided the same variety of seed but packaging and directions were distinct. This combination of factors is to influence the buyer into purchasing a company's seed initially and then to recognize it each time seeds of either Danvers carrot or some other variety were being purchased. It provides a means of recognition and valuation for the buyer. For example, if one were to buy all three packages of Danvers carrot seeds and plant them, and the carrots from one company grew better than the others, that buyer would continue to buy that company's seed. The buyer would tend not to buy seeds from the company whose seeds did not perform as well.

Plant variety protection is used by Michigan State University when new varieties of wheat, oats or beans are developed. Obtaining plant variety protection for these seeds allows the University to distribute these protected varieties as it believes is best. Recently three new varieties of wheat were developed and plant variety protection was obtained for all three. The University decided two varieties should be distributed publicly, should be grown and sold by the farmers, and the third variety was to be licensed privately where a single company would reproduce and sell the seed. These decisions were based upon several factors: ease of reproducing seed, need for high standards for the seeds and the potential market. The two public market varieties were easy to grow, maintain seed quality, and were similar to varieties already being used by farmers. On the other hand, the licensed variety was more difficult to reproduce, to maintain quality and was very new to the marketplace needing considerable marketing. In their own way, each variety was successful. Without plant variety protection, the University may not have been so successful in distributing these varieties nor would the farmers necessarily have benefited from them.

Patent protection for non-biological technologies in agriculture is common and not questioned. Most farm equipment is protected by patents; usually a number of patents protect a number of items on a piece of equipment. The University developed and patented a means of separating bedding sand and cow manure. The invention utilized several pieces of equipment already in the marketplace, putting them together in a unique manner to effect the separation. The company which licensed the University patent owned the patents for several of the pieces of equipment utilized. It did not own the patents for one part. The licensing company worked out an arrangement with the owners of the other patented equipment and now have on the market a unique machine which has various parts protected by three different organizations' patents. Licensing this technology was critical for the University because it could not manufacture the separator and sell it. It did not have in place the means of acquiring patents from others and, most importantly, it wanted the equipment available for the farmers to use. No objections were made about the patenting and licensing this arrangement.

Patenting of biotechnologies is quite new, but just as important as protecting mechanical inventions. Again, by patenting biotechnology developments, one can determine how these developments can be used. Many research organizations discover new biotechnologies, particularly new genetic materials and their use, but few are able to take them beyond the "bench top" or to the commercialization stage. Patenting and licensing allows the research organization to locate the best and most able to carry forward a research discovery of a product needed by the farmer. The University has isolated, characterized, and proven certain genetic materials important in drought and cold resistance. In order to carry these findings forward, it was necessary to find a partner who could get the genetic materials into commercially important plants and still retain certain rights for University researchers. By protecting and then licensing, this goal has been achieved. The biotechnology was protected by more than six patents or patent applications and was licensed to a company that had a number of milestones and goals to its name in order to meet the University's expectations.

Today's Concern For Intellectual Properties

As stated earlier, new mechanical devices or improvements for agriculture have routinely been patented and licensed. Patenting a new device or improvement and licensing it is not questioned or protested.

With the initiation of biotechnology development, there has been considerable concerns about patenting and licensing. These concerns include: the ability to freely exchange research materials, the privatization of blocks of technology resulting in drastically reduced availability of new biotechnologies, the costs associated with products utilizing the biotechnology, the implied licensing of all biotechnologies, and the question of how this might impact the developing country's food supply and economy.

One of the main factors involved in causing this uneasiness is the aggressive nature of industry in developing biotechnologies. These agribusinesses are not only moving aggressively to acquire new biotechnologies, but are also active in consolidating and merging with each other, making it difficult to know from day-to-day who owns what. The aggressiveness is persistent because these companies must make a profit from sales of some form from the biotechnology they acquire. Universities, government agencies, and research institutions (basic research researchers) do not have a profit motive, thus, and these researchers are more interested in conducting research and exchanging research materials. It is these universities, government agencies, and research institutes that do most of the basic research, needed by industry to move forward. In turn, industry uses these basic research findings in its development work to a point where it can be used by the public. These researchers usually only continue their research until they have proven a point or a concept. They are seldom interested in doing development work because most researchers do not have the facilities or support to carry on the development work. These researchers find their reward in publishing papers in scientific journals, educating graduate students, and getting additional funds to continue their research. Meanwhile, industry is profit motivated and is not interested in publication or graduate student education. Industry does support some basic forms of research but only those which they can benefit from.

While basic research and commercial development may seem at odds, they are also very dependent upon each other. Without the basic research results, industry would have little biotechnology development work. Without biotechnology development work, fewer graduate students would be employed after graduation and researchers would be scrambling to find sufficient research funds. These two sectors can actually benefit each other. Together they can develop the food crops that will 1) produce more food per plant, 2) produce pest and disease resistant plants, 3) produce plants which can grow in new areas (i.e., increased drought resistance) because they are able to withstand the rigors of an area, and, eventually, 4) produce plants, which yield large amounts of food materials on less land. All of these objectives need to be met in the near future in order to sustain the earth's growing population.

Basic research institutions and industry do not naturally work together in a harmonious manner. A number of steps must be taken to enable each of them to preserve their basic values and yet benefit from each other. The basic research institution must be able to publish, allow graduate students to experience collegial interactions and publish their theses, and promote funded research composed and directed by researchers. The industry partner must be assured of cooperation in converting basic research results into commercial development, of confidentiality of terms of data, and certain business activities that will be able to realize a profit from this effort. In order to do all this it, is important for both parties to put various agreements in place, to protect new intellectual properties, and to adhere to each party's terms and conditions as well as protection requirements.

Biotechnology Intellectual Property Management in Southeast Asia

In order to have a successful "marriage" between biotechnology basic research institutes and industry, particularly in intellectual property management, the following questions should be asked. First, what is required and is this available in Southeast Asia? Secondly, what impact will this interaction have on the government and the people of the Southeast Asian region.

In the United States this interaction between basic research and industry is developing fairly well. Some research institutions are working closely with industry. Industry on the other hand makes its biotechnology research available to the public. However, there are still many questions, concerns, and uncertainties in this relationship.

What must be in place in order to effectively handle biotechnology creations, distribute the creations, interact with industry, assist the biotechnician, and handle other opportunities associated with biotechnology? The following is a list of items needed to effectively deal with biotechnology. The items are briefly described related with biotechnology intellectual property management, and indicated in terms of status within the Southeastern Asia community. This discussion will also include the status of a particular term in the United States.

National Level:

1. Copyright laws. Most Southeast Asian countries have adequate copyright laws in place. Usually there is sufficient staff available to handle registration of copyrightable materials. However, few countries have the ability to enforce copyright protection continuously. Copyrights provide important protection for written descriptions of

products, processes, methods and directions. One especially important consideration is DNA sequencing. Usually the DNA sequence of a gene, such as gene fragment, plasmid, etc. is written, and copyright protection is important to preserve the creator's right to this material. Computer software is an important aspect of copyright protection too. It provides numerous uses in routine and specialized biotechnology applications and research procedures.

2. Trademark laws. Most countries have adequate trademark laws and offices to handle registration procedures. Similarly, trademark protection is a problem and few countries have adequate personnel to handle its enforcement. Trademarks are extremely important in product and company recognition especially now that the biotechnology field is growing. Agricultural products purchased are often done so because of product identification linked to a particular trademark. For example, "Roundup" resistant crop varieties are related to one company and are easily recognized by trademark. Likewise, trademarks in Southeast Asia are used for many products. However, this application to biotechnology developments for use outside the area is not well established. It is expected that as biotechnology programs expand further, the use of trademarks will also expand. In the United States and Europe trademark protection is used extensively in biotechnology applications as well as non-biotechnology areas.

3. Plant Variety Protection. New plant varieties, whether developed traditionally (breeding) or through biotechnological processes, are inadequately protected in Southeast Asia. This includes new crop varieties developed within the area as well as outside. At a meeting held this spring in the Philippines, a number of countries indicated that they had limited or no plant variety laws. If laws for plant variety protection are not in place, then there is no way in which new varieties can be protected or preserved for the creator of the new variety. The United States has plant variety protection laws, adequate staff to register new varieties as well as the ability to enforce these laws. Some people believe that protecting a variety means that it should be licensed and/or sold but not given to farmers for free. This is not true. Protection allows the owner of the protected variety to determine how to distribute the variety. The variety can be licensed, sold or given away. The owner of the protected variety has the prerogative to keep or give it away. However, the protected variety cannot be taken by anyone else without the owner's permission.

4. Patents. Many countries do have patent laws. However, protection for biotechnologies or plant varieties are not included. Patent offices in many developing countries are usually understaffed and unable to handle efficiently and effectively patent applications. Most of their patent examiners have little or no knowledge of biotechnology. Thus they are unable to handle and properly evaluate biotechnology patent applications. In addition to having inadequate staffing there are also not enough people able to enforce patent laws. In Southeast Asia most of the countries have biotechnology patent problems as well as inadequate patent offices and enforcers. Moreover, only a handful of people are trained to evaluate biotechnology patent applications. The United States is just the opposite. It has appropriate and adequate patent laws, proper staffing of patent examiners and enforcers, and is able to effectively evaluate biotechnology patent applications. Anyone who files for patent protection in the United States knows that despite the considerable cost, the technology filed for patent will be reviewed extensively and, if patented, will be protected. On the other hand, this is not true for filing biotechnology patent applications in many developing countries. The cost may be lower, but questions are raised regarding protection obtained. This doubt

can also affect potential interactions between scientists in developed and developing countries. Would a scientist who has developed a new biotechnology want to share this to someone who may not have the means to protect the intellectual property?

Local Level:

1. Policies. The proper handling of intellectual properties is best done under policies established by the research institute or agency. The policies describe how intellectual properties are to be handled, by what office or individual, how assistance is provided, and by whom. It also describes ownership of newly developed intellectual properties, and who reviews agreements and contracts regarding acquiring and/or licensing out intellectual properties. Policies comply with national and international intellectual property laws. These policies give the researcher direction on how to handle intellectual properties, show the researcher who handles the "paperwork", provide guidance for acquiring intellectual properties necessary to conduct a research program, give limitations on how contracts and licenses can be drafted and/or negotiated, and how costs and/or receipts are handled. An example of a simple patent policy is the one currently being used by Michigan State University. This policy is as follows:

> "Except as otherwise provided by Board-approved policies or legal instruments, any discovery or invention which results from research carried on by, or under the direction of, any employee of the University and having the cost thereof paid from University funds or from funds under the control of, or administered by the University, or which comes as a direct result of the employee's duties with the University, or which has been developed in whole or in part by the utilization of University resources or facilities, shall belong to the University and shall be used and controlled in such a manner as to produce the greatest benefit to the University and the public.
>
> For purposes of this policy, the term "employee" shall include all faculty, staff and students (including postdoctoral appointees, graduate and undergraduate students) engaged in research conducted under the conditions defined above.
>
> Patenting and licensing expenses for each patent will be recovered from its royalty earnings and distributions will be made from the net royalties remaining. Net royalties from licensed inventions will be distributed according to the following schedule:

Net Royalty Income on a Particular Patent	Inventor(s)	Academic Units	University
First $l,000	100%	0	0
Next $100,000	33 1/3%	33 1/3%	33 1/3%
Next $400,000	30%	30%	40%
Next $500,000	20%	20%	60%
All Additional Net Royalties over $1,001,000	15%	15%	70%

The administration of Michigan State University patent matters, including technological know-how that may be licensable but may not be patentable, shall be the responsibility of the President. Patent matters include such activities as accounts, records, and negotiations. Particular patents or items of technological know-how may be transferred to the Michigan State University Foundation for administration. The President has delegated this authority to the Vice President for Research and Graduate Studies.

In addition to this policy are polices at the University concerning copyright, publication, conflict of interest, and other pertinent matters. The researcher knows that it will not be his/her responsibility to negotiate contract terms, draft patent applications, sign documents, etc. and that the research program is the most important duty for the researcher. The researcher knows that if proprietary materials are needed for the research project, there will be an office and/or individual who will handle all legal matters such as drafting a materials transfer agreement, which allows researchers from several institutions to work together (see Attachment A), and who will put together an agreement dealing with intellectual property matters for a potential research project (see Attachment B). Because intellectual property policies, along with appropriate laws, do exist at research institutions and in industry in the United States the interactions between these groups are facilitated. Grey areas still exist under these conditions, but these can be negotiated and usually overcome so parties can work together successfully.

Interactions with a number of Southeast Asian research institutes, agencies, and universities have shown that few have appropriate policies in place to handle intellectual property matters. On the other hand, some that do have policies in place have no staff, because of budget cuts to manage these policies or work with research staff. Research staff expressed concern over intellectual property matters, which are adversely affecting their research programs.

2. Education. In addition to having research and intellectual property policies, all parties must be educated in the importance of these policies, their use, and application to research and development. This educational program should include a familiarity with national and international intellectual property laws which promotes awareness of the importance of intellectual property protection for research efforts. Great strides in intellectual property education are being made in Indonesia, Philippines, People's Republic of China, and Thailand. India and Bangladesh have initiated programs and will have key government representatives in intellectual property management training programs.

Recently, a document was received which contained a statement showing a researcher's naivete regarding the value of intellectual property. This statement was essentially as follows: "Do not worry about protecting any intellectual property developed in the laboratory since we are from a poor country, the intellectual property will have very little value." This statement is absolutely false. Valuable intellectual properties can come from any country regardless of its economic state. Awareness of the potential value of an intellectual property is important and education can help in its assessment. As a result of this statement, an intellectual property education/awareness program was initiated for researchers from Central and South America who were involved in a cowpea research program. Today, the researchers are taking a much different view of their endeavors. Researchers in Europe and the United States are fairly well versed on the importance of intellectual property rights. Southeast Asia on the other hand, is beginning to make progress in this area.

3. <u>Customs.</u> Handling of new products and processes, whether of biotechnological origin or not, are often controlled by customs of an area. Landgrant universities in the United States, like Michigan State University, initially provided the farmer with new crop varieties and other agricultural improvements at no cost. This "free for all" philosophy was supported by the government. Eventually, machinery improvements were licensed to companies who could provide the equipment to farmers because few, if any, farmers had the capability to build farm equipment. Even into the early 1990s Landgrant universities were providing seeds of new crop varieties at no or little cost to farmers. Farmers came to expect free access to new crop varieties; it was the custom. As biotechnological developments became important in new crop variety development and the development of these new varieties became more demanding and costly, Landgrant universities stopped the free distribution of these products. Farmers were upset and demanded that these new varieties be made available to them at little or no cost – they said, "this is the Landgrant philosophy". It became necessary to educate the farmer on the need to handle biotechnologically developed crop seeds differently than seeds developed through traditional breeding. The time and expenses of developing these genetically engineered varieties were two important factors to consider. The safety of these new varieties needed to be ascertained more carefully because government standards must be met. As the farmer learned about the advances through biotechnology, he/she understood better why the Landgrant philosophy was no longer applicable. Also, the university had to review its procedures on releasing new varieties to be sure it interacts properly with the farmers it serves to provide those varieties at little or no cost.

In Southeast Asia the custom is to provide crop seeds at little or no cost to the farmer. From this comes the idea of not protecting new varieties or biotechnology developments because if protected, they cannot be given away as is the custom. This is not true. Through protection one is able to determine how to handle the development. It can be given away, it can be sold, it can be licensed or can be held from anyone who wants to use it. If a biotechnological advancement is made, which benefits the farmer of an area, protecting this development does not prevent the developer from giving it to the farmer. It does however, prevent someone else from coming in and claiming this same development and making restrictions, which may prevent the original developer from distributing as planned. It would also allow the developer to license the biotechnological advance to others and expect a financial reward for allowing the use of the biotechnology elsewhere. It is important to respect customs, but it also necessary to advance and to be alert with possibilities beyond meeting customs. In order to do this it is necessary to 1) educate researchers to look beyond the immediate goal of biotechnologies for free, and to look for other ways to extend the use of the biotechnology; 2) educate the farmer that it is not possible to provide everything for free or only to the farmer, and that looking beyond the farmer's immediate needs, the farmer may actually gain more; and 3) educate government officials so they understand that biotechnology developments may have ramifications far outside their country benefiting people throughout the world, and possibly bring additional revenue to the research and development program. This type of effort is being initiated in several Southeast Asian counties. However, more needs to be done to be able to obtain full realization of biotechnology utilization.

Summary

Understanding of intellectual property protection particularly for biotechnological developments is growing in Southeastern Asia. Through this awakening, plant variety protection laws are being drafted, patent laws are being updated, staff training is beginning, researchers are becoming aware of the importance of intellectual property protection, and government officials are beginning to realize the benefits biotechnology improvements can bring to their constituency and, perhaps the world. While the region is not as established as that of Europe or the United States in intellectual property awareness, utilization, and management, it is important to note its progress. Furthermore, developed countries are likewise encouraged to work in support of the developing efforts in Southeast Asia.

Attachment A

PARTNERS MATERIAL TRANSFER AGREEMENT

This Material Transfer Agreement (hereinafter "MTA") is entered into by and amongst the partners of the Research Program entitled ____. The partners are comprised of ______________________________, ______________________________, and ____________________________ (hereinafter "Partners").

The Partners agree as follows:

1.0 **Definitions**. The following definitions will apply to this MTA:

1.1 "Agreement" means the Intellectual Property Disposition Plan and any related research agreement for the above listed Research Program.

1.2 "Derived Materials" means Outside Materials which have been genetically or chemically manipulated by a Partner to change their molecular or genetic structure, their properties in genetic constructs, or their function when expressed or present functionally in a cellular environment.

1.3 "Effective Date of this MTA" means effective upon signature by all parties below.

1.4 "Outside Materials" means all tangible property including, but not limited to promoters, enhancer sequences, expression elements, structural genes and gene fragments, fusion sequences, operons, vectors, plasmids, genetic cassettes and constructs, recombinant chimeric sequences, shuffled genes and operons obtained from a third party (a non-partner party) which is in the public domain, or was obtained by license or assignment.

1.5 "Partner Transfer Form" (herein after PTF) means a form containing a description of materials to be transferred, the Transferor and the Recipients, the purpose of the transfer, the intended use, and the date of transfer, and the additional information specified in paragraph 2.0 if the materials are Outside Materials or Derived Materials. Each MTA shall have a PTF attached.

1.6 "Research Data" means all data, sequences, test results, schematics, and any other information obtained or developed in the course and performance of the Research Program.

1.7 "Research Materials" means all tangible property obtained or developed in the course of performance of the Research Program including genes, deposits of any type, and research tools and methods.

1.8 "Research Program" means the research effort described in the proposal attached to this MTA, named in the introduction to this MTA.

1.9 "Transfer Materials" means the transfer from a Partner (hereinafter "Transferor") to one or more Partners (hereinafter "Recipient(s)") of any Research Materials (including any materials from a Transferor to be shared among the Partners but may have been developed prior to the initiation of the Research Program, or developed during the research term), Outside Materials, or Derived Materials.

1.10 “Work Plan” means the annual research work plan within the Research Program as defined by the MTA.

2.0 **Material Transfer**. Any Transfer Materials which may be useful to or in furtherance of any research objective under the Research Program may be transferred by one or more Partners to another Partner at any time during the Research Term. Any information accompanying the transfer or provided separately for the use of the Transfer Materials, or adapting them to particular applications shall be designated confidential in accordance with the Agreement. The transfer will be accompanied by a PTF containing the information set forth in paragraph 1.9 above. The PTF will contain further information about the origin of the Transfer Materials, the existence and terms of a license, and the retransfer provisions which may apply to the Partners.

3.0 **Effect of Transfer**. The transfer of materials shall not affect the ownership or other rights which the Tranferor may possess, and the Recipient acquires no rights therein by virtue of the transfer. In the event that a commercial product incorporates Transfer Materials, and such use of the material is outside the scope of the intellectual property provisions of the Agreement, then the commercializing party may negotiate a separate agreement with the Transferor or third party.

4.0 **Research Data**. Research Data generated by a Partner or through a collaboration of a Transferor and a Recipient shall be shared information, and not be treated differently than any other information obtained under the Research Program.

5.0 **Use of Transfer Materials**. Transfer Materials shall be used pursuant to the work plan as part of the Research Program. A Recipient agrees that, unless otherwise understood in a separate agreement between the Transferor and the Recipient, the Transfer Materials can and will be used only in conjunction with the Research Program, and not for other research activities that may be in progress in the Recipient’s laboratories or in the same laboratory. Laboratory personnel will be instructed that such use is restricted, and the Transfer Materials may not be used in a companion, related, or different project even if it would appear scientifically expeditious to do so. Pursuant thereto, the parties to this MTA will exercise diligence in preventing the inadvertent introgression of Transfer Materials into constructs, cassettes, cells of organisms, and the like used in laboratory research other than the Research Program. A Recipient of Transfer Materials (and any data generated therefrom) as it would for any other confidential information. It is further agreed that no Transfer materials will be released to any third party without notification of and approval of the Transferor unless otherwise required by law or court order.

6.0 **Warranty**. Any Transfer materials delivered hereunder is experimental in nature. Transferor MAKES NO REPRESENTATIONS AND EXTENDS NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR THAT THE USE OF Transfer Materials WILL NOT INFRINGE ANY PATENT, COPYRIGHT, TRADEMARK, OF OTHER RIGHTS.

7.0 **Term and Termination**. The term of this MTA shall be commensurate with the term of the Agreement and any extensions. In the event of termination according to the provisions of the Agreement, or upon their expiration, any Transfer Materials are subject to a third party contractual obligation of return or destruction, the Transferor and any Recipient will undertake to comply with such obligations. Any Recipient hereby accepts the same scope and degree of responsibility to comply with such obligations as the Transferor itself. Upon termination or expiration of the Agreement each Partner will construct a written or computer ready inventory of all Transfer materials in their respective possession.

8.0 **Handling**. All Transfer materials will be transferred, maintained, and disposed of in accordance with all applicable state and federal requirements and guidelines.

WHEREFORE, the Partners have executed this MTA as of the Effective Date.

Organization______________________	Organization______________________
By______________________________	By______________________________
Name____________________________	Name____________________________
Title_____________________________	Title_____________________________
Date_____________________________	Date_____________________________

Organization______________________	Organization______________________
By______________________________	By______________________________
Name____________________________	Name____________________________
Title_____________________________	Title_____________________________
Date_____________________________	Date_____________________________

Attachment B

INTELLECTUAL PROPERTY DISPOSITION PLAN

This Agreement between _______________________________________ business concern organized as a Corporation under the laws of _________________ and having a principal place of business at ____ ____, ("COMPANY") and ____________________________, a non-profit, research institution of _____________ ________________________ having a principal place of business at ____ ("INSTITUTION") is entered into for the purpose of allocating between the parties certain rights relating to a ____ project to be carried out by COMPANY and INSTITUTION (collectively known as the "PARTIES" and individually as the "PARTY") under a funding agreement that may be awarded by _________ to fund a proposal entitled ____ ("PROPOSAL") submitted by [INSTITUTION/COMPANY chose one here and adjust throughout] on or about ____________.

1. Applicability of this Agreement.

(a) This Agreement shall be applicable only to matters relating to the funding agent referred to in the preamble above.

(b) If a funding agreement for the PROPOSAL is awarded to INSTITUTION/COMPANY based upon the PROPOSAL referred to in the preamble above, INSTITUTION/COMPANY will promptly provide a copy of the funding agreement to INSTITUTION/ COMPANY and INSTITUTION/ COMPANY will make a sub-award to INSTITUTION/ COMPANY in accordance with the funding agreement, the PROPOSAL, and this Agreement. If the terms of such funding agreement appear to be inconsistent with the provisions of this Agreement, the PARTIES will attempt in good faith to resolve any such inconsistencies. However, if such resolution is not achieved within a reasonable period, INSTITUTION/ COMPANY shall not be obligated to award nor INSTITUTION/ COMPANY to accept the sub-award, as the case may be. If a sub-award is made by INSTITUTION/ COMPANY and accepted by INSTITUTION/ COMPANY, this Agreement shall not be applicable to contradict the terms of such sub-award or of the funding agreement awarded by __________ except on the grounds of fraud, misrepresentation, or mistake, but shall be considered to resolve ambiguities in the terms of the sub-award.

(c) The provisions of this Agreement shall apply to any and all consultants, sub-contractors, independent contractors, or other individuals employed by COMPANY or INSTITUTION for the purposes of this project.

(d) COMPANY warrants that the proprietary interests of any INSTITUTION employee in the COMPANY or the proposed project or the PROPOSAL have been disclosed as required by INSTITUTION policies and procedures. COMPANY acknowledges that if the involvement of INSTITUTION employees in the COMPANY constitutes a conflict of interest, any sub-contract resulting from this submission must be submitted to the INSTITUTION'S ________________________ for review and may need to be approved by INSTITUTION's _________________. COMPANY further acknowledges that if approval is not obtained, INSTITUTION will withdraw this PROPOSAL.

2. Background Intellectual Property.

COMPANY obtains no rights under this Agreement to background patents held by INSTITUTION or to related inventions or discoveries which are not conceived or made by one or more employees of INSTITUTION in the performance of this project ("INSTITUTION Background Intellectual Property"). To the extent it is able to do so, INSTITUTION will negotiate with COMPANY to provide COMPANY with rights, under reasonable terms and conditions to be negotiated, to use INSTITUTION Background Intellectual Property where necessary to allow the practice or commercialization of rights acquired by the COMPANY in the Project Intellectual Property as set forth below.

3. Project Intellectual Property.

(a) "Project Intellectual Property" means the inventions, patent applications, patents, copyrights, trademarks, mask works, trade secrets, and any other potentially legally protectable information, including computer software, first made or generated during the performance of this Agreement and the funding agreement.

(b) Unless otherwise agreed in writing, Project Intellectual Property shall be owned by the PARTY whose employees make or generate the Project Intellectual Property. Jointly made or generated Project Intellectual Property shall be jointly owned by the PARTIES unless otherwise agreed in writing.

(c) Project Intellectual Property shall be commercialized pursuant to the terms of a license agreement to be negotiated in good faith by the PARTIES. Expenses and other liabilities associated with the protection, development and marketing of any product, process, or other innovation or invention will be borne by the COMPANY that exercises its option to obtain exclusive commercial exploitation of Project Intellectual Property as provided below.

(d) The PARTIES agree to disclose Project Intellectual Property to each other, in writing. The PARTIES acknowledge that they will make this disclosure to each other within three (3) months after their respective inventor(s) first disclose the invention in writing to the person(s) responsible for patent matters of the disclosing **PARTY**. All written disclosures of such inventions shall contain sufficient detail of the invention, identification of any statutory bars, and shall be marked confidential, in accordance with 35 U.S.C. Section 205. (Or whatever patent laws would apply)

(e) Each PARTY hereto may use Project Intellectual Property owned by the other PARTY non-exclusively and without compensation in connection with research or development activities for this project, including inclusion (consistent with the requirement to protect Project Intellectual Property by patent, copyright and/or trademark) in project reports and proposals for continued funding of this project for additional periods.

(f) COMPANY will have an option to commercialize the Project Intellectual Property owned by INSTITUTION. The following terms will be included in the license agreement unless other provisions are mutually agreed to in writing:

(1) Where Project Intellectual Property of INSTITUTION is a potentially patentable invention, COMPANY will have an exclusive option for a sole license to such invention, for an initial option period of three (3) months after such invention has been reported to COMPANY. COMPANY may, at its election and subject to the patent expense reimbursement provisions of this section, extend such option for an additional three (3) months by giving written notice of such election to INSTITUTION prior to the expiration of the initial option period.

During the period of such option following notice by COMPANY of election to extend, INSTITUTION will pursue and maintain any patent protection for the invention requested in writing by COMPANY and, except with the written consent of COMPANY or upon the failure of COMPANY to reimburse patenting expenses as required under this section, will not voluntarily discontinue the pursuit and maintenance of any United States patent protection for the invention initiated by INSTITUTION or of any patent protection requested by COMPANY.

For any invention for which COMPANY gives notice of its election to extend the option, COMPANY will, within thirty (30) days after invoice, reimburse INSTITUTION for the expenses incurred by INSTITUTION prior to expiration or termination of the option period in pursuing and maintaining (i) any United States (or appropriate country) patent protection initiated by INSTITUTION and (ii) any patent protection requested by COMPANY. COMPANY may terminate such option at will by giving written notice to INSTITUTION, in which case further accrual of reimbursable patenting expenses hereunder, other than prior commitments not practically revocable, will cease upon INSTITUTION's receipt of such notice.

At any time prior to the expiration or termination of an option, COMPANY may exercise such option by giving written notice to INSTITUTION, whereupon the PARTIES will promptly and in good faith enter into negotiations for a license under INSTITUTION's patent rights in the invention for COMPANY to make, use and/or sell products and/or services that embody, or the development, manufacture and/or use of which involves employment of, the invention. The terms of such license will include: (i) payment of reasonable royalties to INSTITUTION on sales of products or services which embody, or the development, manufacture or use of which involves employment of, the invention; (ii) reimbursement by COMPANY of expenses incurred by INSTITUTION in seeking and maintaining patent protection for the invention in countries covered by the license (which reimbursement, as well as any such patent expenses incurred directly by COMPANY with INSTITUTION's authorization, insofar as deriving from INSTITUTION's interest in such invention, may be offset in an amount to be negotiated by the parties in good faith against the accrued royalties in excess of any minimum royalties due INSTITUTION); and, in the case of an exclusive license, (iii) reasonable commercialization milestones and/or minimum royalties.

(2) Where Project Intellectual Property of INSTITUTION is other than a potentially patentable invention, COMPANY will have an exclusive option for a license, for an option period extending until three (3) months following completion of INSTITUTION's performance of that phase of this project in which such Project

Intellectual Property of INSTITUTION was developed by INSTITUTION. COMPANY may exercise such option by giving written notice to INSTITUTION, whereupon the parties will promptly and in good faith enter into negotiations for an appropriate license under INSTITUTION's interest in the subject matter for COMPANY to make, use and/or sell products or services which embody, or the development, manufacture and/or use of which involve employment of, such Project Intellectual Property of INSTITUTION. The terms of such license will include: (i) payment of reasonable royalties to INSTITUTION on sale of products or services that embody, or the development, manufacture or use of which involves employment of, the Project Intellectual Property of INSTITUTION and, in the case of an exclusive license, (ii) reasonable commercialization milestones and/or minimum royalties.

(3) Where more than one royalty might otherwise be due in respect of any unit of product or service under a license pursuant to this Agreement, the parties shall in good faith negotiate to ameliorate any effect thereof that would threaten the commercial viability of the affected products or services by providing in such license(s) for a reasonable discount or cap on total royalties due in respect of any such unit.

4. Follow-on Research or Development

All follow-on work, including licenses, contracts, subcontracts, sublicense or arrangements of any type, shall be consistent with the provisions regarding Project intellectual Property rights in this Agreement and insure that the PARTIES retain such rights granted herein.

5. Confidentiality/Publication.

(a) Except as otherwise required by law or court order, Background Intellectual Property and Project Intellectual Property of a PARTY, as well as other proprietary or confidential information of a PARTY, disclosed by that PARTY to the other in connection with this project shall be received and held in confidence by the receiving PARTY and, except with the consent of the disclosing PARTY or as permitted under this Agreement or as required by law or court order, shall neither be used by the receiving PARTY nor disclosed by the receiving PARTY to others for a period of three (3) years, provided that the receiving PARTY has written notice within ten (10) days of disclosure that such information is regarded by the disclosing PARTY as proprietary or confidential. However, these confidentiality obligations shall not apply to use or disclosure by the receiving PARTY after such information is or becomes known to the public without breach of this provision or is or becomes known to the receiving PARTY from a source reasonably believed to be independent of the disclosing PARTY or is developed by or for the receiving PARTY independently of its disclosure by the disclosing PARTY.

(b) Subject to the terms of paragraph (a) above, either PARTY may publish its results from this project. However, the publishing PARTY shall provide the other PARTY a thirty (30) day period in which to review proposed publications, identify proprietary or confidential information, and submit comments. The publishing PARTY shall not publish or otherwise disclose proprietary or confidential information of the other PARTY and the publishing PARTY will give full consideration to all comments before publication. Furthermore, upon request of the reviewing PARTY, publication will be deferred for up to one hundred twenty (120) additional days for preparation and filing of a patent application which the reviewing PARTY has the right to file or to have filed at its request by the publishing PARTY.

6. Liability.

(a) Each PARTY disclaims all warranties running to the other or through the other to third parties, whether express or implied, including without limitation warranties of merchantability, fitness for a particular purpose, and freedom from infringement, as to any information, result, design, prototype, product or process deriving directly or indirectly and in whole or part from such PARTY in connection with this project.

(b) COMPANY will indemnify and hold harmless INSTITUTION with regard to any claims arising in connection with commercialization of the results of this project by or under the authority of COMPANY.

7. Termination.

(a) This Agreement may be terminated by either PARTY upon thirty (30) days written notice to the other PARTY. This Agreement may also be terminated by either PARTY in the event of the failure of the other PARTY to comply with the terms of this Agreement.

(b) In the event of termination by either PARTY, each PARTY shall be responsible for its share of the other PARTY's costs incurred through the effective date of termination, as well as its share of such costs incurred after the effective date of termination, and which are related to the termination. The confidentiality, use, and/or non-disclosure obligations of this Agreement shall survive any termination of this Agreement.

AGREED TO AND ACCEPTED--
COMPANY

By: ____ Date:___________
Print Name: ____
Title: ____

INSTITUTION

By: ____ Date:___________
Print Name: ____
Title: ____

Experience in the Development and Commercial Use of Agricultural Biotechnology in China

Zhangliang Chen[1]

China started R & D in transgenic crops in 1983 and initiated field testing in 1989. In 1996, the MInistry of Agriculture (MOA) established the Office of Genetic Engineering Safety Administration (OGESA) to regulate field testing, environmental release and commercialization of transgenic organisms. Since 1997, transgenic crops have been planted on commercial scale in China starting with Bt cotton of Monsanto and the Chinese Academy of Agricultural Sciences (CAAS) which now approaches 400,000 hectares in the year 2000. Other commercialized transgenic crops include virus resistant and shelf-life altered tomato, virus resistant sweet pepper and flower color-altered petunia. Field test of several transgenic major crops such as rice, potato, soybean, tomato, sweet pepper and tobacco for various traits are ongoing. Biosafety tests conducted according to standard procedures showed the biosafety to environment and food safetiness of transgenic crops. Due to external, mostly European pressures, approval of licenses to commercialize other crops has been suspended since 1999.

China is the most populated and one of the largest agricultural countries in the world, with only about seven percent of the world's cultivable land feeding over 20 percent of the world's population. With the rapid increase in population as well as dramatic decrease in cultivable land, food security for the people remains a major concern. Chinese scientists, for many years, have been making great efforts to improve the crop yield by traditional breeding techniques which have contributed significantly to agricultural production. Starting 1983, with the development of transgenic techniques, more and more transgenic plants have been developed and agricultural biotechnology has become a powerful tool for improving agriculture production. This paper discusses the experience in research and development, field release and commercialization of agricultural biotechnology products in China.

Development of Genetically Modified (GM) or Transgenic Crops in China

From 1986 onwards, with support from the National Five Year Plan, National High Tech Planning, National Natural Science Foundation and other grants from the Ministry of Agriculture (MOA), over 100 laboratories in China have been involved in transgenic plant research. Our laboratory released TMV-CP and C-MV-CP transgenic tobacco and tomato plants in the fields for testing for virus resistance in 1990. In 1996, the MOA established the Office of Genetic Engineering Safety Administration (OGESA) to regulate field test, environment release and commercialization of transgenic organisms. In 1997, four licenses for commercialization were granted and 41 field tests out of 55 applications were approved by the OGESA, while seven applications were pending (Table 1). In 1998, out of 16 applications, two licenses for commercialization were granted and 49 field tests out of 68 applications were approved. Eighty thousand hectares of transgenic crops (mainly including insect-resistant Bt cotton, Bt corn, virus-resistant sweet pepper and tomato as stated in Table 2) were planted in 1998 and will reach approximately 400,000 hectares in 1999. By June 1999, the six

[1] Vice President, Peking University and Director, National Laboratory of Protein Engineering and Plant Genetic Engineering, Biotechnology Department, Peking University, People's Republic of China

licensed transgenic crops, three of which were granted to our laboratory (Table 2), were approved for planting in another 20 different locations throughout China for commercialization while 42 field tests were approved.

Table 1. Releases and Commercialization of GMOs in China.

Year	Applications	Commercialization	Environmental releases	Field Trials	Pending
1997	55	4	31	10	7
1998	68	2	10	39	16
June1999	73	20 (different locations)	18	24	11

Source: Data from the Office of Genetic Engineering Safety Administration, Ministry of Agriculture

Table 2 shows the different crops approved for commercialization in China. Of the six licenses approved, the first and second are BT cotton of Monsanto Company and of the Chinese Academy of Agriculture Sciences (CAAS). The third is for tomato of Guandong Agriculture University. Our laboratory obtained the next three licenses for virus resistant tomato, virus resistant sweet pepper, and CHS, or controlled color formation of petunia plants.

Table 2. Commercialization and Field Releases of Transgenic Plants in China.

Commercialization		Field Releases	
B.t. Cotton, insect-resistant	CAAS Monsanto Co.	Rice	Tobacco
		Potato	Corn
		Soybean	Orange
Tomato, virus-resistant	Peking Univ.	Tomato	Eucalyptus
Tomato, shelf-time altered	CCAU	Sweet pepper	Oil-rape
Petunia, flower-colour-altered	Peking Univ.	Poplar	
Sweet pepper, virus-resistant	Peking Univ.		

In 1998, Monsanto Company planted over 66 hectares of Bt cotton and the CAAS planted over 10 hectares in Liaoning province and in Hunan province. During the first year of planting Bt cotton, almost 40 percent of cotton plants in the Hunan province were insect-protected transgenic crop. On the other hand, many other major crops are now being field tested; these include rice, wheat, potato, onion, peppers etc.

During the early phase of field release of the transgenic cotton, farmers, producers and government officials especially the local officials noted the significant differences, especially in the resistance against insect pests and reduced number of application of pesticides resulting in a good yield, between the transgenic and non-transgenic crops. This encouraged the local farmers and local government to use this technology. Many companies were therefore organized to commercialize this technology very rapidly. The area planted to transgenic crops grew from 1997 to 1999, increasing about three-fold in size yearly and now covers more than the Hunan – Hobe province and other provinces.

Controversy over Biosafety

Biosafety of transgenic crops has been a hot issue all over the world in the past years. In China, the public generally accepts commercialization of transgenic crops and most people believe that agribiotechnology is a powerful tool for promoting agricultural production that will provide enough food for the world's increasing population especially those in developing countries in the future. However, because of this controversy on biosafety of GM or transgenic crops especially that in Europe, several applications for commercialization of transgenic crops, including those already field tested like rice, wheat, corn and other major crops for insect resistance, were denied this year.

The government has been paying much attention to agrobiotechnology so that it will be safely used to help tackle the food security problem. Many measures have been taken when conducting transgenic plants field trials, e.g., careful planning and field selection, including the consideration of wild species around. Pollens of transgenic plants had been widely collected and tested for possible gene flaws. In 1995, supported by the European Union, Professor R. Casper of Germany led an EU delegation to China to evaluate the biosafety status of transgenic plants in the fields. They went to several locations in Hunan and Liaoning Provinces to collect samples of transgenic plants and came to the conclusion that transgenic crops behave normally and that no mutated virus was found in our transgenic crops after five years of field releases.

In our laboratory, experiments on evaluating the safety of transgenic tomato and sweet pepper have been conducted, strictly according to standard procedure. The results showed no significant difference between rats fed with GM products and those with normal diets in growth rate, food consumption coefficiency, blood systems, function of livers and kidneys, reproductive systems as well as the metabolism of protein, fat, and sugar.

However, because some countries have different opinions on the safety issue of transgenic foods, the application of agrobiotechnology has been largely retarded, although a large number of safety tests have been and are still being carried out to confirm the safety of transgenic products as food. An international harmonization should be reached because the lack of such harmonization will result in international conflicts on import and export of agricultural products. This will, in turn, indirectly block the development of transgenic technology. It is reasonable for us to believe that within the next 10 years agribiotechnology will help the world resolve the problem of food shortage.

Agricultural Biotechnology in Indonesia

Endang Sukara and I.H. Slamet-Loedin[1]

Biotechnology has been officially recognized by the government of Indonesia as a strategic technology to help attain sustainable agricultural production since 1988. The National Committee on Biotechnology was established by the Ministry of Science and Technology to prepare and formulate a national biotechnology policy and development program. This program is implemented by several "centers of excellence" and each of these centers is tasked to set up a network of institutions in a particular field. After the economic crisis of 1997, the focus and direction of biotechnology, which remained of high government priority, were adjusted to suit the country's conditions. These priorities included the following: (1) immediate application of existing biotechnology for product manufacture in food production, import substitution, and export opportunities, (2) strategic research program based on competitive advantage of the country, e.g., genetic resources, and (3) increased participation of private companies in establishing significant bio-industries. Biosafety regulations were established in 1997 covering genetic manipulation of microbes, plants, fish, and livestock. These regulations were amended in 1999 to cover plantation and forestry plants and food products the implementation of which involved four ministries (Agriculture, Estate Crops and Forestry, Food, and Health). Guidelines for food safety of GM products have been drafted and are expected to be released this year. Constraints to the development of biotechnology in Indonesia cited were shortage of expertise, limited funding and linkage with the private sector.

Introduction

Recognizing the potential role of biotechnology in maintaining a sustainable agriculture production, Indonesia started to place a high priority on biotechnology since 1988 as one of the strategic technologies. Biotechnology became one of the priorities of the National Science and Technology Development Program. The Ministry of State for Science and Technology established the National Committee on Biotechnology, which is responsible in preparing and formulating a national biotechnology policy and development program to assist national development. The committee also gives guidance and encouragement in the development of bio-industry and its supporting R & D and human resources. The committee also gives directions for the establishment of national, regional, and international network of cooperation on biotechnology, and monitors the implementation of the national policy on biotechnology.

To implement this policy, a program was formulated in 1990. The program includes the production of fine chemicals and pharmaceuticals (antibiotics, amino acids, vitamins); mass production through micro-propagation of industrial, horticultural, and forestry plant species; improvement of food crops quality (in particular rice and soybean); improvement of beef and dairy cattle quality through embryo transfer; and production of various diagnostics and vaccines for human and animal diseases.

The program is implemented by several "centers of excellence", as follows:

[1] R & D Center for Biotechnology, The Indonesian Institute of Sciences (LIPI), Bogor, Indonesia

1. Centers of Excellence on Agricultural Biotechnology I and II, coordinated by the Central Research Institute for Food Crops and R & D Center for Biotechnology – LIPI, respectively, both in Bogor;

2. Center of Excellence on Health Biotechnology, coordinated by the Medical Faculty of the University of Indonesia in Jakarta; and

3. Center of Excellence on Industrial Biotechnology, coordinated by the Agency for Technology Assessment and Application (BPPT) in Jakarta.

These centers are tasked to set up a network of institutions active in its particular field. In addition, the government of Indonesia established an inter-university center on biotechnology in three universities, namely: Bogor Agriculture University in Bogor, with focus on agriculture biotechnology; Bandung Institute of Technology in Bandung, with focus on industrial biotechnology; and Gadjah Mada University in Yogyakarta, with focus on health biotechnology.

To accelerate the implementation of the program, the Government of Indonesia also re-vitalized the National Research Council, which is responsible in setting the biotechnology priority for each fiscal year and inviting scientists from the universities and research institutes, both public and private. A panel of experts was set-up to evaluate proposals and give recommendations to the Council. The Council gives advice to the National Planning Board and the Ministry of Finance to fund the recommended proposal. Administratively, LIPI is assigned to help all of the Competitive Research Grants (RUT) while the Agency for Assessment of the Application of Technology helps all of the Partnership Research Grants (RUK).

The Ministry of State for Science and Technology was restructured to improve its performance. A policy guideline on science and technology, which was made available early this year, is one of its major achievements.

Biotechnology Initiative

For the past six to seven years, the Indonesian Government has consistently provided grants for research activities, including the field of biotechnology, through competitive research grants. Through this particular scheme, research activities increase significantly both in quantity and quality. In addition, through the Department of Education and Culture, the Indonesian Government also provides some additional funding for research for university personnel (Hibah Bersaing, Program Pembinaan Riset and Program URGE).

The Indonesian Government has also improved research management through a one- gate policy, activated the National Research Council, and established a panel of experts to help the government in selecting proposals for funding through various funding mechanisms (RUT, RUK, RUSNAS, Hibah Bersaing, Risbin etc.)

The major players on biotechnology research activities are universities and R & D Centers of the departmental and non-departmental bodies. In addition, various private companies also conducted biotechnology R&D activities. (Tables 1 to 3).

Table 1. University faculties with major activities in biotechnology in Indonesia.

University	Location	Field of study
Faculty of Pharmacy, University of Airlangga	Surabaya	Plant cell cultures, bio-transformation with plant cells, rat hepatocyte cultures
Food and Nutrition Development Center and Research Center, UGM	Yogyakarta	Bio-preservation, lactic acid bacteria, cell fusion among *Aspergillus* strains, monoclonal antibodies for aflatoxin
Inter University Center for Biotechnology, UGM	Yogyakarta	Genetic analysis of Waardenburg syndrome, Thalassemia, Dengue viral antigens, diagnostic tools based on PCR, erythromycin and BT toxin production
Inter University Center on Biotechnology, ITB	Bandung	Microbial fermentation, enzyme technology, genetic engineering, biological waste water treatment
School of Medicine, Airlangga University	Surabaya	Reproductive health, infectious deseases, cancer and degenerative diseases, forensic serology
Department of Microbiology UI	Jakarta	Dangue virus diagnostics, Salmonella diagnosis, hepatitis C research
Faculty of Agriculture UGM	Yogyakarta	Baculo virus detection, CVPD-free citrus seedlings, PCR technology, SMZ coat protein genetics for virus-free soybean stocks, food biotechnology
Inter University Center for Biotechnology IPB	Bogor	Improvement of plant productivity by tissue culture, embryo transfer, microbial biotechnology, waste treatment, culture collection

Source: Schmid et al., 1995

Table 2. Research institutes concerned with biotechnology.

Institution	Location/ Supervision	Targets
Indonesian Sugar Research Institute (P3GI)	Pasuruan/ Department of Agriculture	Deranase, xanthan gum, sugarcane breeding, wastewater treatment, genetic engineering techniques
Central Research Institute for Food Crops, Laboratory of Plant Biotechnology	Bogor/ Department of Agriculture	Molecular genetics of rice diseases, cell and tissue culture, nitrogen fixation, bio-fertilizers, bio-conversion
Marihat Research Center	Pematang Siantar/ Department of Agriculture	Tissue culture on cocoa, rattan, vanila, oil palm etc.
Research Institute for Animal Production (Balitnak)	Ciawi-Bogor/ Department of Agriculture	Feed improvement using fermentation, mannanase, embryo transfer, phytase, cassava-protein
Research Institute for Veterinary Science (Balivet)	Bogor/ Department of Agriculture	Cloning of veterinary toxins, veterinary immunology, monoclonal antibodies
Institute for R & D of Agro-based Industry	Bogor/ Department of Industry	Industrial biotechnology, fermentation of soybean curd whey, food quality control
Center for the	Jakarta/ BPPT	Antibiotics production, plant, dish and livestock

Assessment and Application of Technology (BPPT)		production, vitamin, enzyme and amino acid production
R & D Center for Applied Chemistry – Indonesian Institute of Sciences (LIPI)	Bandung/LIPI	Bio-conversion of solasodine, waste water treatment, fermentation, tempe
R & D Center for Biotechnology – Indonesian Institute of Sciences (LIPI)	Cibinong-Bogor/LIPI	Fermentation and enzyme technology for production of enzymes and biocatalysts, plant biotechnology (genetic analysis and transformation), embryo (production/ preservation/manipulation/ transfer technology), aquaculture, natural products
Eijkman Institute for Molecular Biology	Jakarta/Men-Ristek	Mitochondrial DNA mutation in human diseases, aging process, energy-transducing systems, thalassemia, diagnostic kit for Dengue hemorrhagic fever

Source: Schmid et al., 1995

Table 3. Companies active in biotechnology.

Company	Location	Ownership	Products
Perum Bio Farma	Bandung	State Enterprise	Vaccines, sera, diagnostics
PT Kalbe Farma	Jakarta	Indonesian	Pharmaceuticals, diagnostics
PT Meiji Indonesia Pharmaceutical Industries	Jakarta	Japanese	Antibiotics
PT Rhone-Poulenc Indonesia Pharma	Jakarta	French	Pharmaceuticals, vaccines
PT Sandoz Biochemie Farma Indonesia	Jakarta	Swiss	Antibiotics
Pusat Veterinaria Farma	Surabaya	State enterprise	Vaccines, antigens
PT Sasa Inti	Probolinggo	Indonesian	Glutamic acid
PT Ajinomoto	Mojokerto	Japanese	Glutamic acid
PT Miwon Indonesia	Gresik	Korean	Glutamic acid
PT Indo Acidatama	Surakarta	Indonesia	Ethanol
Perusahaan Daerah Aneka Kimia	Surabaya	State Enterprise	Ethanol
Rhizogin Indonesia	Jakarta/Bogor	Indonesian	Rhizobium starter cultures

Source: Schmid et al., 1995

New direction on biotechnology policy

Even after the economic crisis hit Indonesia in 1997, biotechnology remained a main priority in Indonesia. The focus and direction were adjusted to the existing economic conditions. The first priority in biotechnology is to immediately apply an existing biotechnology process for product(s) manufacture to respond to the needs of the people, especially in food production, production of traditional medicine, and added-value of agricultural products for import substitution and export opportunities. The second priority is strategic research, which will respond to the rapid development of biotechnology for long-term investment and will improve national capabilities in the field of biotechnology.

To implement the above strategic development in biotechnology, the national program needs to do the following:

1. **Immediate application of an existing technology**. The use of national capability and facilities for the production of health products and diagnostics kit, including diagnostics kit for hepatitis B and C, dengue and other diseases common to tropical countries, is important. The application of transfer of cattle embryo to increase and improve cattle population to respond to the increasing demand for meat and milk, and improvement of the production of staple foods including rice and soybeans are of great importance to the country.

2. **Strategic research**. A strategic research program to position Indonesia at the edge of global market is important for the country's future. Such program should be based on competitive advantage of the country, such as genetic resources, drug discovery projects, genetic improvement of agriculture commodities (e.g., food crops, horticulture, fruits, animal husbandry etc.), marine biotechnology, environment biotechnology (e.g., bio-remediation) and manufacturing vehicle technology (e.g., unconventional approaches to production processes).

3. **Increase participation of private companies**. Indonesia will not be able to significantly achieve bio-industry development without the participation of the private sector. As a new emerging technology, biotechnology is categorized as a high-risk business. To invite venture capital for the development of industries based on biotechnology findings require excellent entrepreneurs and managers.

4. **Human resource development**. The major constraint in biotechnology development is the limited number of qualified researchers in the country. The commitment of the Indonesian Government to provide facilities and funding and continuous development in human resources is of utmost important.

Future of Indonesian biotechnology development

Indonesia, the largest archipelago in the world, lay on the tropical zone between two continents, Australia and Asia. Indonesia comprises 17,508 islands, which vary in sizes and shapes. The land type also varies from flat, hilly to the mountainous. There are at least 47 different ecosystems. About 17 percent of all living creatures in the world are found in Indonesia, including 10 percent of all flowering plants, 12 percent of mammals, and 25 percent of reptiles. The microbial diversity is tremendous and no one could estimate the actual numbers. The richness of biological diversity is a competitive advantage for the country. Such biodiversity needs to be preserved; its utilization should be considered important.

With its mega-biodiversity, Indonesia should be the richest in terms of genetic resources. With the advancement of biological sciences, particularly in the fields of molecular biology and molecular genetics, the potential gene(s) from the biological resources could be studied, isolated, amplified, preserved, and utilized. The utilization of gene(s) through advance biotechnology has great potential for Indonesian agriculture (production of food), industry (added- value of agricultural products), health (traditional medicine and drug development), and environment (improved quality of environment). Biotechnology, therefore, will be important to the future economic development of Indonesia.

Government support policy remains but funding is limited. For the next five years, the development of infrastructure in universities, public research institutes, and non-public research institutes will be slowed down, if not stopped. The only advantage of the past 10 years experience is that it has been possible for Indonesia to identify the strength of its biotechnology capability. Various strong research groups within the country have been and are being formed. This is one area which could lead to the rapid development of collaboration with the international scientific community and attract funding from various international funding agencies.

In the future, the need for a new vision in biotechnology development and utilization, entrepreneurship, venture capital/bank, and research quality for industrial development will be tremendous.

Biosafety regulation

Biosafety regulations has been established in Indonesia since 1997, as embodied in the Ministerial Decree on Genetically Engineered Biotechnology Product, which was put in place by the Minister of Agriculture. To implement the decree, a committee for biosafety was formed in 1997. The committee is supported by a technical team consisting of experts in plant biotechnology representing different national institutes and universities. The technical team formulated a series of guidelines for the release of genetically-engineered organism. This series of guidelines includes general and specific guidelines for genetically engineered plants, microbes, and animals.

The 1997 decree did not cover plantation and forestry plants and food products. To fulfill the need for wide coverage regulation, the decree was revised in 1999 by the collective decree of four ministries, namely: Ministry of Agriculture, Ministry of Estate Crops and Forestry, Ministry of Food, and Ministry of Health. The committee and technical team members were also expanded, representing different parties. The guidelines of food safety of genetic modified organisms (GMO) products have been drafted and will be released within this year.

However, at present, Indonesia has not yet released any transgenic material. Six applications from Monsanto and Pioneer have been reviewed. The Bt corn, and Bt cotton from Monsanto and the Roundup Ready soybean, corn and cotton have gone through the biosafety committee and are currently under the review process of the plant variety release committee.

Intellectual Property Rights

Indonesia enacted a patent law in 1989, which was enforced in 1991. Under this law, no patent could be granted for any process for production of food, drinks for human and animal consumption, and new plant, and animal or their product. This patent law was revised in 1997 in accordance with the WTO regulations, which allowed patenting of the abovementioned items.

Constraints

The development of biotechnology in Indonesia is hindered by several factors. Capacity building of manpower with specific expertise is very important. At present, in each institute, the critical mass for any particular subject has not yet been achieved. The activities are very much individual and scattered. Therefore, a national center for biotechnology may offer a good alternative to build networking among the experts in the field since the consortium of biotechnology as a voluntary body has not really achieved its objective.

Another set back is that the interest of private sectors to fund research in this field is still very limited, perhaps because it requires a high investment. However, a number of private industries have shown some interest. At present, most funding comes from the government, but the recent economic crisis forced a cut in funding, which has resulted in the termination of several projects.

The development of regional and international linkages is very important in achieving similar goals together.

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Agricultural Biotechnology in the Philippines

Saturnina C. Halos[1]

Agricultural biotechnology is officially recognized by the Philippine government as a tool to attain food security and sustainable agriculture, promote health and food safety and provide people empowerment. This paper traces the development of agricultural biotechnology in the country starting with plant tissue culture activities in the 1960s. Among those utilized at commercial scale are micropropagation of banana and orchids, micropropagation of disease-free sugarcane seed buds for distribution to growers, and to a limited extent, embryo culture of the mutant coconut makapuno. Fermentation-based technologies for agricultural application include soil inoculants, biocontrol agents, enzym es and diagnostics for food and animal diseases. Development of transgenic crops such as papaya with delayed ripening trait and virus resistance and rice with insect and pathogen resistance is ongoing at several institutions. Regulation of R & D of modern biotechnology projects is in place while the regulatory framework for commercialization is being worked out. Only one field trial of Bt corn has been carried out; preparations for other limited field trials of Bt corn and transgenic rice are underway.

INTRODUCTION

Agriculture including fishery is vital to the Philippine economy. Agriculture's contribution to the economy has always been substantial. In 1995, it registered a growth rate of 3.2 percent and its contribution to the gross domestic product is about 23 percent. The country's population is predominantly rural (70 percent of the total) and two-thirds of this population depends on agriculture for their livelihood. Agriculture employs about half of the total labor force. Hence, a sustained expansion of the national economy requires sustained growth in the agricultural sector. This attaches the high priority of transforming agriculture into a modern, dynamic, and competitive sector.
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Philippine agriculture consists of rice, corn, coconut, sugar, banana, other crops, livestock, poultry, and fishery production activities. Biotechnology has yet to make inroads into the improvement of these production activities. The major biotechnology industry in the Philippines consists of the traditional large-scale fermentation industries in beer production, alcohol distillation, monosodium glutamate production, soy sauce and vinegar production, and of small-scale production systems for animal vaccines, nata de coco, bagoong, basi, and other Philippine fermented products. Tissue culture of banana may or may not be integrated into the large-scale commercial production of banana. Sugarcane tissue culture is integrated with sugarcane production and the system is run by an institution (PHILSURIN) supported by the industry. There are small-scale tissue culture laboratories integrated with orchid production.

AGRICULTURAL BIOTECHNOLOGY R & D

Biotechnology R&D in the Philippines formally started with the establishment of the National Institutes for Microbiology and Biotechnology (BIOTECH, now called

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National Institutes for Molecular Biology and Biotechnology), University of the Philippines Los Banos (UPLB) in 1979. Earlier, also at UPLB, tissue culture of coconut (the mutant macapuno) was started at the Department of Agricultural Botany by the late Professor Emerita de Guzman and of banana and rattan at the Institute of Plant Breeding . Within the past two decades, in addition to other UPLB units like Department of Horticulture, Institute of Animal Science, several agencies were also engaged in agricultural biotechnology R&D, namely: Philippine Rice Research Institute (PhilRice-DA), Philippine Coconut Authority (PCA-DA), Bureau of Plant Industry (DA-BPI), Visayas College of Agriculture (ViSCA) University of the Philippines Visayas, Benguet State University, University of the Philippines Diliman and Central Luzon State University (CLSU). Most of the R&D, and especially at BIOTECH, was on the development of fermentation-based technologies for agricultural applications such as production systems for soil inoculants, biocontrol agents, vaccines, enzymes, diagnostics and foods/feeds, and plant tissue culture. Unfortunately, biotechnology R&D is very much under-funded except for projects on enzymes, animal vaccines, and diagnostics. There is no focus with funding spread among too many projects and the facilities and infrastructure support inadequate. In addition, the majority of Philippine researchers lack appropriate skills in modern biotechnology and fermentation engineering and the few trained are spread among a number of institutions.

Of the technologies, plant tissue culture, requiring less capital to develop and use, has been adopted for production of planting stock in large- and small-scale banana tissue culture laboratories; in networks of sugarcane, coconut, and abaca tissue culture laboratories; and modest-scale orchid culture operations. The fermentation-based technologies developed are yet to be commercialized despite demonstrations of effectiveness such as increased yields with soil inoculants substituting for chemical fertilizer or biocontrol agents substituting for chemical pesticides. Marker-assisted breeding is being carried out on mungbean, tomato, rice, mango, and coconut at the UPLB Institute of Plant Breeding where useful genes have also been isolated and staff members sent abroad to train and work on papaya transformation. Transformation of Xa21 rice was done at PhilRice and has recently been tested in the field. Only one instance of a field test of a genetically modified corn (Bt corn) has been carried out that demonstrated the effectiveness of the Bt gene in protecting the corn plant from the Asiatic corn borer, an insect causing 30-80 percent damage in corn.

Previously, the major funding agency for agricultural biotechnology R&D are three councils of the Department of Science and Technology namely: Philippine Council for Agriculture and Resources Research and Development (PCARRD), Philippine Council for Advanced Sciences Research and Development (PCASTRD) and Philippine Council for Industry and Energy Research and Development (PCIERD). The Department of Agriculture through its Bureau of Agricultural Research (DA-BAR) intends to provide substantial funding for agricultural biotechnology including the basic science foundation for biotechnology.

Last year, the DA-BAR organized the Biotechnology RDE Network, comprised of the following research institutions that will implement a national agricultural biotechnology agenda and program: the National Institutes of Molecular Biology and Biotechnology-University of the Philippines System, College of Agriculture-UPLB, College of Arts and Sciences-UPLB, Marine Science Institute-University of the Philippines, Natural Sciences Research Institute-UP Diliman, Visayas College of

Agriculture, and Benguet State University. This Network shall conduct research on basic sciences and problems that cut across various commodities.

In addition, biotechnology research specific to an agricultural commodity is also undertaken by other institutions belonging to commodity networks such as PhilRice-DA, PCA-DA, Philippine Carabao Center (PCC-DA) and Bureau of Plant Industry (BPI-DA). Furthermore, the Department has also included in its recently signed loan agreement with the Asian Development Grant US$34 million for rice biotechnology R&D and also part of the US$11 million for corn research is intended for corn biotechnology R&D. The Department is poised to sign this week a memorandum of agreement with the USDA for the latter to provide technical assistance to the DA Biotechnology Program to be funded with US$7 million from proceeds of a commodity loan from the USA. The program shall be implemented by DA agencies, UP units, and other state universities.

BIOTECHNOLOGY REGULATION

Regulation of modern biotechnology covers only research and development and is administered by the National Committee on Biosafety of the Philippines, a multiagency committee coordinated by the Department of Science and Technology and institutional biosafety committees. The Department of Agriculture is conducting a study on policies for regulation covering the commercial production or use of biotech products. We have recently passed an Intellectual Property Act that specifically excluded plant and animals from patents but included microorganisms for patent protection. We have a pending bill in the House and the Senate on plant variety protection.

There is a small foreign-funded group trying to block the commercial planting and entry of GMOs in the country and has actively tried to block the field test of Bt corn through a very effective system of disseminating misinformation. This campaign has resulted in the passing of a resolution to block the Bt corn field test by the General Santos City Council, resolutions at the House and Senate to investigate the field test, a pending bill at the Senate calling for a ban on GMOs and the filing of a trumped up charge against the DOST, DA and IPB in connection with the Bt corn field test at the Supreme Court which dismissed the case. The anti-GMO group appears to be going around the country campaigning. There are also reports of Roman Catholic priests strongly advising parishioners in their homilies to reject Bt corn.

BIOTECHNOLOGY EDUCATION AND TRAINING

Microbiology courses and curricular programs are offered by several institutions in the Philippines. The first molecular biology course was offered as part of the BS Biology program at the UPLB in 1976. The Natural Sciences Research Institute, UP Diliman first offered a short-term training course on cell and molecular techniques in 1987 and offers annually similar training courses since. The College of Science, UP Diliman started offering academic programs for the degrees, BS, MSc and PhD in Molecular Biology and Biotechnology in 1987. Laboratory facilities for these programs had been provided by the Department of Science and Technology. The BS program has a restricted enrollment of 40 students per year. In 1999, UPLB started offering MS in Molecular Biology and Biotechnology program. The UP Diliman academic programs have produced as of this year more than 200 BS graduates, 3 MS and 5 PhDs. Many of the BS graduates have gone on to medicine and graduate studies.

THE BIOTECHNOLOGY POLICY OF THE DEPARTMENT OF AGRICULTURE

The policies and programs of the Department of Agriculture are guided by two major pieces of legislation, the Agriculture and Fisheries Modernization Act of 1997 (AFMA) and the Fisheries Code of 1998. Both laws provide for support for research and development but it is the AFMA that has a specific provision for biotechnology. AFMA provides that the development of agriculture and fisheries shall be in accordance with the following principles:

Food security – assuring the availability, adequacy, accessibility and affordability of food supply to all at all times including sufficient local production of rice and white corn.

Poverty alleviation and social equity – ensuring that the poorer sectors of the society have equitable access to resources, income opportunities, basic and support services and infrastructure, especially in areas where productivity is low as a means of improving their quality of life as compared with other sectors of society

Rational use of resources – adopting a rational approach in the allocation of public investments in agriculture and fisheries in order to assure efficiency and effectiveness in the use of scarce resources and thus obtain optimal returns on investments

Global competitiveness – enhancing the competitiveness of the agriculture and fisheries sectors in both foreign and domestic markets

Sustainable development – promoting development that is compatible with the preservation of the ecosystem in areas where agriculture and fisheries activities are carried out and exerting care and judicious use of the country's natural resources in order to attain long-term sustainability

People empowerment – enabling all citizens the opportunity to participate in policy formulation and decision-making by establishing appropriate mechanisms and by giving them access to information

Protection from unfair competition – protecting small farmers and fisherfolks from unfair competition by promoting a policy environment that provides them priority access to credit and strengthened cooperative-based marketing system

1. The AFMA provision on biotechnology

The authors of the Agriculture and Fisheries Modernization Act of 1997 have fully recognized the importance of biotechnology in modernizing Philippine agriculture. In fact, Agriculture Secretary Edgardo J. Angara then Chairman of the AGRICOM that drafted the AFMA specifically included a biotechnology provision. The law specifically provides that of the P20 billion first year budget appropriated for AFMA, 10 percent shall be allocated and dsbursed for Research and Development, of which 4 percent shall be used to support the Biotechnology Program. In Rule 83.4 of the IRR for the AFMA, it is provided that the total budget for agriculture and fisheries R & D shall be allocated such that at least 20 percent shall be expended on basic research and not more than 80 per cent shall be expended for applied research. It is provided further that biotechnology is considered as basic research and as such the allocation of four percent of the total R&D budget shall be sourced from that portion allocated for basic research.

2. Attaining the principles of the AFMA using biotechnology

The Department intends to use biotechnology as one of the tools to attain the following goals of the AFMA.

Food security and sustainable agriculture – Developing crops through genetic engineering and marker-assisted selection that are tolerant to drought and resistant to pest and diseases would stabilize yields and ensure production. Drought-tolerant crops require less water thereby conserving an increasingly diminishing resource. Insect and disease resistant crops increase yields per unit area thereby giving farmers higher incomes. More importantly, more people will be fed from on the same land area and prevent more land from being harnessed for agriculture. This is crucial, especially since available lands are in environmentally fragile areas like in the uplands. Insect- and disease-resistant crops increases farm profits by reducing chemical pesticide use, saving not only on chemical inputs but also on labor. Early determination of plant sex using molecular markers will ensure higher yields. Local production of DNA vaccines will ensure animal health providing additional income even for farmers in far-flung areas. The use of microorganisms for efficient soil nutrient management will further increase profitability and prevent fertilizer runoffs thereby maintaining the integrity of our open-water systems.

Promoting health and food safety - Developing rice and white corn with added nutritional values like higher iron content through genetic engineering will ensure better nutrition for our people. Another health-promoting advantage expected from pest protected crops is substantial reduction in pesticide residue and aflatoxin in vegetables and grains.

Promoting people empowerment – The DA-BAR has institutionalized the participation of farmers, fisherfolks, and relevant industry representatives to the formulation of R&D programs with the organization of the Farmer Industry Advisory Committee at the national and regional levels. These advisory groups identify major problems to focus R&D efforts and review programs.

3. The development of biotechnology policies at the Department

Biotechnology policies at the Department are formulated by the Office of Policy and Planning with the assistance of the Biotechnology Technical Advisory Group (BioTAG). This group comprise of technical representatives of regulatory agencies of the Department, specifically Bureau of Plant Industry, Bureau of Animal Industry, Bureau of Fisheries and Aquatic Resources, the Bureau of Food and Drug, Department of Health, the Intellectual Property Office, the National Committee on Biosafety of the Philippines and of research agencies such the DA Bureau of Agricultural Research (DA-BAR), IPB-

UPLB, BIOTECH-UPLB, and PhilRice-DA. (The author represents DA-BAR in this committee.) Following is the major biotechnology policy of the Department.

To develop and adopt biotechnology, the Department shall:

- Adopt a program that facilitates rather than limits the development and application of biotechnology, particularly modern biotechnology in Philippine agriculture while ensuring human health, environmental protection and conservation, and equitable sharing of the benefits of our genetic resources.

- Strengthen the capability of the scientific community to undertake development and risk assessment of biotechnology products such as GMOs through aggressive recruitment of appropriately trained individuals, non-degree and degree-oriented training of research staff and provision of adequate facilities and operating funds for continuing research in selected institutions.

- Develop and adopt a transparent regulatory system for the commercialization of GMOs that is science- or product-based rather than technology or process-based. Considering the limited experience the world has today in modern biotechnology products, the regulatory system shall allow for amendments as data and experience come along. Furthermore, acknowledging the great variety in the type and innovation process of biotechnology, the regulatory system shall treat biotechnology products on a case to case basis.

- Promote the initiative of the private sector in the development and commercialization of biotechnology products through a transparent regulatory system and by focusing the public sector efforts in areas unattended to such as technologies for resource-poor farmers

- Promote the wise utilization of Philippine biodiversity by strengthening existing programs of genetic conservation, assessment and characterization of biological diversity and isolation of potentially useful genes

Along this policy, the Department is implementing a program with the following components: policy analysis and advocacy; biotechnology institutional development and capability enhancement; biotechnology research and development; risk analysis; assessment, management, and communication; and biotechnology commercialization. Given the cost of modern biotechnology, we would like to undertake collaboration with countries of mutual interest. Biotechnology is one of the major areas of collaboration agreed upon by the Department of Agriculture, Ministry of Agriculture and Cooperatives, Kingdom of Thailand and the Bureau of Agricultural Research, Department of Agriculture, Government of the Philippines in a Memorandum of Agreement signed early this year.

For further information about the Department of Agriculture, please visit the DA website at www.da.gov.ph*.*

Agricultural Biotechnology in Vietnam

Tuong-Van Nguyen[1]

The Vietnamese government views agricultural biotechnology as an essential and important prerequisite to achieve national goals for food, feed and fiber production. Present activities which are quite limited due to lack of funding, facilities and human resources include tissue culture for micropropagation, virus elimination, somaclonal variation and anther culture. For livestock and poultry, diagnostics and vaccines are produced to detect and prevent diseases while embryo transfer has been utilized to improve breeds. Plans of the national government include investment of US$60 million (M) for the major institutions (Institute of Biotechnology and United Agricultural Laboratory) $20 M to strengthen other training and research centers, $2.5 M for overseas training, and 25 B DVN for R & D programs and 2 B DVN for information and libraries. Among the priority researches identified concern genetic modification of important crops such as rice, maize, potato, sweet potato etc for pest/disease resistance, abiotic stress tolerance etc., to help achieve food security in the future.

Introduction

One of the greatest achievement that served as the basis of economic transformation in Vietnam has been the phenomenal increase of research-based agriculture productivity. From 1990 to 1995, production of food crops, including paddy/rice, maize, sweet potato, cassava, and potato, in paddy equivalent, increased from 21.98 million tons to 27.55 million tons, posting an average annual growth rate of 4.3 percent. This growth rate far exceeded the population growth rate of 2.2 percent during the same period and led to significant increase in per capita food availability as well as surplus for export. The excellent performance of the agriculture sector in this period had set a firm base for obtaining a 4.5 - 5.0 percent annual growth to 2000 and higher to 2010 (Fig.1).

Many of the opportunities for opening new agricultural technologies to cultivation have already been exploited. This is especially true for Vietnam, where there is already very little uncultivated land left to bring under the plough. Among the applied technologies, biotechnology has made a significant contribution and has been judged as critical for increasing crop production to satisfy the increasing domestic needs, to meet new export market demands, and, to a certain extent, conserve natural resources by developing improved and more sustainable agricultural systems.

The role of biotechnology in agriculture development has been marked by many efforts from the governmental and ministerial levels to the policymakers and scientists. A National Council on Biotechnology was established under the chairmanship of the head of the Department of Fundamental Sciences of the State Committee for Sciences in 1991. In addition, a national program on agro-biotechnology was established to: (1) improve and produce biomaterials for agriculture; (2) improve quality and productivity of

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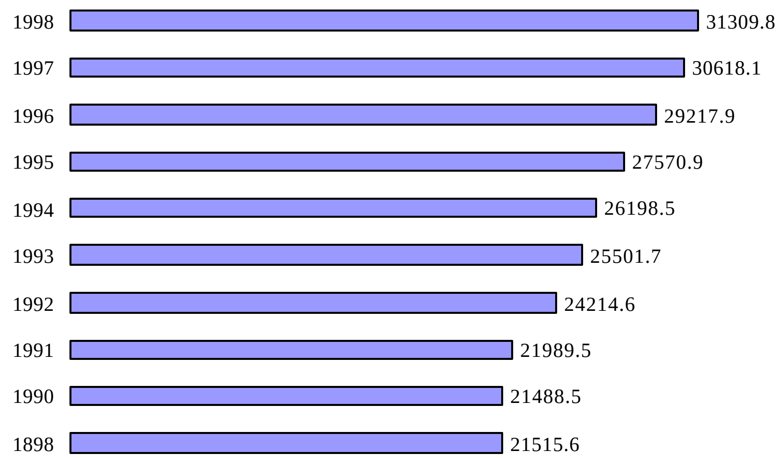
crops and livestock husbandry; and (3) conserve biodiversity and protect the environment. Specifically, the program recognizes the need for genetic engineering, plant cell technology, and DNA recombination techniques as prerequisite technologies for agricultural productivity.



Data source: Socio-economic statistical data of 61 provinces and cities in Vietnam (Statical Pubishing house, 1998)

Figure 1. Agriculture production (in thousand tons).

Current Status and Constraints

Organizations

Vietnam has assigned the highest priority to agri-biotechnology. Government policy views it as an essential and increasingly important prerequisite to achieve national goals and objectives for food, feed, and fiber production. Accordingly, substantial resources have been devoted to build capacity in several national institutions. The main institute for biotechnological research is the Institute of Biotechnology (IBT) at the National Center of Natural Science and Technology, followed by two research institutions belonging to the Ministry of Agriculture and Rural Development (MARD), namely: Institute of Agricultural Genetics (IAG) and Institute of Agricultural Sciences (IAS). In the universities, new courses specializing in genetic engineering and biotechnology began to be offered. Establishment of genetic engineering research centers within the universities have also been started.

Research institutions are still scattered and are not integrated. The research works are not always coordinated. These lead to difficulties in proper planning and management of government investment in all aspects (research facilities and personal training). As a result, there is a lot of duplication of research efforts, which are wasteful.

Investment

The international benefit of biotechnology to agriculture production has drawn more attention from the government, policymakers, and scientists to the biotechnology R&D program. Even if the master program for biotechnological development has not been approved, the Ministry of Science, Technology, and Environment (MOSTE) and related ministries and local government units have explored capital from many sources for biotechnology investment. Several plant tissue culture laboratories have been set up in many provinces to meet the requirement for quality, quantity, and productivity of vegetative crops (Table 1).

Table 1. Biotechnology investments in different provinces in Vietnam.

Provinces	Budget (USD)	Year
Laocai	30,000	1995
Caobang	30,000	1995
Nghean	30,000	1995
Thaibinh	30,000	1996
Kontum	30,000	1996
Hatinh	110,000	1996-1998

The support for basic research is also expanding. In the period 1994-1996, MOSTE has funded several activities in three research institutes (Table 2).

Table 2. MOSTE funding in three Vietnamese Research Institutions, 1994-1996.

	Institutions	Budget (USD)	Activities
1	IBT	124 000	- Genetic engineering and DNA recombination laboratories - Fermentation technology complex
2	Biotechnology Center, Vietnam National University	5 000	- Enzyme-protein technology - Molecular genetic laboratory
3	IAG	3 000	- Molecular biotechnology laboratory - Tissue culture and cell technology

Nevertheless, the government's capital investment for biotechnological research and development remains unappreciated, compared with other countries in the region. Apart from several billions of Vietnam Dong in the period 1991-1995, there is no more foreign investment for research. At present, only about one percent of the national budget is spent on agriculture research in all aspects. It hardly covers 30 percent of the total requirement. Also, there has not been adequate international support in this regard, except for purchase of equipment on a small- scale level. This leads to the inadequacy, backwardness, distraction, and un-synchronization of research facilities. The backwardness is also seen in the lack of policies and available services to meet the requirements for equipment, chemicals, information, and international relations.

Manpower

Human resources are also an important factor for facilitating technology transfer and adaptation. The government is taking the necessary steps to ensure that the target will be met, including a significant investment in human capital that will build a sustainable capacity in biotechnology in Vietnam. Local universities have opened biotechnological courses for biology and agriculture students. In recent years, we have had more than 200 scientists involved in R&D biotechnology. However, at present, there are not enough capable scientists with adequate exposure to advanced biotechnology, especially in genetic engineering, which is a promising trend in agro-biotechnology. In addition, they lack of opportunities for interaction with national and international research scientists and organizations. Therefore, many of them remain deprived of the new basic knowledge to undertake fundamental and adaptive research. The lack of appreciation and recognition of good work does discourage the creativity of the scientists.

Research and development

Vietnamese agro-biotechnology is largely at the stage of improving technology imported from the advanced countries. The conventional technologies such as *in vitro* micropropagation, virus elimination, somaclonal variation, anther culture, and haploid lines effectively improved crop productivity over the past decade. Production of diagnostic and vaccines to detect and prevent livestock diseases and pathogens, and reproduction of domestic animals (embryo transfer) have also been applied for a better husbandry.

Gene transfer to breed disease and pest-resistant varieties, as well as plants tolerant to adverse environment conditions is being pursued. The development of transgenic crops for the potential control of viral and fungal disease is not completely developed, but already tested at laboratory levels. Various interesting genes have been cloned or imported from other countries (Table 3) and advanced techniques have been practiced extensively in research institutions (Table 4).

Table 3. Useful genes used in Vietnam's laboratories.

	Gene	Expression	Origin
i Plants			
1	Cry IA (a, b, c, d)	Insect resistance	Ottawa University, Canada
2	GNA	Bacterial resistance	John Inne Institute, England
3	Xa21	Bacterial resistance	UC, Davis, USA
4	Asp1	Increase store protein	Demegen, USA
5	Chitinase	Fungal resistance	UG, Belgium
6	P5CS	Drought tolerance	VUB, Belgium
7	OAT	Drought tolerance	VUB, Belgium
8	HAL	Drought tolerance	PUV, Spain
9	Nha	Salt tolerance	PUV, Spain
10	Bar	Herbicide tolerance	PMB, France
11	Dhpds	Drought tolerance	VUB, Belgium
12	CP	RSV resistance	IBT, Vietnam
13	ACC antisense	Increase shelf-life	IBT, Vietnam
14	Chil442	Chilling tolerance	IBT, Vietnam
15	Tps	Drought tolerance	PUV, Spain
16	myb family	Rice crop improvement	NIAR, Japan
ii) Animal and Env			
17	Growth hormone	Growth control	Berlin, Germany
18	CryIII	Mosquito larva killing	IBT, Vietnam ICGB, India

Table 4. Application of molecular biological techniques in Vietnam.

Traits	Techniques	Institution
1) *Livestock husbandry*		
Disease- resistant gene for pig	PRC	Institute of Livestock Husbandry
Milk- related genes	PCR gene, k-casein and β-lactoglobulin	IBT
Determination of cow gender	PCR	IBT
Samonella infection	PCR	Institute of Food technology
2) *Biodiversity and environment*		
Animal and plant species classification	Gene sequence analysis	IBT
Biodiversity of rice	PCR, SSR, Waxy gene comparison	Rice Research Institute (RRI) IAG
Genetic diversity of alga	Molecular marker	IBT, VNU
3) *Crop improvement*		
Rice breeding	Tissue culture, RAPD	IBT
MS of rice	Gene mapping	IAG
Salt- tolerant gene of rice	Gene mapping	IBT

Biotechnology work on rice, being a very important crop in Vietnam, using both conventional and advanced methods, has been carried out in various research institutions (Table 5).

Table 5. Rice biotechnology in Vietnam.

Technology	Institution
Anther culture for DH lines	ITB, IBT, AGI, RRI, CPRI, INSA
Somaclonal variation selection for stress tolerances	IBT, AGI
Three-line technology for hybrid varieties	HAU, INSA, AGI, CPRI, RRI
Lingage mapping for chilling and drought tolerance	IBT
Gene transformation for pest and disease resistance	IBT, AGI, ITB

Planning for 2000-2005

Strategies:

- Commit to sustainable agriculture development and protection of the environment.
- Improve international networking with applied research institutes and encourage foreign investment in agro-biotechnology to facilitate the transfer of technology.
- Improve research facilities, particularly applied research, aiming at adapting international technology to local needs.
- Rationalize the number of research institutes, improve coordination of research, and increase training staff.

With such strategies, the Vietnamese government has a plan to invest $60 million to IBT and United Agricultural Laboratories and to spend $20 million to strengthen eight training centers (H-VNU, HCM-VNU, Hanoi Technology University, HCM Technology University, HAU), $2.5 million for overseas training, 25 billion DVN for R&D programs, and 2 billion DVN for information and libraries.

The first priority during this period has been given to crop biotechnology focusing on the improvement of genetic modification of basic crops such as rice, maize, root crops and tubers, soybean, sugarcane, cotton, and fruits and vegetables (Table 6) to achieve food security in the future.

Table 6. Crop biotechnology priorities of Vietnam.

Crops	Biotechnology
Rice	Hybrid, gene transformation
Maize	Diagnosis
Potato	*In vitro* tuberization
Sweetpotato	BT transgenic plants
Casava	Propagation
Soybean	Abiotic stress tolerance, Rhizobia strains for Mekong Delta Soil
Sugarcane	Germplasm, progagation, ruster and stem borer resistance
Fruits and vegetables	PSV resistance (papaya)
Cotton	Transgenic BT plants

Conclusions

Even with limited funding, facilities, and biotechnology-experienced scientists, Vietnam has recognized the important role of biotechnology in the development of agriculture. It has started to increase the investment and encourage capable scientists to get actively involved in biotechnological research and development. So far significant results have been obtained.

Agricultural Biotechnology in Thailand

Hiran Hiranpradit [1]

The government of Thailand has recognized biotechnology as an important tool for improving agricultural development since 1983, establishing the National Center for Genetic Engineering and Biotechnology (BIOTECH) in the same year to spearhead activities in this area. The National Biosafety Committee (NBC) is tasked to regulate genetic engineering and other related work. Guidelines for laboratory practices, field trials, and planned release of genetically modified (GM) organisms have been set up and implemented. As of the year 2000, six limited field trials of GM crops (Bt cotton and Bt corn) and confined experiments of GM tomato, rice, corn, and papaya with various traits had been conducted in Thailand. Importation of transgenic crops covering 40 species is allowed only for experimentation and not commercialization. However, the importation of processed GM food and GM soybean and corn for the food, feed and other industries is allowed.

Recognizing biotechnology to be of great potential for improving agricultural development as well as for the country's competency, the National Center for Genetic Engineering and Biotechnology (BIOTECH) was established in 1983 under the Ministry of Science, Technology and Environment (MOSTE). At present, BIOTECH is affiliated with the established autonomous agency, the National Science and Technology Development Agency (NSTDA).

Biosafety Regulations

Since there has been social controversy over the creation and the use of genetically modified organisms (GMOs), the issue of biosafety has become one of the main concerns of the country. The National Biosafety Committee (NBC), which has the technical advisory function, has been established to assess risks and to develop guidelines for genetic engineering and works relevant to biotechnology. Guidelines for laboratory practices, field trials, and planned release of GMOs have been set up and implemented. Scope of the guidelines embraces all work related to gene manipulation employing recombinant DNA technology for all purposes, including the improvement of transgenic plants, animals, and microorganisms; commercial and industrial manufacturing of r-DNA derived products, pharmaceauticals, and nutraceauticals; and release of transgenic materials and its products into the environment. The guidelines are considered as soft laws, with voluntary basis involvement. Separate Biosafety Sub-committees for Plants, Food, and Microorganisms have also been established. NBC also encourages the appointment of Institutional Biosafety Committee (IBC) in relevant public agencies and academic institutions to serve their own mandatory functions while it assists the IBC as technical advisory committee.

NBC and the Department of Agriculture IBC (DOA IBC) have set up guidelines for introduction permits of transgenic plants/materials for trials. The proponent files a request at the Department of Agriculture for introduction permits of transgenic plants/materials. Documentary information concerning field trial

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methodology and results, novel gene, gene transformation techniques, and relevant data are required for biosafety pre-audit before the issuance of permits. Upon approval, the proponent sets up plan and design of experiment for biosafety assessment, which will be monitored and supervised by appointed competent field working groups. Parameters and data collection will be in conformity with the Biosafety Protocol set up by the Department of Agriculture. Results of the trials will be evaluated and reported by appointed committee for further approval by competent higher authorities. Steps of procedures are illustrated in Figures 1 and 2.

Commercialization

Anticipating future commercialization in the country, the government and private sectors are involved in the introduction of transgenic plants/materials for research purposes and for local biosafety assessment. Examples are insect resistant cotton (Bt cotton) and herbicide resistant corn. From 1995 to the present, 16 transgenic plants/materials had been permitted to be introduced and to undergo biosafety assessment/investigation under competent supervision (Table 1). Stages of investigation ranges from laboratory, confined containment, and field trials. Nevertheless, none of the items had ever been deregulated for commercialization. In the case of the Bt cotton introduced by the Monsanto (Thailand) Ltd. in 1995, it has become a controversial issue as raised by ecologists and activists. Despite the various biosafety trial results, deregulation of the crop for commercialization requires results from additional large scale field trial to gain a higher degree of faith and public acceptance.

To regulate importation of genetically modified plants/materials, the Ministry of Agriculture and Cooperatives issued the Ministerial Notification regarding the specification of plants, plant pests, and pest carriers from certain sources as prohibited materials under the Plant Quarantine Acts B.E. 2507, Amended 2542. The Notification covers 40 species of GMOs known to have undergone genetic transformation worldwide as prohibited materials, with the exception of processed food. Soybean and corn grains for the purposes of food, feed, and industries are also exempted (Table 2). Additional GMO species will be listed and notified as deemed necessary. The listed GMO species are not allowed to be imported into the country except for experimental purposes. At present, there is no issue of deregulation of any imported GMO species being made for further investigation toward commercialization.

The export of produce/products and importation of raw materials for food, feed, and industrial use are regulated by Acts administered by the Ministry of Commerce (MOC). Since soybean and corn grains are exempted by the Ministry of Agriculture and Coopertives (MOAC) Ministerial Notification, guidelines and rules are to be set up to prevent contamination of the imported materials into agricultural production sector. Collaborative action and enforcement are to be undertaken seriously by both MOAC and MOC. Table 3 illustrates soybean and maize sources of import.

Biotechnology research activities are encouraged and undertaken by MOAC, **MOSTE** and MOH as well as by the various academic institutes. Accordingly, the MOAC has placed biotechnology as high priority research area under long-term policy. The Department of Agriculture (DOA) has been assigned as nucleus unit with research function as well as intra/inter MOAC coordination activities. A Central Biotechnology Laboratory with satellite labs located in relevant research centers under the DOA was established to provide research facilities and to carry out research activities. Collaborative research programs are encouraged to strengthen outputs and outcome and to minimize duplication. International collaborative research programs are also undertaken. Figure 3 illustrates collaborative approach.

In order to facilitate trade, certification for non-GM produce/products requested by bilateral trade partners can be issued by relevant competent authorities. Certification can either be to certify as tested samples or to certify as lot. Testing procedures for the detection of GM materials are standardized among the competent laboratories and bench marking with international standards.

The social controversy over the creation and the use of GMOs throughout the world is no exception for Thailand. Public attitudes toward the risks have developed into an important area of concern and causes rising demands to explain the likely consequences of potential hazard of the products to the consumers, general public, and the environment. In terms of food safety derived from GM food, Thailand's Food and Drug Administration is responsible for the risk assessment as well as for food labeling. The position of Thailand's FDA toward GM food labeling is still under process.

Since Thailand is an agricultural-based country, cautious steps toward GMOs have been taken and that no commercialization of GM plant production is one of the national policies being issued. Moreover, public awareness programs about GMOs have been strengthened.

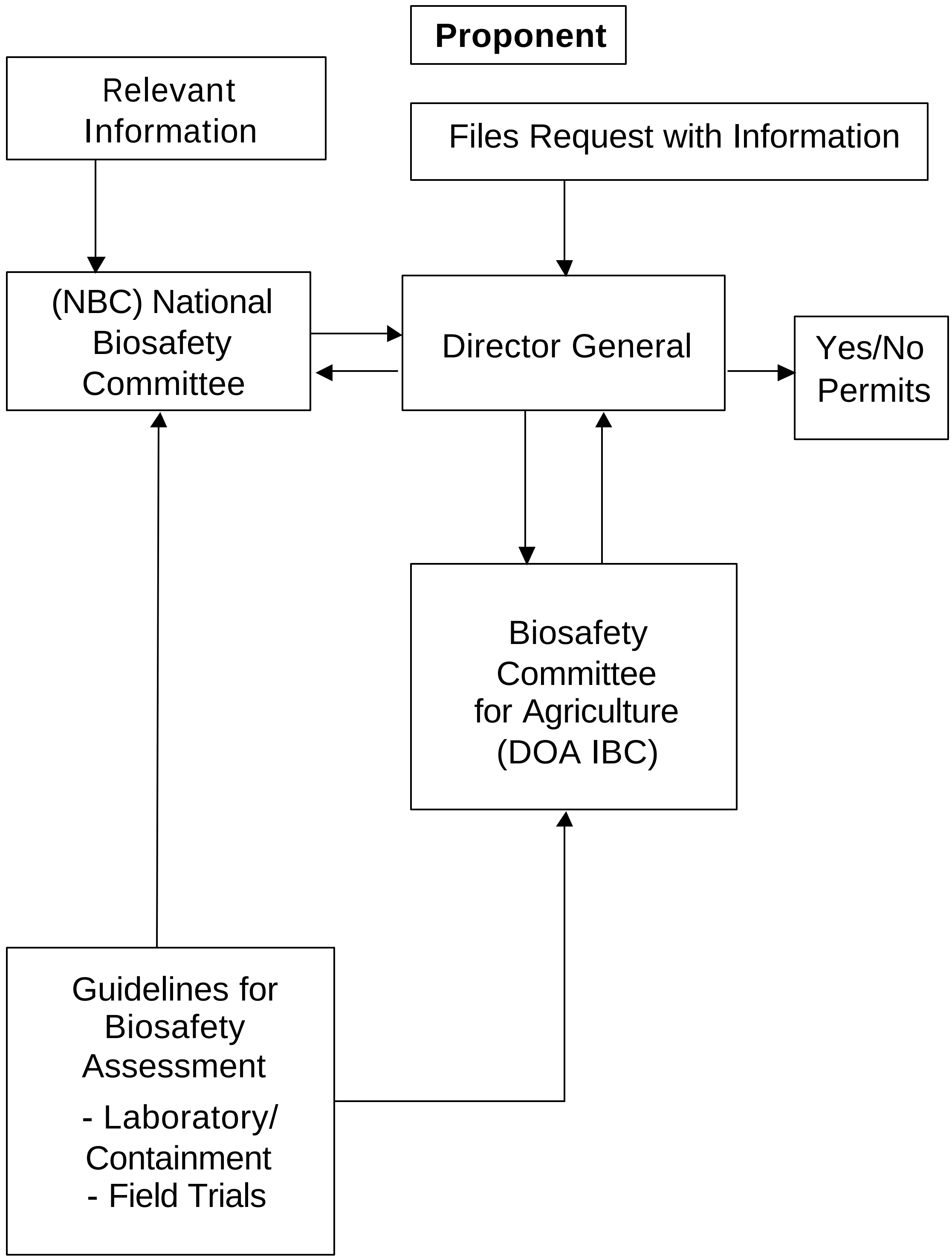

Fig. 1. Procedures for introduction permits of transgenic plants/materials for trials

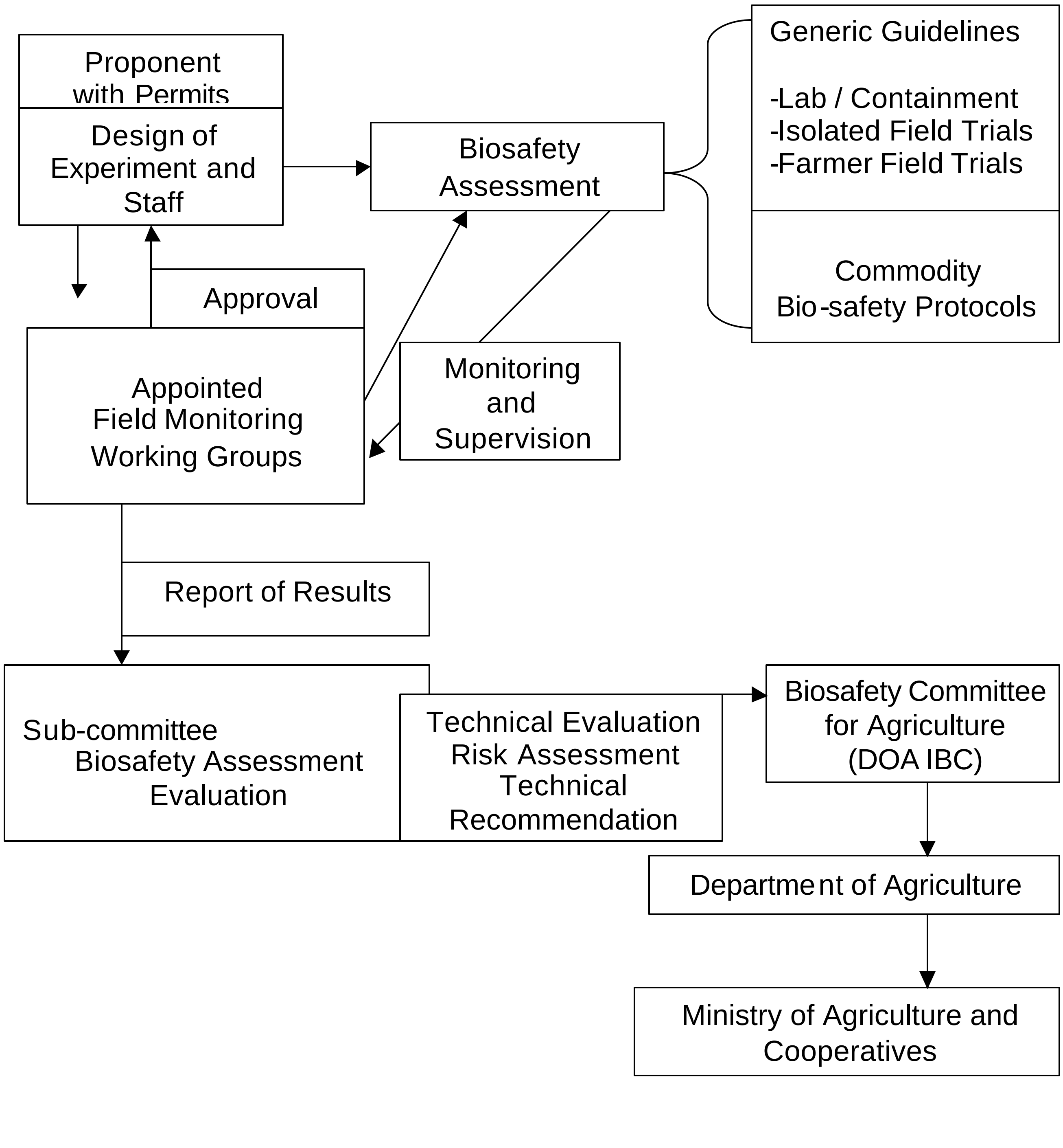

Fig. 2. Procedures for genetically modified organisms biosafety assessment.

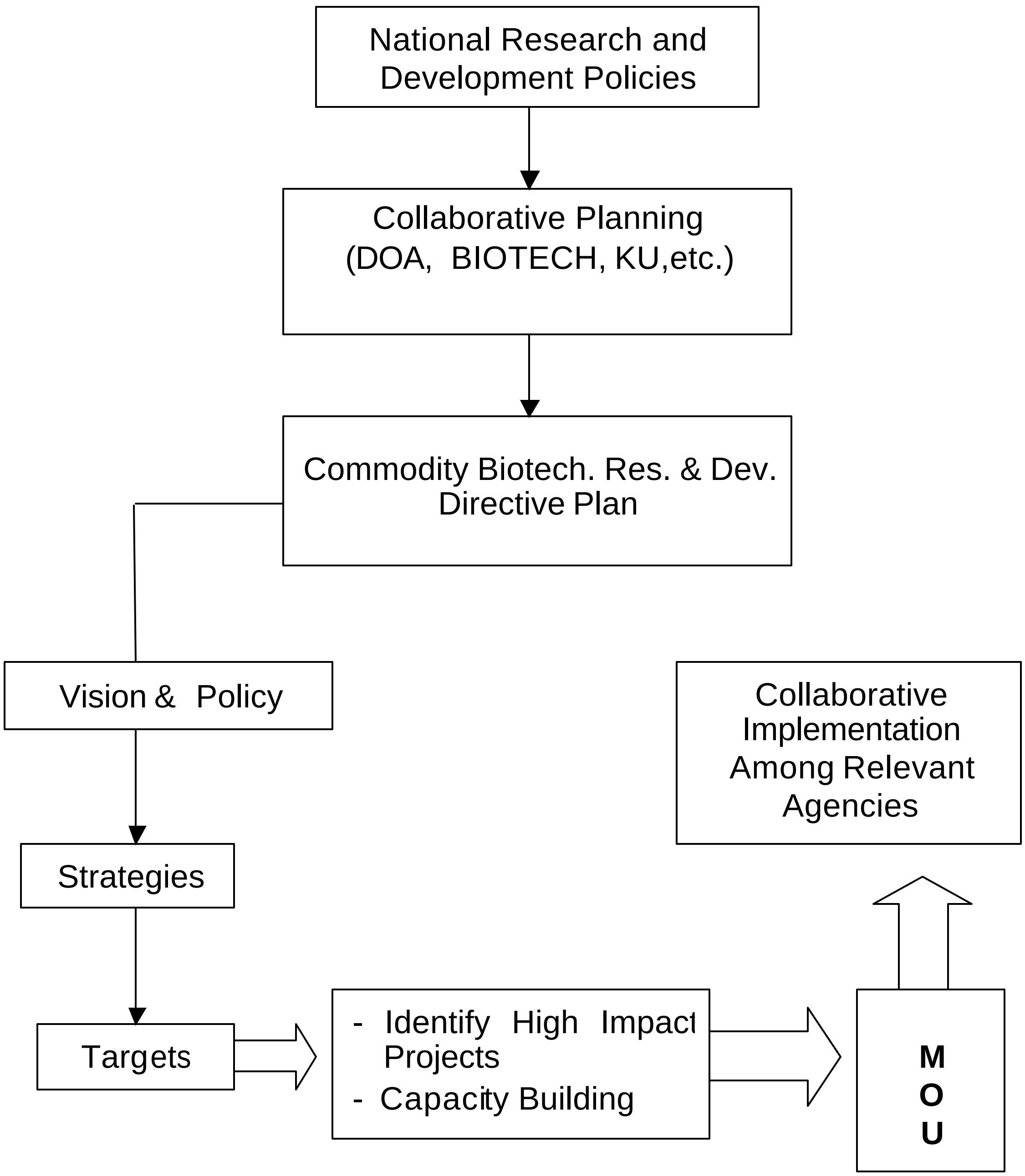

Fig. 3. Collaborative research and development approach among relevant agencies.

Table 1. Introduction permits for GM plants/material into Thailand since 1995.

Date	Proponent	Transgenic Items	Assessment Location	Status of Assessment
2 Aug 95	Upjohn Co.	Tomato seed pCGN 4109 Pcgn 1436 FLAVRSAVR	Sakol Nakorn	Final
18 Oct 95	Monsanto (Thailand) Ltd.	Cotton seed Cry 1A(c) Bt. Var. Kurstaki (B.T.K.) USA. endotoxin toxic to Lepidoptera	Confined containment	Bio-safety Assessment
10 Jul 96	Monsanto (Thailand) Ltd.	Cotton seed Cry 1A(c) Bt. Var. Kurstaki (B.T.K.) USA. endotoxin toxic to Lepidoptera	Field trials	Bio-safety Assessment
8 Oct 96	Novartis (Thailand) Ltd.	Maize seed Bt.	Confined containment Field trial Nakorn Sawan	Bio-safety Assessment
30 Sep 96	Plant Pathology Div. DOA	Callus, Cucurbit Coat protein Papaya ring-spot Virus Thai strains	Laboratory Confined containment	Bio-safety Assessment
22 Apr 97	Monsanto (Thailand) Ltd.	Cotton seed NUCOTN 32B NUCOTN 33B Bt	DOA Field trial Farmer Field trial	Bio-safety Assessment
15 May 97	Hort. Res. Institute DOA	Tissue, seedlings Papaya ring-spot Virus Thai strains	KhonKaen Confined containment	Bio-safety Assessment
27 May 97	Pioneer Oversea Corp. (Thailand) Ltd.	Maize seed Bt corn borer resistant	Confined containment	Bio-safety Assessment
11 Aug 97	Rice Res. Institute DOA	Rice Seedling KDML 105 Xa 21	Confined containment	Bio-safety Assessment
19 Feb 97	Monsanto (Thailand) Ltd.	Maize seed Round up Glyfosate resistant USA.	Confined containment	Bio-safety Assessment
1 May 98	Monsanto (Thailand) Ltd.	Maize seed Bt USA.	Confined containment	Bio-safety Assessment
24 Aug 98	Cargill Ltd.	Maize seed Bt USA.	Confined containment	Bio-safety Assessment
24 Aug 98	Novartis (Thailand) Ltd.	Maize seed Bt USA.	Isolated area field trial	Bio-safety assessment
24 Aug 98	Novartis (Thailand) Ltd.	Maize seed Hybrid Bt USA.	Isolated area field trial	Bio-safety Assessment
28 Jan 99	Cargill Ltd.	Maize seed Round up Glyfosate resistant USA.	Confined containment	Bio-safety Assessment
28 Jan 99	Monsanto (Thailand) Ltd.	Maize seed Round up Glyfosate	Confined containment	Bio-safety Assessment
10 Jun 99	Monsanto (Thailand) Ltd.	Bt corn (Mon-810)	Isolated area Field trial	During quarantine process

Table 2. Genetically modified species listed as prohibited materials.

No.	Plant / pest / carriers	Source of Origin	Exemption
1	*Oryza sativa* L.	All	Processed food
2	*Zea mays* L.	All	Processed food, Grains for food, feed and industries
3	*Gossypium* spp.	All	Processed food
4	*Linum* spp.	All	Processed food
5	*Glycine max* L.	All	Processed food, Grains for food, feed and industries
6	*Helianthus* spp.	All	Processed food
7	*Brassica napus L.*	All	Processed food
8	*Solanum tuberosum L.*	All	Processed food
9	*Asparagus officinalis* L.	All	Processed food
10	*Ribes nigrum* L.	All	Processed food
11	*Brassica* spp.	All	Processed food
12	*Dancus cerote* L.	All	Processed food
13	*Brassica oleracea* var/bpmutos L.	All	Processed food
14	*Apium graveolens* var. dulce (Mill.)D.C.	All	Processed food
15	*Cucumis sativus* L.	All	Processed food
16	*Solanum melongena* L.	All	Processed food
17	*Vitis* spp.	All	Processed food
18	*Actinidia chinensis* Plandon	All	Processed food
19	*Luctuca sativa* L.	All	Processed food
20	*Cucumis melo* L.	All	Processed food
21	*Pisum sativum L.*	All	Processed food
22	*Rubus* spp.	All	Processed food
23	*Frataria* spp.	All	Processed food
24	*Cucurbita* spp.	All	Processed food
25	*Beta vulgaris* L. sub sp. *vulgaris*	All	Processed food
26	*Nicotiana tabacum* L.	All	Processed food
27	*Lycopersicon esculentum* Miller	All	Processed food
28	*Dianthus caryophyltus* L.	All	Processed food
29	*Chrysanthemum* spp.	All	Processed food
30	*Ipomoea* spp.	All	Processed food
31	*Medicaco sativa* L.	All	Processed food
32	*Pitunia* spp.	All	Processed food
33	*Armoracia rusticans* P.	All	Processed food
34	*Amrlanchier spp.*	All	Processed food
35	*Stylosanthes* spp.	All	Processed food
36	*Pyrus malus L.*	All	Processed food
37	*Carica papaya L.*	All	Processed food
38	*Poputos spp.*	All	Processed food
39	*Pyrus communis* L.	All	Processed food
40	*Juglans* spp.	All	Processed food

Table 3. Thailand soybean and maize sources of import,1998.

Commodity/ Source of Import	Quantity (tons)	Presumed GMF (tons)	Value (million bahts)	Remarks
Soybean				
USA	414,358	149,168	4,254	GMOs
Argentina	154,760	92,856	1,504	GMOs
Brazil	118,250	0	1,384	?
Total	681,368		7,158	
Maize				
Argentina	96,725	0	485.8	GMOs
Indonesia	70,168	0	357.9	GMOs
Peru	59,766	0	308.7	?
USA	4,527	996	94.1	GMOs
Total	231,186		1,264.5	

Source : NFI Thailand, 1999.
Adopted from BIOTECH Report on Thailand GMOs Status, January, 2000.

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REGIONAL CONFERENCE ON AGRICULTURAL BIOTECHNOLOGY

Objectives, Rationale and Mechanics of the Workshop

Gil C. Saguiguit, Jr.[1]

In order to draw from this multi-sectoral group specific recommendations related to the overall objectives of the conference, we will now move into a small workshop. Participants will be divided into two discussion groups and will be re-convened later to present their report and recommendation in a plenary session.

First, to set things in proper perspective, let us review the things we set out to do at the start of the conference. We have set the following objectives:

1. To assemble base information or knowledge on the global and regional developments in biotech R&D.

2. To gain a general understanding of what biotechnology is for developing countries in Southeast Asia. What is biotechnology from the perspective of the different countries in the region? How it can help sustainable development efforts?

3. To provide a situationer on biotechnology in national programs and policies of governments in the region. More importantly, we want a basic understanding of the issues, problems, and constraints in the development and use of agricultural biotechnology.

4. To set some general directions for a multisectoral regional cooperation in the effective use of agricultural biotechnology.

The papers that have been presented since yesterday are of two categories. The first group of papers showed general trends and developments and issues on agricultural biotechnology in the region. Subsequently, this morning, we went into papers focused on country-specific experiences in biotechnology. This provides a backdrop for the small-group discussions that we will be having shortly. The workshop is for the purpose of distilling and identifying regional needs and priorities in biotechnology. To facilitate the discussions, two important guide questions need to be addressed:

Question 1 – What is agricultural biotechnology in Southeast Asia? Is biotechnology compatible with sustainable agriculture?

Question 2 – What is required for the effective development and use of agricultural biotechnology in the region? This refers more to the enabling environment by which biotechnology could prosper in the region.

In the plenary session that follows our workshop, we will ask the two groups to report the outcome of their discussions. This then becomes the basis for further discussions later in the afternoon focusing on the specific recommendations for stakeholders. By this, we mean the possible role the institutions represented in this

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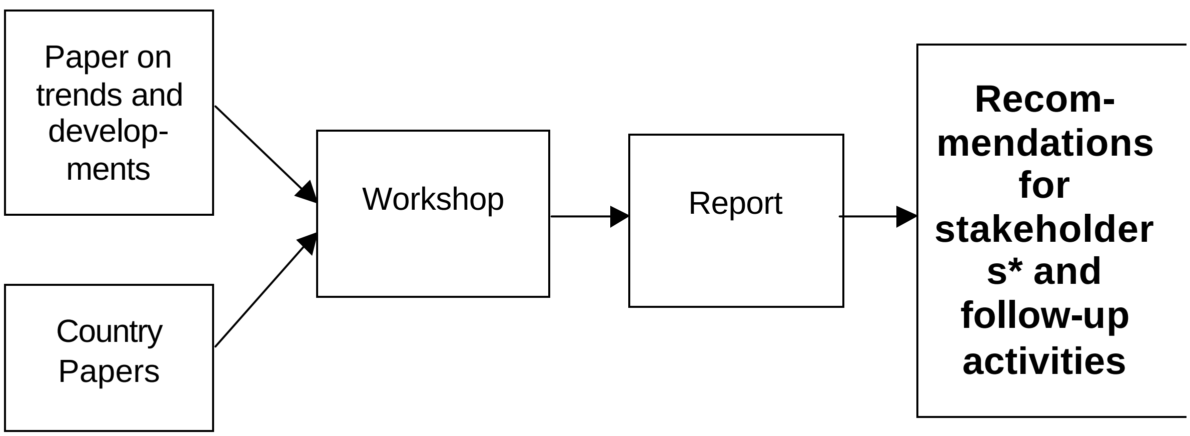
[1] Manager for R&D, SEAMEO SEARCA

conference can play in the development and use of agricultural biotechnology in Southeast Asia as well as in addressing its attendant problems and constraints. I have listed those who we consider as stakeholders, more or less, particularly in the context of this workshop.

I should mention that SEARCA considers itself as a stakeholder given that biotechnology is included in our new 5-Year Development Plan. The recommendations of this group therefore could provide us with the necessary and appropriate guidance in focusing on certain issues and concerns related to biotechnology that we must address.

The other stakeholders we identified are the IARCs, the private sector, the NGOs, the academic community, governments, and the general public. These constitute the list of stakeholders who we would like to cover. Included in this set of recommendations, as I have said, is what we would like to see after this conference. In terms of how we will move forward, what directions will we want to take? Can we talk about some possible cooperation from institutions represented in this conference? Hopefully, all these will contribute to the realization of this conference's objectives.



The Process

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*SEARCA, IARCS, PRIVATE SECTORS, NGOs, Academic Community, Governments, General Public

Regional Conference on Agricultural Biotechnology

Program of Activities

First Day, 29 June 2000

7:30-8:00	*Registration*
8:00-8:15	*Welcome Remarks*
	The Asia and Pacific Seed Association (APSA) *Food and Agriculture Organization of the United Nations(FAO)* *SEAMEO Secretariat*
8:15-8:30	*Opening Remarks*
	Dr. Ruben L. Villareal *Director, SEAMEO SEARCA*
8:30-9:00	*Keynote Speech*
	Dr. Emil Q. Javier *Chair, Technical Advisory Committee, CGIAR* *"Global Developments in Agricultural Biotechnology: Current Status and Future Prospects"*

Plenary Session 1 – Southeast Asian Agriculture and Biotechnology

	Dr. Endang Sukara, chair and moderator, Session 1
9:00-9:30	*Dr. Sutat Sriwatanapongse* *Deputy Director, BIOTEC Thailand* *"Regional Developments in Agricultural Biotechnology: Capacity Building in the 21st Century"*
9:30-10:00	*Dr. R. B. Singh* *Assistant Director-General, FAO* *"Biotechnology, Biodiversity and Sustainable Agriculture - A Contradiction?"*
10:00-10:15	*Open Discussion*
10:15-10:30	*Photo Session/ Coffee Break*

Plenary Session 2 – Agricultural Biotechnology: What is it for Developing Countries?

	Dr. Frederic Erbisch, chair and moderator, Session 2
10:30-11:00	*Ms. Lim Li Lin* *Third World Network* *"Agricultural Biotechnology: What is it for Developing Countries? - A Perspective from a Non-Government Organization"*
11:00-11:30	*Dr. Paul S. Teng* *Director, Regional Science and Technology, Monsanto Phils.* *"Agricultural Biotechnology: What is it for Developing Countries?- A Perspective from The Private Sector"*
11:30-12:00	*Dr. William G. Padolina* *Deputy Director General for Partnerships* *International Rice Research Institute* *"Agricultural Biotechnology: What is it for Developing Countries? - The Role of the International R&D Centers"*
12:00-12:30	*Open Discussion*
12:30-1:30	*Lunch Break*

Plenary Session 3 – Emerging Issues in SEA Agricultural Biotechnology

	Dr. Sutat, Sriwatanapongse, chair and moderator Session 3
1:30-2:00	*Ms. Julie Howden* *Executive Director, Asian Food Information Council* *"Communicating Biotechnology: Conquering the Fear of the Unknown"*
2:00-2:30	*Dr. Linda Posadas* *ASEAN Secretariat* *"Harmonization of Biosafety Framework in SEA"*
2:30-3:00	*Dr. Tetsuo Matsumoto* *International Cooperation Center for Agricultural Education* *"Managing Technology Transfer in Agricultural Biotechnology"*
3:00-3:15	*Coffee Break*
3:15-3:45	*Dr. Frederic H. Erbisch* *Former Director, Intellectual Property Office* *Michigan State University* *"IPR in Agricultural Biotechnology"*

3:45-4:15	*Open Discussion*	
4:15-4:30	*Wrap-up and closing of the first day*	
7:00-9:00	*Cocktails and Welcome Dinner*	

Second Day, 30 June 2000

Plenary Session 4 — Country Situationer

Dr. Randy A. Hautea, chair and moderator, Session 4

7:30-8:00	*Registration*	
8:00-8:30	*Dr. Zhangliang Chen* *Director, National Laboratory of Plant Genetic Engineering* *"Experience of a Developing Country: The Case of China's Development And Commercial Use of Agricultural Biotechnology"*	
8:30-8:50	*The Case of Indonesia*	*Dr. Endang Sukara*
8:50-9:10	*The Case of the Philippines*	*Dr. Saturnina Halos*
9:10-9:30	*The Case of Thailand*	*Dr. Hiran Hiranpradit*
9:30-9:50	*The Case of Vietnam*	*Dr. Tuong-Van Nguyen*
9:50-10:15	*Open Discussion*	
10:15-10:30	*Coffee Break*	

Workshop Proper

10:30-10:45	*Objectives, Rationale, and Mechanics of the Workshop*	*Dr. Gil C. Saguiguit, Jr.* *R&D Manager, SEAMEO SEARCA*
10:45-12:00	*Workshop Proper*	
12:00-1:00	*Lunch Break*	
1:00-2:00	*Continuation of the Workshop*	
2:00-3:00	*Presentation of Workshop Reports*	
3:00-3:15	*Coffee Break*	
3:15-3:45	*Summary, Integration and Conclusion*	*Dr. Evelyn Mae T. Mendoza* *Professor, Institute of Plant Breeding* *College of Agriculture* *University of the Philippines Los Baños*
3:45-4:15	*Awarding and Closing Ceremony*	

DR. NERLITA M. MANALILI
Master of Ceremonies

Plate 1. Opening ceremonies of the conference-workshop. (L-R) Dr. Ruben Villareal, Dr. R. B. Singh, Mr. Andrew Roberts, Dr. Emil Javier, Dr. Suparak Racha-Intra

Plate 2. Dr. Villareal, SEAMEO SEARCA Director, giving his Opening Remarks and welcoming the delagates to the conference.

Plate 3. Dr. Emil Q. Javier, chair of the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR), delivering his Keynote Speech during the opening ceremonies.

Plate 4. Delegates and participants of the 2-day regional conference-workshop on agricultural biotechnology posing for posterity during the photo opportunity session after the Opening Ceremonies.

Plate 5. Dr. Saguiguit, (extreme right) R&D Head of SEAMEO SEARCA, moderating the press conference held for some members of the Thai media. Attending the press conference were (L-R) Dr. Zhangliang Chen of Peking University, Dr. Villareal, Dr. Javier, and Dr. Hiran Hiranpradit of the Thai Department of Agriculture.

Plate 6. Dr. Saguiguit and Dr. Nerlie Manalili, head of SEAMEO SEARCA's Policy Studies Project, supervising the conduct of the 2-day conference-workshop.

Plate 7. Dr. Randy Hautea (right), Center Director of ISAAA, presiding over the country paper session of the conference. Beside him is Dr. Endang Sukara of the Indonesian Institute of Sciences (LIPI).

Plate 8. Dr. Zhangliang Chen of Peking University during his presentation of the People's Republic of China's experience in the development and commercial use of agricultural biotechnology.

Plate 9. Dr. Saturnina Halos of the Philippine Department of Agriculture during her presentation of the Philippine country paper.

Plate 10. Group 1 in action during the workshop session. The question on the table is whether or not agribiotechnology is compatible with Sustainable Agriculture.

Plate 11. Group 2 in action tackling the issue of an "enabling environment" by which agribiotechnology could prosper in the region.

Plate 12. (L-R) Dr. Javier, Dr. Villareal, with officials of the Suranaree University during conference lunch break.

Plate 13. Light moments during coffee breaks. (L-R) Mr. Keith Chapman, Dr. Fred Erbisch, Dr. William Padolina and Dr. Linda Posadas

Plate 14. (L-R) Dr. Javier, Dr. Villareal, and Dr. Saguiguit

Plate 15. (L-R) Dr. Hiran Hiranpradit, Dr. Saturnina Halos, Dr. Evelyn Mae Mendoza.

Plate 16. Dr. Villareal giving the conference token and Certificate of Appreciation to Dr. Mendoza for being the project coordinator of the conference-workshop.

Regional Conference on Agricultural Biotechnology

Biotechnology Research and Policy: Needs and Priorities in the Context of Southeast Asia's Agricultural Objectives
Fortune Hotel, Bangkok, Thailand
29-30 June 2000

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