Plant Biology in The Service of Mankind and His Environment

Jozef S. Schell

A responsible society, which concerns itself not only with the wellbeing of its present population but also with future generations, must not ignore or hinder progress in plant biotechnology. On the contrary, society must encourage new advances. Even in the near future, agriculture, whether global or regional, whether intensive or extensive, whether industrial or familial, will no longer be optimally productive without an important contribution of new scientific knowledge and without responsible application of the best and most effective technologies.

In this talk on the occasion of the 1998 Japan Prize in the field of Biotechnology in Agricultural Sciences I shall begin by giving a brief review of the scientific discoveries which underlie present day plant biotechnology. I shall then discuss the potential of plant biotechnology to contribute to the solution of current and future problems. I will conclude with an evaluation of the public debate regarding the value to society of research, both fundamental and applied.

Two scientific breakthroughs underlie genetic engineering in plants. First was the development of recombinant DNA technology which made it possible to isolate individual genes from any organism. The second was the discovery that there are bacteria in the soil, *Agrobacterium tumefaciens*, which transfer genes into plants. This was the first documented instance of genetic engineering in nature. *Agrobacterium tumefaciens* bacteria modify the properties of the host plant cells to their own advantage by introducing new and specific genetic elements into the genome of the plant cells. This work provided the basis for the development of vectors and methods for the introduction and expression of novel and modified genes in plants and opened the way for molecular plant breeding. Such vectors and methods have thus far also been important in the elucidation of plant cell development and the role of plant hormones and could be used to revisit and further develop many aspects of Plant physiology, -biochemistry, and even -taxonomy and -ecology.

To evaluate the possibilities of plant biotechnology one should keep in mind the following:

1. Agriculture, as it is practised currently, is one of the biggest sources of environmental pollution. Continuation of these practices can lead to rapid and possibly irreversible deterioration of the environment, thus putting the sustainability of agriculture in question.
2. Agriculture must be productive in order to be commercially viable, and socially and environmentally acceptable. If agriculture is to remain an attractive occupation, it must be economically rewarding. If one wants to diminish the negative impact of agriculture on the environment, one should optimize productivity, i.e. maximum quality and yield for a given input, such that one can reduce input and at the same time conserve or even improve quality and yield.
3. Plant breeding is one of the few, and one of the most effective methods, to improve agricultural productivity without simultaneously destroying the environment. This is true for the industrialized world, perhaps even more true for the developing world and holds for both intensive and extensive agriculture.
4. If plant breeding is to contribute to the solution of the enormous problems which we must face in the next decades, then the best techniques must be used including genetic engineering. The resulting plants must then be compared to already available crops for their effect on health and on the environment.

In relation to gene technology in particular one must remember:

1. Transgenic plants and microorganisms can help to diminish the negative environmental

effects of intensive agriculture.

2. Several thousand tests in the field have already been carries out around the world and have given no indication of real dangers or consequences which had not been predicted.
3. Transfer of genes occurs in nature (as in the case of *Agrobacterium tumefaciens*).

Gene transfer into plants and marker assisted breeding can contribute to four overall goals in plant biotechnology.

1. change the characteristics of plant products
2. improve plant resistance to pests, pathogens and abiotic stresses
3. increase output
4. produce unique metabolites e.g. pharmaceuticals, vaccines

New science and technology are viewed with caution and indeed fear. This is particularly pronounced in Europe. Unfortunately, precisely the organizations and political parties whose support is based on environmental protection and on providing optimal social conditions, have been most active in rejecting plant biotechnology. The potential of this new technology to protect the environment has been largely ignored. On the other hand, experience gained from the use of nuclear power, e.g. Chernobyl, as well as the pollution resulting from the use of chemicals make clear that new technologies can bring new and unexpected dangers. Regulations, therefore, are necessary but should be rational, based on solid facts and considerations. Even more important is the development of informed public opinion through education and objective reporting by the media.

Novel Plants for Tropical Agriculture: How will we achieve this and who will do it?

Marc C. E. Van Montagu

Few amongst us realise that the sharp increase in world population is an event of the last fifty years. At the end of the second World War, the planetary population numbered two billion people, yet today we are nearly six billion, and even accounting for the decline in the birth-rate, it is expected that this figure will climb to ten or twelve billion in the first half of the next century. Eighty percent of this growth is expected to take place in tropical areas and it is just this that represents the major challenge to food production, the environment and to medicine.

There are only two ways in which we can increase agricultural output ; either by enhancing productivity, or by increasing the area cultivated. In the latter case, this can only occur at the expense of the limited natural habitats still remaining. The green revolution has shown that human ingenuity can achieve substantial yield improvements by creating new cultivars and by improving agricultural practices. Such new varieties demand a high input of fertilisers and other environmentally-unfriendly chemicals such as herbicides and pesticides. These new cultivars are also based on a narrow genetic background, which means that there is a permanent threat that a virulent disease could develop for which these plants have lost their natural resistance. Furthermore, this intensive agricultural approach has only been developed for a limited number of crops which are cultivated mostly by the industrialised world and not for the plants used by the subsistence farmer in tropical agriculture.

If today, intensive agriculture is already considered quite polluting, then this is unfortunately even more the case with our industries. Yet we can only hope to obtain global peace and equilibrium if the poor and overpopulated tropical regions can also industrialise. Hence it becomes clear that we have a responsibility to concentrate all our efforts on creating new, environmentally-acceptable industries.

Primary amongst the medical problems that we can expect in an overpopulated world, will be the appearance of new infectious diseases. To help the poor areas will require a reorientation of the entire medical system towards the development of inexpensive vaccination systems, drugs and antibodies. Here again, the bio-engineering of plants to produce more and better secondary metabolites and proteins has unique potential. Hence I firmly believe that all three of these problems can be tackled by intensifying the research and development of plant biotechnology.

As soon as the *Agrobacterium* mediated gene engineering of plants opened the molecular studies into plant growth and development, biotech R&D companies tried to engineer improved plants. Early attempts, involving the transfer of altered genes from bacteria showed good expression levels, and created confidence that this was indeed a valid approach. Slowly, the major agrochemical companies have started to invest in this new endeavour.
Some of the major results resulting from this direction are ; the production of plants that are able to defend themselves against a given insect pest by synthesising an insecticidal protein ; the engineering of major crop species to degrade new, environmentally-acceptable herbicides, leading to the possibility of a non tillage agriculture. Hybrid vigour, which since the mid-thirties has been used to substantially improve yields in corn, has been obtained at reduced cost through engineering male sterility into plants. This approach has lead to the development by the Ghent-based company Plant Genetic Systems, of *rapeseed (Canola)* with a 25% increase in yields and to the extension of the hybrid vigour concept to many new plants. Other successes, which include delayed fruit ripening, an aid to storage

and transport, alteration of the seed oil content, and more recently, the production in plants of such medically important proteins as antibodies and enzymes, all indicate the growing economic importance of transgenic plants. The plant genome project, just as the human genome project, is providing us those genes that might influence important traits, and suggesting what alterations can be engineered into the plant to lead to improved crops and novel industrial plants.

We also have available new DNA fingerprint techniques that are helping to accelerate the analysis of the outcome of crosses and making it possible to start genetic analyses on plant species never even previously cultivated. This opens the door to the identification and capture of the commercial and scientific value contained in the huge diversity of plant species still present in untouched habitats. Hopefully, this will help to convince many countries of the importance/value of the biodiversity they possess and to cease the rapidly, irreversible extinction that results from the destruction of these irreplaceable habitats.

In recent years major agrochemical industries such as Novartis, Dupont and Monsanto along with several smaller companies, have shown that they are convinced that next century will be the century of the life sciences. Through their intense mergers and acquisitions they have manoevoureed themselves into a position, where, as owners of patents and of proprietary knowledge in the field of plant biotechnology, they merely have to decide when and where a new plant will be commercialised.

So what does all this mean for tropical agriculture? Improvement depends on the quality of the country's agricultural research stations and on the initiatives of the local seed companies. Internationally, there is help from many of the richer countries through the World Bank-sponsored Consultative Group of International Agriculture Research, the CGIAR. For more than 25 years this has funded research on mandate crops in sixteen CGIAR institutes spread over most of the tropics. However, due to the population explosion time is running out, and the results of plant biotechnology R&D will have to be rapidly and efficiently implemented in order to create in due time the improved plants needed by tropical agriculture. Can this be achieved technically? Will there be the freedom to operate? Indeed, if the OECD asks all countries to sign the international legislation on intellectual property rights, it is clear that tropical plant engineering will come to depend almost entirely on the existing patents, owned by the major multinational companies. Is it then possible that tropical agriculture will become the privilege of the elite farmers who use the engineered seeds produced under license of these major companies? Can the enormous variety of cultivars used by the subsistence farmers be improved notwithstanding possible patent infringements? I believe that co-operation between the scientists of advanced institutes and the specialists in tropical agriculture can bring about major new discoveries in molecular plant physiology. This new knowledge will in turn lead to inventive steps and new tools in a technology that is needed by all, including the leading multinationals of today. Further, if well protected by patents, the inventions obtained through this co-operation can allow an exchange of licenses, thus bringing the necessary operating freedom to tropical agriculture. I consider that the knowledge and much of the enabling technology exist already in the advanced institutes, and that more will be developed . But time is short that we need to act immediately.