Advanced Journal of Microbiology Research Vol. 2004
Available online at http://internationalscholarsjournals.org/journal/ajmr

Perspective

Plant gene technology: Social considerations

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Accepted 30 December 2003

The genetic modification of plants by gene technology is of immense potential benefits, but there may be possible risks. The advantages and social concerns of plant gene technology are discussed.

Key words: Gene technology, genetically modified plant, agriculture.

INTRODUCTION

Since the time of Gregor Mendel (1822 - 1884), the concept of gene inheritance, chromosome structure and arrangement, inheritance of traits and speciation are bases for the development of plant genetics. Knowledge of plant physiology and biochemistry also had fundamental contribution. Experience with plant breeding and mechanizations in agriculture coupled with the spray of chemicals and use of fertilizers has been increasing crop yield ever since the beginning of traditional genetic recombination (hybridization). Regardless of all efforts made to obtain sufficient food, however, the need for feeding the ever-increasing population is becoming greater. This has led to further searches for more powerful, precise and rapid methods of hybridization and selection. Gene technology is one of the results of the searches and it has become a leading field of research in this modern age.

Now, we are in an era where a gene is being isolated and inserted or deleted or duplicated. In contrast to classical breeding where hybridization was intraspecific, two totally unrelated organisms (e.g. bacterial and higher plant cells) can serve as source of genes for each other in recombinant DNA technology. Moreover, it is very rapid, precise and specific. The achievements made in plant genetic engineering are so enormous that every gene is potentially manipulatable.

As a new endeavour, however, people have a mixed feeling about gene technology. The feelings go to the extent of strong rejection (Hoyle, 1998), especially by religious people who believe it as intervening in God's domain (O'Neil, 1998). Those who are optimistic also have certain reservations (The Royal Society, 1998) paying attention to its possible unexpected hazards to the gene pool of organisms and likelihood of humans. But, it is also considered, by others, as a means to fight hunger (Vasil, 1998). In this paper, I have presented the overview of potential benefits, societal concerns, and possible managerial precautions of plant gene technology.

POTENTIAL BENEFITS OF PLANT GENE TECHNOLOGY

Plant biotechnology may provide an opportunity to develop new plant varieties offering a number of advantages over the current rate of food production and medical care. Some of these advantages include:

Food Production: Food shortage in the developing and over populated parts of the world is leading to wide spread social, economic and political unrest, making food security a serious threat to international peace and stability. What is happening in many places of Africa is partly evidence to this. The main source of instability is the lower standard of living which is result of low food production, distribution and management. In the hope that world population can be stabilized at 11 billion by about 2050 (Vassil, 1998), the challenge for the agricultural sector is to double food production on less per capita land, with less water, and under increasingly challenging environmental conditions. Many people believe that there is abundant food production in the world. The distribution, they say, is the problem. While this may be true, there still is inadequate use of available living resources, specifically plants, which has led to reduced rate of production.

Alternatives to agricultural chemicals (fertilizers): Using microorganisms (e.g. *Rhizobium*), it is possible to supply mineral nutrients to plants with out adding exogenous fertilizers. This process, in addition to increasing yield, may maintain the soil ecosystem undisturbed by chemical fertilizers. Modern agriculture relies intensively on chemical additives for fertilizing the soil. These chemicals (fertilizers) degrade the soil, increasing its acidity or alkalinity, and endangering all fauna and flora. If plants are modified to fix their own fertilizers, external application can be avoided and the risk to soil organisms and plants can be minimized.

Resistance against pests and diseases: Chemicals that are sprayed to control insect pests, fungal pathogens, and viral diseases are expensive and have deleterious effects on other organisms. To solve this problem, research in plant gene technology has developed a technique of transforming plants with resistance genes to these pests and diseases. The insect killing property of the bacteria, *Bacillus thuringiensis* (Bt) transformed into cotton is a good example. After successfully inserting the Bt toxin encoding genes from *B. thuringiensis* to cotton varieties, the transgenic cotton plants produced the toxins in their leaves and become resistant to noxious insects belonging to Lepidoptera, Coleoptera and Diptera (Watson, 1997). The same principle may work to control other plant diseases caused by fungi, bacteria and virus. Besides saving a lot of money that was used to buy insecticidal chemicals, this technology is environmentally very friendly.

Improving the quality of food products: It has become possible to delay the ripening and softening of tomatoes so as to handle, transport and store them safely between harvest and consumption (Reiss and Straughan, 1996). Manipulating the genes that encode the enzymes responsible for ripening (ethylene forming enzyme, EFE) and softening (polygalactronase) accomplishes this. Other quality improvements like non - browning potato, starch composition of wheat flour, increased and improved oil content of seeds have also been made into reality by gene biotechnology (Watson, 1997).

Industrial products: The potential for the production of biodegradable plastics, obtaining therapeutic proteins, pharmaceuticals and edible vaccines from transgenic plants may be economically quite considerable. This, potentially, can replace use of petroleum products (Vassil, 1998).

Other applications may include tolerance against environmental stresses, increasing yield through rapid, precise and appropriate selection of cultivars. Achievement of all the above require a much better understanding of the molecular and genetic basis of plant developmental processes and the discovery of agronomically important genes and the elucidation of their regulatory mechanisms. The basic research for the possible beneficial outcomes has to be encouraged and funded. When the enormous technological advancements of modern era were conceived at the beginning of the last century, their practicality was always in doubt.

CONCERNS ABOUT PLANT GENE TECHNOLOGY

In many countries, especially in Europe, there is considerable opposition to the cultivation and use of transgenic crops as human food. These concerns are real because unforeseen biological and ecological disruptions may occur due to the introduced transgenic plant(s).

Among the most important concerns on plant gene technology (The Royal Society, 1998; Hoyle, 1998; McGaughey et al., 1998; Reiss and Staughen, 1996) are:

1. Uptake of modified genes by humans and animals via the food chain.
2. Transfer of genes from GM plants to wild relatives and non-GM plants.
3. The terminator technology (a technology that makes sterile seeds).
4. Development of antibiotic resistance by insect pests and other pathogens.
5. Possible ecosystem disturbances – targeted groups (like insects) of organisms may be eliminated and the natural ecological web may be disturbed (modified).
6. Plants genetically engineered with virus particles may lead to the evolution of new viruses, some of which might pose dangers to existing crops.
7. Distant transfer of genes – the introduction of animal genes (like that of fish) in plants.

This list indicates how far the society is concerned with the production of genetically modified organisms in general and plants in particular. As a powerful technology that can interfere in the natural gene pool of organisms and even threaten the well being of humans, the concerns being shown are appreciable.

However, carefully designed risk management systems can minimize these risks. It is essential that there be scientifically defensible methods for evaluating the risks associated with introductions of GM organsms.

Knowledge on the purpose of the gene transformation, the toxicity, pathogenecity, allerginicity of the donor and recipient organisms, adaptation and geographical distribution of both donor and recipient organisms, mechanisms of propagation (reproduction), and means of transforming and expression of the transgenes can provide foundations for avoiding unanticipated outcomes by genetic transformations.

To begin with all GM plants do not have foreign genes inserted in them. There are two strategies of modifying plants. The first is introducing a foreign gene in order to add a new characteristic. Examples include the development of disease resistance, insect resistance, and herbicide resistance varieties. The second is modifying gene activity in order to change an existing characteristic. Examples are delaying the ripening, softening, and browning of fruits and vegetables until they reach the consumers.

The possibility for the transfer of genes from GM plants to wild relatives and non-GM crops can also be controlled by many alternative ways. This include making the GM plants sterile so as to prevent cross-pollination with wild relatives and non-GM plants, growing the GM plants in a location far away from wild relatives and non-GM plants, growing the GM plants in a contained environment especially when they are meant to produce specific products such as vaccines and inserting the transgene(s) in places other than the nucleus of the host cell, such as chloroplasts and mitochondria.

However, our concerns of GM plants are real and any achievement in the technology requires a detailed, long term and conclusive evidences that these do not cause any harm to both the user and the environment. Nevertheless, the potential benefits are so enormous, especially to developing countries that plant gene technology should be embraced.

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