Bioethic

Bioethics and genetic engineering in plants

The field of ethics is a complex one from all angles. It relates with the way people think about their lives and the world surrounding them. It is further complicated by the fact that viewpoints about life and the world can be individual or collective, thus related to religious or cultural beliefs. The possibility to create new living organisms such as improved varieties with genetic combinations not naturally-occurring is increasing exponentially because of the continuous discovery of new genes and gene functions. These genetic modifications can be achieved either by: somaclonal fusion.

Genomes of non-sexually compatible species (tomato and potato) can be recombined. Genetic engineering. Genes (1-10) can be integrated into the genome of almost any plant. These transgenes can be genuine, foreign, chimerical or synthetic. Gene therapy. Modification of a specific DNA sequence into the plant genome can be achieved using an oligonucleotide partially complementary with the target sequence. Transgenomic. The introduction of activators and inhibitors of genetic expression of genes randomly in the genome can generate a new biodiversity used for the selection of new genotypes with desirable characteristics. The freedom to access such powerful tools sometimes generates a mixed feeling among the public opinion, which often is based on anxiety and fear towards the unknown. This phenomenon happens with many new and powerful technologies that are able to directly affect our lives.

However, such anxiety is not always ungrounded, because real risks have been attributed to new as well as old technologies after it became widely used such as in the case of drugs or pesticides. Therefore it is not the intention here to provide an ethical view on issues related to genetic engineering in plants but rather to provide an answer to a few major ethical concerns about engineering the potato genome from a scientific perspective.

Does the technology offer enough advantages considering the resources mobilized which might be better used for more direct impact on poverty alleviation?

Biotech crop development represents a huge investment in human and financial resources. Often, such high-cost technologies (such as aerospace research) are found unethical considering that these resources could be directly used to impact positively on the lives of millions of poor people. Although the money equation sounds unethical at first glance, the two are not connected.

Funds for biotech research and aid assistance to population in danger are not connected at all. Hence, increase in biotech research does not divert resources for aid assistance. In addition, the real potential of biotech crop is these crops becoming low-input crops with less pesticides and fertilizers, high yielding on less land, and having improved processing qualities for higher incomes. The genetic engineering of potato has reach several milestones, resistance to pest and diseases (Colorado Potato Beetle, Tuber Moths, PVY and PLRV, late blight, nematodes), and modified starches (high solids, amyllose-free, amylopectin-free).

None of the conventional or low-tech approaches offer in a realistic timeframe the same potential. In addition, the cost of development of a transgenic potato variety including risk assessment in the range of US$1 to 10 millions is expected to go down as for any new technologies and is not that far from the cost of a conventional variety (US$1.35 million for Canchan-INIAA). Hence, at this point of scientific development of biotechnology, it would be rather unethical to prohibit investigation in this field considering its potential for environment and human welfare.

Is the control by scientists on genes and genetics ethical?

Often, the scarecrow of mad scientists producing monsters feeds the feeling that scientists should not decide on what genes and genetic recombinations should be selected. Ethical principles have been claimed to justify this opposition to human control over genetic recombinations. Humans have always selected genetic recombination in plants by choosing not only the parents but also selected individuals of their progeny.
This process started with the advent of agriculture 10,000 years with farmers domesticating wild plants to produce crops which were genetically improved by plant breeding in the last 100 years. Nowadays, there is no doubt that this process of selection has allowed the development of humanity, which totals today more than 6 billion humans. The recombinant DNA made by scientists is actually just new set of methods of the old process of selection of the most suitable to human. In this sense it does not appear to be inherently unethical that human directs DNA recombination. On the contrary, the use of genetic engineering to perpetuate and sustain humanity by providing increased yields and lower human and energy inputs is perfectly ethical.

Is the insertion of foreign DNA into the genome ethical, considering that it does not happen in nature?

Inserting a foreign gene into the genome appears to be a violation of the genome integrity and hence is sometimes invoked as an ethical concern. The insertion of foreign DNA (for example from a microorganism) into the plant genome violates the compatibility between species, which is often seen as crossing an ethical barrier. This phenomenon, although limited to certain species, has actually been observed in nature. The genomic sequencing of the *Arabidopsis thaliana* genome and other plants has shown that insertion of genetic material, such as foreign DNA into the nuclear genome is a common phenomenon due to the presence of mitochondria and plastid genomes. The method frequently used to genetically transform plants in genetic engineering is actually a natural process of insertion of foreign DNA into plant genome. Indeed, the transformation mediated by *Agrobacterium tumefaciens* was discovered in the 70s when this bacteria was shown to be capable of transferring a segment of its plasmid DNA into the plant genome to gain a selective advantage in the microflora. When this process was studied at the molecular level, it allowed for the development of a transfer method of any DNA into a large number of plant species. Therefore, the insertion of foreign DNA into plant genome is not precisely new or unnatural.

Are all genetic recombinations equally ethical?

The genes used in genetic engineering are usually not present in the crop plant or when they are, have a modified regulation. Therefore, genes from various origins including chimerical or synthetic genes are currently used, which creates the feeling that the use of genes from other species and even other kingdom is an unethical manipulation. Humans have always developed technologies to exert control over anything they can. As such, it has been in many cases for the benefit of the society. There are no scientific reasons to set aside genes as an untouchable entity. Genes are evolutionary products, and because of that they are fundamentally equivalent to organisms or natural resources that humans can use and exploit for the benefit of the society. The analysis of DNA structure throughout species and kingdoms has revealed an essential fact, the universality of the genetic structure and function. What makes a plant gene different from a bacterial gene is a sometimes extremely small difference.

One of the observations from the genome sequencing era is the evidence of gene transfer from prokaryotes to eukaryotes which have occurred repeatedly during evolution. Another aspect is the origin of the species. Biological evolution of species indicates a common ancestor to all species on earth. Therefore, genes with homology between species derive from a common ancestor. They have adapted to allow the organism to increase its fitness but essentially they are the same genes. Hence, gene shuffling or the use of genes from various sources is not inherently unethical.

Can humans or private companies own, through intellectual property rights, plants and genes?

The ownership over life forms as well as genes has repeatedly been quoted unethical. However, the intellectual property on biological resources didn’t start with the development of biotechnology. For many decades, human inventions have been protected through a variety of systems. Plant varieties have been recognized as the intellectual property of its developer through plant breeder’s rights. Since the 80s, the discovery of DNA molecules (a gene sequence for example) has been subjected to intellectual property right protections. This protection, extended to DNA molecules, is no more than an extension of the common
practice for other molecular compounds. Furthermore, the protection by patents of transgenic varieties started because they provide a stronger protection for the inventor. The patents over genes and genetically modified organisms are regularly questioned for its ethical correctness, especially when exclusive rights for commercial uses are confounded with ownership. If the concern is valid for life forms that are naturally occurring, then there is no doubt that it applies to a wider range of inventions apart from biotechnology. One of the questions to ask is where life forms end and chemistry begins. For example, the patenting of chemical compounds or products is perfectly compatible with the ethical norms, even when these are found in nature. Genes though, can also be regarded as being chemical elements.

Another aspect of the concerns over ownership in biotechnology is that many of the inventions are owned by large and powerful multinational companies. Their ownership of biotechnological innovations is often viewed as a threat to social equity. Indeed, the main objective of such multinational companies is to obtain high rate of wins to recover their investments. Therefore, it is unclear how the technology being in the hands of such entity will contribute to rural development and the improvement of the livelihoods of the poor. Clearly, this is where the public sector in partnership with the private sector has to vest human and financial resources in order to reach goals such as sustainable rural development.

**A tentative conclusion**

Regarding these ethical concerns on genetic engineering in plants, the civil society needs to go into a process of reflection and education, where all actors of the society are involved. Often this debate is skewed by political, commercial, and non-rational interests. The tendency to export these critics and spread them beyond any rational base has increased in the last years at the cost of the potential of this technology to benefit the agriculture in developing countries. Therefore, it is extremely important that the civil society in developing countries develop their own conscience about genetic engineering in order to apply this technology in a way that is most beneficial.