Will You or Won't You Propagate Genetically Engineered Plants?

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INTRODUCTION

Worldwide plants are now being genetically engineered to provide such characteristics as herbicide resistance, insect resistance, delayed ripening, and altered flower colour. While the question many people are asking themselves is whether they wish to **eat** genetically engineered plants, the question plant propagators worldwide must ask themselves is whether they will **propagate** genetically modified plants. In this short paper I have focused on three of the more common questions that are asked relating to genetic engineering:

1) What is the technology underpinning genetic engineering?
2) How do we genetically engineer a plant?
3) What are the risks associated with genetically engineered plants?

THE TECHNOLOGY

The technology is called recombinant DNA (rDNA) technology because two pieces of DNA (usually from different species) are combined. The first step in the procedure is to cut open a piece of DNA in a precise place using restriction enzymes This opens a gap into which another piece of DNA can be inserted The new DNA is referred to as rDNA and an organism with a new piece of DNA in it as a genetically modified organism (GMO)—the GMO has been "genetically engineered"

Currently we have genetically engineered microbes, plants, and animals. Genetically engineered microbes provide us with insulin, hepatitis C vaccine and, soon, interferon Further, much modern biological and medical research is based on rDNA technology If we said "no" to GMOs in New Zealand, apart from the medical setbacks, both biological and medical research would be seriously disadvantaged However, the use of rDNA and GMOs for research is one thing, the use of genetically engineered plants for agriculture, horticulture, and forestry is another

How Do We Genetically Modify a Plant? There are two predominant methods in use One uses *Agrobacterium tumefaciens* as a biological vector to place the DNA into the plant while the other, commonly referred to as "particle bombardment", essentially blasts DNA-coated gold or tungsten particles into the plant in the hope that some of the DNA will be incorporated into the plant DNA. With particle bombardment, the process is completely random, whereas *A tumefaciens* is often referred to as nature's own "genetic engineer" When this bacterium infects a plant a piece of its own DNA (the tDNA or transfer DNA) is transferred and incorporated into the plant's own DNA The bacterial DNA causes the plant to produce excess auxin and cytokinin which leads to the formation of a gall and the development of crown-gall disease. The genetic engineer discovered that pieces of the tDNA could be removed and other DNA put in instead The piece of DNA that is spliced in is then transferred naturally by the *Agrobacterium* into the plant The plant then produces the new products coded for by the new DNA These new products may lead to the plant being resistant to insects, to slower ripening of fruit, or even to a plant with a modified growth habit. *Agrobacterium* does not infect most monocotyledonous plants, such as the cereals, and for these plants the particle bombardment process usually is used.

ASSESSMENT OF GENETICALLY ENGINEERED PLANTS

The first issue to determine here is the basis of the risk assessment. From what perspective(s) do we assess genetically engineered plants? Ideally, this would be from the perspective of a nonhungry world with a sustainable food supply. However, I believe we must assess these plants in the context of today's world where current agricultural methodology is nonsustainable, where arable land is declining, and where the predicted population will be 8 billion by the year 2025.

While sustainable land management must be a target, an instantaneous move to sustainable organic-style agriculture is completely out of the question if we are to continue to feed the world's population. However, genetically engineered plants could become part of an integrated programme that may help towards the establishment of a sustainable food supply. Genetic engineering alone is certainly not the miracle answer to the world's food problems, but it may help if used wisely.

So how do genetically engineered plants measure up? Can we use genetic engineering to improve on what we do now? For example, consider the following scenarios:

1) If we were to genetically engineer a plant to be resistant to a herbicide that has been shown to be less damaging to the environment than the current herbicide regime, surely that is a step forward. This is Monsanto's argument for the introduction of the Roundup Ready Soybean. Roundup is considered a more "environmentally friendly" herbicide than many others currently in use.
2) If we were to genetically engineer a plant to be resistant to a set of insect pests and no longer have to spray on insecticide that is toxic to both the insect and to mammals, surely that is also a step forward.
3) And if we can genetically engineer into cowpeas a protein that inhibits the digestion of an insect pest (but not of a human) and reduces the storage losses of that staple food, surely that is a step forward (over 30% of the world's food is lost postharvest!)
4) If we were to engineer resistance to a herbicide in blackberry (blackberrry is a rampant, noxious weed in New Zealand) in New Zealand, that would be nonsensical, and in fact, would not be allowed by the regulatory authorities.
5) If we could use plants as chemical factories to produce industrial oils, surely that would be replacing a nonrenewable resource with a renewable one.

Genetic engineering **can** be used to improve on what we do now.

Unknowns Are Also Associated with Classical Plant Breeding. Opponents to genetic engineering of plants often claim it is a very risky process, that we don't know where the new DNA is inserted, and that we must select the ideal plant. However, some of these concerns could equally be applied to plants derived from standard plant breeding programmes.

For instance, if a cultivated potato cultivar was to be crossed with a wild relative showing, for example, virus resistance, the first cross would dilute the genetic material of the cultivated cultivar by 50%, rendering it essentially useless. Up to 20 backcrosses and selections may be required to "regain" essentially the original cultivar along with the new genetic material containing the virus resistance trait. Along with the new trait will be a significant number of linked genes of unknown character.

Using genetic engineering, the single gene conferring virus resistance (along with a marker gene) can be inserted into the selected crop plant via *Agrobacterium*. Genetic engineering thus provides a faster route, the integrity of the genetic material of the crop plant is maintained and we know precisely what DNA has gone into the plant. Further, we can subsequently determine where the new DNA has inserted into the genome of the plant. There are obvious, significant advantages to genetic engineering in terms of time to produce a new culitvar and knowledge of the DNA inserted.

Can the Inserted Gene Escape into the Wild? This is indeed possible. However, it must be remembered that classical plant breeding is also aiming to derive, for example, virus-resistant, herbicide-resistant, and insect-resistant plants. **Management** of the new cultivars is the issue at question, less so the origin of the genetic material in the new cultivars. It is highly improbable that one genetic engineering event will turn a cultivated plant into a superweed, but an awareness of the relatedness of the new cultivar to the local weed and cultivated species, as well as to the indigenous flora is needed to determine the potential for escape and hybridisation. For instance, a genetically engineered plant should not be grown in the centre of origin of that particular crop plant.

Are There Health-related Risks? There are health-related risks associated with **both** classical plant breeding and genetic engineering: but both sets of plants must be and are subjected to testing. It was testing that picked up that an allergenic protein from brazil nut had been incorporated into soybean (this in an attempt to improve the nutritional quality of the soybean protein).

CONCLUSIONS

Traditional plant breeding is a well established and accepted practise but it is not without its own set of "risks". When evaluating the issues surrounding the propagation of genetically engineered plants, traditional plant breeding should be the key reference point.

USEFUL REFERENCE MATERIALS

Conner, A.J. 1997. Genetically engineered crops—environmental & food safety issues. Roy. Soc. NZ Miscellaneous Series 39.

Gene technology. 1997. Benefits and risks. Roy. Soc. NZ Miscellaneous Series 46.

Plant Biotechnology. 1996. Talking technology conference: Final report and proceedings from the conference. Wellington, 22-24 Aug.

Steinbrecher, R.A. 1996. From green to gene revolution. The environmental risks of genetically engineered crops. The Ecolog. 26(6):273-281.

Tiedje, J.M., R.K. Colwell, Y.L. Grossman, R.E. Hodson, R.E. Lenski, R.N. Mack, and **P.J. Regal**. 1989. The planned introduction of genetically engineered organisms: Ecological considerations and recommendations. Ecol. 70(2):298-315.