



Non Food/Feed Uses of GM Plants

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Non Food/Feed Uses of GM Plants

-Production of molecules of pharmaceutical use
-Production of molecules for industrial use
-Production of biodegradable polymers
-Biofuels
-Specialty Oils
-Bioremediation

Non Food/Feed Uses of GM Plants

Advantages:

- Absence of pathogens that can infect humans or animals
- Unparalleled potential scalability for virtually unlimited production (no need for expensive reactors)
-It can be not only easily scaled up but also reduced, without affecting major investments on reactors, to adapt to market demand
-Initial production is low-tech and inexpensive
-Protein modifications similar to animal cells

Disadvantages

- Undesirable gene flow
- Some protein modifications might differ from animal cells
- Protein yield still challenging
-Public perception

Production of molecules of pharmaceutical use

Types of products:

Antibodies, blood products, cytokines, growth factors, hormones, recombinant enzymes and human and veterinary vaccines.

Increased production natural bioactive secondary metabolites

Some are approaching commercialization:

Gastric lipase for cystic fibrosis and antibodies to prevent dental caries and non-Hodgkin's lymp

Table 1 | Plant-derived pharmaceutical proteins that are closest to commercialization for the treatment of human diseases

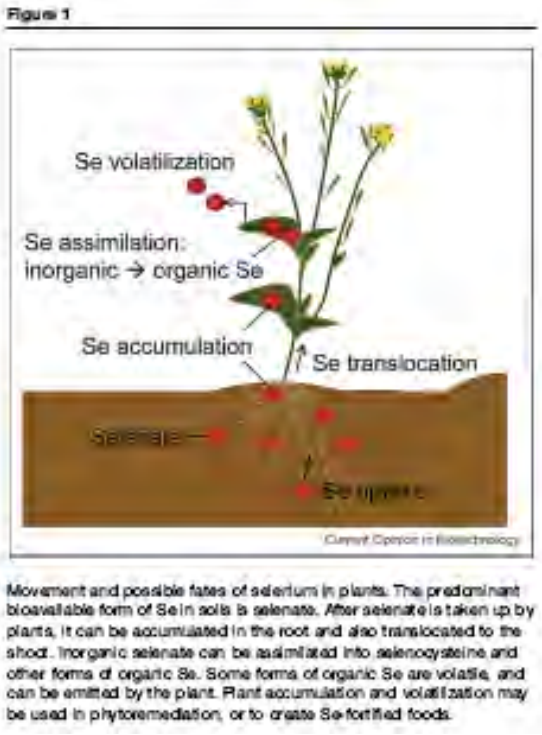
Product	Class	Indication	Company/Organization	Crop	Status
Various single-chain Fv antibody fragments	Antibody	Non-Hodgkin's lymphoma	Large Scale Biology Corp	Viral vectors in tobacco	Phase I
CaroRx	Antibody	Dental caries	Planet Biotechnology Inc.	Transgenic tobacco	Phase II
E. coli heat-labile toxin	Vaccine	Diarrhoea	Prodigene Inc.	Transgenic maize	Phase I
			Arntzen group (Tacket *et al*, 1998)	Transgenic potato	Phase I
Gastric lipase	Therapeutic enzyme	Cystic fibrosis, pancreatitis	Meristem Therapeutics	Transgenic maize	Phase II
Hepatitis B virus surface antigen	Vaccine	Hepatitis B	Arntzen group (Richter *et al*, 2000)	Transgenic potato	Phase I
			Thomas Jefferson University/ Polish Academy of Sciences	Transgenic lettuce	Phase I
Human intrinsic factor	Dietary	Vitamin B12 deficiency	Cobento Biotech AS	Transgenic *Arabidopsis*	Phase II
Lactoferrin	Dietary	Gastrointestinal infections	Meristem Therapeutics	Transgenic maize	Phase I
Norwalk virus capsid protein	Vaccine	Norwalk virus infection	Arntzen group (Tacket *et al*, 2000)	Transgenic potato	Phase I
Rabies glycoprotein	Vaccine	Rabies	Yusibov *et al* (2002)	Viral vectors in spinach	Phase I

Production of molecules of industrial use

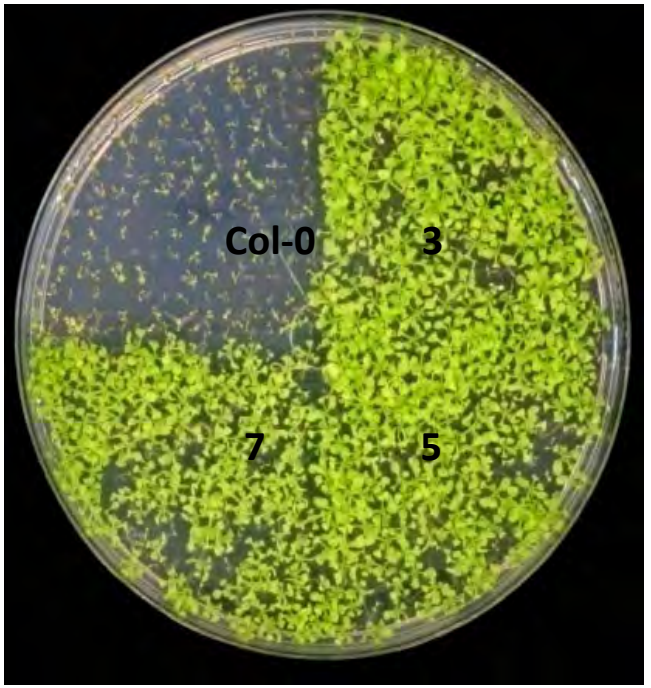
-Trypsin, use in detergents and tanning leather
-Lacasse (multicopper oxidase), used in detergents and paper industry
- Avidin, b-glucuronidase,lysozyme, aprotinin, etc.
- Biodegradable plastics (3-hydroxyacids, polyhydroxybutyrate)
-Inks, plasticizers and paints
-Wood with reduced lignin content for paper production
-Oils for industrial use
-Biofuels
-Replacements for secondary petrochemistry

Use of GM plants for bioremediation

-Removal of toxic heavy metals: selenium, mercury, arsenic
-Removal of herbicides, explosives (using P450 enzymes, i.e. TNT, NTG) and small organic compounds
-Removal of reduced forms of phosphorus produced by CD and DVD industry.



Movement and possible fates of selenium in plants. The predominant bioavailable form of Se in soils is selenate. After selenate is taken up by plants, it can be accumulated in the root and also translocated to the shoot. Inorganic selenate can be assimilated into selenocysteine and other forms of organic Se. Some forms of organic Se are volatile, and can be emitted by the plant. Plant accumulation and volatilization may be used in phytoremediation, or to create Se-fortified foods.

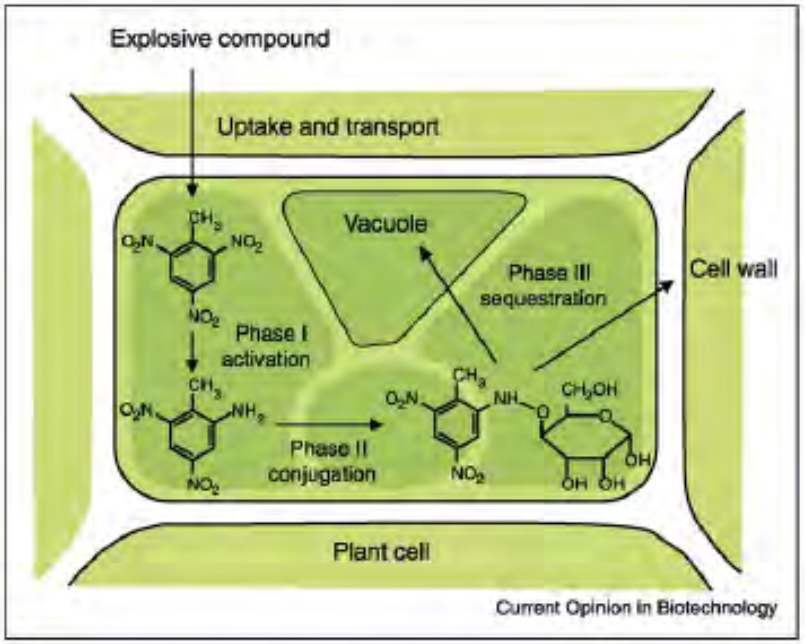


Use of GM plants for bioremediation

Table 1

Transgenic plants engineered for the transformation of explosives.

Gene	Source	Plant	Target pollutant
Pentaerythritol tetranitrate reductase	*Enterobacter cloacae*	*Nicotania tabacum*	GTN and TNT
Nitroreductase	*Enterobacter cloacae*	*Nicotania tabacum*	TNT
Nitroreductase	*Escherichia coli*	*Arabidopsis thaliana*	TNT
Cytochrome P450	*Rhodococcus rhodochrous*	*Arabidopsis thaliana*	RDX
Nitroreductase	*Pseudomonas putida*	*Populus tremula* × *Populus tremuloides*	TNT



The three phases of the 'green liver' model: hypothetical pathway

Strategies for preventing or monitoring gene flow

- Integration in chloroplast genome (mainly maternally inherited, not transmitted through pollen

-Male sterile plants (several strategies already exist including the “terminator technology”

-Use of visual markers linked to genes used for molecular farming or other industrial purposes.

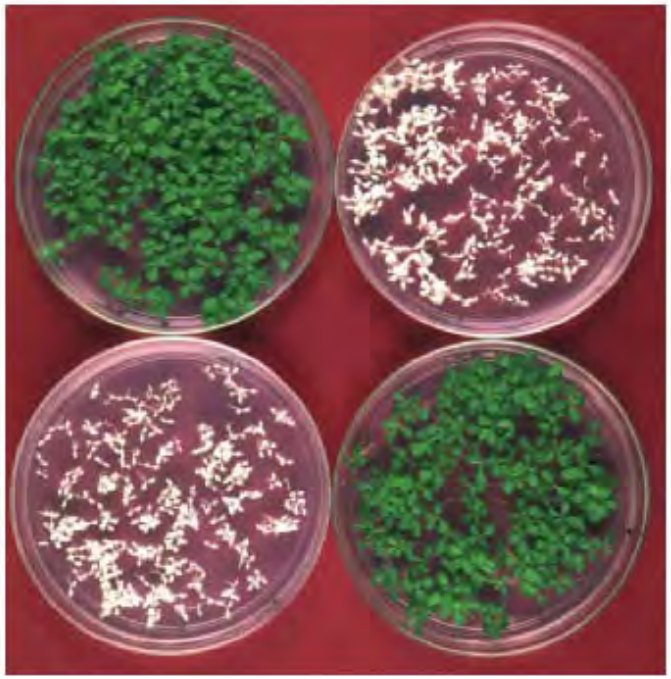


Fig 1 | Reciprocal crosses showing maternal inheritance of a transgene integrated into the chloroplast

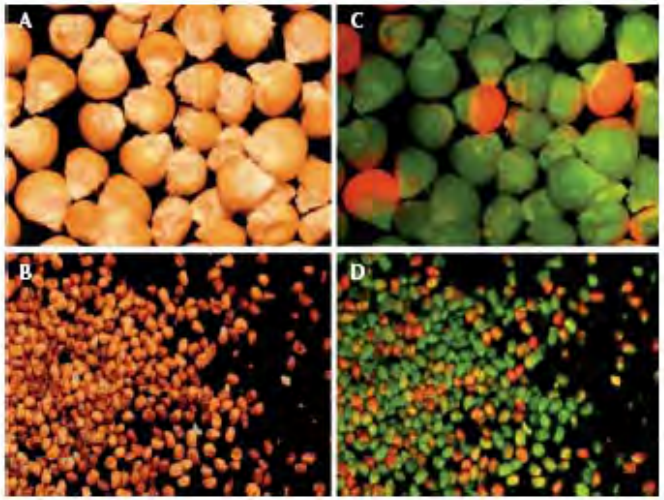


Fig 2 | Detection of transgenic seeds using red fluorescent protein (DsRed) as a visible marker. Maize and tobacco seeds (A and B) observed under green light (C and D). Courtesy of T. Rademacher (RWTH, Aachen, Germany).

Other important applications of GM technology for non-food purposes, also important food/feed production

-GM plants with enhanced water use efficiency

-GM plants with enhanced fertilizer use efficiency

-GM plants with increased photosynthesis

We already have problems in terms of water, nutrient and land availability, thus it is urgent to develop technologies to produce GM plants with lower requirements of water and nutrients particularly phosphate

> …molecular farming is reaching the stage at which it could challenge established production technologies that use bacteria, yeast and cultured mammalian cells

Plant genomics and microbial metagenomics will dramatically increase the possibilities of non-food applications of GM plants

We have to be careful to develop the appropriated guidelines to prevent the accidental escape of transgenes developed for molecular farming, particularly those designed for pharmaceutical products.

It would be advisable to avoid the use of plant species that are currently used, or are planed to be used, for food and feed production.

Although technology is already available to substantially decrease the risk of undesirable transgene flow, these cases require particular care