GM potato field trials on *Phytophthora* resistance

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Phytophthora is the biggest threat for potato cultivation. Phytophthora costs in Belgium: >1000 tons of fungicides and 10 -15 times spraying/season ≈ 55 million euro/year. Estimation for Europe > 1 billion euro costs/year.
**Phytophthora** is a world wide problem on potato

21 million ha globally, losses about 10 billion €...
Resistant varieties are the best solution

- Resistance genes available in wild relatives
  
  \( S. \text{stoloniferum, S. venturi, S. bulbocastanum} \) and others, 
  > 20 genes in total

- Introduction into potato through, either:
  - Conventional breeding
  - Genetic modification
Breeding: what happens to the DNA?

Crossing a tomato with a wild relative

Backcrossing with the cultivated tomato plant to retrieve all the good characteristics
Breeding: what happens to the DNA?

First cross: progeny resistant but with small non-edible fruits

DNA fragments of the wild variety are combined with the chromosomes of the edible cultivar.
Breeding: what happens to the DNA?

In case the wild relative is not related enough, no natural recombination can occur, irradiation is used to break chromosomes.

A DNA fragment of the wild variety is attached to one of the chromosomes of the edible cultivar, example: current wheat varieties have pieces of grass chromosomes.
Resistant varieties obtained by breeding: results from the field trial in 2011, Belgium

Sarpo Mira
(Danespo)
Several R genes

Toluca
(Agrico)
Blb2

Bionica
(C.Meijer)
Blb2
Disadvantages of breeding

• Sarpo Mira has several resistance genes (Rietman et al., 2012, MPMI), but the eating and processing qualities are low (only suitable for french fries).

• Bionica and Toluca are more palatable but not good for processing and they contain only one resistance gene > virulent Phytophthora strains develop very fast > resistance is not functional anymore.
Bionica & Toluca contain blb2

Conventional breeding is very slow and in case of interspecific crosses involves in vitro techniques (embryo rescue, colchicine*).

GM is fast but the authorisation procedure is time consuming and expensive. Environmental and food safety tests required (animal testing).
The essence of plant genetic engineering

- A specific piece of DNA is introduced into the plant cell.
- Plant transformation methods use *Agrobacterium* or physical means (microparticles) to introduce the DNA.
- DNA integration into the plant genome has been studied very well.
- The DNA is inserted in one of the chromosomes of the target plant by natural **DNA repair** enzymes (>> event).
- Very precise technology: one gene can be isolated from one organism and introduced in “another”, this new gene is stably integrated and inherited as any other gene, location unknown at beforehand but characterised > **known**.
GM is fast

- Resistance in one step through isolation of one gene out of 20-40,000 and introducing it into a good variety.

- Variety characteristics remain.

- Possible to introduce multiple resistance genes at the same time: several potato lines in the field trials had R genes from *Solanum bulbocastanum*, *S. venturi* & *S. stoloniferum*.
Lab and greenhouse tests

Resistance tests in the lab and greenhouse to identify the best resistance genes and the lines with best performance.

Désirée

Désirée + Rpi-chc1
A Belgian field trial with GM late blight resistant potatoes
The GM potatoes in the Belgian trial in 2012

From Wageningen UR (DuRPh project):

– 7 lines with sto1 resistance gene + nptII marker
– 8 lines with vnt1.1 resistance gene (cisgenic)
– 10 lines with sto1, vnt1.1. and blb3 resistance genes + nptII marker

All in Désirée

From several sources: resistant and susceptible reference lines.
Potatoes are resistant to late blight without fungicide treatment because of natural resistance genes from wild relatives (cisgenesis)
Results of the field trial

Resistant GMO lines: no spraying is needed for late blight protection

Susceptible reference: destroyed by late blight if not sprayed
A genetically modified organism (GM) means an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination.

GM plants and GM food have a specific regulatory framework.

Several specific applications are exempted.
EU-regulation GMO and exemptions

- This Directive should not apply to organisms obtained through certain techniques of genetic modification which have conventionally been used in a number of applications and have a long safety record, e.g. micro-organisms that have been engineered to produce enzymes.

- Techniques/methods of genetic modification to be excluded from the Directive, (1) mutagenesis, (2) cell fusion (including protoplast fusion) of plant cells of organisms which can exchange genetic material through traditional breeding methods.
What type of tests are needed before GM potatoes can be cultivated?

- Agronomical tests
- Molecular characterisation
- Environmental risk assessment (e.g. non targets)
- Toxicity (possibly animal tests)
- Allergenicity
- Compositional analysis

- All these tests have to be done on samples from independent experiments (e.g. from field trials in different years on different locations).
Genetic engineering is often seen as unnatural in contrast to breeding

- Breeding not only done within species but also between species (interspecific) and even between genera (intergeneric) cfr. *Triticum* X *Agropyron* & *Aegilops*.
- Irradiation can be used to break the chromosomes.
- Colchicine is a chemical that blocks chromosome separation during meiosis to induce higher ploidies.
- Progeny are often too weak to survive >> in vitro embryo rescue.
Some genes have been transferred without any human intervention from one organism to another in evolution by HGT (horizontal gene transfer).

Adzuki Bean Beetle, Nicotiana tabacum, Linaria vulgaris, Matveeva et al. MPMI 2012

Elysia chlorotica
Certain plants obtained by breeding have been taken from the market after introduction because of toxicity

⇒ potato that caused diarrhea
⇒ celery that caused burns.

GM plants on the market are the best studied crops.
Breeding versus cisgenesis

Cultivar

Wild plant

After breeding

After cisgenesis
Conclusion

Classical breeding

Cisgenesis

• EFSA Scientific Opinion, 2012:
The Panel concludes that similar hazards can be associated with cisgenetic and conventionally bred plants.

• EU Working Group New Breeding Techniques, 2012:
Cisgenesis .... could be considered to be excluded from the EC Directive on GMO’s.
Let’s hope decisions are based on science...

The Scientific Method
Here are the facts, which conclusions can we draw?

The Political Method
Here is the conclusion, which facts do we find to support it?

Thank you!
Questions?