New methods and tools in plant breeding

Per Hofvander, Brussels, 5 November 2013
Plant Breeding

- Historically of great importance for a secure food supply and food safety by domestication and adaption of crops for climate zones, day length zones, biotic challenges, nutritional value and reduction of antinutrients and toxic substances.

- Future importance for above and a growing focus on a biobased economy.

- For a biobased economy an improved input biomass material reduces the energy input you need to get a desired value out.
Plant research and breeding

- High degree of interconnectivity of academic plant research and plant breeding
- We develop and use similar technologies although we may utilize them for different purposes
- European plant research is very important for European plant breeding and the other way around

- Genetic diversity and inheritance
- DNA based markers
- Genotyping and selection of lines in breeding
- Genes and pathways
- Genetic modification
- Introduction of new traits
Plant breeding tools related to hereditary material

Passive – assess what is there

- DNA sequencing
- DNA based markers

Active – influence change

- Crosses
- Cell fusions
- Chemical and ionizing radiation mutagenesis
- “TILLING” (screening technology – passive)
- ”Genetic modification” as defined by 2001/18/EC
- Directed in vivo mutagenesis
Technology examples – directed mutagenesis

DNA binding region

DNA nicking or cutting protein

Nucleic acid – DNA and RNA

DNA repair can result in changes

Traceability

No

Use of nucleic acid guide for DNA repair to introduce limited desired changes to DNA sequence

Not really

Use of nucleic acid guide for DNA repair to introduce larger DNA elements

Yes
Status of examplified technologies

Regulated under 2001/18/EC or not?

- Risk assessment of technology where outcome cannot be distinguished from unregulated technologies – traceability, legal enforcement

Why an important question?

- Huge difference in cost of developing plant varieties using regulated technologies according to directives than using those outside the scope
- New plant breeding tools will be accessible to smaller enterprises if the resulting plant varieties are not regulated according to 2001/18/EC
- E.g. DNA based markers, tissue culture techniques are used by smaller enterprises
Personal reflections

- This is not about agricultural practices, this is about tools and technologies for plant breeding.
- This is about tools used before you have a variety which can be propagated and put in the field.
- New plant varieties to support a biobased and sustainable economy.

EU Plant breeding toolbox

- Crosses
- DNA based markers
- TILLING
- Doubled haploids

Cis- intragenesis

Genetic modification

Reverse breeding

Directed *in vivo* mutagenesis
THANK YOU!
Definition of GMO in 2001/18/EC

- 25 years old, same as in 90/220
- Definitions are rather open and vague

Article 2
Definitions
For the purposes of this Directive:
(1) “organism” means any biological entity capable of replication or of transferring genetic material;
(2) “genetically modified organism (GMO)” 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.
Within the terms of this definition:
(a) genetic modification occurs at least through the use of the techniques listed in Annex I A, part 1;
(b) the techniques listed in Annex I A, part 2, are not considered to result in genetic modification.

Article 3
Exemptions
1. This Directive shall not apply to organisms obtained through the techniques of genetic
modification
listed in Annex I B.
ANNEX I A
TECHNIQUES REFERRED TO IN ARTICLE 2(2)
PART 1
Techniques of genetic modification referred to in Article 2(2)(a) are inter alia:
(1) recombinant nucleic acid techniques involving the formation of new combinations of genetic material
by the insertion of nucleic acid molecules produced by whatever means outside an organism, into any virus, bacterial plasmid or other vector system and their incorporation into a host organism in which they do not naturally occur but in which they are capable of continued propagation;
(2) techniques involving the direct introduction into an organism of heritable material prepared outside the organism including micro-injection, macro-injection and micro-encapsulation;
(3) cell fusion (including protoplast fusion) or hybridisation techniques where live cells with new combinations of heritable genetic material are formed through the fusion of two or more cells by means of methods that do not occur naturally.
PART 2
Techniques referred to in Article 2(2)(b) which are not considered to result in genetic modification, on condition that they do not involve the use of recombinant nucleic acid molecules or genetically modified organisms made by techniques/methods other than those excluded by Annex I B:
(1) in vitro fertilisation,
(2) natural processes such as: conjugation, transduction, transformation,
(3) polyploidy induction.
ANNEX I B
TECHNIQUES REFERRED TO IN ARTICLE 3
Techniques/methods of genetic modification yielding organisms to be excluded from the Directive, on the condition that they do not involve the use of recombinant nucleic acid molecules or genetically modified organisms other than those produced by one or more of the techniques/methods listed below are:
(1) mutagenesis,
(2) cell fusion (including protoplast fusion) of plant cells of organisms which can exchange genetic material through traditional breeding methods.
Traceability

- Insertion of genetic elements – yes
- Insertion of genetic elements then outcross - no
- Mutagenesis targeted to specific locus – no
- Guided repair mutagenesis - perhaps