



Crop Genetic Improvement Technologies: Indispensable Tools to Tackle the Challenge of Feeding the World

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IAP Workshop

Science for Poverty Eradication and Sustainable Development: a Call for Action

Manaus, Brazil, 3-5 December 2014

Global agricultural and societal challenges



- Food security – in the face of population growth, changing consumption patterns, climate change (mitigation and adaptation), social and economic instability (urbanisation)
- Sustainable balance of supply and demand
- Avoiding further loss in biodiversity
- Degraded agricultural land (ca. 25% globally)
- 60% more production over next 40 years (on same land area)
- Additional demand from the bioeconomy – livestock feed, renewable energy and chemical feedstocks

Crop Genetic Improvement Technologies are indispensable tools!

Crop Genetic Improvement Technologies



Breeding technologies portfolio

Coventional Breeding (CB)

Random undirected genome alterations through crossing or mutagenesis...

Selection based on phenotype or biochemical markers...

Defined low level regulation, no risk assessment

Genetically altered crops with superior characteristics (traits),
e.g. higher yield, pest resistance, drought tolerance,
nutrient use efficiency, nutritional value

New Plant Breeding Techniques (NPBT)

Specific directed genome alterations with or without DNA integration or site specific mutagenesis...

Selection by molecular markers...

*Regulatory requirements **not** decided, low level recommended (as CB)*

Genetic Engineering (GE)

Specific undirected genome alterations by cisgenic (same gene pool) or transgenic (different gene pool – access to full biodiversity potential) DNA integration...

*Selection by molecular markers or phenotype... Defined **high** level regulation including risk assessment*

Techniques that crop breeders use to create new plant varieties: GM & NPBT (1)

- **Transgenesis (GM):** transfer a gene (DNA coding region) from another organism.
- **Cisgenesis:** transfer a gene to a plant of the same or closely-related species (inter-fertile).
- **Intragenesis:** insert a reorganised, full or partial gene derived from the same species (usually combined with a promoter or terminator from another gene of the same species).
- **Targeted mutagenesis:** specific mutation produced by an Site Directed Nuclease (SDN) technique.

Techniques that crop breeders use to create new plant varieties: GM & NPBT (2)

- *Transient introduction of recombinant DNA*: mutations directed by **oligonucleotides** or **infiltration techniques** give rise to end products that can be similar to, and indistinguishable from, plants derived through conventional plant breeding.
- *Other techniques*: **RNA-induced DNA methylation** (gene silencing) and **reverse breeding** -> intermediate products are genetically modified but end products are indistinguishable from plants obtained through conventional breeding. **Grafting** a non-genetically modified scion onto a genetically modified rootstock -> chimeric plant where only the lower part carries the genetic transformation.

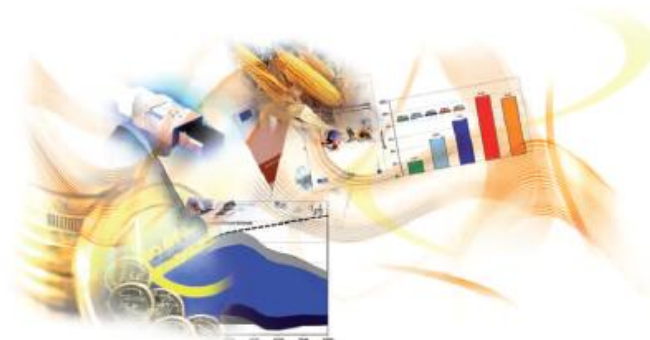
New Plant Breeding Techniques

JRC Scientific and Technical Reports



New plant breeding techniques State-of-the-art and prospects for commercial development

Maria Lusser, Claudia Parisi,
Damien Plan and Emilio Rodríguez-Cerezo



Lusser et al., 2011
JRC Scientific and technical report

Gene targeting techniques

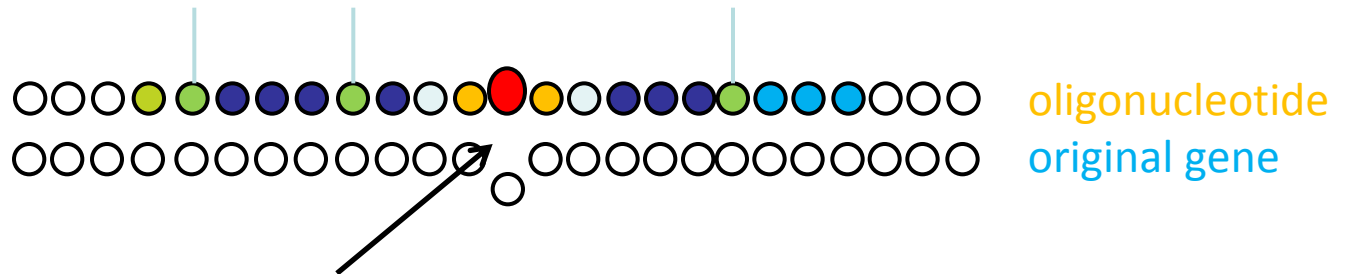
Oligo-directed mutagenesis

Synthetic genomics (biology)

Site-directed nuclease (SDN) technique

Oligo-directed mutagenesis

An oligonucleotide modified for stable binding induces a point mutation



stabilised mismatch, repair via MMR leads to point mutation



Works like a natural point mutation

Creation of herbicide resistance and disruption of catalytic centers

Only small alterations are possible

Synthetic genomics (biology)



Whole new genomes synthesized in vitro & transplanted into an empty host cell performed by Craig Venters group with a *Mycoplasma mycoides* genome (Gibson et al., 2008, 2010, Science)

One or more genes synthesized & transformed into a living cell for production

Ideas

- synthesizing of enzymatic pathways for a specific chemical
- transplantation of these into plant cells
- e.g. as chromosomal integration or extrachromosomal (mini chromosome)
- Developing of a new chloroplast genome as a factory for new products (Agapakis et al., 2011. PLoS One)
- Programmable Ligand Detection System in Plants through a Synthetic Signal Transduction Pathway (Antunes et al., 2011 PLoS One)

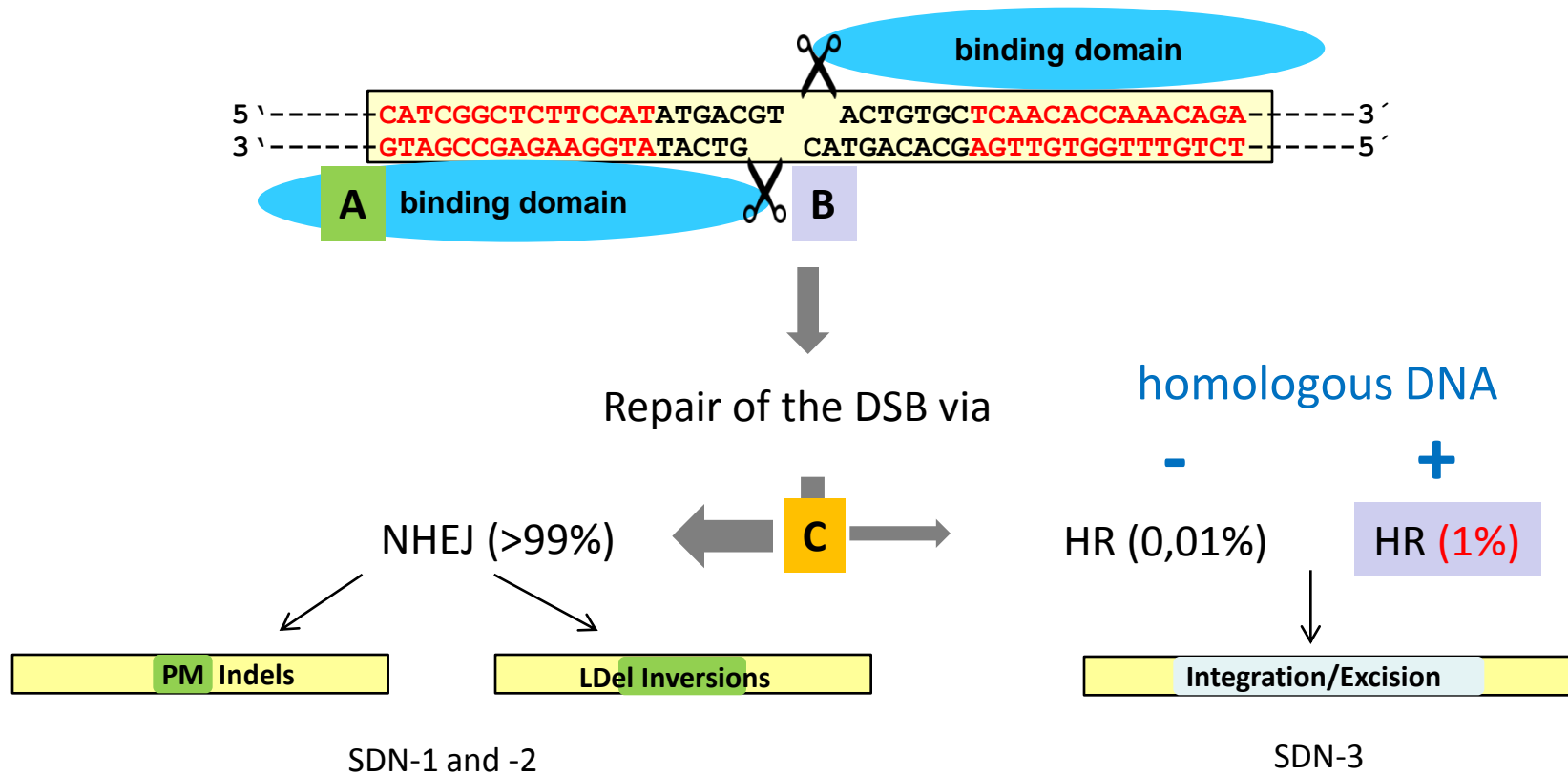
Site-directed nucleases (SDN)

The principles for all kinds of SDNs are similar:

- a DNA binding domain is either encoded or fused to a restriction domain
- the nuclease is stably or transiently expressed in vivo
- after binding of a specific DNA sequence a double strand break (DSB) is induced
- the DSB is repaired by the cellular repair machinery
- during DNA repair point mutations, indels, translocations or homologous recombination (HR) can occur

The repair by HR can be used for efficient gene targeting

SDN communalities



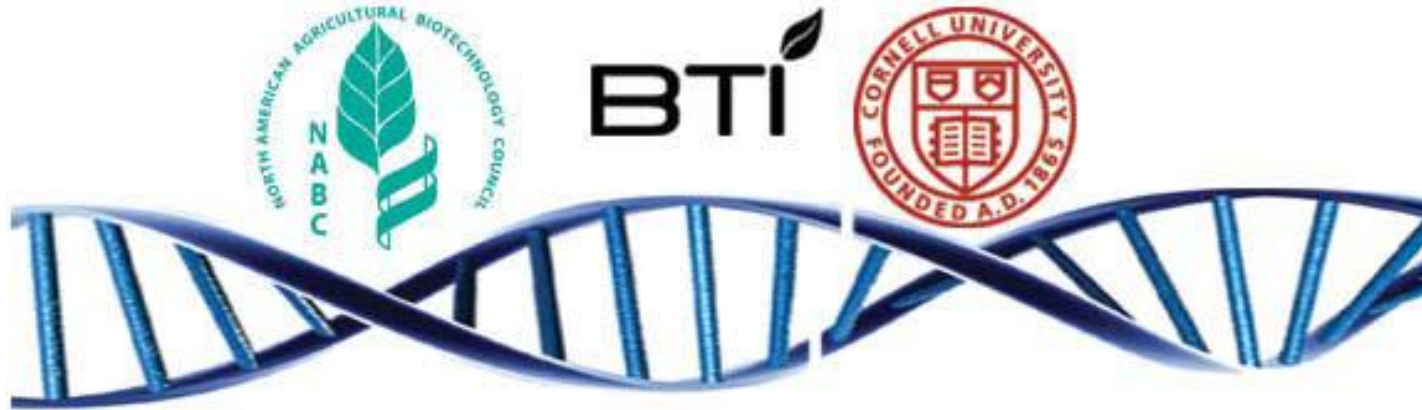
EPSOs request to the European Commission



- The European Plant Science Organisation welcomes the outcome of the majority opinion of the Member States expert working group (the “New Techniques Working Group”) report and asks the European Commission to provide a guideline document in the same sense to get timely legal certainty for science and industry concerning the application and exploration of New Plant Breeding Techniques.
- Since more and more new breeding techniques will be developed a more detailed and comprehensive discussion on a new approach for the regulation of new plants is required. This new approach might be based on new characteristics of a product/trait and should take the following into account:
 - a. A clear and reliable definition based on scientific evidence what a plant novel trait exactly is, that is to be deregulated (*legal certainty*);
 - b. It should not lead to a situation of overregulation where more and more processes and products will have to undergo expensive and lengthy authorization procedures (*disadvantage for SMEs and scientists*);
 - c. It should uncouple the question of environmental risk and safety assessment from the question of GMO-labeling (*consumer acceptance*).



EU perspectives on NPBTs (1)



NABC 26

New DNA-Editing Approaches: Methods, Applications and Policy for Agriculture

October 8-9, 2014, Ithaca, New York

“EU perspectives on New Plant Breeding Techniques”

EU perspectives on NPBTs (2)

- **Does the European Union have a position on NPBTs?**
- **Does the European Commission have a position on NPBTs?**
- **When will the European Commission touch the “hot potato”?**

- **Does the European Scientific Community has a position?**
 - New Techniques Working Group (2012) Final Report
 - Position statement (2012) of the ZKBS on new plant breeding techniques
http://www.bvl.bund.de/SharedDocs/Downloads/06_Gentechnik/ZKBS/02_Allgemeine_Stellungnahmen_englisch/05_plants/zkbs_plants_new_plant_breeding_techniques.pdf%3F__blob=publicationFile%26v=2
 - Report (2011/2012) of the Joint Research Center (JRC) working group
 - ETP “Plants for the Future” (2012) Position paper on New Breeding Techniques
<http://www.epsoweb.org/file/1096>
 - EFSA-Opinions (2012) on safety assessment of Cisgenesis and ZFN-3
 - **Report of the European Academies Science Advisory Council (2013)**
 - ETP ‘Plants for the Future’ & NBT platform information meeting (2014) ‘The Future of Plant Breeding Techniques in the European Union’
 - Biotechnology and Biological Sciences Research Council (BBSRC) Position Statement (2014) ‘New Techniques for Genetic Crop Improvement’

EASAC Report “Planting the Future”



Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture



EASAC policy report 21

June 2013

ISBN: 978-3-8047-3181-3

This report can be found at
www.easac.eu

building science into EU policy

European Academies Science
Advisory Council
Launch June 2013, Brussels

www.easac.eu

- Introduction
- International comparison of policy choices and GM experience
- The connections between the EU and Africa
- Connecting the evidence base and EU policy development
- Conclusions and recommendations

Endorsement of the report



Anne Glover, Chief Scientific Adviser to the President of the European Commission

“The ‘Planting the Future’ report of the European Academies’ Science Advisory Council (EASAC) is an authoritative, joint statement of the national science academies in the EU Member States.”

“The conclusions of the report are based on the best possible evidence and I endorse its conclusions whole-heartedly.”

“There is no evidence that GM technologies are any riskier than conventional breeding technologies and this has been confirmed by thousands of research projects.”

“Finally, we shouldn't forget that there are also other promising novel plant breeding technologies, post-GM, and we shouldn't make the mistake of regulating them to death as we have done with GM.”

*Interview at
<http://www.euractiv.com>*

Project/Report “Planting the Future”



Aims

- To explore implications for EU policy-making of alternative strategic choices in utilising crop genetic improvement technologies for sustainable innovation of agriculture
- To compare what is happening in other economies who have adopted GM crops more actively
- To collaborate with African experts in agricultural biotechnology to evaluate how previous EU policy debates have affected African countries
- To examine multiple EU issues for regulatory reform: science base, public engagement, intellectual property, new environmental challenges, other applications in the bioeconomy

Case studies from comparator countries: Specific focal points

- Impact of GM herbicide-tolerant soybean in Argentina
- Socio-economic impact of Bt cotton in India
- History of developments in Bt cotton in Australia
- Trends in GM research in Brazil
- Regulatory system for plants with novel traits in Canada



Case studies: Emerging cross-cutting issues

- Export of agricultural commodities is increasingly part of economy of competitor countries. One consequence is stimulus to basic science and innovation.
- Vital to distinguish between any specific effect of a technology and consequences of other changes in agronomic practice and social developments.
- Increasing volume of evidence to document benefits of GM crops. GM technology itself has no greater adverse impact than any other technology used in plant breeding.
- Streamlined, transparent, effective regulatory frameworks can be devised that encourage investment and innovation – must focus on product/trait rather than on technology.

Analysis of connections between EU and African agriculture by Science Academies

- Involved academies from 13 African countries; case-studies from Ghana, Uganda, Tanzania and Kenya
- Evidence shows that EU actions historically constrained use of crop genetic improvement technologies in African countries, creating difficulties for farmers, scientists, policy-makers
- Recently, increasing activity in Africa to characterise and cultivate GM crops to address local needs
- Significant opportunities for information-sharing and R&D partnership between EU and Africa to strengthen local systems
- Continuing role for science academies to work together to identify science and technology priorities, strengthen centres of excellence, contribute advice to support policy-making and public debate

Conclusions: what are the strategic priorities for the EU?

- **Land use, innovation and productivity**
 - The EU is falling behind competitors
 - Biotechnology for crop improvement must be part of response to societal challenges
- **Regulation**
 - Requires evidence-based framework with firm foundation in sound science
- **Promoting competition**
 - Stimulating open innovation
- **Global context**
 - Understanding the wider consequences of EU decisions
 - Tackling policy disconnects between EU domestic objectives and the development agenda

EASAC recommendations (1)



- **Public engagement:** **“Speak up, stand up, gang up!”**
(Anne Glover)
 - Scientific community must articulate consequences of research findings and opportunities for innovation
 - Key role of European Innovation Partnerships (EIP) in agriculture
- **Achieving coherence in policy for agric. innovation**
 - For example: integration of GM crop objectives with Integrated Pest Management strategies
 - Reformulating regulatory framework to focus on product/trait; science-based, transparent, proportionate and predictable, taking account of international experience and evidence

EASAC recommendations (2)



- **R&D**
 - Capitalising on Horizon 2020
 - Attending to infrastructure and training
 - Support for public-private sector collaboration
- **International partnerships**
 - EU can learn from rest of world about “what works“ in regulatory practice and innovation
 - EU must also take into account impact of decisions on others
 - New opportunities for collaboration in research and innovation

In conclusion

- The potential of crop genetic improvement technologies is very significant
- It is urgent for the EU to capture these benefits
- This requires better policy coherence to exploit the research and technologies that the EU was instrumental in generating: in common with other sectors, the aim should be to **regulate the trait and/or the product but not the technology** in agriculture
- We have collective responsibility to provide and utilise scientific solutions to improve agricultural productivity globally and reduce the adverse impact of agriculture on the environment
- All available approaches – traditional and novel – must be deployed

Conclusions for Legislation on GMOs (+ NPBTs)



Anne Glover,
Chief Scientific Adviser to the President
of the European Commission

“ ... now in 2013 with more research into GM technology than almost any other area of food research, there is no evidence to suggest that the GM technology *per se* poses any unique risk compared to any other plant breeding technology.”

“To be provocative - can we meet the demand for food to feed 9 billion citizens by 2050 without using every tool in the tool box? Is it ethical to reject technology without evidence but on the grounds of preference when 1 billion global citizens every single day are starving?”

“Our obligations as citizens is to look at the evidence presented and have the courage to reposition our views as that evidence accumulates.”

Editorial EPSO NL29

Abolition of the post of Chief Scientific Advisor



EASAC has signed two letters recently in support of the continuation of the position of Chief Scientific Advisor to the European Commission's President.

- The first letter, dated 4 July 2014, was a joint letter by the 4 European academy networks ALLEA, EASAC, Euro-CASE and FEAM and the pan-European Academy *Academia Europaea*, addressed to the President-elect of the European Commission, Jean-Claude Juncker.
- The second letter, of 24 July 2014, was a direct reply to calls from a group of NGOs that the post of CSA be abolished. This letter points out that independent science advice is needed for European citizens to have confidence in the way policies are developed.
- EASAC has also written to EU President Juncker in November 2014, voicing its concern over the abolition of the position of CSA.

Source: EASAC Newsletter December 2014

Abolition of the post of Chief Scientific Advisor



EASAC President voices concern over abolition of Chief Scientific Advisor

EASAC's President and Vice-Presidents have voiced their grave concern over the abolition of the post of Chief Scientific Advisor (CSA) in [letters to Jean-Claude Juncker](#), President of the European Commission. Since Anne Glover began work in 2012, EASAC developed a constructive and valuable relationship with her, and she greatly improved communication between the Commission and the scientific community. The most recent letter also asks the Commission for clarification on its future plans for the provision of scientific evidence in European policy formulation.

Source: EASAC Newsletter December 2014

*Thank you very much
for your attention*



Photo:
Anke
Schiemann

**Those who want the world to continue as it is,
do not want the world to continue.**