



European Food Safety Authority

# Protection goals and the evaluation of potential adverse effects of altered cropping and management practices associated with GMHT crop cultivation – an EFSA GMO Panel perspective

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Yann Devos, Paolo Bàrberi, Joe N Perry, Geoffrey R Squire, Jeremy B Sweet, Antoine Messéan

Yann Devos (PhD) – scientific officer

GMO Unit – European Food Safety Authority (EFSA)

[Yann.Devos@efsa.europa.eu](mailto:Yann.Devos@efsa.europa.eu)



## 1. Introduction

## 2. Challenges

## 3. Scenario-analysis / case study

## 4. Conclusion

# Introduction

## Role of European Food Safety Authority (EFSA)

- **Genetically modified organisms (GMOs)**
  - Independent & transparent science-based advice
    - GM plant market authorisation applications
      - Import & processing for food & feed uses
      - **Cultivation**
    - Specific issues
      - National safeguard clause / emergency measures
      - Annual post-market environmental monitoring reports
      - ...
    - Guidelines
      - Risk assessment
        - » **2010: Environmental risk assessment of GM plants**
      - Post-market environmental monitoring
      - ...



- GM plants for which the EFSA GMO Panel has issued a scientific opinion for cultivation

### Maize



#### Insect resistance (IR)

1507 (Cry1F)

Bt11 (Cry1Ab)

MON810 (Cry1Ab)

#### Herbicide tolerance (HT)

NK603 (CP4 EPSPS)

GA21 (2mEPSPS)

#### IR + HT

MON88017

(Cry3Bb1 + CP4 EPSPS)

### Potato



#### Amylopectin (starch)

EH92-527-1

(granule bound starch synthase protein (GBSS))

### Soybean



#### HT

40-3-2 (CP4 EPSPS)



Focus on **potential adverse effects of altered cultivation, management & harvesting techniques associated with GMHT crop cultivation**



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# Challenge 1

## Interplay between GMO and PPP legislation

### Potential adverse effects of altered cropping and farm management practices associated with GMHT crop cultivation

1

Impact on farmland biodiversity (including weed community diversity/weed shifts)

2

Selection of weed communities composed of more tolerant or resistant weeds

3

Impact on soil microbial communities

In the remit of GMO legislation or not?  
To be considered under PPP legislation?

- **Protection of environment / (farmland) biodiversity**
  - Too broadly defined to be operational
    - Translation needed to operational protection goals & assessment/measurement endpoints
    - Diversity in operational protection goals
      - Food production (yield) (e.g., Ewers et al., 2009; Godfray et al., 2010)
      - Biological control (e.g., Albajes et al., 2008, 2009, 2010, 2011)
      - Beneficial weeds (e.g., Storkey, 2006; Storkey and Cussans, 2007)
    - Lack of clarity on limits of concern
      - Beneficial weeds
        - » ‘How many weeds’ or ‘what type of weeds’ are desired in arable fields? What change represents environmental harm?
      - Receiving environments
        - » Environments that sustain little farmland biodiversity
        - » Environmentally sensitive areas



- **Complex, diverse & dynamic systems**
  - Complex
    - Arable ecosystems
      - Many interconnected parameters/factors
    - Many external drivers (e.g., policies, market demands)
  - Diverse
    - Diversity in farm management & cropping practices
      - Environmental factors
      - External drivers
      - Spatial and temporal scale
      - ...
  - Dynamic
    - Temporal scale



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### ■ Scenario-analysis

- Forecasting tool to use in situation of uncertainty
- Concept
  - EFSA (2010) Guidance on the environmental risk assessment of GM plants. EFSA Journal 8(11):1-111 [1879],  
<http://www.efsa.europa.eu/en/efsajournal/doc/1879.pdf>
- First implementation
  - EFSA (2012) Scientific Opinion on an application (EFSA-GMO-NL-2005-24) for the placing on the market of the herbicide tolerant genetically modified soybean 40-3-2 for cultivation under Regulation (EC) No 1829/2003 from Monsanto. EFSA Journal 10(6):1-110 [2753],  
<http://www.efsa.europa.eu/en/efsajournal/doc/2753.pdf>

- If RR soybean was to be approved for cultivation in the EU, will the farm management & cropping practices associated with the cultivation of **RR soybean** lead to greater, similar or less reductions in weed community diversity compared with current practices used in **conventional soybean** cropping systems?



### ■ Adverse effects on weed community diversity?

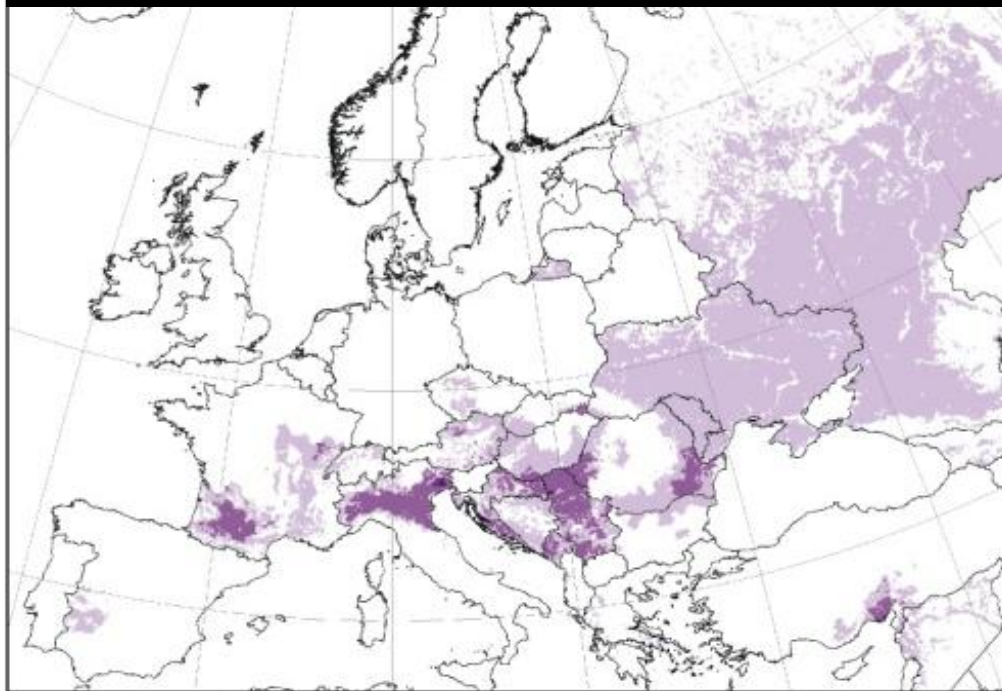
#### – Approach

- **Step 1:** to review farm management & cropping practices specific to soybean
  - Conventional soybean cropping systems (EU)
  - RR soybean cropping systems (Argentina, Brazil, USA, Romania, scientific literature)
  - Changes associated with adoption of RR soybean
- **Step 2:** to assess environmental impact relative to current practices
  - Scenarios
  - Risk index (formula / model)
- **Step 3:** to recommend risk management strategies
  - Risk mitigation measures
  - Post-market environmental monitoring

- **Adverse effects on weed community diversity?**
  - Farm management & cropping practices in conventional soybean cropping systems (EU experience)

G) Soybean  <0.1% 0.1-1% 1-10% 10-20% >20%

Purple = harvested area of soybean as % of total area of each grid cell. Map based on data from Monfreda et al. (2008)



In 2011, EU cultivation area of soybean (including Croatia) = approximately 475,000 ha

- Italy (35%)
  - Romania (16%)
  - Croatia (12%)
  - France (9%)
  - Hungary (9%)
  - Austria (8%)
  - Slovakia (4%)
  - the Czech Republic (2%)
- (Eurostat)

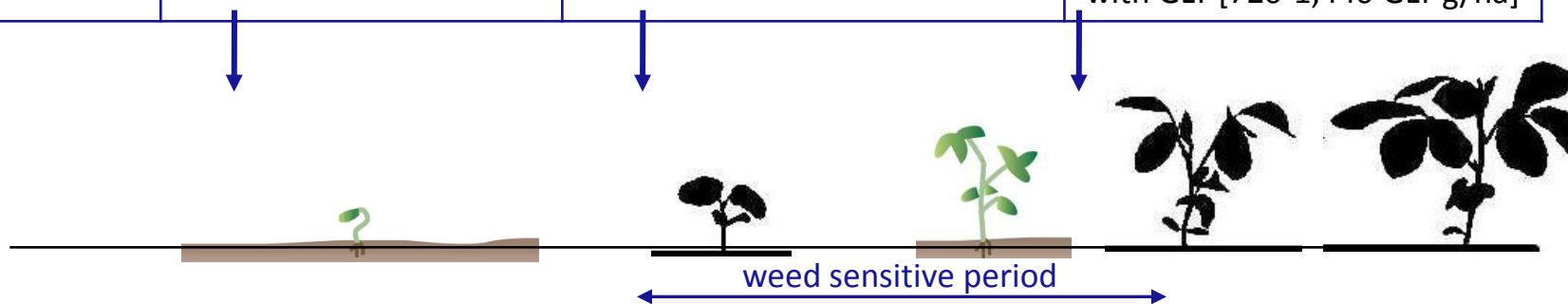
- **Adverse effects on weed community diversity?**
  - Farm management & cropping practices in conventional soybean cropping systems (EU experience)
    - **Crop rotation**
      - 2-yr rotation (soybean-wheat/maize) in FR and IT
      - 3-yr rotation (soybean-wheat-maize) in RO
      - 4-yr rotation in FR, HU, IT and RO
      - Continuous soybean = not common practice, but soybean can be occasionally cropped for up to 3 consecutive years
    - **Herbicide regimes**
      - Applications pre-emergence of soybean (PRE)
      - Application post-emergence of soybean (POST)
      - Sequential application or mixture of PRE & POST herbicides



### Adverse effects on weed community diversity?

- Farm management & cropping practices in RR soybean cropping systems (recommendations public & private sector)

Options	PRE of soybean	unifoliate stage of soybean	1 <sup>st</sup> -3 <sup>rd</sup> trifoliate stage of soybean
A	(reduced rate of residual herbicide)	GLY [720-1,080 GLY g/ha]	
B		GLY [720-1,440 GLY g/ha]	GLY [720-1,080 GLY g/ha]
C		tank mix reduced rate of residual herbicide with GLY [720-1,080 GLY g/ha]	GLY [720-1,080 GLY g/ha]
D		GLY [720 GLY g/ha]	tank mix reduced rate of broad spectrum herbicide with GLY [720-1,440 GLY g/ha]





- **Adverse effects on weed community diversity?**
  - Farm management & cropping practices used in RR / conventional soybean cropping systems
    - Potential changes in cropping & management practices in response to adoption of RR soybean (experience in Argentina, Brazil, Romania, US)
      - Herbicide usage & regimes (move towards GLY-based systems)
        - » GMHT crops allow GLY use '*over the top of the crop*' = substantial change in cultivation/management of GMHT crops compared with conventional crops
        - » Initial trend: GLY-based systems only
        - » Current trend: residual herbicides + GLY
      - No or reduced tillage systems
      - Length of soybean crop rotation
      - Share of soybean cultivation at a landscape level

### ■ Adverse effects on weed community diversity?

#### – Scenarios

- Typical 2-, 3- & 4-yr crop rotations
- Conventional soybean cropping system
  - Baseline (a typical scenario)
    - » CONV soybean (spring-sown) + 1 x PRE + 1 x POST + ploughing
- RR soybean cropping system
  - Substitution scenario
    - » RR soybean (spring-sown) + 1 x PRE + 1 x GLY + ploughing
  - Worst-case scenario
    - » RR soybean (spring-sown) + 1 x PRE + 2 x GLY + ploughing
    - » Continuous RR soybean (spring-sown) + 1 x PRE + 2 x GLY + ploughing OR adoption of other RR crops in rotation
  - Best-case scenario
    - » RR soybean (spring-sown) + 1 x GLY + no or reduced tillage

### ■ Adverse effects on weed community diversity?

#### – Risk index (formula / model)

- Comparative assessment – estimation of **relative** risk
  - Crop rotation
    - » Number of different crops in rotation
    - » Degree to which growing season changed within rotation
    - » Competitive ability of crops with regard to weeds
  - Herbicide usage
    - » Use of GLY // CONV herbicides applied PRE & POST
    - » Weed control efficacy
    - » Duration of weed control
  - Tillage
    - » Type of tillage (conventional inversion (= ploughing), no or reduced tillage)
    - » Diversity of tillage systems employed during rotation

**Table WD.** Comparison of relative risks of reductions in weed community diversity within various soybean and soybean 40-3-2 cropping systems. Relative risks compared with appropriate baseline are defined as follows: LL (considerably lower risk than baseline), L (lower risk), S (similar risk), H (higher risk), and HH (considerably higher risk). Comparisons should be made within columns.

Scenarios		Crop rotations		
		2-year (soybean -maize*)	3-year (soybean- maize- wheat*)	4-year (soybean- maize- oilseed rape- wheat*)
<b>Conventional soybean cropping systems</b>		Baseline <sub>2</sub>	Baseline <sub>3</sub>	Baseline <sub>4</sub>
<b>Soybean 40-3-2 cropping systems</b>				
Best-case WD	Substituting with RR soybean, GLY <sub>[1x]</sub> , no- or reduced-till	LL	L	L
Substitution WD	Substituting with RR soybean, PRE <sub>[1x]</sub> + GLY <sub>[1x]</sub> , inversion	S	S	S
Worst-case WD	Substituting with RR soybean, PRE <sub>[1x]</sub> + GLY <sub>[2x]</sub> , inversion	H	H	S
Very-worst-case WD	Replacing with continuous RR soybean, PRE <sub>[1x]</sub> + GLY <sub>[2x]</sub> , inversion	HH	HH	HH

Abbreviations: GLY = glyphosate; PRE = conventional pre-emergence herbicides; POST = post-emergence herbicides; [x] = number of applications; WD = weed community diversity

\* In all cases, the following cropping and management practices were assumed: for soybean, spring-sown / inversion / treated with 1 × PRE + 1 × POST; for maize, spring-sown / inversion / treated with 1 × PRE + 1 × POST; for oilseed rape, winter-sown / inversion / treated with 2 × POST; and for wheat, winter-sown / inversion / treated with 2 × POST

- **Mitigate adverse effects on farmland biodiversity**
  - Practices associated with RR soybean cultivation could result in more environmental harm under certain conditions
    - Use GLY on RR soybean only in regimes that have similar or reduced environmental impact compared with conventional soybean cultivation
    - Mitigation targeting cropped areas
      - e.g., reduced tillage, crop rotation, less intense in-crop weed management, early over-the-row band spraying followed by later overall spray, combine different weed management practices in integrated & diverse systems
    - Mitigation targeting uncropped land
      - e.g., limit GLY drift to protect adjacent habitats, adopt/reintroduce better management of field margins or other ‘out of crop’ measures
    - Risk mitigation measures should remain proportionate!

- **Monitor changes in weed community diversity within fields**
  - 3-step approach
    - **Recommend specific herbicide/cropping regimes to farmers**
      - No more harmful than current conventional management practices
      - Be consistent with local protection goals
      - Be based on field data (e.g., efficacy trials)
      - Tool: stewardship programs
    - **Monitor if regimes recommended are implemented**
      - Tool: FQ (e.g., info on herbicide/crop management, weeds)
    - **Monitor if recommended regimes have proposed efficacy to mitigate harm to biodiversity**
      - Tool: targeted multi-annual scientific studies (i.e., Nichterlein et al., 2012)
      - See EFSA (2012) for specific recommendations



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- **Impact of altered farm management & cropping practices**
  - Scenario-analysis
    - To identify under which conditions farm management & cropping practices associated with GMHT crop cultivation could lead to <, similar or > environmental harm than a typical baseline
    - To identify under which conditions risk mitigation & monitoring may be required
  - Applicability
    - Other GMHT crops + areas of environmental concern
    - Other weed management options
    - Adaptable to local conditions
  - Further work/discussion required to fine-tune approach
    - Choice of baselines + scenarios
      - » Fine-tune to local conditions & protection goals (dialogue)
    - Risk index (formula / model) (e.g., Young et al., 2013)



- EFSA (2010) Guidance on the environmental risk assessment of GM plants. EFSA Journal 8(11):1-111 [1879],  
<http://www.efsa.europa.eu/en/efsajournal/doc/1879.pdf>
- EFSA (2012) Scientific Opinion on an application (EFSA-GMO-NL-2005-24) for the placing on the market of the herbicide tolerant genetically modified soybean 40-3-2 for cultivation under Regulation (EC) No 1829/2003 from Monsanto. EFSA Journal 10(6):1-110 [2753],  
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Thank YOU for your attention!

