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Faculty of Agrobiolgy, Food and Natural Resources
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GLYPHOSATE USE – FACTS AND MYTHS IN CURRENT DEBATE, IMPACT ON WEED COMMUNITIES AND ENVIRONMENT

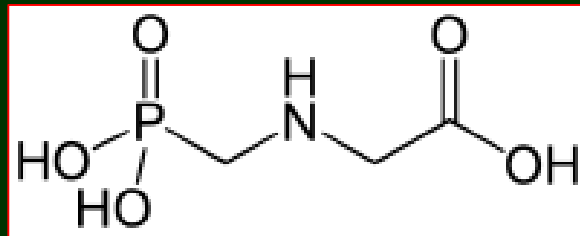
Josef Soukup

**K. Hamouzová, P. Košnarová, M. Jursík, J. Holec, P. Hamouz, P. Saska
*et al.***



Characteristics of glyphosate

- N-(phosphonomethyl) glycin
- active ingredient in (non-selective) herbicides
- wide efficacy spectrum



- described in 1970 (John E. Franz)
- market launch of **Roundup** in 1974
- patent terminated in USA in 2000

Formulation of herbicides containing glyphosate

- **Active ingredient (glyphosate)**

- acid
- ammonium salt
- **isopropylamine salt (IPA)**
- potassium salt, sodium salt
- trimethylsulfonium (trimesium)

- **Adjuvants**

- **POEA** – polyethoxylated alkylamines: surface active ingredients (surfactants) improving spread and intake
- other co-formulants...

Glyphosate uses

● Agricultural land

- between crops on arable land
 - after harvest / stubble tillage
 - before sowing
- *pre-harvest application in grains*
- recultivation of meadows and pastures
pastvin
- *herbicide tolerant crops (HT)*

● Non-agricultural land

- railways and roads (non desirable vegetation)
- *municipalities (weeding on hard surfaces)*
- forestry (non desirable vegetation, sprouting)

● Hobby users

- gardeners, owners of real estates

World use of glyphosate

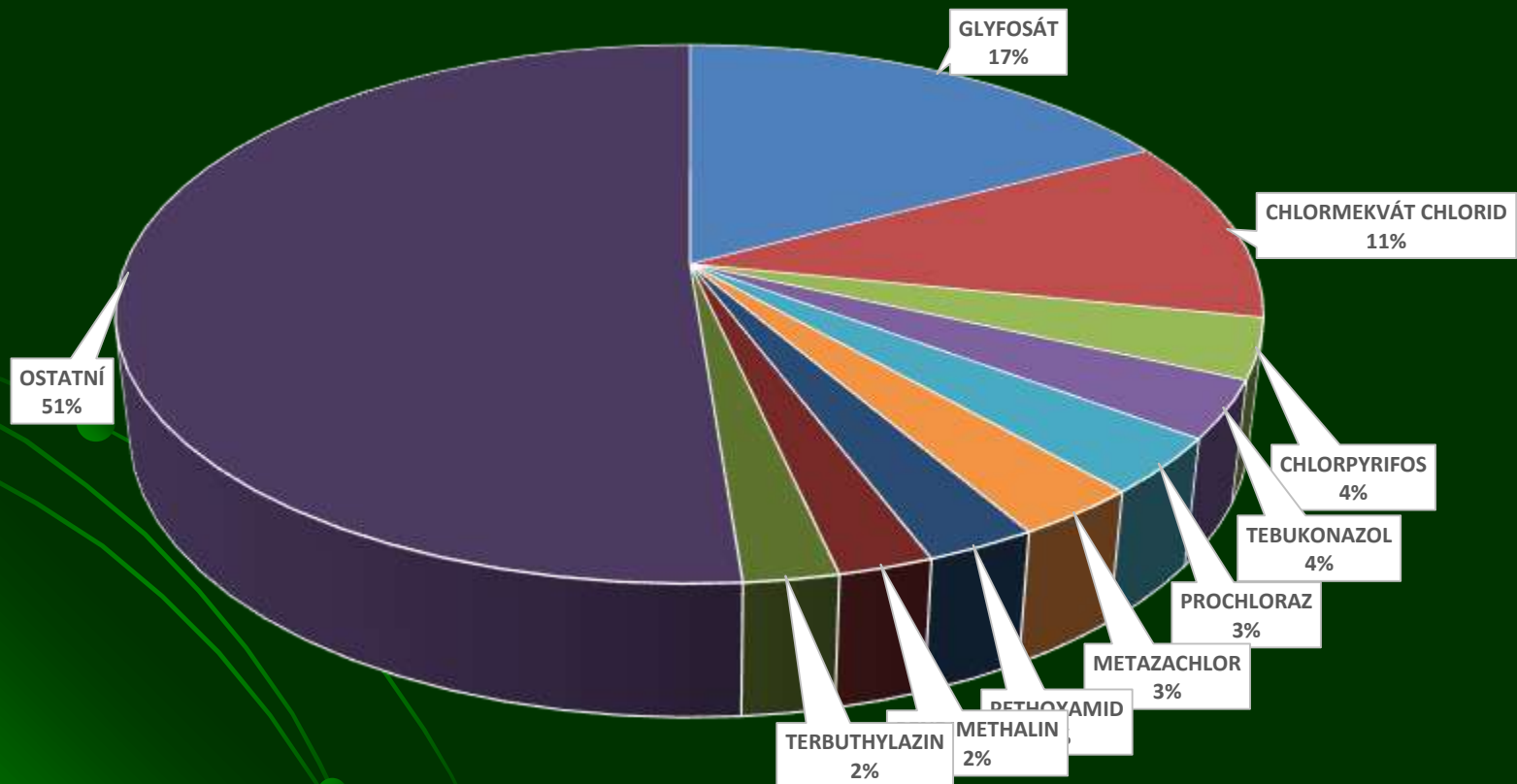
- Market demand: **718 600 tonnes** in 2012
 - turnover 5,46 billions USD
- 42.5 % of total sales are used in HT crops
- Expected growth about 7.2% between 2013-2019
 - turnover 8.79 billions USD in 2019

Extent of glyphosate use in current cropping systems (EU)

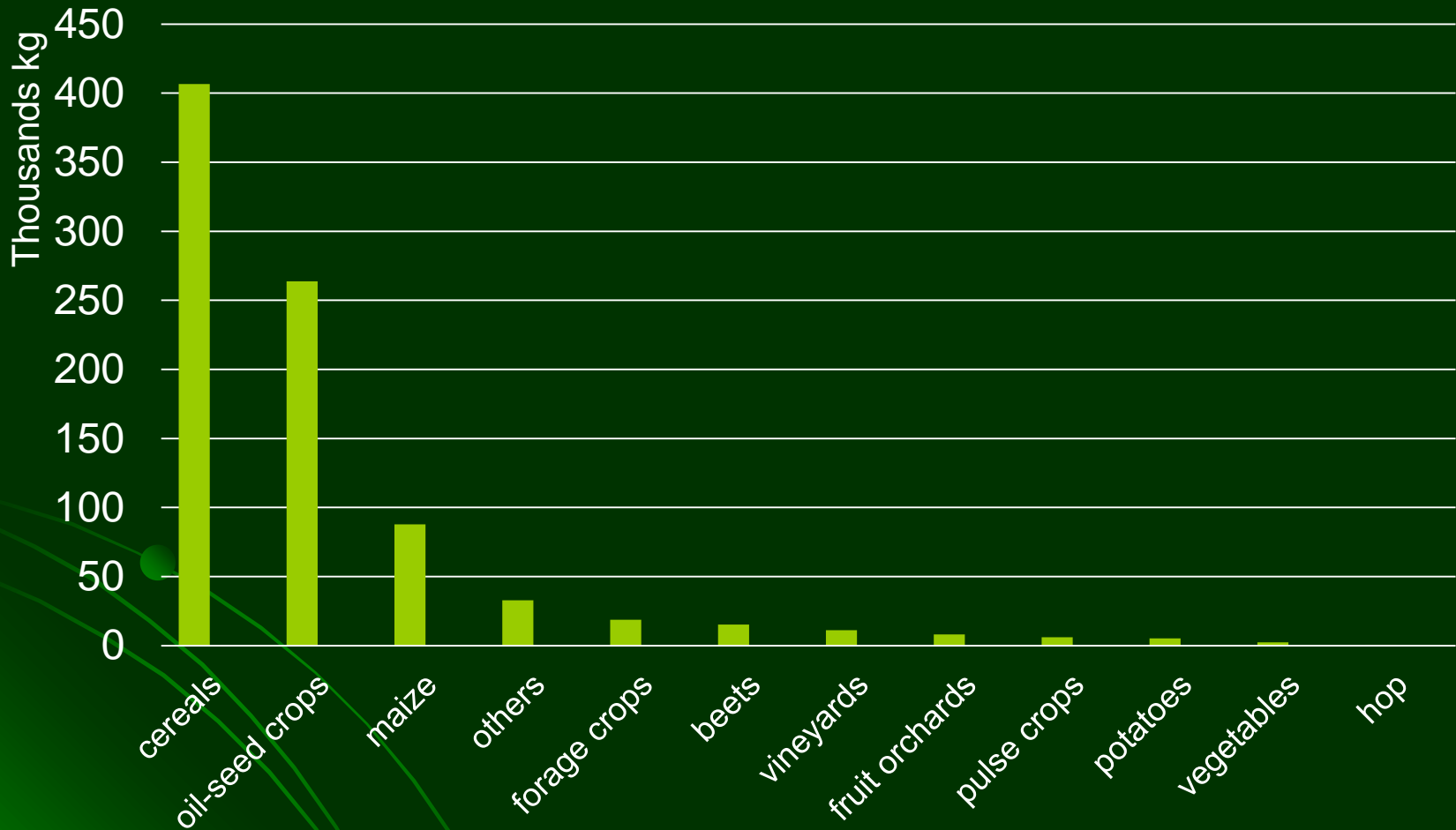
- **England** (Cook S.K. *et al.*, 2010, Wynn S.C. *et al.*, 2014)
 - between crops: treated 50-85 % area for wheat and OSR
 - pre-harvest applications: 25-40 % in wheat, 60-75 % in rape
- **Germany** (Garvert H. *et al.*, 2013)
 - 30% of arable land treated by glyphosate
 - 7% of cereals and 18 % of OSR area treated before sowing
 - 41 – 50% area for maize and sugar beet
 - pre-harvest applications on 5-20 % of cereals; 65% in case of winter barely in coastal region
 - 28 % of stubbles treated after cereals and 52 % after the OSR
- **Czech Republic** (data ÚKZÚZ and own estimation)
 - 15% of arable land treated by glyphosate
 - 15% of cereals, pre-harvest applications are rare
 - 25 % of OSR area; 5-10 % as a pre-harvest

Share of glyphosate on the total consumption of all PPP in the Czech Republic in 2014

- Yearly consumption (active ingredients) of all PPP: **5 007 627 kg**
- Yearly consumption of glyphosate: **858 511 kg**



Consumption of glyphosate according to crops in the Czech Republic in 2014



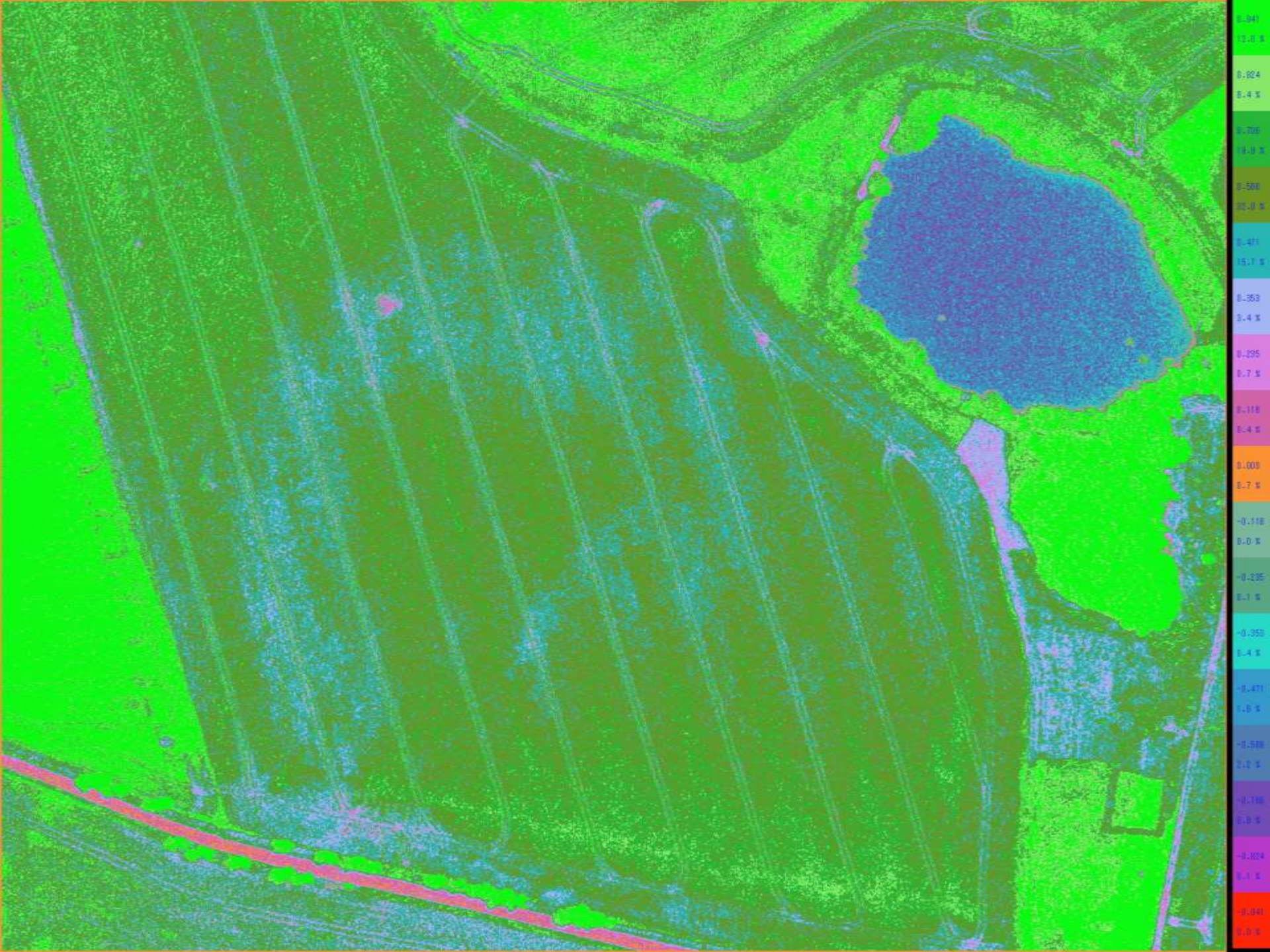
Source: Musil B., ÚKZÚZ Brno

Spread of reduced soil tillage systems



Pre-harvest application in oil-seed rape






Site-specific application can save 50-80% of glyphosate



Photo: K. Novotná

Consequences of the reliance on glyphosate

- Glyphosate resistance
 - Contamination of the environment
 - Health risk
 - Regulatory and social aspects
 - farmers
 - consumers
 - decision making
- 

Glyphosate resistance in Europe

- Not found on arable land yet
- Perennial cultures (oliva orchards, vineyards)
 - *Conyza canadensis*, *C. bonariensis*, *C. sumatriensis*
 - *Lolium rigidum*, *L. multiflorum*, *L. perenne*
- Non agricultural land
 - *C. canadensis* (CZ, Poland)

Development of resistance in *Conyza canadensis* (CZ, 2013)

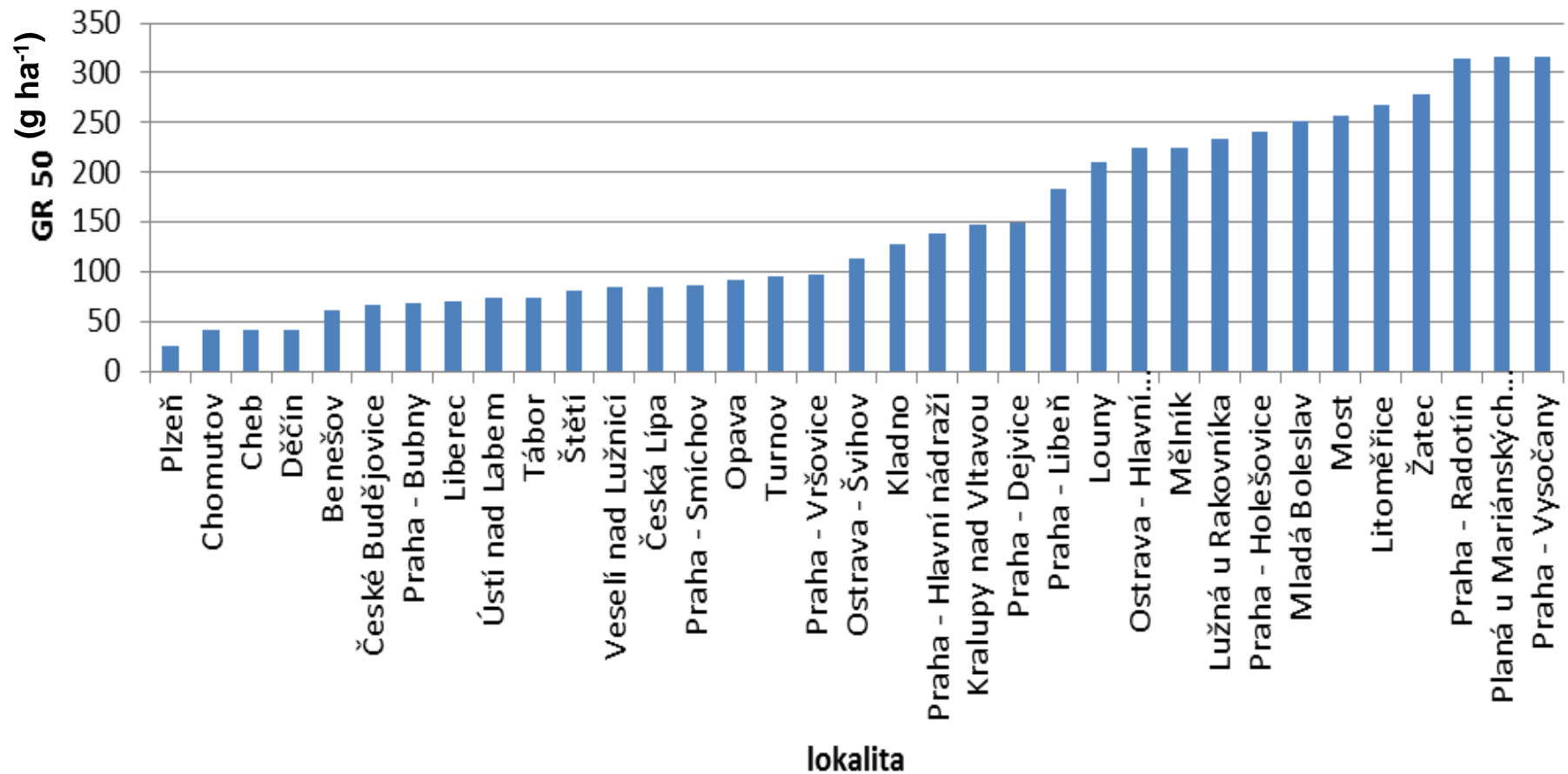
Sensitive population



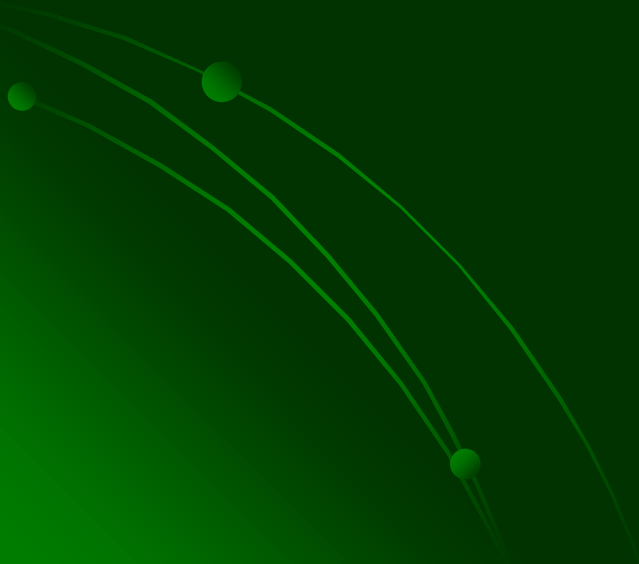
Resistant population



Inter-population variability in sensitivity of *Conyza canadensis* to glyphosate on railways in the Czech Republic



Environmental and eco-toxicological aspects

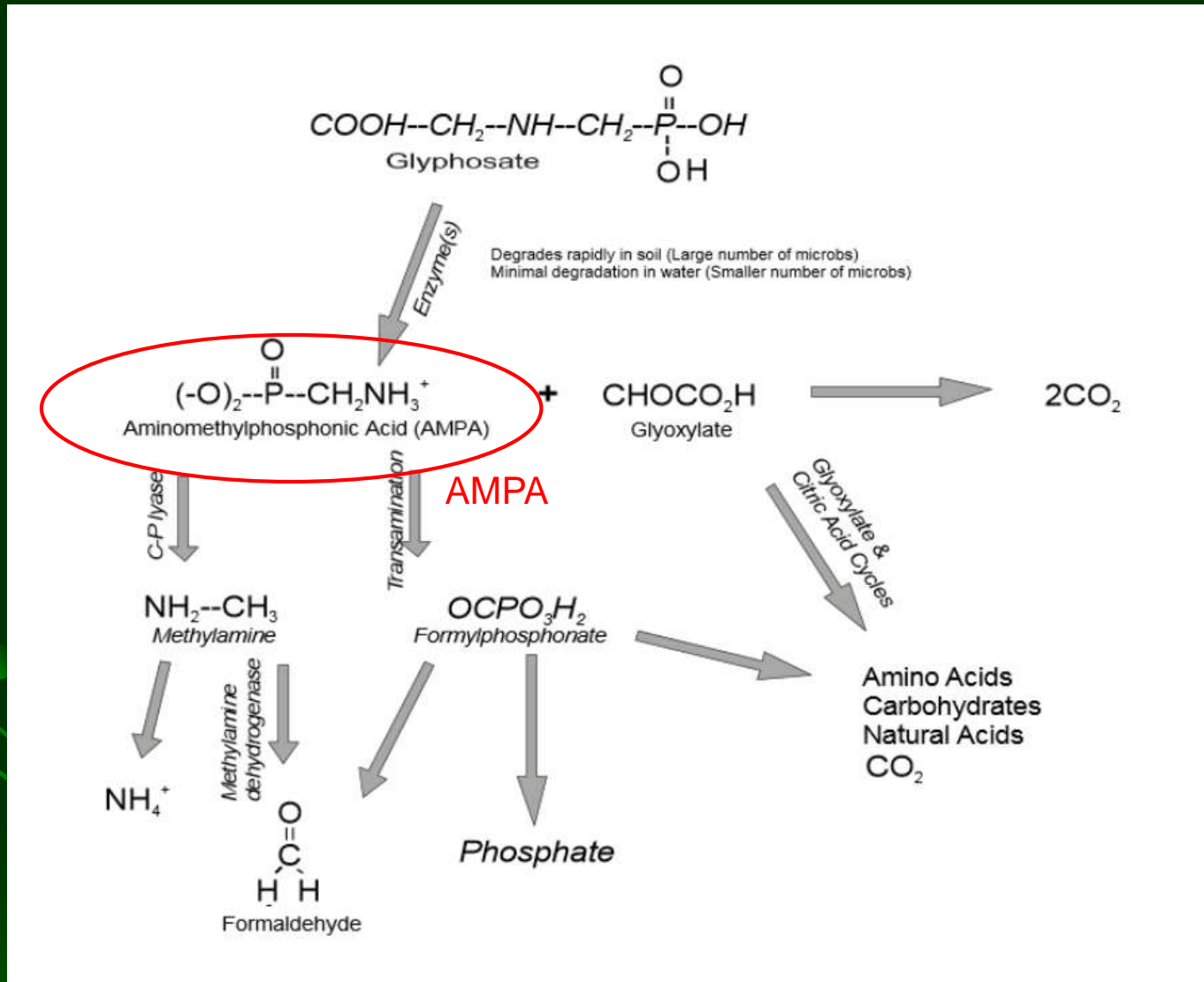


Physico – chemical properties and environmental fate of glyphosate

	Parameter	glyphosate	pendimethalin	clomazone
Low volatility	vapour tension (mPa)	< 0,01	1,94	19,2
High water solubility	solubility (mg L ⁻¹)	11600	0,33	1100
Strong adsorption in soil and water environments	K _{oc}	24000	15000	300
Fast degradation	DT ₅₀ (dny)	32	90	28-84

Source: PPDB: Pesticide Properties DataBase

Degradation of glyphosate in soil and water



Selected toxikological data

● Acute toxicity for mammals LD₅₀ (rat)

- glyphosate: 4320 mg/kg
- POEA (surfactant): 1200-14000 mg/kg
- AMPA (metabolite): 8300 mg/kg
- kitchen salt: 3000 mg/kg
- alcohol: 7060 mg/kg
- aspirin: 200 mg/kg
- cofein: 192 mg/kg

● Acute toxicity (LC₅₀) for freshwater fishes

- glyphosate: 22 – 620 mg/lit (non-toxic – slightly toxic)
- glyphosate-IPA: 98 - >1000 mg/lit (non-toxic – slightly toxic)
- AMPA: 520 mg/lit (non-toxic – slightly toxic)
- POEA (MON 0818): 1 – 13 mg/lit (moderately – strongly toxic)
- formulated herbicide with POEA (Roundup): 1,8 – 16,1 mg/lit (moderately – strongly toxic)

NK-603 Roundup Ready maize trial with focus on biodiversity (weeds, invertebrates)

Conventional vs. Roundup Ready weed control systems

- 600 m² / plot, 4 ha in total
- 3 soil tillage systems
- 5 herbicide treatments (2 conventional + 3 RR)
- sampling of weeds and invertebrates
- efficacy, yield



Summary of collected data

● Carabids:

- 11.622 individuals from 42 species
- 20.000 individuals from 31 species (20%)
- 3–8 species created 95% of all individuals
- *Amara rufipes*, *Pterostichus melanarius*
- 2 rare and threatened steppe species



● Spiders:

- 1.860 individuals from 36 species
- 21.000 individuals from 32 species (21%)
- *Oedothorax apicatus*, *Pardosa* created 95% of total individuals



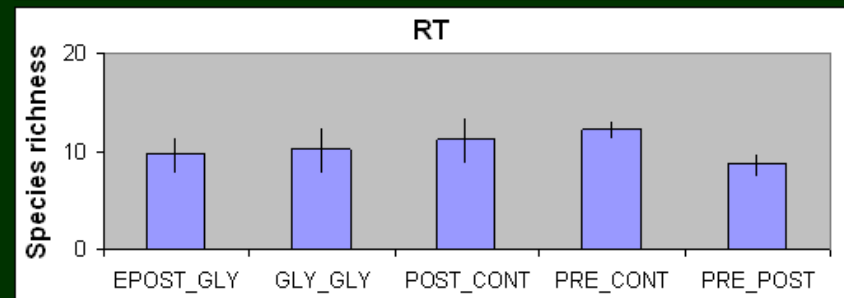
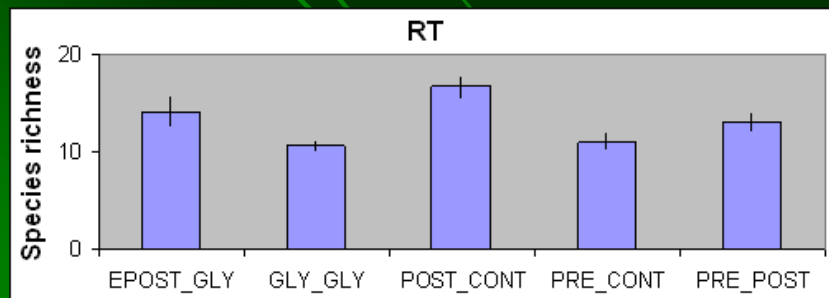
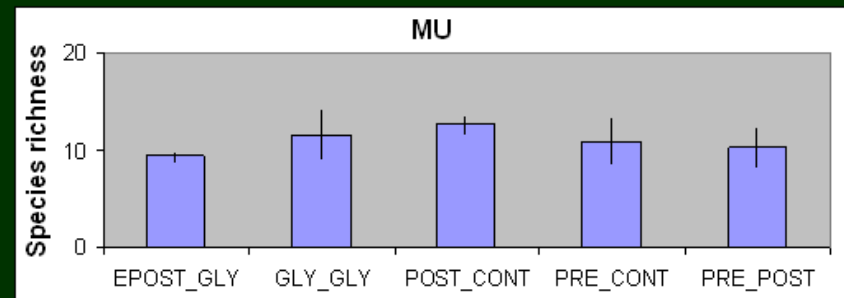
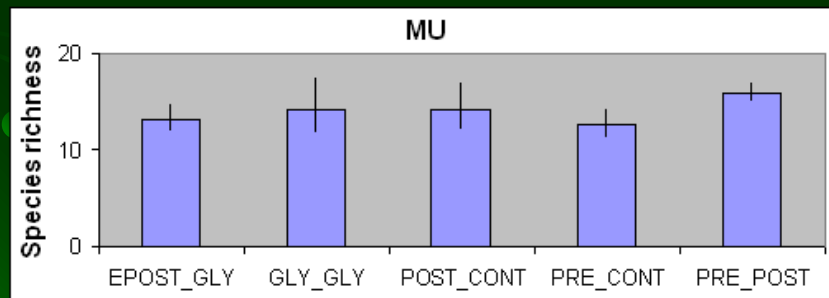
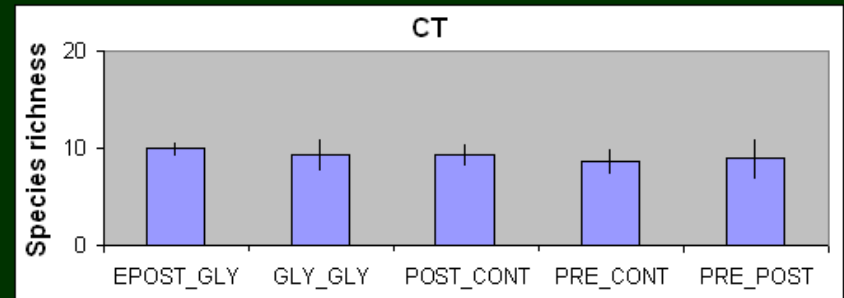
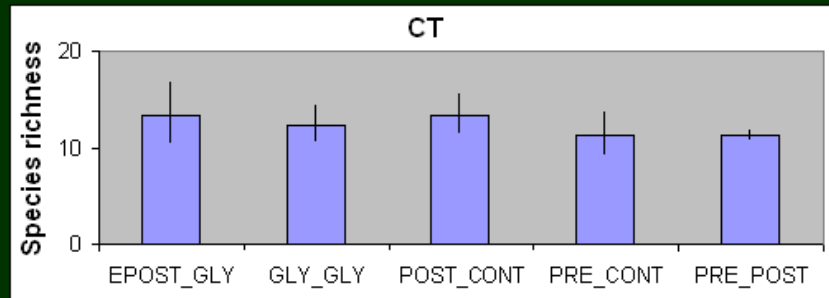
Species richness - carabids

2010

2011

	Df	X2	P(> Chi)	
TILL	2	6.237	0.04423	*
WEED_CONT	4	14.285	0.00644	**
X	1	0.010	0.92062	
Y	1	0.335	0.56290	
TILL:WEED_CONT	8	60.609	3.539e-10	***

	Df	X2	P(> Chi)	
TILL	2	5.09	0.079	.
WEED_CONT	4	8.16	0.086	.
X	1	1.37	0.241	
Y	1	0.11	0.735	
TILL:WEED_CONT	8	19.37	0.013	*



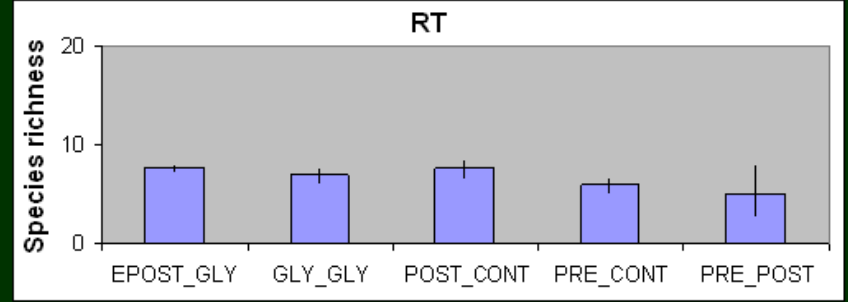
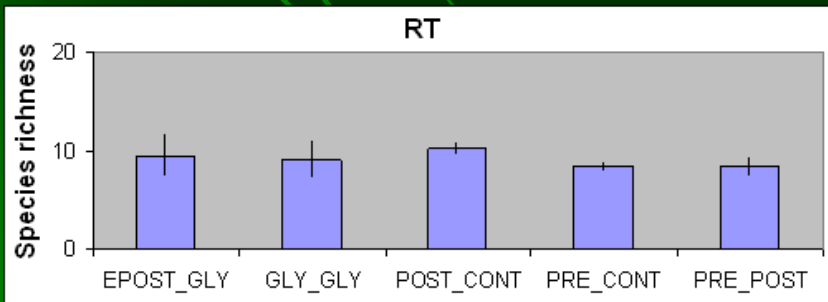
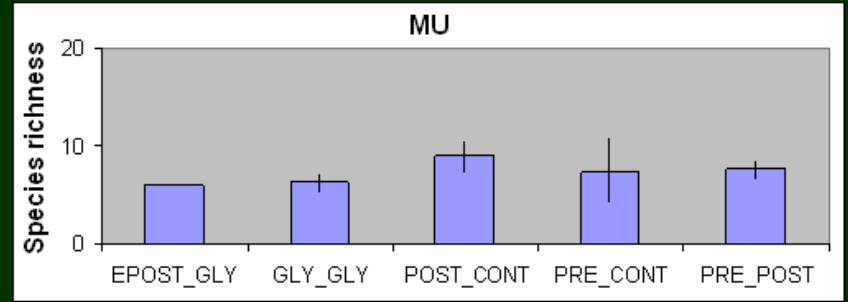
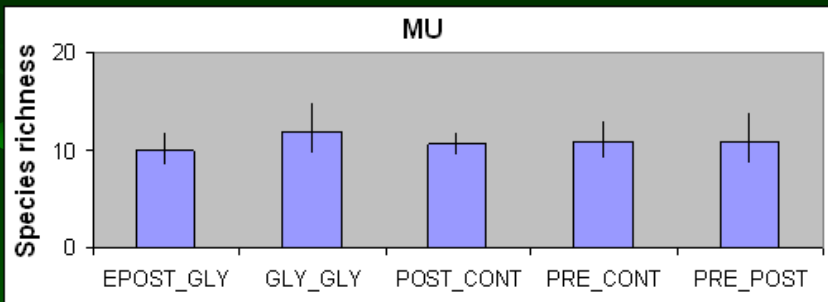
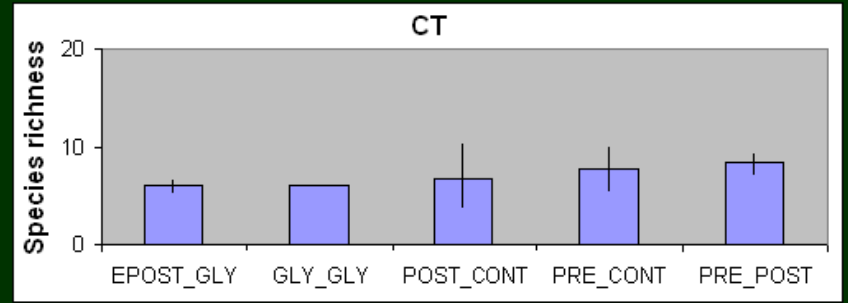
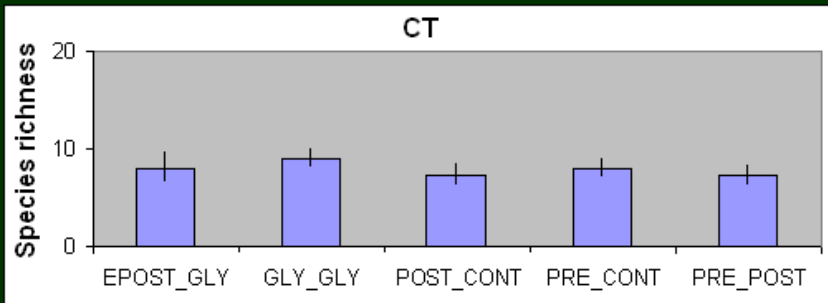
Species richness - spiders

2010

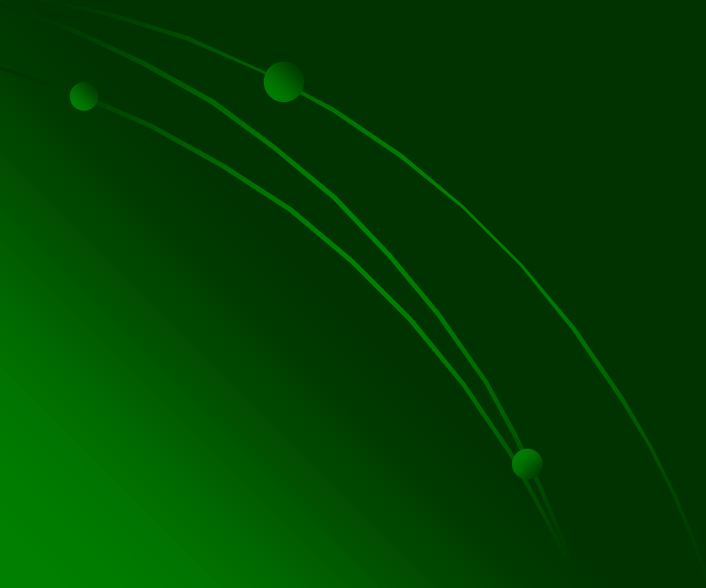
2011

	Df	X2	P(> Chi)
TILL	2	28.34	7e-07 ***
WEED_CONT	4	2.42	0.6592
X	1	0.01	0.9165
Y	1	1.13	0.2874
TILL:WEED_CONT	8	20.91	0.0074 **

	Df	X2	P(> Chi)
TILL	2	0.55	0.7600
WEED_CONT	4	3.83	0.4294
X	1	3.77	0.0521
Y	1	0.05	0.8255
TILL:WEED_CONT	8	21.14	0.0068 **



Health risk



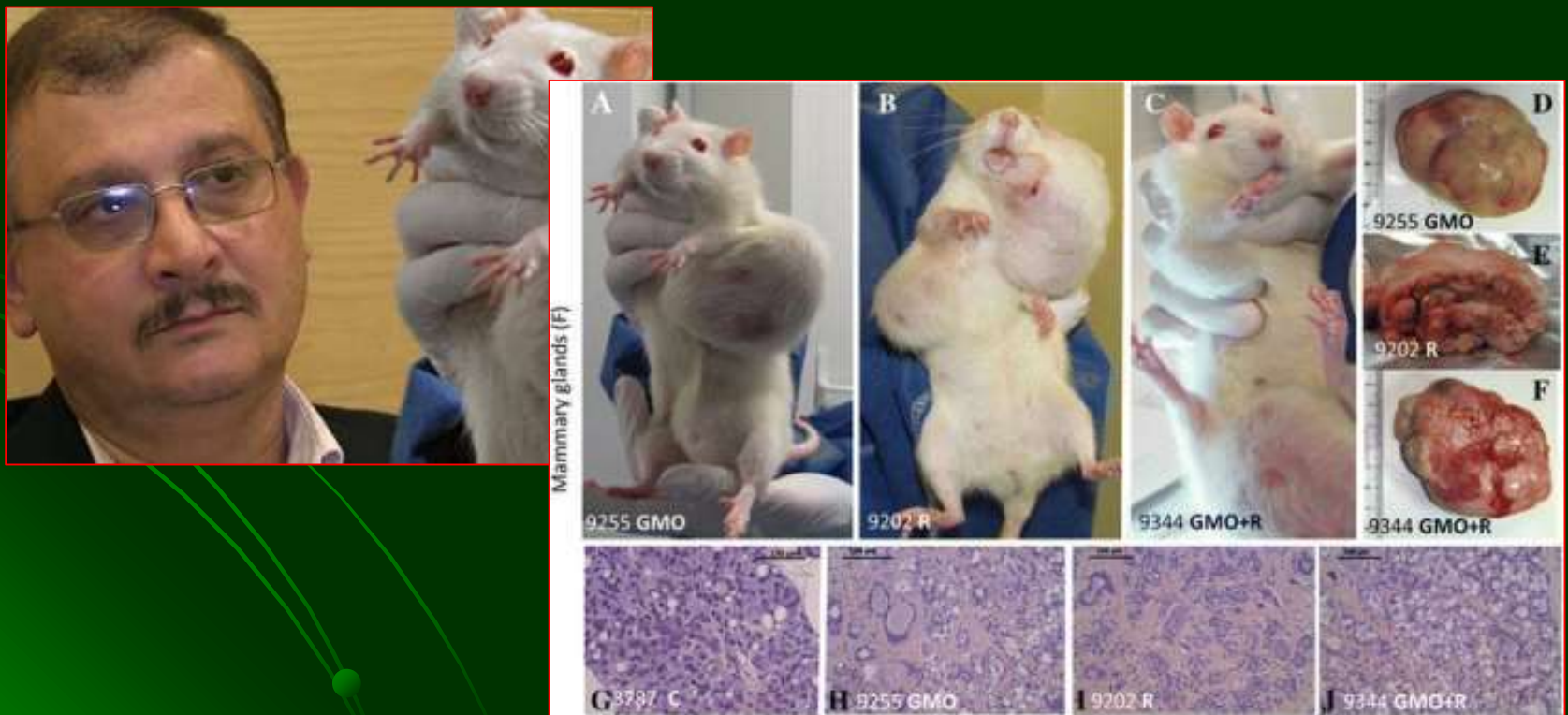
Germany: glyphosate was found in beer!



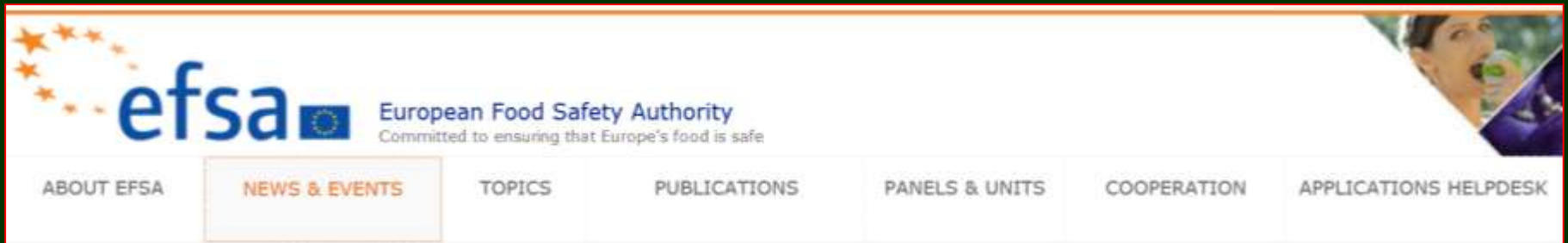
14 beer samples analysed
concentrations up to 30 ug/l
health risk would occur after 1000 liters beer / day

Seralini's studies on toxicity of glyphosate

- Benachour, N. et **Séralini, G.-E.** 2009. Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells. *Chemical Research in Toxicology* 22 (1), 97–105.
- **Séralini, G.-E.** *et al.* 2012. Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. *Food and Chemical Toxicology* 50, 4221–4231.



Serious defects found in methodology soon...



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Séralini et al. study conclusions not supported by scientific community

Research And Journals

Elsevier Announces Article Retraction and Chemical Toxicology

"Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize has been retracted by the journal Food and Chemical Toxicology"

Share this:

Cambridge, MA, November 28, 2012
Elsevier announces that the article "Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize," by Gilles Eric Séralini et al. has been retracted from *Food and Chemical Toxicology*.

Food and Chemical Toxicology 50 (2012) 4031–4038

Current contents available at SciVerse ScienceDirect

Food and Chemical Toxicology

journal homepage: www.elsevier.com/locate/foodchemtox

Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize

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^aUniversity of Caen, Institute of Biology, UMR229 and UMR 6104, 14032, Caen Cedex 3, France; ^bUniversity of Caen, UFR Sciences de la Vie, UFR 1023, 14032, Caen Cedex 3, France; ^cUniversity of Caen, UFR Sciences de la Vie, UFR 1023, 14032, Caen Cedex 3, France

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ABSTRACT

The health effects of a Roundup herbicide, glyphosate, and a Roundup-tolerant genetically modified maize (from 172 in the diet), cultivated with or without Roundup, and Roundup alone (from 4.5 mg/kg in water), were studied 2 years in rats. In females, all treated groups died 1–1.1 times more than controls, and more rapidly. This difference was visible in 3 main groups fed GMZ. All results were hormone and sex dependent, and the pathological problems were compatible. Female rats developed 10% secondary tumors almost always more often than and before controls, the uterine wall was almost always disabled organ, the sex hormonal balance was modified by GMZ and Roundup. Treatments created males, lower spermatozoa and increases were 2.5–3.5 times higher. This is the first time, confirmed by epilepsy and transmission electron microscopy. Males and overall kidney neoplasms were 1.5–2.3 times higher. Males presented 4 times more large palpable tumors than controls which occurred up to 800 days earlier. Biochemistry data confirmed very significant differences in renal metabolism; for all treatments and both sexes, 70% of the altered parameters were significantly different from controls. These results can be explained by the low dose reduction disrupting effects of Roundup, by the high dose effects of Roundup, and by the effects of the Roundup-tolerant GMZ and its metabolites. © 2012 Elsevier B.V. All rights reserved.

1. Introduction

There is an ongoing, controversial debate as to the necessary length of mammalian toxicology studies in relation to the consumption of genetically modified (GM) plants including regular metabolic analyses (Séralini et al., 2011). Currently, no regulatory authority requires mandatory chronic animal feeding studies to be performed for registered and formulated pesticides. However, several long-term (consisting of 90-day rat feeding trials) have been conducted in the biotech industry. These investigations mostly concern GM corn and maize that are rendered either herbicide tolerant (to Roundup (R) is 80% of cases), or engineered to produce a modified Bt toxin insecticide, or both. As a result these GM crops contain new pesticide residues for which new maximal residual levels (MRL) have been established in some countries.

If the petioleers conclude in general that there is no major change in genetically modified organisms (GMO) subchronic toxicity studies (Domingo and Graf Berthelme, 2011; Harron et al., 2004, 2006a,b), significant disturbances have been found and may be interpreted differently (Séralini et al., 2006; Spiroux de Vendômois et al., 2010). Detailed analyses have revealed alterations in kidney and liver functions that may be the signs of early chronic diet intoxication, possibly explained at least in part by pesticide residues in the GM feed (Séralini et al., 2007). Several

Review

Glyphosate's Suppression of Cytochrome P450 Enzymes and Amino Acid Biosynthesis by the Gut Microbiome: Pathways to Modern Diseases

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Summary:

- ... glyphosate enhances the damaging effects of other food borne chemical residues and environmental toxins
- ... consequences are most of the diseases and conditions associated with a Western diet, which include gastrointestinal disorders, obesity, diabetes, heart disease, depression, autism, infertility, cancer and Alzheimer's disease

International Agency for Research on Cancer



World Health
Organization

20 March 2015

IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides

Lyon, France, 20 March 2015 – The International Agency for Research on Cancer (IARC), the specialized cancer agency of the World Health Organization, has assessed the carcinogenicity of **five organophosphate pesticides**. A summary of the final evaluations together with a short rationale have now been published online in *The Lancet Oncology*, and the detailed assessments will be published as Volume 112 of the IARC Monographs.

What were the results of the IARC evaluations?

The herbicide **glyphosate** and the insecticides **malathion** and **diazinon** were classified as *probably carcinogenic to humans* (Group 2A).

Group 2A means that the agent is ***probably carcinogenic to humans***. This category is used when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals. *Limited evidence* means that a positive association has been observed between exposure to the agent and cancer but that other explanations for the observations (called chance, bias, or confounding) could not be ruled out. This category is also used when there is limited evidence of carcinogenicity in humans and strong data on how the agent causes cancer.

Misunderstanding between „hazard based“ and „risk based“ assessment

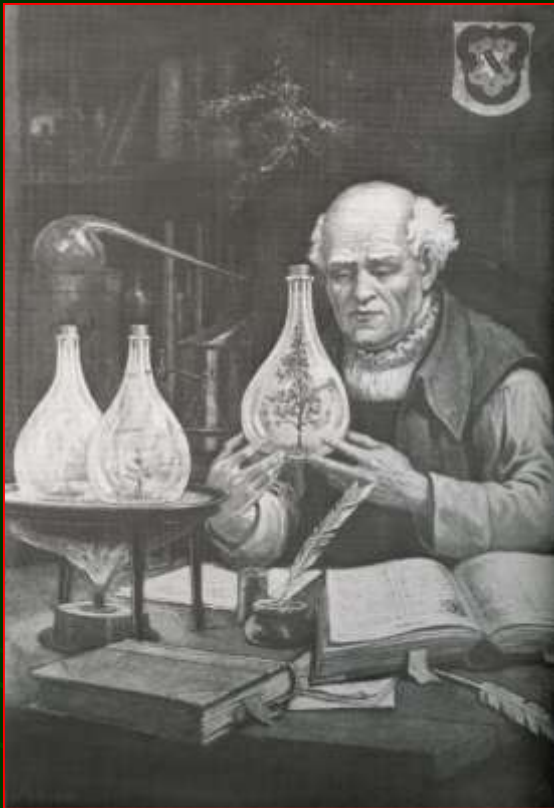
- **Hazard-based assessment**

considers only whether an adverse outcome could occur and not how it is likely under real exposure situations (approach used in basic research)

- **Risk-based assessment**

weight-of-evidence assessment, determines the likelihood and extent to which the adverse outcome can occur if the product is used under real scenarios (approach used by regulatory bodies)

RISK = HAZARD x EXPOSURE



Paracelsus, 1493-1541

Examples of probably carcinogenic compounds and processes from 2A group by IARC

(similar risk like glyphosate)

- acrylamide
- nitrites and nitrates
- UV radiation
- biomass fuel (primarily wood), indoor emissions from household combustion
- art glass, glass containers
- hairdresser or barber
- consumption of red meat and hot beverages
- shiftwork that involves circadian disruption

Source: <http://monographs.iarc.fr/ENG/Classification/>

- ... all substances are poisons; there is none which is not a poison
- ... the dose makes the poison
- ... the right dose differentiates a poison and a remedy

Reregistration of glyphosate in EU

- evaluation conducted by BfR (Germany)
- delivered 118 folders
- containing 2777 studies
- including 391 new studies
- in total on 77500 pages



Results of risk assessment by BfR under real exposure scenarios

- Glyphosate is non-genotoxic based on the legal data requirements
 - **Dietary intake** (ADI = 0,5 mg/kg bw)
 - long-term dietary intake (0-3% ADI)
 - short-term dietary intake (max 9% ARfD)
 - **Operator exposure:** 28-32 % AOEL
 - **Bystanders and residents:** 4,1 – 20,8 % AOEL

History of glyphosate registration renewal

March 2011	submission of the dossier (BfR, Germany - RMS)
August 2012	assessment of the active substance
December 2013	RMS sends the Renewal Assessment Report on EFSA
June 2014	public consultations, additional information
January 2015	revised RAR
March 2015	information about carcinogenicity by IARC
November 2015	publication of (positive) EFSA opinion
January – March 2016	voting in ScoPAFF – no qualified majority
March 2016	international meeting of EP – glyphosate yes or no?
June 2016	initiated evaluation by ECHA
June 2016	EC – limited extension of the current approval until ECHA has concluded its review

Some limitation in the glyphosate use

● June 2016:

- agreement of MS on the ban of use of POE-tallowamines as co-formulants in glyphosate based products
- minimise the use of the substance in public parks, public playgrounds and gardens
- minimise the pre-harvest use of glyphosate

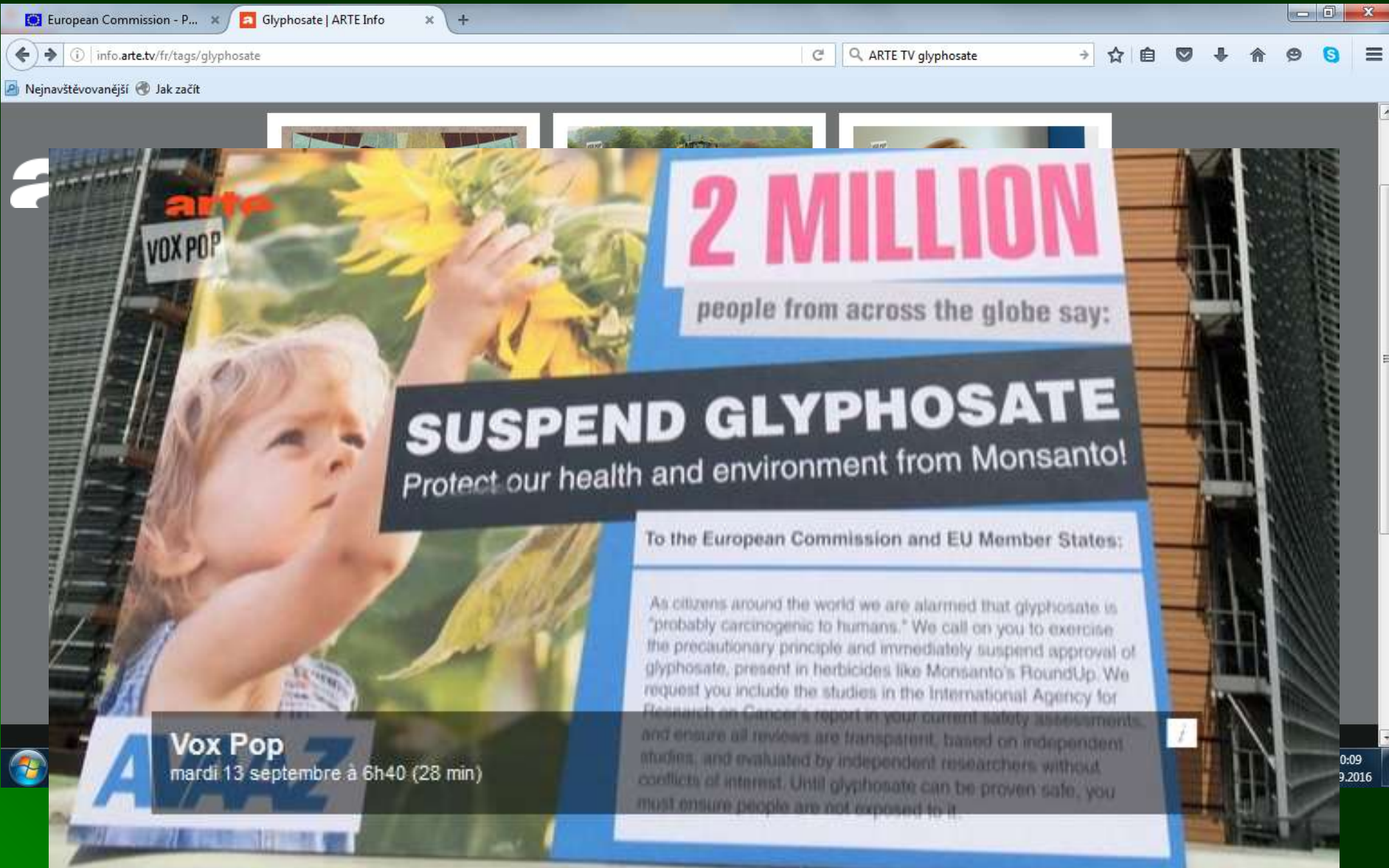
● July 2016

- Letter of Soil association (UK)
- the initiative „Not in our bread“ request the EC to ban glyphosate application in the bread wheat

„*Vox populi*“ in streets is misused
by politicians and some of them feed it...



Media manipulate with public opinion...



European Commission - P... x Glyphosate | ARTE Info x +

info.arte.tv/fr/tags/glyphosate

ARTE TV glyphosate

Nejnavštěvovanější Jak začít

arte
VOX POP

2 MILLION
people from across the globe say:

SUSPEND GLYPHOSATE
Protect our health and environment from Monsanto!

To the European Commission and EU Member States:

As citizens around the world we are alarmed that glyphosate is "probably carcinogenic to humans." We call on you to exercise the precautionary principle and immediately suspend approval of glyphosate, present in herbicides like Monsanto's RoundUp. We request you include the studies in the International Agency for Research on Cancer's report in your current safety assessments, and ensure all reviews are transparent, based on independent studies, and evaluated by independent researchers without conflicts of interest. Until glyphosate can be proven safe, you must ensure people are not exposed to it.

Vox Pop
mardi 13 septembre à 6h40 (28 min)

0:09
9.2016

Message from the top EU politicians:

- Commissioner Andriukaitis (Lithuania, social democrat):
 - *„scientists should not get involved in political debates“*
- EU Ombudsman Emily O'Reilly (Ireland, former journalist):
 - *„the problem with experts is the so-called revolving doors“*
- MEP Gilles Pargneaux (France, socialist):
 - *„...this is what I wish for: that glyphosate is completely ban in Europe; I have been leading difficult fight with Monsanto who has been intoxicating us for 30 years...“*

Conclusions

- Glyphosate is one of the key herbicide active ingredients, only difficult to be substituted
- Authorities worldwide (including Europe) considered glyphosate as not possessing unacceptable health- and environmental risk
- Toxicological and environmental properties of glyphosate are favourable, but the use causes political tensions
- Doubts of politicians and NGOs about the regulatory process endangers the trust of public in the European regulatory system (what some politicians want...)
- Decision making and market with plant protection products are becoming unpredictable for both manufacturers and farmers
- **Agriculture and industry is in a hard position but has to accept strategies how to use the glyphosate in a more sustainable way**