Roundup – pros and cons of super herbicide

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Summary:

The spread of plant protection products (pesticides) in the environment is undeniable fact. Only agricultural products from farms carried out in the organic system (natural-origin insecticides are acceptable and natural methods to combat weeds are applied in such cases) are inherently free from the presence of chemicals. According to a current scientific knowledge and the legislation, the presence of pesticides in agricultural goods and food should not be alarming, provided that the level of pesticides does not exceed the established maximum permissible values (e.g. for cereals it is the range from 0.1 to 20 mg/kg; for sugar beet 15 mg/kg; for fruits, root vegetables and legumes 0.1–0.5 mg/kg). Is the legally recognized presence of synthetic chemicals in food safe for humans and the environment? The aim of the study is to present empirically documented risks, and profits resulting from the massive use of pesticides, using the example of herbicides with glyphosate (commonly known under the trade name Roundup). Discussion upon the impact of herbicides with glyphosate on living organisms applied the results of research published in peer-reviewed worldwide journals. There is no other common herbicide (containing active ingredient in a form of glyphosate), which inspires much controversy as Roundup and other glyphosate herbicides. Extreme opinions of scientists, farmers and consumers of agricultural products, divided society into two groups: the supporters and the opponents of this preparation. By analyzing various aspects of glyphosate spread within the environment, authors of this work sought to get to the source of conflicting opinions.

Key words: plant protection means, glyphosate, health safety of food

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Introduction

There are three basic systems of growing crops: conventional, organic and integrated. The first one often applies to large cultivation areas and is based on the use of intensive mechanical and chemical treatment and the philosophy of getting high and satisfactory yields with the minimum of work input. Pesticides are often used automatically only to prevent potential yield loss (Fig. 1). Ecological systems of cultivation aim to produce crops without the use of a wide range of plant protection products, based solely on a natural ecological phenomenon occurring in agrosynthesis and biopreparations containing natural ingredients and natural organic fertilizers applied in specific doses and conditions. This system is not as efficient as the conventional one and therefore products of this type are more expensive (Kuś and Stalegna, 2006; Frąc et al., 2011). The integrated system of growing plants can be treated as a compromise between the two previously mentioned (described in a nutshell) extreme cultivation systems. It combines the ideas of mass production that is economically justified, while simultaneously minimizing the environmental burden caused by chemicals (Zimny, 2007).

Taking under consideration the widespread pollution of the environment and food from plant protection products as well as the questionable health safety of certain pesticides, the Commission quite clearly accepted a policy of withdrawal from massive use of pesticides. An obligation to apply the principles of integrated corps protection by all farmers have been introduced in the European Union countries since 2014 following the provisions of Directive 2009/128/EC and Regulation No. 1107/2009/EC. Integrated crops protection is a series of agricultural treatments that prevent excessive growth of pests and weeds, using only non-invasive biological methods (Matyjaszczyk, 2012). However, is this concept reflected in farm operation, and do farmers understand the need of protecting the environment and consumer's health? Other questions arise as well, as whether farmers receive substantial support within the implementation of integrated corps protection on their farms, or if the market offers bio-preparations that can replace pesticides?

What are glyphosate and Roundup and what they are used for

Each pesticide (or plant protection product) consists of at least one active substance that is devastating for a broader or narrower group of organisms burdensome

Fig. 1. Aerial spraying of crops using pesticides to eliminate pests or weeds

Source: https://pixabay.com

in agricultural production (e.g., insects, weeds, snails or fungi). Glyphosate is one of many synthetically produced active ingredients of pesticides. Roundup is the trade name of a pesticide containing glyphosate (Biziuk, 2001; Praczyk and Skrzypczak, 2004). There are many herbicides (pesticides designed to eliminate weed) that contain glyphosate (e.g. Avans Premium 360 SL, Glifocyd 360 SL, Klinik 360 SL, Kosmik 360 SL, Taifun 360 SL, Roundup® 360 SL, Roundup Max 2). Herbicides with glyphosate (the first one was called Roundup®) were introduced to the market by Monsanto, an American company, in 1976. The company is still the most important manufacturer and distributor of plant protection products and sells them on a massive scale (close to one million tonnes per year). Monsanto's patent for the use of glyphosate in manufacturing total herbicides expired in 2000, which means that other companies can sell their own herbicides based on that substance. Thanks to the commercialization of genetically modified corps (with a built-in gene that is resistant to glyphosate, e.g. RR Soy) Monsanto annually gains multi-billion profits from the sales of its products (USD) (Lisowska and Chorąży 2011, Steinmann et al., 2012; Kwiatkowska et al. 2013).

Glyphosate is a phosphoric acid derivative combined with glycine (Fig. 1). In order to enhance the effectiveness of glyphosate, modification of its cell is applied. It is present in the formulations in the form of acid or ammonium, sodium and potassium salts, isopropyl salt and trimethylsulfate salt. In addition to the active substance, Roundup formulations (and other ones containing glyphosate) contain substances that facilitate passage through cellular membranes of plants (so-called adjuvants) and other commercially confidential components. Two greatest benefits having impact on the popularity of glyphosate pesticides are their versatility

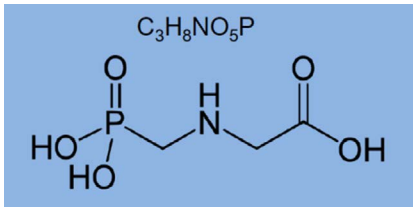


Fig. 2. Schematic structure of the glyphosate molecule

(it works on most weeds and its effectiveness depends on the dose) and a wide range of applications (fields, orchards, forests, stubble wasteland, gardens) (Różański, 1992; Praczyk and Skrzypczak, 2004) (Fig. 2).

Upon the contact of herbicide with a sensitive part of a green plant, its growth is suppressed already on the first day. Glyphosate inhibits the activity of an enzyme, i.e. EPSP (5-enolpyruvylshikimate-3-phosphate) synthase, which is a key biocatalyst of the shikimic pathway responsible for the biosynthesis of aromatic amino acids (tryptophan, tyrosine and phenylalanine). Due to the deficiency of aromatic amino acids in the cell, plants die out. These amino acids play an important role in plant metabolism, as they are part of structural, reserve and enzymatic proteins and undergo further transformation generating different metabolites that are important for the functioning of the plant (e.g. phytohormones, lignin precursors, flavonoids, phenylcarboxylic acids, cinnamic acid derivatives). Glyphosate interferes with the process of photosynthesis, thus lowering the concentration of chlorophyll in the leaves of plants; this is destructive to other elements of metabolism and ultimately causes withering (Pieniążek et al., 2004; Kwiatkowska et al., 2013) (Fig. 2). Farmers use the effect of plant dying with the use of glyphosate to accelerate uniform cereal growth (desiccation). Before harvest, they spray the field with herbicide to dry the green biomass and make it easier to harvest (Wróbel, 2006; Jaskulski and Jaskulska, 2011). However, as a consequence, grain with glyphosate is transferred to consecutive produc-

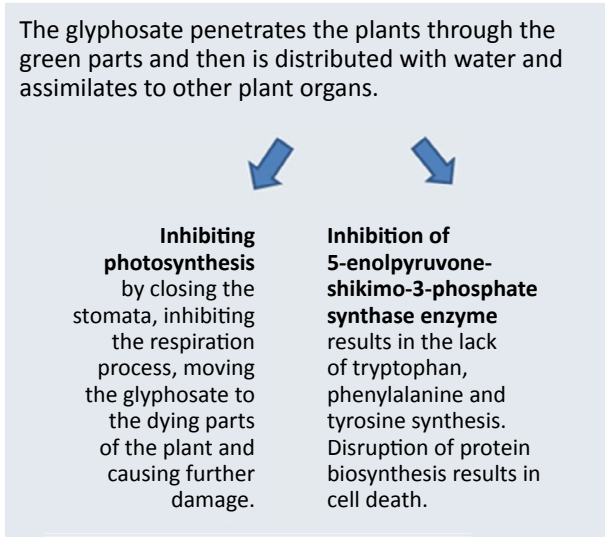


Fig. 3. The mechanism of glyphosate activity in the plant
Source: own elaboration based on Kwiatkowska et al., 2013.

tion steps, eventually reaching the human and animal body (bread and animal feed are most polluted).

The efficacy of herbicides with glyphosate; problematic issue of super weeds

The efficacy of weed control methods with herbicides containing glyphosate is confirmed by field studies and the opinions of the users of these substances (Rzymowska et al., 2015). For example, after the application of Sting CT 120 SL herbicide (120 g glyphosate and 285 g of ammonium sulfate in 1 dm^3) at a dose of 4 dm^3/ha or Classic 360 SL Glyphosate (360 g of glyphosate in 1 dm^3) at a dose of 2 dm^3/ha along with ammonium sulfate (5 kg/ha), lmost 100% efficacy in weed control was achieved. Almost all weeds (97-100%) of the following species were killed: goosefoot (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), barnyard grass (*Echinochloa crus-galli*), redshank (*Polygonum persicaria*), Persian speedwell (*Veronica persica*), and black bindweed (*Polygonum convolvulus*), and 95% of couch grass (*Elymus repens*); only field bindweed (*Convolvulus arvensis*) was resistant – 80% of the weeds remained (Badowski, 2004). The efficacy of Roundup 360 SL formulation was evaluated in another experiment (Lisek, 2012): 360 g glyphosate in one liter of the formulation was applied individually (at 5 dm^3/ha) and AS 500 SL adjuvant (3 and 1 dm^3/ha) in an apple orchard. After 28 days after spraying, high efficacy (95-100%) was recorded with chickweed (*Stellaria media*), annual bluegrass (*Poa annua*) and small geranium (*Geranium pusillum*); while lesser efficacy (80-90%) was reached with glyphosate (there was no significant difference between individual use and with adjuvant) for purple archangel (*Lamium purpureum*), common dandelion (*Taraxacum officinale*) and fringed willowherb (*Epilobium adenocaulon*).

The promises made by Monsanto – the manufacturer of the Roundup herbicide – on its total and perpetual effectiveness were doomed to be ruthlessly verified by nature. Over time, the weeds adapt to unfavorable habitat and active substances in pesticides, and sooner or later due to high yield resistant biotypes spread in the environment It is just a matter of time (Różański, 1992). The emergence of the glyphosate-resistant weed species first occurred in Australia in 1996. Glyphosate-resistant biotypes of rigid ryegrass (*Lolium rigidum*) were discovered; the weeds appeared for the first (documented) time in orchards, where Roundup had been used 2-3 times a year for 15 years. Since 2006, rigid ryegrass resistance to glyphosate has become a reality also in Europe (France, Spain, Italy). Since 2004, the weeds emerged with increased frequency in the world; today they make 25 species, of which some biotypes show resistance to glyphosate preparations. Complete information on the phenomenon of the development of pesticide resistance in weeds, a full list of new cases and a number of pub-

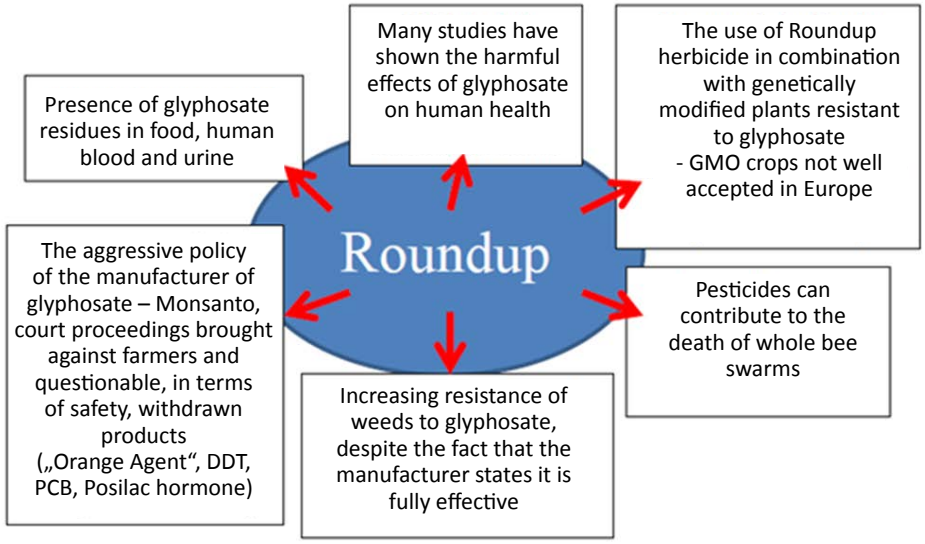


Fig. 4. Sources of controversy regarding herbicides with glyphosate

lications on this topic can be found on an international website "International Survey of Herbicide Resistant Weeds" (Heap, 2016).

Controversy over the use of herbicides with glyphosate

The controversy over the use of glyphosate formulations involves several aspects (Fig. 4). The ones that deserve special attention are:

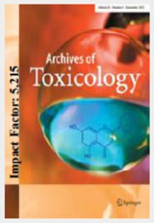
- Scientific reports on the hazard related to these herbicides, both for people and the environment, connected with the presence of glyphosate and its metabolites in food, water and organisms (Richard et al., 2005; Gasnier et al., 2009; Clair et al. , 2012; Koller et al., 2012);
- Suggestions that the herbicides are responsible for bee extinction (Balbuena et al., 2015);
- Information about growing glyphosate resistance in an increasing number of weed species (company assure farmers of 100% efficacy) (Heap, 2016);
- Correlation between glyphosate and transgenic crops that are not very popular in Europe (Benbrook, 2012; Steinmann et al., 2012);
- Aggressive market policy of Monsanto, the leading glyphosate manufacturer, and repeated "mistakes" during the 100-year history of the company (production of "Orange Agent" which was contaminated with dioxin, DDT, PCB, synthetic hormone Posilac) (Lisowska and Chorąży, 2011).

Some studies (of Hardell and Eriksson, 2002; Cavas and Konen, 2007; Benachour and Seralini, 2009; Romano et al., 2010; Cavalli et al., 2013) show that glyphosate or preparations that contain this substance have either a negative impact on human and animal health, or this impact is negligible (several dozen scientific elaborations on the basis of which the European Commission has included glyphosate to the list of permitted active substances). They disorientate public opinion, including farmers and consumers. The main reason for the extremely inconclusive research results is the modification of glyphosate properties by adjuvants. Roundup herbicide is 17-32 times more toxic than glyphosate is on its own (Pieniążek et al., 2003). In addition, the efficiency of pesticides is also affected by environmental conditions (e.g. temperature, soil pH, microbiocenosis composition) and the properties of water used to prepare working fluid (e.g. the content of mineral salts). The development phase of organisms at the time of the application is also important. All of this causes that the studies on the impact of glyphosate or herbicides are very diverse (Pieniążek et al., 2003; Kwiatkowska et al., 2013).

Gasnier C., Dumont C., Benachour N., Clair E., Changon M. Séralini G. 2009. *Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines.* Toxicology. 262:184–191

Human HepG2 liver cell responses to glyphosate formulations (Roundup Express, Bioforce, Grands Travaux, Grands Travaux Plus) were studied.

- Aromatase activity inhibited at 10 ppm glyphosate concentration (after use of preparations), which impaired normal cell hormone management (levels of androgens, testosterone, estradiol)
- An increase in damage in cellular DNA has been observed (Comet Assay technique), starting from cell incubation in 5 ppm (Grand Travaux)
- Glyphosate preparations were significantly more potent on cell viability (tested with Alamar blue, MTT) than glyphosate alone (lethal effect significant from 10 ppm)



Koller V. J., Furhacker M., Nersesyan A., Misik M., Eisenbauer M., Knasmueller S. 2012. *Cytotoxic and DNA-damaging properties of glyphosate and Roundup in human-derived buccal epithelial cells.* Arch. Toxicol. 86:805–813

Human epithelial cells isolated from the lips (TR146 line) treated with glyphosate and Roundup Ultra Max herbicide were examined.

Significant cell changes were observed at 10-20 mg/gm3 glyphosate concentrations (Roundup) during the 20 minute incubation (e.g. increased nuclear aberrations that reflect DNA damage, increased micronuclei frequency; nuclear bridges between nuclei). The authors confirm a possible correlation between exposure to Roundup and the occurrence of cancer.

Richard S., Moslemi S., Sipahutar H., Benachour N., Seralini G. 2005. *Differential effects of glyphosate and Roundup on human placental cells and aromatase.* Environ Health Perspect. 113(6):716-20.

The response of human placental cells (JEG3 line) to Roundup and glyphosate was studied.

- Aromatase activity in cells was reduced by 50% already at a concentration of 0.04% of Roundup in the culture, the same amount of glyphosate in the culture at the same time did not affect the enzyme content.
- Cell viability. In ground with Roundup (1%) 70% of cells were killed after an hour of incubation, the same dose of glyphosate alone reduced the number of cells by as little as 10%.

Fig. 5. Summary of the results of studies on the impact of glyphosate and herbicides on human cells (selected scientific)

The impact of glyphosate and its herbicides on human cells and on mammals, aquatic organisms and microorganisms

There are many publications documenting the negative impact of phosphonate herbicides on cells and organisms (Fig. 4, 5, 6, 7); the most frequently described are the devastating effects of glyphosate that involve (selected from a number of presented peer-reviewed scientific studies):

- Damage to the genetic material, which can result in (or has been proved to result in) the rise of cancer in humans or animals (Marc et al., 2002; Monroy et al., 2006; Paz-y-Miño et al., 2007; Benachour and Seralini , 2009; Mañas et al., 2009; Koller et al., 2012).
- Inhibition of the aromatase, a key biosynthesis enzyme of steroid hormones, which can result in (or has been proven to result in) impaired fetal development, hormonal disorders, cancer of the mammary gland and breast, infertility, impaired sexual behavior in animals or humans (Richard et al., 2005; Dallegrave et al., 2007; Soso et al., 2007; Clair et al., 2012);
- Level and transformation deregulation of retinoic acid in human and animal cells, which may result in (or has been proved to result in) fetal development impairment (Paganelli et al., 2010).

Well-documented toxicity of glyphosate is significant in biodiversity preservation, especially of herbicides containing this substance for aquatic organisms (plants, amphibians, fish, crustaceans) (Sopińska et al., 2000; Relyea, 2005; Cavas and Konen, 2007).

The manufacturer of herbicides containing glyphosate states on the product labels that these substances are "toxic (or extremely toxic) to aquatic organisms and may cause long-term adverse effects in the aquatic environment (information labels attached to herbicides). Taking the above into consideration, any organisms in water reservoirs (waterholes and ponds), field drainage ditches and ones directly adjacent to chemically protected areas are particularly vulnerable to glyphosate.

Glyphosate-resistant transgenic plants emerged due to microorganisms. Monsanto researchers have isolated genes responsible for the production of enzymes that deactivate the effect of glyphosate (Staub et al., 2012) from the bacteria naturally resistant to glyphosate (e.g.,. *Agrobacterium tumefaciens* strains, *Achromobacter* sp. *Ochrobacterim antropi*). In general, soil microorganisms make varying response for glyphosate and its herbicides (they may be resistant – tolerant, biodegrading, sensitive). Strains of bacteria and fungi may develop adaptive mechanisms to the presence of the described xenobiotic. There are several mechanisms that cause resistance (Stalker et al., 1985):

- overproduction of EPSPS enzyme (5-enolpyruvylshikimate-3-phosphate synthase) by *epsps* gene amplification. This enzyme is suppressed by glyphosate;
- activity of the alternative EPSPS enzyme that is resistant to glyphosate (*aroA* gene);
- the presence of the GOX enzyme (glyphosate oxidoreductase) that is encoded by the *gox* gene, which in turn catalyzes the degradation of the glyphosate enzyme.

However, some microorganisms do not possess the characteristics that give them glyphosate resistance, and therefore they die upon a contact with it. Glyphosate impact on microorganisms generally does not have long-term negative effects (Weaver et al., 2007). Smaller or larger numbers of glyphosate-resistant microorganisms, that are typically present in soils, replace the vulnerable ones thorough succession. All chemicals change the quantity and quality of microorganisms in the environment; biological balance is constantly modified (as under the influence of natural environmental factors).

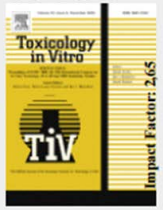
2013 publication (Shehata et al., 2013) on the impact of glyphosate on pathogenic and symbiotic bacteria colonizing chicken intestines brings up disturbing data on the interaction mechanism. It has been shown that the majority of tested pathogenic and opportunistic bacteria (e.g. *Salmonella entritidis*, *S. gallinarum, S. typhimurium, Clostridium perfringens, C. botulinum*) showed tolerance to glyphosate, while those regarded as positively affecting the functioning of the gastrointestinal tract (*Enterococcus faecalis, Enterococcus faecium, Bacillus badius, adolescentis Bifidobacterium, Lactobacillus* spp.) were usually sensitive. The authors of the publication concluded that an unfettered activity of pathogenic (or opportunistic) bacteria, which remained without competition in the body, can cause infection susceptibility in animals and indirectly result in dysfunction of other organs associated with the digestive tract. These results, combined with data on the recently widely described central role of the human microbiome in shaping health, provide a picture of the threat of glyphosate as a substance promoting micro-organisms dangerous to health and eliminating those beneficial (Tilman et al., 2016).

Supervision over introducing agrochemicals to the market

This begs the question, aren't there any legal regulations concerning the marketing authorization for commercial pesticides? Can be all chemicals traded, regardless of toxicity? Of course, such regulations exist. The European Union has a very extensive and strict system of testing and controlling new active substances and pesticidal preparations (Directive of the European Parliament and Council Directive 2009/128 / EC estab-

Clair E., Mesange R., Travert C., Seralini G., Seralini E. 2012. A glyphosate-based herbicide induces necrosis and apoptosis in mature rat testicular cells in vitro, and testosterone decrease at lower levels. Toxicol. In Vitro. 26:269–279.

The effect of Roundup Bioforce on rat cell nuclei was studied (Leydiga and Sertoli).



At just 1 ppm of Roundup slight damage to Leydig cells and a drop in testosterone levels by 35% was observed. Glyphosate alone did not significantly affect cells in all variants of culture.

Romano R.M., Romano M.A., Bernardi M.M., Furtado P.V., Oliveira C.A. 2010. Prepubertal exposure to commercial formulation of the herbicide glyphosate alerts testosterone levels and testicular morphology. Arch. Toxicol. 84:309–317

The effect of Roundup Transorob on rats was studied (testicular and adrenal morphology, hormone levels, sexual behaviour). Testicles and adrenal glands underwent hypertrophy in subjects treated with R. at all doses.

At the lowest dose, the testosterone level decreased by about 30%.

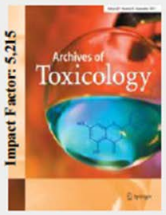


Fig. 6. Summary of the results of studies on the impact of glyphosate and herbicides on animal cells, and the animals themselves (selected scientific papers)

Sopińska A., Grochała A., Niezgoda J. 2000. *Influence of water polluted with herbicide Roundup on the organism of fish.* **Med. Weter. 56: 593–597.**

Roundup (4; 6; 8 mg/l) is toxic for carps, it results in a decrease in the performance of the immune system, as well as abnormalities in liver and kidney function, where post-mortem histopathology has shown degenerative changes.

Cavas T., Konen S. 2007. *Detection of cytogenetic and DNA damage in peripheral erythrocytes of goldfish (Carassius auratus) exposed to a glyphosate formulation.* **Mutagenesis. 22(4):263–268**

DNA damage of erythrocytes of goldfish was investigated (Comet Assay test). Roundup (5; 10; 15 ppm) was introduced to the aquariums. The number of damaged erythrocytes increased with the dose (even by several dozen %) and with each day (by approx. 10%). After six days of exposure to subsequent doses there were 8%, 30 and 40% more damaged cells than in the control group.

Relyea R. A. 2005. *The lethal impact of Roundup on aquatic and terrestrial amphibians.* **Ecological. Applications. 15:1118–1124**

Roundup „Weed and Grass Killer" was introduced into experimental tanks at a concentration corresponding to the maximum detected on the fields, in ponds (3.6 mg/l). Three species of amphibians (the grey tree frog, American toad and leopard frog) were very sensitive to the preparation, there remained only 14 to 32% of the young ones (one day after the application), while only a few percent of tadpoles survived.

Fig. 7. Summary of research results on the effects of the Roundup herbicide on soil microorganisms.

Weaver M.A., Krutz L.J., Zablotowicz R.M., Reddy K.N. 2007. *Effects of glyphosate on soil microbial communities and its mineralization in a Mississippi soil.* **Pest Manag. Sci. 63(4):388-93.**

The effect of the Roundup Ultra herbicide (applied at field dose and 3 times higher) on microbiocoenosis was insignificant and short-lived. Even at the highest dose, glyphosate did not have a long-term effect (up to a week) on the changes in the composition and amount of microorganisms of a given biovar (specific to the species FEME profile).

Fig. 8. Summary of the results of research on the effects of the Roundup herbicide on gastrointestinal microbes, isolated from poultry.

Shehata A. A., Schrodl W., Aldin A.A, Hafez M., Kruger M. 2013. *The Effect of Glyphosate on Potential Pathogens and Beneficial Members of Poultry Microbiota In Vitro.* **Curr Microbiol. 66:350–358.**

Roundup did not significantly affect the pathogenic species such as Salmonella and Clostridium, whereas the commensal and symbiotic strains of the species *Enterococcus faecalis*, *Enterococcus faecium*, *Bacillus badius*, *Bifidobacterium adolescentis*, *Lactobacillus* were from moderate to susceptible.

lishing a framework for Community action to achieve the sustainable use of pesticides, Regulation of the European Parliament and Council Regulation (EC) No. 1107/2009 concerning the placing of plant protection products and repealing Council Directive 79/117/EC and 91/414/EEC Directive of the European Parliament and Council Directive 2009/127/EC, amending Directive 2006/42/EC with regard to machinery for pesticide application). For a pesticide to reach the client, it has to go through a multi-step journey from laboratory to field testing. The company that plans to launch a new product is required to outsource a broad spectrum of diagnostic testing units. These are substantial financial expenses that need to be reconsidered after a decade on the occasion of security verification of any registered pesticides. Among other things, toxicity tests are carried out on selected species of mammals. Ecotoxicity, biodegradability and effectiveness against pathogens is checked (Biziuk, 2001; Struciński et al., 2006). However, not everything is under control. For example, legislative studies put an emphasis on short-term and not long-term toxicity (studies carried out up to two years). This is important because certain diseases may occur after several years from the exposure to a toxic agent, as tests on rats demonstrated (Romano et al., 2010; St. Clair et al., 2012). Likewise, it was assumed that if any active substance that doesn't accumulate is rapidly excreted from the body, there is no health hazard. However, given the widespread presence of glyphosate in bread, people are chronically – day by day – exposed to this factor despite the lack of accumulation in the tissues (Bojanowska 2011, Kwiatkowska et al., 2013; Chow, 2016). As mentioned, the impact of the sole active substance may be much weaker than of a pesticide containing that substance; pesticides also contain adjuvants – aids, which by their nature, should enhance the toxic effect. Meanwhile, these are active substances that are closely researched; much closer than pesticides containing a given substance.

The International Agency for Cancer Research of the World Health Organization took a position in the public debate about the safety of glyphosate, and evaluated this product as potentially carcinogenic to humans. Even then, in July 2016, the European Commission extended the company's permission for market operation of herbicides with glyphosate. European Food Safety Authority (EFSA) gave the decisive opinion, basing its positive stance for glyphosate on scientific data compiled on behalf of the Monsanto corporation.

Summary and conclusions

Demand for herbicides containing glyphosate is driven by farmers, municipal services and home gardeners. Using glyphosate, one can easily and quickly get rid of unnecessary vegetation, eliminate weed from fields, sidewalks, tracks, industrial areas and remove the vegetation barrier from canals and reservoirs. Farmers apply Roundup on a mass scale to desiccate cereals; it is the main cause of contamination in everyday consumption products such as bakery and confectionery products. Therefore there is a demand for equally effective product that brings profit to companies that offer agrochemicals. Unfortunately, there are also scientific publications – not a few, but and at least dozens – in independent scientific journals, proving the negative effects of herbicides with glyphosate on specific elements of the trophic chain, humans including. There is probably a conflict of interest; on one side there is the industrial giant – the Monsanto company (acquired in September this year by the Bayer pharmaceutical company) and farmers' satisfaction with the effectiveness of herbicides with glyphosate; and on the other hand, there are the legitimate concerns about the health of consumers worldwide. Herbicides with glyphosate will probably be withdrawn eventually from the market (Fig. 9), because even in the United States (which is liberal in terms of

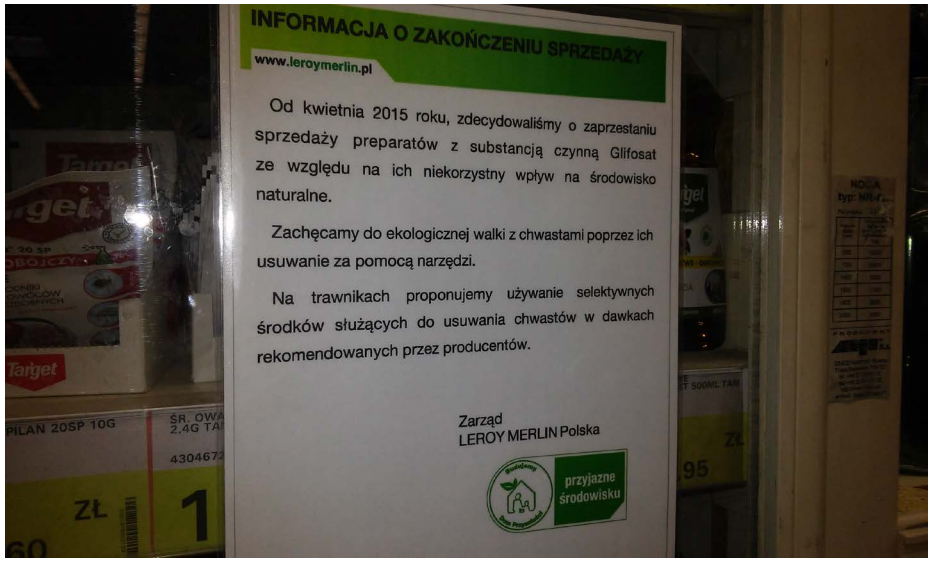


Fig. 9. Information placed on the stand of Leroy Merlin (a chain store in Szczecin).

use of chemicals in agriculture) the concern of those preparations is increasing. A few months ago, the Environmental Protection Agency of State of California put glyphosate on the list of carcinogenic substances.

Despite the unquestioned efficacy of glyphosate, we should be guided by the precautionary principle and should assume that glyphosate is harmful to the environment. Pesticides containing glyphosate should be reasserted for risk (obligatorily, including chronic toxicity), which should be conducted with full transparency, especially for toxicology scientists.

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