



HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

**INVESTIGATION OF THE NON-TARGET EFFECTS OF GM
MAIZE CONTAINING CRY1 AND CRY3 TOXINS**

DOCTORAL (*PhD*) DISSERTATION

GERGŐ GYURCSÓ

Gödöllő

2026

The doctoral school

Name: MATE Doctoral School of Natural Sciences

Field of science: Environmental Sciences

Head: Csákiné Dr. Erika Michéli
institute director, full professor, Doctor of the
Hungarian Academy of Sciences (*DSc*), full member
of the Hungarian Academy of Sciences
MATE, Szent István Campus
Institute of Environmental Sciences
Department of Soil Science

Supervisor: Dr. Béla Darvas
president, honorary professor
Doctor of the Hungarian Academy of Sciences (*DSc*)
Hungarian Ecotoxicological Society

Co-supervisor: Dr. Sárospataki Miklós
head of department, associate professor (*CSc*)
MATE, Szent István Campus
Institute of Wildlife Management and Nature
Conservation
Department of Zoology and Ecology

.....
Approval of the head of the
doctoral school

.....
.....
Approval of the supervisors

TABLE OF CONTENTS

1. BACKGROUND OF THE WORK, OBJECTIVES SET.....	3
2. MATERIAL AND METHODS	5
3. RESULTS.....	6
4. NEW SCIENTIFIC RESULTS	11
5. CONCLUSIONS AND RECOMMENDATIONS	13
6. PUBLICATIONS RELATED TO THE TOPIC OF THE DISSERTATION	17

1. BACKGROUND OF THE WORK, OBJECTIVES SET

Among *Bacillus thuringiensis* (*Bt*) toxin-producing maize varieties, the MON810 event produces the Cry1Ab protein, which is primarily effective against target pests belonging to the order Lepidoptera. In the Pannonian biogeographical region, maize cultivation is carried out in a mosaic landscape structure, with diverse field margins and weed communities. The weed flora within the field and the vegetation of the buffer strips along the field largely determine what host plants are available for caterpillars near maize. Patches dominated by nettles (*Urtica* spp.) are especially important, because the larvae of several lepidopteran species associated with nettle develop here; such a species is the peacock butterfly (*Inachis io*) as well. In Hungary, Act LIII of 1996 on the protection of nature stipulates that many lepidopteran species are under protection (several hundred protected and several dozen strictly protected species); therefore, refining exposure and species-specific sensitivity has direct nature conservation relevance and is also necessary for risk management. The effectiveness of Cry toxins and the starting points of risk assessment are further nuanced by the phenomenon of resistance. Cry-toxin resistance developing in target pests is a known problem from an agricultural point of view; at the same time, sensitivity between populations may also vary in non-target organisms.

Maize is also widely used in fish feeding. China is the largest aquaculture-producing country; in 2021 it accounted for about 58% of the world's freshwater fish production. One of the most important species in freshwater aquaculture is grass carp – *Ctenopharyngodon idella* (Valenciennes) – with an annual volume of about 5.76 million tons. At the same time, it is the second largest maize producer and user. In recent years, 21 transgenic varieties producing Cry1Ab toxin have been authorized. Grass carp can consume plant material amounting to as much as 140% of its body weight. In fish farms that

raise grass carp, maize leaves may be used as feed. Authorization documents and our own measurements also show that the amounts of Cry toxins are the highest in the leaf. In addition, one of the main routes of utilization of GM maize is feeding: a significant proportion of the yield is used as animal feed, so encountering Cry protein toxins at higher levels of the food chain is also conceivable. It is therefore justified to assess how GM maize with different Cry-toxin profiles may affect growth, metabolism, immune-system functioning and the histological characteristics of the digestive tract, and whether Cry toxin can be detected in feed and in fish tissues. This doctoral dissertation integrates two research directions. On the one hand, using field and laboratory approaches, it performs a risk assessment of the possible effects of MON810 maize pollen on non-target lepidopterans, with special attention to young larvae of *I. io* and the comparison of sensitive versus tolerant phenotypes. As part of this, it explores the weed communities of maize fields and the vegetation of field margins, examines the presence of larvae occurring in nettle patches, and quantifies the temporal pattern of pollen shed and the Cry1Ab toxin content of the pollen. On the other hand, in controlled feeding experiments the thesis evaluates the responses of the herbivorous grass carp using GM maize varieties (MON810 and DAS-59122) and their isogenic lines.

2. MATERIAL AND METHODS

For the risk assessment of MON810 maize pollen, we examined the weed and margin vegetation of maize fields, as well as the possibility of tolerance/resistance of the peacock butterfly (*I. io*) to Cry1Ab toxin. For weed surveying, we repeated a Hungarian sampling carried out in June 2003 in June 2024 for comparative purposes: we assessed weed cover within the maize field in four zones (at -1, 2, 7 and 50 m from the field edge). We also surveyed the vegetation of the nearby forest belts (shelter belts) close to the fields.

In the resistance study we used the offspring lines of four fertilized peacock butterfly females; in the experiments we used egg batches of the first reared generation, thus obtaining four independent parental lines. We applied a maize pollen suspension (MON810 and isogenic control) onto nettle leaves. We recorded mortality and measured larval mass on day 8.

In the grass carp (*C. idella*) feeding experiments, exposure lasted 1, 3 and 6 months, and sampling and processing were carried out at the end of each period. The fish were kept in 12 aquaria of 200 liters (20 individuals per aquarium) at 18–22 °C, with weekly partial water changes; before the main experiment, the fish were acclimated by diet switching to a wet feed based on maize-leaf meal. The treatment groups were defined by the plant component of the feed: we fed a diet prepared from dried maize leaves of MON810 (Cry1Ab) and its near-isogenic control, DAS-59122 (Cry34Ab1/Cry35Ab1) and its control line, and, for comparison, a Sudan grass-based feed. The investigations covered monitoring growth and condition (body weight), blood chemistry and digestive-enzyme endpoints, as well as dissection, histological evaluation (liver and intestinal tract) and measurements of an immunological nature; furthermore, using ELISA we measured the detectability and fate of Cry toxins in the digested feed and in different tissue samples.

3. RESULTS

Weed survey

In maize fields, the number of frequent weed species recorded during the flowering period in Hungary was 44 in 2003, whereas it was 26 in 2024. The weed cover of no single species exceeded, on average, 20% in any zone, including the –1 m field margin. *Urtica dioica* showed a significant cover at the margins of maize fields, which can be explained by the fact that the fields are often bordered by drainage ditches, because of a traditional Hungarian water-management practice going back about one hundred and fifty years. This weed-association type is not affected by weed-control treatments, as these areas are generally not sprayed. *U. dioica* is usually able to spread only up to the first meter of the field.

In the buffer strips (forest belts) associated with maize-growing areas, the average cover of shrubs was very low. At that time, the most frequent plant communities of buffer strips near maize fields were dominated by *Robinia pseudoacacia* (48%) in the canopy layer, *Sambucus nigra* (10%) in the shrub layer, while *U. dioica* and *Rubus species* were decisive in the herb layer. The average cover of woody plants was 73.5%, whereas that of weeds was 32.8%.

Occurrence of peacock butterfly larvae

In 2024, at the end of June we surveyed 8 fields in Fejér county. Based on the results, the proportions matched a previous survey; at Mocsán we observed damage caused by peacock butterfly larvae. During our survey, nettle occurs in the margins of less than 50% of Hungarian maize fields, in the wet ditches next to the field. In less than 20% of these areas, damage caused by peacock butterfly larvae can be observed, affecting less than 1% of the area. The survey results indicate a very low degree of involvement from the point of view of the peacock butterfly population. Even in the most unfavorable case, <50% larval mortality is expected if we do not apply three detasseled (or unmodified)

border rows, which would prevent *Bt* -maize pollen from reaching nettle leaves.

All this, under the current Hungarian nature conservation laws (Act LIII of 1996 on the protection of nature), still does not make the cultivation of MON810 Bt maize acceptable, because it changes the quality of the habitat.

Cry1Ab-toxin resistance of the peacock butterfly

With 120 ng Cry1Ab/g MON810 maize pollen, 350 pollen/cm² (which can be considered average at the field margin) induced only moderate mortality, whereas 460 pollen/cm² (on the windward side) caused substantial mortality in two strains as well ('B' and 'D'), which, relative to the other two ('A' and 'C'), can be considered more sensitive based on our results. Our results suggest that populations of field-collected *I. io* larvae do not behave identically to Cry1Ab toxin. The degree of mortality is a function of the amount of Cry1A toxin produced in the pollen of the specific MON810 variety and the tolerance of *I. io* larvae.

Among the 4 peacock butterfly (*I. io*) offspring lines originating from the Nagykovácsi area, we observed pronounced, differing responses: two lines proved sensitive to Cry1Ab effects, while two were tolerant, as reflected by the mortality, and the day-8 body weight and developmental status of surviving larvae. MON810 pollen generally caused developmental delay (larvae often remained in the L1 stage even on day 8), but some lines responded differently, indicating heterogeneous sensitivity. Interpretation is complicated by the fact that early mortality due to toxin/pollen exposure selected the population: by day 8 we could often weigh only the more viable individuals, so changes in larval mass may appear contradictory in places. . Several mechanisms may underlie tolerance, for example intermittent cessation of feeding (lower Cry-toxin intake), because Cry toxin stops gut peristalsis.

Grass carp body-weight measurement

In the grass carp feeding experiment, we continuously followed body-weight change, and we evaluated the animals by dividing them into small (A), medium (K) and large (N) groups based on their initial weight. After a month, significant developmental lag occurred only in the smallest (A) group, in the fish fed with Sudan grass (-4.93 ± 2.49 g), while the body weight of groups fed with MON810 or DAS-59122 did not differ from that of fish fed with near-isogenic control maize. After three months, the same pattern was repeated: in the small-weight Sudan-grass group, growth retardation was still detectable (non-infected: -3.66 ± 0.85 g; infected with tapeworm: -4.06 ± 1.48 g), while the GM-maize treatments (MON810, DAS-59122) still did not cause significant body-weight differences compared to the near-isogenic controls; after six months, the growth of fish fed with GM maize did not diverge from the control either.

Measurement of the mass of abdominal organs supported the same overall conclusion. After one month, in the Sudan-grass-fed A group, a more 'underdeveloped' state was also observable based on abdominal organ masses. In the large body weight (N) group, in individuals infected with *Bothriocephalus acheilognathi*, we measured significantly larger abdominal organ mass in the MON810 group (2.29 ± 0.49 g) than in non-infected ones (1.49 ± 0.17 g), which can be explained more by an edematous/water-retention phenomenon than by a direct feed effect. After three months, there was no significant difference in abdominal organ masses among the MON810, DAS-59122 and near-isogenic groups; however, in the K group, infected individuals may have had larger abdominal organ mass associated with MON810 treatment compared to non-infected ones, again with a pattern suggesting edema. Overall, therefore, neither based on body weight nor on the mass of abdominal organs was a consistent performance-reducing effect confirmed for

GM maize-leaf-based feeds; the observed differences were mainly linked to the Sudan-grass diet and to parasite infection.

Grass carp blood chemistry

Overall, the blood-chemistry results of the grass carp feeding experiments showed that with GM maize-leaf-based feeds (MON810, DAS-59122) most of the examined serum parameters did not differ consistently from the near-isogenic controls, and part of the observed differences disappeared when excluding *Bothriocephalus acheilognathi* infection. After one month, based on inorganic phosphate (typically 2–5 mmol/l), fructosamine (150–350 μ mol/l) and liver enzymes (ALT: 1–5 U/l; AST: 40–150 U/l), we did not confirm a treatment effect; a slight increase in phosphate in the Sudan-grass groups could be attributed to parasite infection. After three months, triglyceride and cholesterol levels in groups A and N did not change with MON810 or DAS-59122 feeding; however, in the N group, serum albumin was significantly lower in MON810-fed individuals compared to the MON810 near-isogenic control (DAS-59122 caused no difference). For inorganic phosphate and calcium, apparent treatment differences in the N group (e.g., MON810 vs. near-isogenic) disappeared when excluding infected individuals. For bile acids we observed high variability, therefore a general treatment effect could not be demonstrated; however, in infected fish, pronounced increases occurred in some groups.

Grass carp enzymology

Based on the grass carp digestive-enzyme investigations, neither the MON810- nor the DAS-59122-based feed caused detectable changes in the measured enzyme activities: the activity of α -amylase (mid- and hindgut), trypsin (hindgut) and leucine-aminopeptidase (LAP; midgut) in the GM groups did not differ consistently from the near-isogenic controls. At the same time, body-weight-dependent differences occurred: after three months of

feeding, in the larger body weight (N) group, midgut amylase activity was significantly higher compared to the medium (K) group, which can be explained more by physiological/metabolic adaptation rather than by the genetic event of the feed.

Amounts of Cry34Ab1 and Cry1Ab toxins in grass carp tissues

We followed the appearance of Cry34Ab1 and Cry1Ab toxins in grass carp by ELISA. The toxin content of the dried maize-leaf meal used to prepare the feed was 182.9 ± 26.3 $\mu\text{g/g}$ (Cry34Ab1) for DAS-59122 and 25.7 ± 2.1 $\mu\text{g/g}$ (Cry1Ab) for MON810.

After three months of feeding, no difference in either Cry34Ab1 or Cry1Ab values was detectable between the K and N body-weight groups; in the intestinal content, Cry34Ab1 was measurable only in a few samples at a low level (mean ~ 8.65 ng/g), while Cry1Ab typically remained below the detection limit.

After six months of feeding, Cry34Ab1 was detectable in the intestinal content in every fish (mean ~ 10.86 ng/g) and also appeared in the blood (mean ~ 12.59 ng/ml); in one individual infected with tapeworm we measured a higher blood level, which suggests increased Cry-toxin transport associated with damage to the intestinal wall. Cry34Ab1 was also detectable in small amounts in several tissues at the ng/g order of magnitude (intestine, liver, muscle, kidney, head kidney).

Grass carp apoptotic cells and immunology

At the end of the 6-month feeding period, we evaluated apoptosis from blood samples using the TUNEL-assay. Feed containing DAS-59122 did not cause a TUNEL-detectable change in the number of apoptotic cells compared to the isogenic control; in contrast, MON810 feeding was associated with a significant increase in the number of apoptotic cells in blood relative to its corresponding isogenic line.

The overall picture of the immunological (flow-cytometric) investigations indicated mild, group-dependent cellular shifts. After 6 months, MON810 did not detectably influence the number of mature erythrocytes, whereas with DAS-59122, in the N body weight group the number of mature erythrocytes increased significantly compared to the isogenic control; ; at the same time, a smaller-sized erythrocyte population (X6) decreased in the N groups under both GM treatments. Among white blood cell populations, DAS-59122 significantly increased lymphocyte counts in the N group, while MON810 significantly decreased platelet counts in the N group, and for DAS-59122 in the N group granulocyte counts were significantly lower than in isogenic control.

4. NEW SCIENTIFIC RESULTS

1. Based on the 2024 field surveys, nettle patches (*Urtica* spp.) were present at almost half of the maize fields, and peacock butterfly (*I. io*) larvae occurred patchily in about 20% of these; damage occasionally affected at most ~1% of the nettle patches. When projected to area, this would mean low MON810 pollen exposure that is negligible for the Hungarian *I. io* population.
2. We experimentally demonstrated that after pollen exposure containing Cry1Ab toxin, surviving, tolerant peacock butterfly individuals remain; among the offspring of several females, both sensitive and tolerant groups occurred, which indicates response differences within the population and the possibility of selection for tolerance/resistance.
3. In 1-, 3- and 6-month feeding experiments on juvenile grass carp (*C. idella*), we demonstrated that feeding with dried leaf biomass of MON810 and DAS-59122 maize (Cry1Ab: ~3–7 µg/fish/day; Cry34Ab1: ~18–55 µg/fish/day) did

not cause mortality and did not result in a significant difference in body weight or the mass of abdominal organs compared to the near-isogenic controls.

4. Most serum biochemical parameters examined in grass carp showed no difference among treatments; in the N group, a slight decrease in albumin level was observed for MON810 versus its near-isogenic counterpart, while infection with the tapeworm *B. acheilognathi* influenced indicators related to mineral homeostasis (e.g., inorganic phosphate, calcium). Based on histological examinations, neither MON810 nor DAS-59122 feeding caused detectable, treatment-specific differences in basic morphological characteristics of the liver and intestinal tract; in contrast, intestinal mucosal thinning associated with tapeworm infection and accompanying lesions were clearly observable.

5. We demonstrated that in grass carp, gastrointestinal degradation of Cry toxins is extremely rapid; Cry34Ab1 was detectable in blood (at an average order of magnitude of ~12.6 ng/ml), while Cry1Ab was typically detectable only near the detection limit. Cry34Ab1 was also detectable in samples of the parasite (*B. acheilognathi*).

6. Our experiments demonstrated that after 6 months of feeding, mild immunological-type differences could be observed in grass carp: in the case of MON810, in one group the proportion of apoptotic cells increased significantly ($p < 0.05$) and platelet count decreased, whereas in the case of DAS-59122, granulocyte count decreased significantly compared to the near-isogenic line.

5. CONCLUSIONS AND RECOMMENDATIONS

Risk assessment of MON810 maize pollen for Cry1Ab-toxin-sensitive and tolerant young peacock butterfly larvae

Based on the results of the studies, it can be stated that pollen of MON810 maize containing Cry1Ab toxin is only very unlikely to pose a real risk to protected lepidopteran species associated with nettle living at the edges of maize fields. The magnitude of the risk is lower than that of any insecticide intervention applied in the period examined. In Hungary, maize - with the exception of seed dressing - generally does not receive insecticide treatment; therefore, Bt pollen is a noteworthy factor for protected species, but in terms of its effect it is only of marginal significance. Cry1Ab toxin content shows considerable varietal variability in the pollen of MON810 hybrids, which may potentially influence environmental risk. Its control and keeping it uniformly at a low level is primarily the task of seed producers. The EU insect-resistance-management program, however, seeks to prevent resistance development in pest insects by using high-toxin varieties alongside refuge strips, according to the so-called high-dose/refuge strategy. Comparing modelling studies with field results indicates that earlier predictions regarding the expected population reduction caused by *Bt*-pollen were exaggerated. Larvae of *I. io* avoid microenvironments with high pollen density (*e.g.*, depressions along leaf veins, upper leaves), and other ecological factors (*e.g.*, natural dispersal of larvae) further reduce actual exposure. In multivoltine species (*e.g.*, *I. io*, *Aglais urticae*), *Bt*-pollen may affect only part of the second generation. The presence of tolerant individuals in natural populations can be demonstrated, and in the long term the development of resistance is also likely - similarly to phenomena observed in other maize pests. This further reduces ecological risk. Field exposure can be reduced simply and effectively: by applying three rows of detasseled border, pollen shed measured at the field edge can be

reduced on average from 350 pollen/cm² to about 50 pollen/cm². This intervention practically eliminates the possibility of endangering protected species. An ecologically important finding is that the design of buffer strips and shelterbelt forest strips in the studied areas is currently not adequate. Stands that are species-poor and composed predominantly of *Robinia pseudoacacia* and *Sambucus nigra* cannot fulfill their ecosystem-service role. Planting continuously flowering trees, shrubs and understory vegetation (e.g., *Apiales*) could support both pollination and the formation of nesting sites for bird species. From a legal point of view, Hungary has one of the strictest habitat-protection regulations within the EU, which sanctions environmental damage caused to protected species. Similar-level regulation is not typical in other Member States. EFSA's earlier opinions are sound and are in line with the justification of the Hungarian moratorium. At the same time, the Danish-German models overestimated the risk for methodological reasons.

Grass carp studies

Studies conducted on fish are available in much smaller numbers than studies carried out on livestock, but with appropriate scientific rigor. In feeding salmonids, the use of soybeans requires special attention because anti-nutritive components found in it can induce inflammatory (*enteritis*) lesions and functional changes in the intestine; the literature often describes this phenomenon as the soy effect, the extent of which is primarily determined by the inclusion level and the degree of processing of the ingredient. In a 3-month feeding of young Atlantic salmon with *RR* soybean (MON-04032-6), no mortality and no significant difference in growth were observed, while differences in spleen mass and in the mass and condition of the distal intestinal section already appeared compared to the control. More detailed investigations of the intestine suggest that on a soy-containing diet - partly independently of GM status - histological signs indicating enteric stress (e.g.,

changes in enterocyte structure, widening of the *lamina propria*) and decreased enzyme activity (leucine-aminopeptidase, maltase) may also occur, while shifts in some markers related to immune response (*e.g.*, lysozyme, alkaline phosphatase) can be observed. At higher *RR*-soy inclusion, metabolic and body-composition changes (*e.g.*, lower plasma triglyceride and glucose levels, shifts in fatty-acid ratios) as well as larger spleen mass were also described, and the hemoglobin–spleen-mass relationship raises the possibility of a weaker immune response. In longer-term (7-month) feeding, differences between GM and non-GM soybean were mostly moderate and time-varying, indicating that a substantial part of the soy effect is life-cycle dependent.

Salmon experiments carried out with Bt maize (MON810) provide a more direct basis of comparison with our own Bt maize-leaf feeding results. In salmon, this dietary context was associated at the biomarker level with mild stress and immune-response signals (shifts in antioxidant enzyme activities, increased HSP70, changes in white-blood-cell proportions), suggesting that for MON810 the effects in salmon often appear as a subtle, system-level adaptive response. In juvenile salmon, in line with this, growth endpoints are often less sensitive, but smaller yet significant enzyme-activity differences (*e.g.*, decreases in leucine-aminopeptidase and maltase activity, changes in amylase activity, shifts in bile salts) may occur. In contrast, in our study, during feeding the herbivorous grass carp with MON810 and DAS-59122 maize leaves – with 1-, 3- and 6-month exposure – we did not observe differences either in body weight or in the mass of abdominal organs, and the vast majority of blood-chemistry parameters (*e.g.*, bile acids, triglyceride, cholesterol, ALT/AST) did not show a consistent pattern that could unambiguously be attributed to the GM events examined; MON810 was associated with a mild, group-dependent decrease in albumin level, whereas in the case of DAS-59122 we did not observe blood-parameter changes after

3 months. At the same time, we followed the fate of the *Bt*-component from a toxicokinetic angle: based on our ELISA measurements, the toxin load of the feed was Cry1Ab 25.7 ± 2.1 $\mu\text{g/g}$ for MON810 and Cry34Ab1 182.9 ± 26.3 $\mu\text{g/g}$ for DAS-59122 (with matrix effects manageable at 1:50 dilution); Cry1Ab in the gastrointestinal tract typically decreased below the detection limit, while Cry34Ab1 decreased by orders of magnitude in the intestine but in the blood of every individual remained measurable above the detection limit (12.59 ± 1.89 ng/ml); in one *B. acheilognathi*-infected individual we measured a higher blood level, which may be consistent with the idea that intestinal-wall damage can increase toxin penetration. Together with the MON810 data obtained in salmon, this reinforces that feeding effects of the same genetic event cannot be transferred automatically between species: feeding type and feed matrix (maize grain vs. leaf) fundamentally determine whether differences appear rather in feed intake/growth and stress-immune biomarkers, or rather at the level of toxin detectability without performance decline. On this basis, the feeding effects of different genetic events cannot be classified generally as harmless. Dense-sown MON810 or DAS-59122 mixed with other plants may be suitable feed for *C. idella*; however, widespread use of GM feed in fish would necessitate further, mainly immunological, investigations. Such biological tests, however, currently do not play a determining role in the authorization of plant-protection products either

6. PUBLICATIONS RELATED TO THE TOPIC OF THE DISSERTATION

1) SCIENTIFIC JOURNAL ARTICLES:

- a) Published in a *foreign language*, peer-reviewed scientific journal
GYURCSÓ, G., DARVAS, B., BASKA, F., SIMON, L., TAKÁCS, E., KLÁTYIK, S., SZÉKÁCS, A. (2022): Herbivorous juvenile grass carp (*Ctenopharyngodon idella*) Fed with genetically modified MON810 and DAS-59122 maize varieties containing Cry toxins: Intestinal histological, developmental, and immunological investigations. *Toxins*, **14**, 153. IF: 4.0 Q1
- DARVAS, B., GYURCSÓ, G., TAKÁCS, E., SZÉKÁCS, A.** (2022): Potential risk of pollen from genetically modified MON810 maize containing Cry1Ab toxin to protected lepidopteran larvae in the Pannonian Biogeographical Region – A retrospective view. *Insects*, **13** (2), 206. IF: 2,9 Q1
- b) Published in a *foreign-language journal without impact factor*
SERES, A., HRÁCS, K., GYURCSÓ, G., SÁROSPATAKI, M., SZAKÁLAS, J., NAGY, P. I. (2016): Laboratory studies on the effects of a neonicotinoid-containing seed treatment product on non-target soil animals. *Columella: Journal of Agricultural and Environmental Sciences*. **3** (2), 7-14.
- KLÁTYIK, SZ., DARVAS, B., MÖRTL, M., OTTUCSÁK, M., TAKÁCS, E., BANÁTI, H., SIMON, L., GYURCSÓ, G., SZÉKÁCS, A.** (2016): Food safety aspects of pesticide residues in spice paprika. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering.*, **10** (3), 156-159.
- c) Published in a *Hungarian-language domestic journal without impact factor*
GYURCSÓ G., KLÁTYIK SZ., SZÉKÁCS A., DARVAS B. (2025): A *MON810* kukoricapollen kockázatbecslése Cry1Ab-toxinra érzékeny és toleráns *Inachis io* fiatal lárvák esetében. *Ökotoxikológia*, **7** (3-4), 5-20.
- DARVAS B., GYURCSÓ G., SZÉKÁCS A.** (2024): Csípőszúnyog-állománygyerítés Magyarországon. *Ökotoxikológia*, **6** (1), 21-39.
- GYURCSÓ G., SZÉKÁCS A., DARVAS B.** (2024): Gyakoribb kukoricagyomok Magyarországon és az ellenük alkalmazott gyomirtó hatóanyagokra előre jelezhető tolerancia. *Ökotoxikológia*, **6** (3-4), 40-49.
- DARVAS B., GYURCSÓ G.** (2023): A Föld bioszférájának becsült tömege. *Ökotoxikológia*, **5** (1), 31-39.
- DARVAS B., GYURCSÓ G., SZÉKÁCS A.** (2023): *NGT* kontra *GMO* – a tervezett Európai Unió szabályozás keretei. *Ökotoxikológia*, **5** (3-4), 45-54.
- DARVAS B., GYURCSÓ G., TAKÁCS E., SZÉKÁCS A.** (2021): Cry1Ab-toxint tartalmazó pollen (*MON 810*) és potenciális veszélye a hazánkban élő védett lepkékre (visszatekintés). *Ökotoxikológia*, **3** (2), 6-8.
- GYURCSÓ G.** (2020): GM-növények haltakarmányként való felhasználása. *Ökotoxikológia*, **2** (1), 20-25.
- DARVAS B., GYURCSÓ G.** (2020): Géntechnológiai eljárással módosított növények az Európai Unióban. *Ökotoxikológia*, **2** (1), 4-19.
- DARVAS B., GYURCSÓ G., TAKÁCS E., SZÉKÁCS A.** (2018): Mezőgazdasági géntechnológia – No2 Genomszerkesztés és géncsendesítés (*GEO* és *GSO*). *Biokontroll*, **9** (2), 4-27.
- DARVAS B., GYURCSÓ G., TAKÁCS E., SZÉKÁCS A.** (2018): Mezőgazdasági géntechnológia – No1 Transzgenikus szervezetek (*GMO*). *Biokontroll*, **9** (1), 19-35.

- DARVAS B., VARGA CS., **GYURCSÓ G.**, TAKÁCS E., KLÁTYIK SZ., OLÁH M., MÖRTL M., SZÉKÁCS A. (2017): Hormonmodulánsok a környezetünkben. *Biokontroll*, **8**, 4-34
- GYURCSÓ G.**, SIMON L., SZÉKÁCS A., DARVAS B. (2016): Gyomnövények ellen alkalmazott hatóanyagok akut toxicitása. *Biokontroll*, **7** (2), 4-10.
- DARVAS B., SIMON L., NECHAY E., **GYURCSÓ G.**, SZÉKÁCS A. (2016): Mikroszkopikusgombák ellen alkalmazott gombaölő hatóanyagok akut toxicitása. *Biokontroll*, **7** (1), 4-10.
- DARVAS B., SIMON L., NECHAY E., **GYURCSÓ G.**, SZÉKÁCS A. (2015): Akut toxicitás - I. Ízeltlábúak ellen alkalmazott zoocidek. *Biokontroll*, **6** (2), 57-66.
- GYURCSÓ G.**, DARVAS B. (2015): Magyarországon felhasznált növényvédőszer-hatóanyagok III. Gyomirtó szerek. *Biokontroll*, **6** (1), 15-28.
- GYURCSÓ G.** (2014): A gödöllői ivóvíz 2010-es *atrazine*-szennyezése. *Biokontroll*, **5** (1), 30-34.
- 2) CONFERENCE ABSTRACTS:
- a) *International conference abstracts:*
- GYURCSÓ, G.**, KLÁTYIK, SZ., TAKÁCS, E., MÖRTL, M., CHEN, K., DU, M., ZALÁN, ZS., SZÉKÁCS, A. (2025): Overview of the potential role of lactic acid bacteria in the reduction of mycotoxins and pesticide residues in food and feed. *Proceedings of the 31rd International Symposium on Analytical and Environmental Problems* (Szeged, Magyarország), 322-326.
- TAKÁCS, E., SOUYADET, P., SIAKAWA, A., GÉMES, B., KLÁTYIK, SZ., **GYURCSÓ, G.**, SZÉKÁCS, A. (2025): monitoring of carbamazepine pharmaceutical active ingredient in river danube and lake balaton. *Proceedings of the 31rd International Symposium on Analytical and Environmental Problems* (Szeged, Magyarország), 240-240.
- GYURCSÓ, G.**, MÖRTL, M., TAKÁCS, E., FEJES, Á., SIMON, L., DARVAS, B., SZÉKÁCS, A. (2017): Effects of Glyphosate-based herbicides and their components on the embrional development of zebrafish (*Danio rerio*): assessment of the role of retinoids. *Proceedings of the 23rd International Symposium on Analytical and Environmental Problems* (Szeged, Magyarország), 420-425.
- KLÁTYIK, SZ., DARVAS, B., MÖRTL, M., SIMON, L., BÁNÁTI, H., **GYURCSÓ, G.**, SZÉKÁCS A. (2016) Pesticide residues in spice paprika in the RASFF system. In: Brauning, J. and Hensel A. *SPICED Symposium Spices and Herbs: A Risk-Free Taste Experience?: Abstracts*. Spiced Symposium (Berlin, Németország), 116.
- OTTUCSÁK, M., KLÁTYIK, SZ., **GYURCSÓ, G.**, MÖRTL, M., DARVAS, B., SZÉKÁCS, A. (2015) Environmental monitoring of glyphosate and assessment of its combined cytotoxicity with adjuvants. *Proceedings of the 21st International Symposium on Analytical and Environmental Problems* (Szeged, Magyarország), 64-67.
- b) *Hungarian conference abstracts:*
- GYURCSÓ G.**, DARVAS B., TAKÁCS E., SZÉKÁCS A. (2025): A géntechnológiaiúton módosított MON810 kukorica Cry1Ab-toxintermelése és annak lehetséges veszélyei. *Ökotoxikológia*, **7** (3-4), 47.
- GYURCSÓ G.**, DARVAS B., TAKÁCS E., SZÉKÁCS A. (2025): A géntechnológiaiúton módosított *MON810* kukorica Cry1Ab-toxintermelése

- és annak lehetséges veszélyei. *In: SZÉKÁCS, A. és MÖRTL, M., 13. Környezetkémiai Szimpóziuma, 18.*
- GYURCSÓ G., KLÁTYIK SZ., TAKÁCS E., MÖRTL M., CHEN K., DU M., ZALÁN, ZS., SZÉKÁCS, A. (2025):** A tejsavbaktériumok potenciális szerepe a mikotoxinok és növényvédőszer-maradékok csökkentésében az élelmiszerekben és takarmányokban. *Ökotoxikológia, 7 (3-4), 49-50.*
- OLÁH M., MÖRTL M., GYURCSÓ G., SZÉKÁCS A. (2024):** Nagy perzisztenciájú ipari eredetű rovarirtószer-hatóanyag és bomlástermékeinek kimutatása a Budapesti Vegyiművek környékéről származó talajmintákból. *In: Talajtani Vándorgyűlés programfüzet, 72.*
- DARVAS B., GYURCSÓ G., SZÉKÁCS A. (2024):** A csípőszúnyog-állománygyerítés hazai gyakorlata. *Ökotoxikológia, 6 (3-4), 60.*
- GYURCSÓ G., DARVAS B. (2020):** GM-növények takarmányozási célra való használata halakon. *Ökotoxikológia, 2 (2), 13-14.*
- GYURCSÓ G., SIMON L., TAKÁCS E., SZÉKÁCS A., DARVAS B. (2019):** Cry1- (*MON810*) és Cry3-toxinokat (*DAS-59122*) termelő kukoricák hatása az amurra (*Ctenopharyngodon idella*) 1-, 3-, 6-hónapos kísérletekben. *Ökotoxikológia, 1 (2), 9-10.*
- GYURCSÓ G., BASKA F., MÖRTL M., SIMON L., PASARÉTI GY., CSÉFFÁN T., SZÉKÁCS A., DARVAS B. (2019):** Húszhetes glyphosate-expozíció hatása a zebradánio ivardeterminációjára. *Ökotoxikológia, 1 (1), 38-39.*
- SIMON L., GYURCSÓ G., SZIKORA B., BASKA F., MATKÓ J., TAKÁCS E., SZÉKÁCS A., DARVAS B. (2018),** Húszhetes glyphosate-expozíció harmadára csökkenti zebradánio (*Danio rerio*) granulocitaszámát. *Abs. VIII. Ökotoxikológiai Konferencia (Budapest), 33-34.*
- GYURCSÓ G., BASKA F., MÖRTL M., SIMON L., PASARÉTI GY., CSÉFFÁN T., SZÉKÁCS A., DARVAS B. (2018):** Húszhetes glyphosate-expozíció hatása a zebradánio ivardeterminációjára. *Abs. VIII. Ökotoxikológiai Konferencia (Budapest), 11-12.*
- SIMON L., GYURCSÓ G., BASKA F., TAKÁCS E., SZÉKÁCS A., DARVAS B. (2017):** Egy, három és hathónapig tartó *MON810*- és *DAS-59122*- etetés hatása az amurra. *Abs. VII. Ökotoxikológiai Konferencia (Budapest), 34-35.*
- GYURCSÓ G., SIMON L., BOHUS P., MÖRTL M., TAKÁCS E., OLÁH M., FEJES Á., SZÉKÁCS A., DARVAS B. (2017):** Glyphosate és formázó anyagainak hatása a *Danio rerio* embrionális fejlődésére. *Abs. VII. Ökotoxikológiai Konferencia (Budapest), 15-16.*
- SZÉKÁCS A., MÖRTL M., TAKÁCS E., KLÁTYIK SZ., GYURCSÓ G., SIMON L., OLÁH M., DARVAS B. (2017):** Növényvédő szerek és állatgyógyászati termékek adalékanyagainak meghatározása és ökotoxikológiai értékelése. *Program és előadás-összefoglalók – 60. Magyar Spektrokémiai Vándorgyűlés és XIII. Környezetvédelmi Analitikai és Technológiai Konferencia (Debrecen), 74.*
- TAKÁCS E., BÁNÁTI H., GYURCSÓ G., MÖRTL M., BATA-VIDÁCS I., SZÉKÁCS A., DARVAS B. (2016):** Fűszerpaprika-termelési technológiából származó mosóvizek ökotoxikológiai vizsgálata. *Abs. VI. Ökotoxikológiai Konferencia (Budapest), 37-38.*
- KLÁTYIK SZ., DARVAS B., MÖRTL M., SIMON L., BÁNÁTI H., GYURCSÓ G., SZÉKÁCS A. (2016):** Fűszerpaprika-tételek növényvédőszer-maradékos szennyezettsége a RASFF adatbázisa alapján. *Abs. VI. Ökotoxikológiai Konferencia (Budapest), 16-17.*

- GYURCSÓ G.**, SIMON L., BÁNÁTI H., JURACSEK J., KLÁTYIK SZ., TAKÁCS E., PASARÉTI GY., SZÉKÁCS A., DARVAS B. (2016): Háromhónapos takarmányozási kísérlet *MON810* és *DAS-59122* GM-táppal amuron (*Ctenopharyngodon idella*) - [No4] Enzimológiai vizsgálatok (amiláz, tripszin, leucin-aminopeptidáz) a közép- és utóbélben. *Abs. VI. Ökotoxikológiai Konferencia* (Budapest), 14-15.
- BASKA F., SIMON L., VINCZE B., **GYURCSÓ G.**, PASARÉTI GY., DARVAS B. (2016): Az amur (*Ctenopharyngodon idella*) tápcsatornájának szövettani vizsgálata 1-, 3- és 6-hónapos Cry1- (*MON810*) és Cry3- toxinnal (*DAS-59122*) való etetés után [No2]. *Abs. VI. Ökotoxikológiai Konferencia* (Budapest), 6-7.
- DARVAS B., PASARÉTI GY., CSÉFFÁN T., **GYURCSÓ G.**, VAJDOVICH P., SZABÓ B., BASKA F., SIMON L., BÁNÁTI H., TAKÁCS E., KLÁTYIK SZ., FEJES Á., JURACSEK J., MAGYARÓSY B., ARDÓ L., SZÉKÁCS A. (2015), Egy- és háromhónapos takarmányozási kísérlet *MON810* és *DAS-59122* GM-táppal amuron (*Ctenopharyngodon idella*) - [No1] tömegmérés és vérkémia. *Abs. V. Ökotoxikológiai Konferencia* (Budapest), 11-12.
- FÜLEKI L., KLÁTYIK SZ., **GYURCSÓ G.**, BÁNÁTI H., KARDOS C., SZTERNÁCSIK K., TAKÁCS E., MAGOR CS., SZÉKÁCS A., DARVAS BÉLA. (2014), A Magyarországon 1962-2013 között gyomok ellen alkalmazott hatóanyagok [No3]. *Abs. IV. Ökotoxikológiai Konferencia* (Budapest), 11-12.