Géza Ripka[1], Anna Rónai[1]

Received: March 2018 – Accepted: May 2018

Measures for the protection of honey bees and other pollinating species in plant protection

Keywords: honey bee, pollinating organisms, plant protection, pesticides harmful to bees, synergism, dimethoate, chlorpyrifos, acetamiprid, triazole type fungicides

1. Summary

The Hungarian pesticide authorization authority, the Directorate of Plant Protection, Soil Conservation and Agri-environment of the National Food Chain Safety Office (NÉBIH NTAI) strives to ensure with new measures that the risk to bees and other pollinating organisms is minimized during the proper use of pesticides. This article provides an overview of the causes of recent bee deaths and of the authorization changes intended for the protection of pollinators. Bee protection measures serve not only the economic interests of beekeepers, but they also deal with food chain safety issues due to the appearance of pesticide residues in honey. For example, limiting the use of dimethoate has considerably reduced the dimethoate residue contamination of honey.

2. Introduction

Cultivated plants are endangered by a large number of harmful organisms, for example, disease-causing bacteria and fungi, pests and various weeds. Of course, the plant protection agents applied for the protection of commercial crops affect not only harmful species, but also beneficial and indifferent, so-called non-target organisms. Ever since pesticides has been used to control pests, it has been a cause for concern that chemicals applied to plants may have health-damaging effects on honey bees and wild bees. The pollinating activity of bees is indispensable for the economical and sustainable cultivation of many crops. In agriculture, the honey bee is undoubtedly the most important pollinating species. The importance of honey bees is increasing continuously, since the growing area of oilseed rape and sunflower in Hungary has been increasing over the last decade and bees play an important role in their pollination. In contrast, the growing area of fruit species important to bees has been decreasing **[1]**.

The international intergovernmental body, IPBES (Intergovernmental Platform for Biodiversity and Ecosystem Services) published its first comprehensive international report on the status of pollinators and pollination in 2016 **[2]**. According to the document, the number and population of wild species involved in pollination has decreased in North America and Northwest Europe. Many wild bee and butterfly species are endangered. The unfavorable trends observed in the diversity and richness of pollinating communities are partly due to intensive agricultural cultivation and changes in land use. In Hungary, the honey bee population has not decreased, and there is no clear trend in the case of wild bees; there are species whose numbers are growing, while the populations of others are stagnating or even declining.

3. Pollinating arthropods and pesticides

The goal of Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides, and regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC, among other things, to make sure that pesticides can be used safely from an environmental point of view. In order to protect pollinating insects, including

[1] NÉBIH Directorate of Plant Protection, Soil Conservation and Agri-environment

bees, Commission Implementing Regulation (EU) No 485/2013 limited the use of neonicotinoid insecticides harmful to bees, such as imidacloprid, chlotianidin and thiamethoxam **[3]**. In accordance with the regulation, authorization documents of pesticides containing such active substances had been modified by EU member states before September 30, 2013, and further restrictions are being introduced in 2018. In addition, NÉBIH NTAI pay special attention to the Hungarian bee health situation and places great emphasis on the reduction of all risks, including environmental risk, due to the use of pesticides **[4]**.

Of course, it is not possible to take risk-mitigation measures for all pesticides, based on their risk to bees. In this regard, there are significant differences between the different active substances. For example, there are active substances that present an acceptably low risk/danger to honey bees, while other active substances present an unacceptable risk/danger to species that visit flowers. In addition, there are active substances that have a significant contact toxicity, but which degrade on the plants relatively rapidly, while other active substances have long-term effects. In addition to contact poisoning, further exposure is caused by the fact that pesticides applied to blooming plants can be picked up by pollen and can also enter the nectar. And pollinating arthropods feed on these, collect them and feed their larvae partly with them.

Bee toxicological properties (the toxicological profile) of active substances are determined on the basis of laboratory, semi field and field tests. These are taken into particular account by the authorizing body for the protection of bees and other pollinating insects and, furthermore, the precautionary principle is applied in the authorization documents of pesticides. For example, no pesticide expressly harmful to bees can be applied to blooming cultures visited by bees in the blooming period, or if the plant culture to be treated is visited by bees for any other reason. Such causes include the collection of honeydew, carrying water from the liquid drops secreted by the plant, or even the presence of blooming weeds. Restrictions are imposed by the authority not only in the case of pesticides sprays, but also in the case of seed coating agents, whose absorbed active substance may appear in the nectar and pollen in amounts that pose a risk to bees.

For the protection of bees, of course, the existence of regulations is only a necessary, but not sufficient condition. Implementation of the regulations in industrial practice depends on the law-abiding behavior of experts responsible for plant protection.

Bee deaths due to pesticides may have several reasons. The most common reason is the spraying of blooming plants with pesticides that are risky/ harmful to bees. Another case is when the spray drifts from the treated field to neighboring or nearby blooming plants. A further risk could be the poisoning of bees getting in contact with the seed coating powder removed from the surface of coated seeds during sowing. The bodies and limbs of bees and bumblebees are covered with dense hair, which can adsorb large amounts of pollen or seed coating powder. In field and horticultural crops it can happen that the sprayed, cultivated crop itself is not blooming, but there are blooming weeds among them, and these are visited by pollinating insects (e.g., bumblebees, bees, wasps, flies, butterflies). In such cases, there is a high risk of damage to pollinators. Finally, it is also a known case when pesticides are absorbed by the bees not only from the flower of the sprayed plant (pollen, nectar), but from the contaminated drops of water on the surface of the foliage, from rainwater, irrigation water or dew collected in a space enclosed by corn stalks or leaf sheaths, from guttation fluids secreted by the plants, or from puddles collected on the ground of a treated field. Many proboscis insects (e.g., aphids, scale insects, psyllids) secrete honeydew which forms a sticky coating on the surface of the plant. This carbohydrate-rich secretion is collected not only by ant species, but also by honey bees. Plants covered by honeydew also has to be considered a culture visited by bees. In this case, in plant protection activities, the same prescriptions have to be followed as if the culture was blossoming. Maize, grapes, potatoes and cereals also have to be considered as pollen sources, especially in periods poor in pollen.

Based on years of experience, spring is the most critical period in terms of bee deaths, particularly the blossoming period of fruit trees, rape and mustard (usually April). The exposure of bees to pesticides is greatest at this time. Another key period is the period of blooming of sunflower (usually from the end of June to the beginning of August). During these periods, pests that plants need protection against appear both in fruits and arable crops. It is the responsibility of the experts directing plant protection to make sure that protection is carried out at the right time and using pesticides, the proper use of which is not expected to present an unacceptable risk to pollinating insects.

However, during plant protection work, not only the phenological state of cultivated crops, but also nearby blossoming plants have to be taken into consideration, because they are often visited by the bees. It is not uncommon, that fields of arable crops are bordered by blossoming herbaceous plants and shrubs (e.g., blackthorn, black elderberry), lines of trees, protective forest areas (e.g., black locust trees). In the case of fruit orchards and vineyards, spacing areas could be covered by blossoming plants visited by bees (e.g., dandelion, nettle, white clover, Veronica species). In the spring and summer periods, plants at the borders of the fields are visited by a large number of pollinating insects. During plant protection activities carried out in these periods (spraying with insecticides, fungicides,

herbicides), particular attention should be paid that no pesticides risky or harmful to bees is adsorbed by the blossoming field border when spraying the neighboring plants (e.g., rape or cereals). Next to blossoming field borders, only those insecticides can be used that are not mandatorily labeled (not harmful) to bees and can be applied using technologies that are gentle to bees. Spraying must be carried out in such a way that protective distances specified in the authorization documents of the pesticides in order to protect non-target insects are observed, combined with drift reduction nozzles, if necessary, so that the spray does not drift to other plants from the treated culture. In addition, in areas utilized by nitrogen-binding secondary crops of ecological importance, the use of pesticides risky or harmful to pollinating insects has to be avoided, if possible.

When sowing coated seeds, to prevent the drifting of the powder containing the coating agent, the use of a deflector on pneumatic seeders is mandatory, which guides the flaking material to the ground through a pipeline.

4. Plant protection aspects of bee poisonings from an authority point of view

In the following, the material assembled for the article that was published in Issue 4, Volume 26 of the journal Agrofórum is quoted, in an expanded form **[5]**.

In the spring period, during plant protection work, special attention should be paid to the protection of bees and other pollinating insects when using pesticides harmful or risky to them. The goal is to avoid getting pesticides risky or harmful to bees on plants attractive to insects performing the collection.

Unfortunately, bee poisonings due to inappropriate plant protection technologies occur each year. Their number varies from year to year, but approximately 25 to 45 cases are published annually nationwide. Compared to bee deaths caused by other conditions harmful to bees, these case numbers are fortunately small, but for the beekeeper affected by the deaths, they cause serious economic losses, since the result is not only the destruction of the animals and the weakening of the families, but also a loss of revenue.

5. Authority procedure in case of bee poisoning

Bee poisoning as a result of plant protection work has to be reported immediately by the beekeeper to the territorially competent county government office. On the basis of the notification, the authority will initiate an official investigation of the bee deaths. Since the publication of the National Food Chain Safety Office (NÉBIH) guideline „Procedure for investigating bee poisonings presumably as a consequence of plant protection activities" (November 2012) **[11]**, cases reported to the authority are investigated by authority veterinarians and plant protection inspectors working in the county government offices together. During this, samples are taken from dead bees by the committee investigating the bee poisoning, with the help of the veterinarian and the person responsible for bee health, and the losses are assessed. Two samples are taken per apiary for veterinary inspections and pesticide analysis. Following this, (blossoming) cultures that are visited by the bees are mapped out by the plant protection inspector within a radius of at least 3 km, and flower samples are taken from the areas. If dead bees can be found in the area concerned, they are also collected, separately from the other bee samples.

Samples are processed by the pesticide residue analytical laboratories of the Veterinary Diagnostic Directorate (ÁDI) of NÉBIH and of the Directorate of Plant Protection, Soil Conservation and Agri-environment (NTAI) of NÉBIH. In the pesticide residue analytical laboratories, bee and plant samples are analyzed for more than 200 active substances currently or formerly used, in addition to insecticides, for herbicides and fungicides as well.

A summary and evaluation of the bee health and pesticide residue reports related to the bee deaths is prepared by the Hydrobiological Laboratory of the ÁDI and the NÉBIH NTAI. Help to the compilation of the summary reports are provided by the environmental models of authority pesticide evaluation, and by the pesticide residue analytical results of the authority itself. During the toxicological analysis of the bee samples it is determined whether the pesticide or biocidal agent found in the samples can have an adverse effect on the outgoing bees. If necessary, pollen and nectar samples taken from the hive are also analyzed.

When analyzing plant samples, it is decided by the authority on the basis of the results of the analytical test, whether the pesticide residue content of the culture samples in the blossoming phenological state recorded in the report indicates proper or improper use. Proper pesticide use, in accordance with the EU pesticide evaluation and authorization procedure, cannot mean an unacceptable bee toxicology risk. This requirement must be interpreted as meaning that the active substance of the pesticide applied can only negligibly affect the health status of the bee families in question. The same applies to wild bees, bumblebees and solitary bees. To find improper plant protection technologies or to impose sanctions, it is sufficient to establish that an active substance is not authorized for the treated culture, or that the amounts of its residues significantly exceed the expected levels. The latter is often the case when the phenological restrictions prescribed for the use of the pesticide are ignored. It is also considered improper application when the necessary measures to prevent the drifting of the pesticide are not taken. The offense is particularly serious if the neighborhood of the treated area is covered by blossoming plants, for example, there is a row of black locust trees near the treated area.

The activities of the different authorities and laboratories are coordinated by the new bee poisoning procedure, cooperation is required. The number of reports submitted to the authority by practicing beekeepers, requesting compensation for the damages suffered increases each year, but still only some of the cases reach the authority. Sometimes it is the case that the parties to the dispute, to maintain a good relationship, settle the issue with each other without involving the authority.

6. Pesticide residue database

In order to produce the summary evaluation of bee poisoning cases, the authority needs data, based on which it can be decided whether the pesticide residue content of the plant sample taken during blossoming according to the standard procedure indicates proper, i.e., in accordance with the authorization document, or improper technological use.

To determine pesticide residue levels that appear when using the proper technology and to evaluate bee deaths according to the standard procedure, field experiments were set up by NÉBIH in 2013 in 13 counties in six cultures attractive to bees (autumn oilseed rape, sunflower, maize, cherry, sour cherry and apple), using 7 insecticide sprays and 11 insecticide seed coating agents, the active substances of which were most often detected in dead bees collected during the investigation of the cases. A summary of the results was published in the trade journal titled Növényvédelem (Plant protection) **[6]**.

The purpose of the study, from a bee poisoning evaluation point of view, was to determine pesticide residue reference values that characterize the pesticide residue contents of samples taken from blossoming cultures in the case of proper treatment. In other words, if the pesticide residue content of the given sample significantly exceeds the reference range in terms of the active substance harmful to bees, it indicates that plant protection treatments have been carried out using improper technologies (at higher doses than authorized or at a later phenological stage).

The analyses also provide an opportunity to serve as an objective basis for the possible modification of the authorization documents of certain pesticides.

7. Bee poisoning cases investigated between 2013 and 2017

In connection with the bee poisoning cases reported to the authority, based on the pesticide residue analytical results of plant samples, numerous plant protection technological errors have been discovered by the authority between 2013 and 2017 which could have been the source of severe poisonings in the case of both honey bees and wild pollinating organisms.

Technological errors – use of unauthorized products **[5]**:

- Diazinon in blossoming sour cherry orchard (1 case);
- Bifenthrin in rape (1 case);
- Dimethoate in blossoming apple undergrowth (1 case);
- Dimethoate in apple blossoms (5 cases);
- Dimethoate in plum blossoms (1 case);
- Dimethoate in blossoming plum undergrowth (1 case);
- Dimethoate in sour cherry blossoms (1 case);
- Dimethoate in oil radish (1 case);
- Dimethoate in blooming sunflower (1 case);
- Dimethoate in maize tassel (1 case);
- Dimethoate in grapes (1 case);
- Chlorpyrifos in apple blossoms (10 cases);
- Chlorpyrifos in cherry blossoms (1 case);
- Chlorpyrifos in plum blossoms (1 case);
- Clothianidin/thiamethoxam in apple blossoms (16 cases);
- Clothianidin/thiamethoxam in maize (6 cases);
- Imidacloprid in oil radish (1 case).

Since 2013, over the past five years, in 50 cases, active substances have been detected in plant samples by the laboratory which had been withdrawn from the given culture or, in certain cases, even removed from the European Union pesticide active substance positive list. One common mistake of this type is the improper application of products with the active substance dimethoate. Earlier, formulations containing dimethoate were allowed to be used widely in several cultures, but this has changed fundamentally. Currently, this active substance can be used exclusively in sugar beet, tobacco, cabbage, garlic, shallot and onion cultures. Thanks to the measures, the dimethoate contamination of bees has dropped significantly, presumably because of the restriction regarding stone fruits and pome fruits.

Recently, the authorization documents of products containing chlorpyrifos as an active substance have been modified several times, as a result of which the use of this active substance has been prohibited in the case of several cultures. Currently, it can no longer be used in most fruit crops, such as apples. Since chlorpyrifos is one of the most commonly identified active substances in dead bees, authorization conditions of its products will be discussed later.

According to the restrictions introduced in 2013, spraying of cultures attractive to bees is forbidden before blossoming, using products that contain neonicotinoid active substances (imidacloprid, clothianidin, thiamethoxam), which are particularly dangerous to bees. As a consequence, for example, clothianidin/thiamethoxam pesticide residues

found in apple blossom samples clearly indicate an infringement. 16 such cases have been revealed by the authority over the past five years.

Seed coating and treatment of maize using the above active substances have also been restricted. Following the restriction, proceedings were initiated by the authority in 6 cases because of chlotianidin/ thiamethoxam pesticide residues detected in maize tassels in amounts exceeding the limit of quantification.

Technological errors – drifting of pesticides to other plants attractive to bees **[5]:**

- Cypermethrin in fruit orchard undergrowth (9 cases);
- Chlorpyrifos in fruit orchard undergrowth (16 cases);
- Chlorpyrifos in blooming field borders, ruderals (3 cases);
- Clothianidin in blooming ruderals (1 case);
- Clothianidin/thiamethoxam in fruit orchard undergrowth (8 cases);
- Lambda-cyhalothrin in blooming field borders, ruderals (2 cases);
- Chlorpyrifos in black locust blossoms (2 cases);
- Dimethoate in milkweed flowers (2 cases).

One of the most commonly experienced mistakes is that the producer does not consider that the treated area or its vicinity is covered by flowering weeds that are visited by bees. Over five years, active substances especially harmful to bees have been found by the authority in flowering undergrowth or ruderals in a total of 43 cases, even though the regulation provides that the treatment of crops by such agents is prohibited if the area is visited by bees for any reason (FVM decree 43/2010) **[10].**

Technological errors – use of improper technology **[5]:**

- High cypermethrin level in apple blossoms (1 case);
- High cypermethrin level in rapeseed flower (7 cases);
- High chlorpyrifos level in rapeseed flower (6 cases);
- High chlorpyrifos level in apple blossoms (10 cases);
- High chlorpyrifos level in oil radish (1 case);
- High chlorpyrifos level in maize tassels (1 case).

Over the 5 years investigated, it was determined in 26 cases that, based on the amount of pesticide active substance found in the culture, application was carried out either too late (i.e., in the blossoming period), or in unjustifiably high doses different from what is specified in the authorization document **[6].**

Of course, the technological infringements detailed above have financial consequences as well. The plant protection authority is obligated to initiate proceedings against the owner of the plant sample, provided that its pesticide residue content is cause for suspicion. If the infringement can be proven, the proceedings may be subject to plant protection or food chain supervision fines, the amount of which varies between 15,000 and 150,000,000 HUF, depending on the nature and severity of the infringement.

To avoid such mistakes and similar offenses, it is advisable to continuously monitor the information published on the NÉBIH website regarding current restrictions and, in addition, the data on the labels of the products should be studied before each spraying, based on which it can be decided whether the products can be used in the given culture or not.

8. Changes in the authorization documents of products containing chlorpyrifos

The maximum residue level (MRL) inspection report regarding chlorpyrifos was adopted by the Standing Committee on Plants, Animals, Food and Feed (ScoPAFF) of the European Union on November 22, 2017. In parallel with this, taking into account the assessment of consumer risks, the MRL values for certain products had to be modified. As a consequence of the introduction of modified limit values, the authorization documents of the pesticides containing chlorpyrifos that are permitted to use in Hungary were reviewed by the authority and the necessary changes have been made. The decision concerns the following products:

- From the authorization document of the product Cyren EC the authorization for use in *quince, medlar*, *wine grapes and empty warehouses*, as well as the use in *maize and sunflower* cultures for stock treatment were deleted. Therefore, the preparation cannot be used in *maize and sunflower* after sowing;
- From the authorization document of the product Dursban 480 EC the use in *quince, wine grape, fodder and silage maize and sweet corn* cultures was deleted;
- From the authorization document of Dursban Delta CS *wine grape and maize* cultures were deleted;
- From the authorization document of Kentaur 5 G the use in *potatoes* was deleted;
- The authorization for use of Nurelle-D 50/500 EC in *wine grapes* was withdrawn;
- The authorization for use of Pyrinex 25 CS in *wine grapes and maize* was deleted;
- The authorization for use of Pyrinex 48 EC in *quince*, *medlar and wine grapes* was withdrawn. It can be used in *maize only during or before sowing;*

- From the authorization document of Pyrinex Supreme the use in *maize* was deleted.

Other specifications of the authorization documents remained unchanged. The restrictions listed above apply from January 1, 2018 **[7].** Modified authorization documents of the products are available in the NÉBIH Pesticide database on the NÉBIH website **[8].** Strict compliance with the prescriptions is also mandatory during the cultivation of plants sown for greening **[9].**

9. The issue of synergism

Result of international and domestic bee toxicological studies show that the acetamiprid active substance found in products not regulated for bees, when used together with certain triazole type fungicides, in synergy with them, poses a greater risk to bees and other pollinating organisms than when sprayed alone. In view of this, modifications were introduced in the authorization documents of these products by the Hungarian pesticide authorization body. The essence of the modification is that products with acetamiprid as the active substance can only be applied together with the tebuconazole active substance, if a technology that is gentle to bees is used, i.e., in the case of such a combination spraying can only commence after the end of the daily active flight of honey bees, no more than one hour before the astronomical sunset and should be finished no later than 11 p.m. The evaluation of similar combinations is currently under way.

10. Conclusions, recommendations

Thanks to the latest research results, the opinion on pesticide active substances changes continuously, which may lead to changes in the specifications for product use from time to time. For this reason it is advisable to monitor constantly the up-to-date versions of regulations and recommendations concerning the field, and it is also worth keeping in touch for experts in plant protection with those working in the beekeeping industry, since ensuring as safe a plant protection as possible and a healthy agricultural environment is our shared national interest.

11. References

[1] A fontosabb növények vetésterülete, 2017. június 1. KSH Statisztikai Tükör. https://www.ksh.hu/docs/hun/xftp/gyor/vet/vet1706.pdf (Acquired: 23.03.2018.)

[2] IPBES (2016): Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. S.G. Potts, V. L. Imperatriz-Fonseca, H. T. Ngo, J. C. Biesmeijer, T. D. Breeze, L. V. Dicks, L. A. Garibaldi, R. Hill, J. Settele, A. J. Vanbergen, M. A. Aizen, S. A. Cunningham, C. Eardley, B. M. Freitas, N. Gallai, P. G. Kevan, A. Kovács-Hostyánszki, P. K. Kwapong, J. Li, X. Li, D. J. Martins, G. Nates-Parra, J. S. Pettis, R. Rader, B. F. Viana (eds.). pp 1–28. viewed and downloaded at www.ipbes.net (Acquired: 04.03.2018.)

[3] Anonim (2013): A Bizottság 485/2013/EU végrehajtási rendelete (2013. május 24.) az 540/2011/EU végrehajtási rendeletnek a klotianidin, a tiametoxám és az imidakloprid hatóanyag jóváhagyási feltételei, valamint az e hatóanyagokat tartalmazó növényvédő szerrel kezelt vetőmagok használatának és értékesítésének tilalma tekintetében történő módosításáról. Az Európai Unió Hivatalos Lapja I. 139: 12–26.

[4] Gábriel G., Tóthné Lippai E. (szerk. 2013): Nemzeti Növényvédelmi Cselekvési Terv 2012. NÉBIH Növény-, Talaj- és Agrárkörnyezet-védelmi Igazgatóság. Budapest, 58 pp.

[5] Rónai A. K., Nagyné Sipos A. (2018): Méhmérgezések növényvédelmi vonatkozásai a hatóság szemszögéből. Agrofórum, 29 (4): 34–36.

[6] Ripka, G., Repkényi, Z., Griff, T., Dienes, D., Vásárhelyi, A. (2015): The results of analytical residue studies on certain insecticides applied in flowering crops. (Virágzó növénykultúrákban végzett rovarölő szermaradék-analitikai vizsgálatok 2013. évi eredményei.) Növényvédelem, 51 (4): 167–182.

[7] www.facebook.com/nebih.hu; http://portal.nebih.gov.hu/-/tovabb-korlatozodik-a-klorpirifosz-tartalmu-novenyvedo-szerek-felhasznalasa (Acquired: 23.03.2018.)

[8] www.facebook.com/nebih.hu; https://novenyvedoszer.nebih.gov.hu/Engedelykereso/kereso (Acquired: 23.03.2018.)

[9] www.facebook.com/nebih.hu; http://portal.nebih.gov.hu/-/zolditeskor-ugyeljunk-a-beporzo-rovarokra- (Acquired: 04.03.2018.)

[10] 43/2010. (IV. 23.) FVM rendelet a növényvédelmi tevékenységről. https://net.jogtar.hu/jogszabaly?docid=a1000043.fvm (Acquired: 04.03.2018.)

[11] Eljárásrend a vélhetően növényvédelmi tevékenység következményeként történt méhmérgezések kivizsgálására. Belső használatra kiadott útmutató, Nemzeti Élelmiszerlánc-biztonsági Hivatal (NÉBIH). 2012. 11. 1.