BeePro Handbook

Rational use of plant protection products and fertilizers in terms of the impact on bees in the ecosystem

This handbook provides general guidance and recommendations regarding the rational use of plant protection products and fertilizers, with a particular focus on their potential impact on bees and the broader ecosystem. The information and advice presented herein are intended for informational purposes only and should not be considered a substitute for professional advice or specific local regulations.

Funded by the European Union

BEEPRO: Rational use of plant protection products and fertilizers in terms of the impact on bees in the ecosystem.
PROJECT NO. 2021-1-SK01-KA220-VET-000025257

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Financed by the European Enion. The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Preface

This Handbook is one of the key results within the BeePro Project: "Rational use of plant protection products and fertilizers in terms of the impact of bees in the ecosystem", with the aim of providing training support materials to improve knowledge, skills and competences on the impact that the use of plant protection products is having on bees and other pollinators and the correct ways of use and application of these agrochemicals (otherwise essential in today's agriculture) in order to minimize the impact they have on bees and the environment in general.

The aim of the BeePro Project has been to produce useful training materials and tools for VET organizations, teachers-trainers of VET students, farmers, beekeepers and agricultural advisors, among others, in order to update and improve their knowledge and awareness in the field of organic beekeeping and the proper rational use of plant protection products and fertilizers.

The loss of bees has become a major problem because bees are among the most important pollinators of both agricultural crops and wild plants. Bees provide many benefits in the form of cross-pollination essential for environmental conservation and in the form of the therapeutic effect of their various bee products. Sometimes we do not realize how vital honeybees are and that our lives probably could not exist without them.

There is a lack of complex information and comprehensive knowledge relevant to organic beekeeping, with a particular focus on the effect of the use of plant protection products and fertilizers on bees and other pollinators. Moreover, these topics are constantly evolving and there is a need to update and improve the training of professionals to help agriculture and beekeeping adopt increasingly efficient and sustainable production methods and cooperate with each other.

There are different EU reports that urge member states to promote greater cooperation and exchange of knowledge and information, including advanced and mutual early warning systems and collaborative systems between farmers, beekeepers, foresters, scientists, etc., on methods and periods of application of insecticides and plant protection products in general; disease prevention and control, bee-friendly technologies and plant protection methods that minimize the impact of pollinators.

The BeePro Project aims to support the VET educational programs of the different EU states, so the project has produced different tools and training materials, including the BeePro Handbook, which are very useful for formal and non-formal VET (schools and teachers) but also for farmers, beekeepers, agricultural advisors and applicators of agrochemical products and the general public interested in these subjects.

Preface

Characteristics of the BeePro Handbook

The purpose of the BeePro Handbook is to help understand and provide knowledge about honeybees, bees in nature, the effects of different types of agrochemicals on beneficial insect, the proper use of plant protection products in the agriculture production, the organic beekeeping, organic agriculture production and good practices for using chemicals in an environmental friendly way. This handbook provides all necessary knowledge, information and practical examples.

The BeePro Handbook tries to be useful for beneficiaries and therefore attempts to have a well-structured content, an attractive shape and a high essential quality. The content included in this handbook has been tested and improved after a Pilot testing phase, with the previously online developed training content adapted to the format of a handbook and with some additional elements and parts. This handbook will be in printed and electronic version available on-line and offline (e-book).

This educational material is a structured manual that is mainly intended to facilitate the training of trainers and teachers, farmers, beekeepers, advisors, but it will also serve for the lifelong learning of anyone interested in agricultural, beekeeping or environmental issues.

In order to be as practical and manageable as possible, this handbook, in addition to developing the main contents through different chapters, includes a section of practical cases, conclusions, useful references and finally an annex with a glossary of the main concepts.

This material is expected to be transferable and adaptable to the different educational environments of the different EU countries in order to improve and update the training of teachers, trainers and professionals related to these topics, hence it has been produced in English and in five more different European languages.

Preface

Beepro E-Learning Platform

The complete BeePro training material in English, Slovak, Polish, Spanish, Romanian and Greek (including interactive glossary, videos, links, quiz and other resources) is also available on the interactive e-learning platform: BeePro Virtual Learning Environment – https://edu.beepro.sk/ .

To access the courses on the platform, you need to create an account at first: https://edu.beepro.sk/login/signup.php. When registering, please follow the instructions of the form, remember the entered login details or write them down. Subsequently, an email will be sent to your email address that you entered in the registration form, which will contain a link to confirm your registration. After logging into the portal, you can enter the <English/Slovak/Polish/Spanish/Romanian/Greek> course by selecting the specific language version and then by clicking on the “Enroll me“ button.

Chapter 1

KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.1. Introduction

Among the animals used by humans, bees are among the oldest. They probably originated in the Cretaceous period. Bees found in amber are mostly from the Eocene period and are approx. 40 million years old. Man learnt to use bee products very early on. The first 'documents' painted on cave walls were made 7-12,000 years ago. You can see on them that smoke was already being used then to relieve attacking insects, just as we do today. This was obviously not bee-keeping, but the extraction of their products by robbing nests, which is also practised today in certain parts of the world (mainly in Asia). Bees have always been an important part of the ecosystem, depending on insect-pollinated plants while performing the important 'service' of pollinating their flowers. It is no coincidence that most flowers have adapted their size and structure to pollination by bees. They have been adapted through evolution to the pollinators that were most abundant in the environment, namely bees. Bees, on the other hand, have adapted to make the best use of the food resources offered by plants. The biology of the bee colony is adapted to the annual rhythm of the appearance of food sources in the form of mass flowering plants. This is evident both in our climate and in the tropics, where there are dry and rainy seasons. This harmonious symbiosis of bees and plants has been gradually deformed by man-made environmental changes, which have recently gone so far as to threaten the continued existence of bees.

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1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.1. Introduction

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Bees are a highly specialised group of animals, dependent on the food they find in flowers and needing it in relatively large quantities for both colony development and sizable winter supplies. Therefore, the biology of both the individual worker bee and the whole colony is directed towards making the best use of food sources. Perhaps the most important feature is the ability to remember and learn certain behaviours, as well as the ability to pass on certain information to other individuals. The bee has an excellent sense of direction and is able to return to the hive even from several kilometres away without difficulty. A sensitive sense of smell and relatively good eyesight make it easy to find new food sources. If successful, the bee alerts other bees on its return to the hive. In this way, most forager bees know where the food is and do not waste energy searching for it. The raw material brought into the hive is processed by other, younger bees. The exact division of labour in the colony depends on the age of the bee to get the most out of it. Relatively recently, it was discovered, surprisingly, that the oldest bees or bees affected by certain diseases fly out on the riskiest flights, so that their loss puts the least strain on the colony. The annual biological cycle of the colony is adapted to the development of the melliferous flora of the geographical region. This is clearly influenced by the environment in which the population evolved. Moved to different climatic and foraging conditions, it tries to behave as if it had remained in its previous location.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

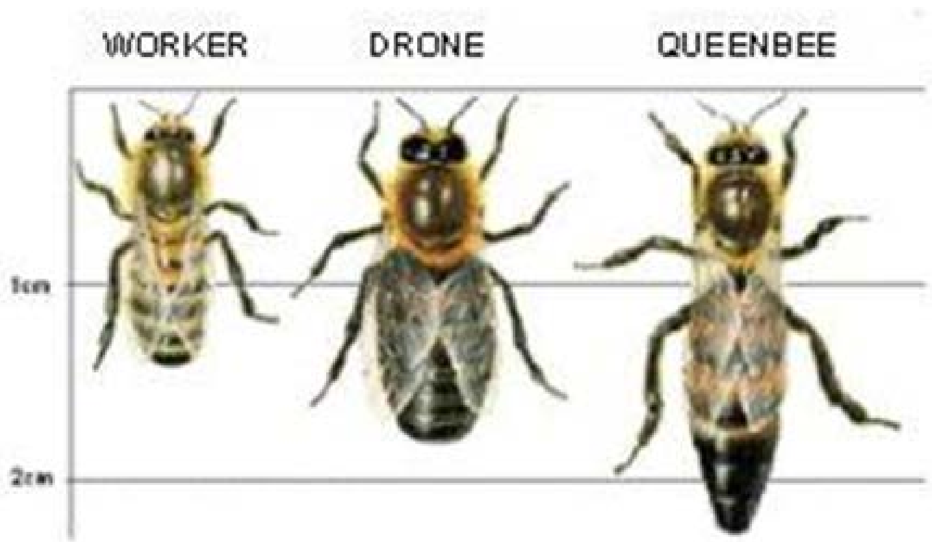
1.1.2. Bee Colony Biology

Honey bees are one of the few insects that have a social lifestyle. A bee colony consists of one reproductive queen, drones (males) and numerous workers, which are females with erect genitalia.

Bees are social insects, that is, the life of one individual is strongly dependent on the actions of other members of the bee colony. Insects living in aggregation are practically always characterised by polymorphism, that is, multiformity, which in bees manifests itself in three forms:

- female - this is the queen/mother bee,
- male - drones,
- worker bee - a female with retarded reproductive organs.

The body dimorphism of the different forms of bees is closely related to the lifestyle they lead.



1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.2. Bee Colony Biology

Bee Queen

In a properly functioning bee colony, there is usually only one queen. However, it can happen that for a certain period of time, two queens live side by side in the same hive, this being the result of a so-called silent exchange of queens, which for some reason does not suit the worker bees. The task of the queen is to lay eggs from which all the individuals of the colony develop. The queen bee does not show any care for her offspring during her entire life, which would not be possible due to her enormous fecundity; these tasks are undertaken by the worker bees. Compared to the other bee forms, the queen bee has the largest body size, her structure is characterised by an elongated and pointed abdomen, which is slightly paler in comparison to the rest of the bees. Her average body length is 16-20mm. Immediately after mating, they weigh from 152 to as much as 200mg. After mating flight, their weight can increase by up to 60%.

Factors determining the emergence of new queens are the composition of the royal jelly fed to the larvae by the worker bees. Royal jelly for queen rearing usually contains a higher proportion of monosaccharides (fructose, glucose) and juvenile hormone (HJ).

Bee queens usually live for 3-5 years, with some living up to 7 years. As they get older, the number of eggs laid decreases and it is then advisable to replace the queen with a new one, this is done on average every two years.

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1.1.2. Bee Colony Biology

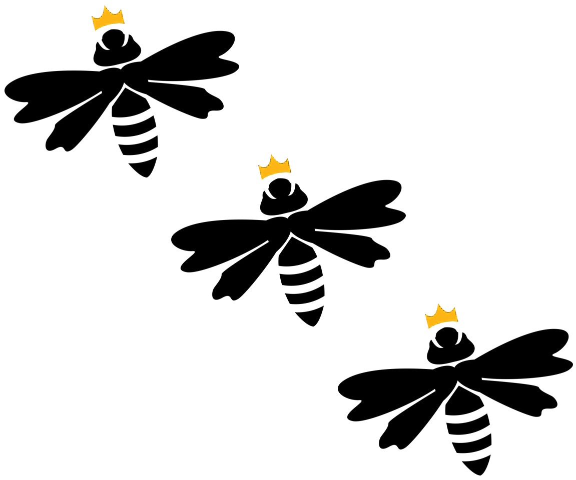
Mating Flights

The queen bee leaves the hive for only two reasons, firstly because of the mating flight and secondly because of swarming. The queen bee flies out of the hive for the first time on the fifth or sixth day after mating. Before the flight, the bees react vigorously to the presence of the new queen.

During the first mating flight, the queen/mother explores the area and familiarises herself with her surroundings, at which time work in the hive ceases and the pickers pause their flights. The actual mating flight usually takes place up to 3 days after the orientation flight. During this journey, the queen bee travels to what beekeepers call the 'droning ground'. Insemination of the queen may take place during one or more flights.

Copulation of drones with the mother can only take place in the air at a certain height. Drones confined together with their mother in the hive do not react to her at all, being attracted by her only during flight.

Mating flights are carried out in warm, sunny and windless weather from twelve to seven pm; increased mating flights are carried out during the afternoon hours from four to seven pm. Air temperature plays a key role, the better the weather the more drones are in the air.



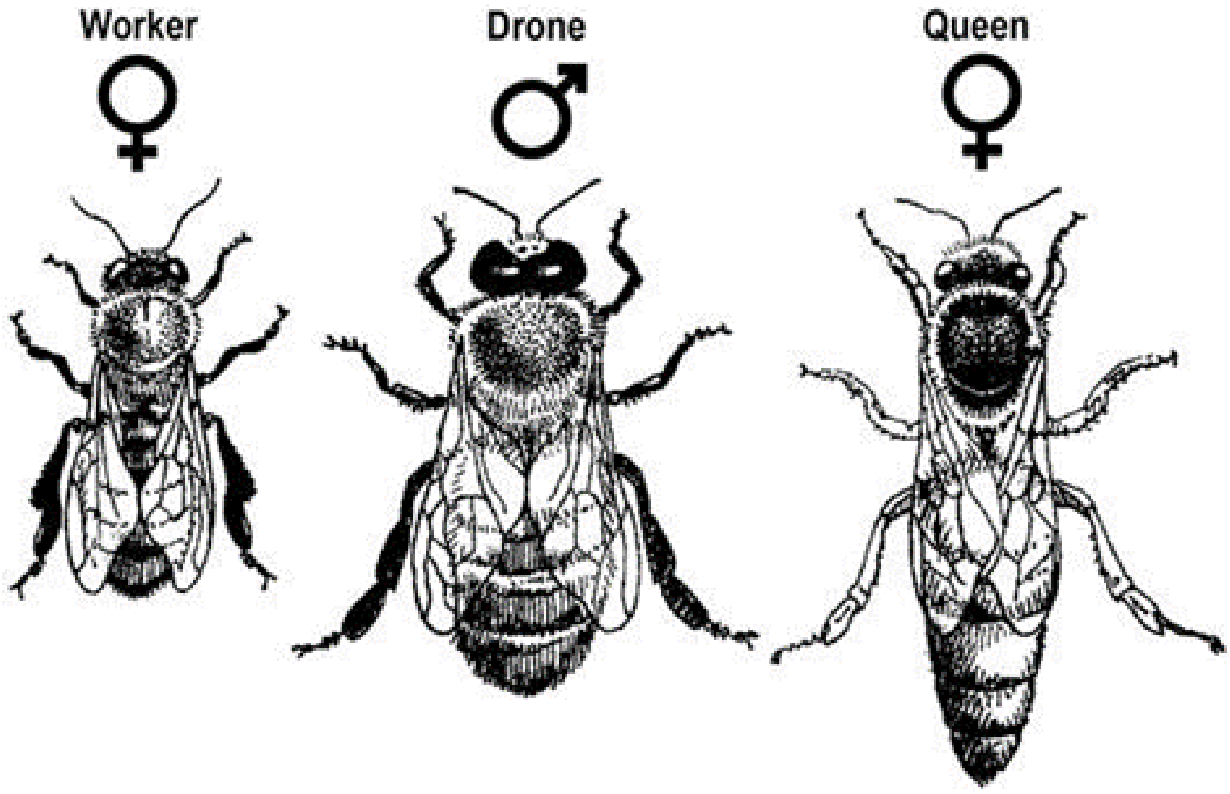
1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.2. Bee Colony Biology

Bee Drone

Drones are the male version of the honey bee. Unlike worker bees, drones do not have stingers and do not collect nectar or pollen. The primary role of drones is to fertilise the queen bee. Drones are not able to inseminate the queen immediately after emerging from the cell; they reach sexual maturity after 13 to 17 days. In the natural environment, the number of drones in a nest varies from several hundred to several thousand. Many beekeepers limit their number due to the fact that rearing and feeding consumes considerable amounts of food. It is worth bearing in mind that a complete lack of drones in spring and summer adversely affects bee performance.



1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.2. Bee Colony Biology

Worker bees

The most numerous part of the bee colony is the worker bees. The type of work done in the hive by the worker bees depends on their age. The youngest bees, apart from cleaning the cells, feed the larvae (older than three days), while those older than six days start feeding the youngest larvae and the brood queen. Some of the oldest bees are involved in building the combs and sealing the cells, others collect nectar from the flying bees, then process it into honey, whisk pollen into the cells, remove impurities, collect water, and at the end of the third week of life, some bees take on the role of guard bees. This or a similar order of work is only found in 'normal' colonies where there is a correct ratio between older and younger bees.

Worker bees are the smallest of the three forms of bees. Their bodies are small and 11-15 mm long. Worker bees are shorter and more slender than the drones and queen, and have baskets on their hind legs to help collect pollen. Like the mother, worker bees have stingers.

The lifespan of a worker bee largely depends on the time of year. Worker bees that emerge in spring and summer generally live 35 to 45 days, and no more than four weeks during the busy season. In contrast, bees that emerge in autumn can live up to nine months.

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1.1. BEE BIOLOGY

1.1.2. Bee Colony Biology

Bees communicate by means of:

- pheromones (fragrances),
- sonically (e.g. the singing of a young mother before leaving the second swarm),
- by touch,
- visually.

From the point of view of bee colony functioning, visual communication, i.e. through dances, is the most important. Through the dances, the bees communicate information to each other about the location of the food source (recruitment dances), the exit and settlement point of the hive (swarming dances), the need to defend or protect the colony and the nest (alarm dances), or hygiene (massaging and cleaning dances), which stimulate the bees to clean each other from the various contaminants on their body surfaces.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.3. Melliferous Plants

The honeybee has a key function in the environment. Its most important task is the pollination of insect-pollinated plants, which contributes to fruit setting and seed production.

White/yellow fennel
It also called 'honey clover', or 'white meliot', it is grown as a catch crop or for animal feed because of its nitrogen-fixing properties in the soil. Nostrel gives off a characteristic smell, so it attracts bees and other pollinating insects.
White foxglove belongs to a small group of the most productive honey plants growing in temperate climates. It flowers for 2 months starting from the end of April. The plant does not stop nectaring even during drought. Its honey yield can reach up to 600 kilograms of honey per hectare.

Blue phacelia
It is an annual plant with a short development period. It flowers roughly 50 to 60 days after sowing and continues to flower for another 5 weeks. The plant can be sown in virtually any type of soil, although it grows and nectars best in fertile soils. Phacelia grows up to a metre in height. It forms beautiful purple-blue inflorescences during the flowering season. Phacelia can be sown together with other plants such as lupins.According to observations, about 300 - 500 kg of honey can be obtained from blue phacelia under good conditions.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.3. Melliferous Plants

Borage

It forms sizable bright blue inflorescences. According to research, borage is capable of yielding 150 - 200 kg of honey per hectare. Bees are very keen to fly over this plant even in cold weather.

White clover

White clover grows effectively on all soil types except acidic ones. It is a drought tolerant plant and ranks as one of the most productive honey plants. It grows widely in Poland and can be sown to either increase or diversify its forage. White clover starts to flower at the end of May/beginning of June, this condition persists for the next month. Under favourable conditions, about 100 kilograms of honey can be obtained from one hectare. White clover is also sown for use as fodder for animals.

White mustard

It grows very well on most soils except barren sands and clay, and nectars best on fertile, calcium-rich soils. It tolerates spring frosts very well and can therefore be sown as early as early spring. It begins to flower 40 days after sowing, with a flowering period of approximately three weeks.

Mustard is ideal as a catch crop, although it is underestimated by many farmers and beekeepers. Sown immediately after the harvest, mustard begins to flower at the end of August, thus providing bees with nectar and pollen at that time. Honey yield is between 25 and 170 kg of honey per hectare.

Winter oilseed rape

Oilseed rape flowers secrete large amounts of nectar and pollen easily accessible to bees, which are the main pollinators. Bees are very eager to fly over winter oilseed rape, even when it is at a considerable distance from the apiary; unfortunately, the flowering period is in spring, when temperatures can drop sharply, at which point many of the forager bees die outside the hive, resulting in weakened colonies. For this reason, for oilseed rape crops, hives are driven as close to the field as possible.

Oilseed rape often becomes a breeding ground for a dangerous parasite, the oilseed rape strawberry, which damages the inflorescences and destroys the crop through its activities. Insecticides used to control it should only be applied before flowering of the oilseed rape, as the sprays can also be lethal to the bees. The honey yield of oilseed rape is about 150 - 200 kg of honey per hectare.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.4. Interesting facts about bees

What are the breeds of honey bee?

Of course, as with any species that specialises very slowly during the evolutionary process, the honeybee has developed races. In Poland, the Central European bee is naturally found, whose range (before the invention of exportation), covered an area from France to the Urals.

Since honeybees of other breeds began to be used in breeding, our native European honeybee is found very rarely. This bee is characterised by a dark body with grey hairs. The abdomen rings do not have distinct stripes and sharp colours. The worker bees appear uniformly coloured throughout the body. The breed is highly resistant to very harsh climatic conditions, but their colonies are late coming into strength. In addition, they are aggressive and swarming, which is why other varieties, such as the popular krainian bee, began to displace them from apiaries. The last bee breed found in Poland is the Caucasian bee. It is characterised by gentleness and low swarming. It also tends to masticate the nest abundantly. Of all the races discussed, it has the longest uvula (about 7 mm), which allows it to take nectar from flowers that is inaccessible to other insects. Its disadvantage is that colonies are slow to develop in spring and reach low strength. They overwinter worse and the workers are prone to robbery. In addition, they are not resistant to diseases. In Poland, they are used almost exclusively for crossbreeding with other breeds.

Breeders also refine each breed and among them there are many lines that have specialised traits tailored to the needs of the beekeeper, such as the location of the apiary.

The above-mentioned breeds can be found in Europe. On other continents, there are honeybee breeds that have adapted to the conditions there. For example, there is the heat-resistant Saharan bee (Apis mellifera sahariensis) in Africa or the Syrian bee (Apis mellifera syriaca) found in the Middle East and Israel.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.4. Interesting facts about bees

How many bee species live in Poland and how many in the world?

Of course, we are talking about the species we know, because the insect cluster is so diverse and numerous that scientists assume we have yet to learn hundreds of them. There are around 20,000 species of bee (Apiformes). They live wherever there are flowers - which is why they are not only found in Antarctica. In 2000, Józef Banaszak determined that there are 469 species and subspecies of bees in Poland, belonging to 52 genera. Of this number, the existence of 15 species in Poland is doubtful, and nine may appear in our country, arriving from other areas.

Bees work until the end of their lives

Bees during the summer season live for a maximum of six weeks, during which time they are able to visit around 1,000 flowers and produce less than one tablespoon of honey. To produce a kilogram of honey, bees travel a distance expressed in air miles, which is three times the circumference of the earth.

Bees perform different tasks depending on their age

An amazing fact about bees is that they divide their work based on age. For example, bees aged 1-2 days are given the task of cleaning cells, combs and the entire hive, bees aged 3 - 5 days feed the older larvae. As they get older, they begin to develop milk glands and produce the royal jelly needed to raise queen bees. All bees, regardless of age, are tasked with gathering food. When the bee reaches about three weeks of age, it begins to produce bee venom, after which time it can begin guardian work.

All worker bees are female

All worker bees are female, but they do not have the same reproductive capacity as the queen. Worker bees are born infertile and their only purpose in life is to work, they are the backbone and main driving force of the bee colony, without them there would be no one to look after the queen and the larvae. The worker bees get rid of the bee-productive drones from the hive every time the end of the summer season approaches.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.4. Interesting facts about bees

What does a bee career look like?

The bee's career begins as soon as the worker bee is bitten out, because the first thing she does is clean the cells. It removes the moults and faeces after the larvae and pupae. Slightly older insects take an even more thorough approach to cleaning, smoothing the edges of the cells, removing the remains of the roux and polishing the walls with propolis. The young worker bees are fed plenty of pollen - a diet rich in protein and fats, which leads to the swelling of the throat and rumen glands, which produce royal jelly. This allows the insects to proceed to feed the three-day-old larvae with a mixture of royal jelly, pollen and honey. After six days, the bees begin to feed only royal jelly to the younger, 1-3 day-old larvae.

Around the ninth day of life, the bees fly out for their first flight around the hive to empty their gut of faeces. The flight intensifies around the twelfth day of life. They are then so-called housekeeping workers, engaged in removing waste and dead bees from the hive and converting the nectar collected from the collectors into honey and beating the pollen pellets dropped into the cells to convert them into feathers. Around day 10, when the bees are working all shifts in the hive, their wax glands begin to produce wax. It is the young hive workers who build the combs. For the three weeks they spend in the hive, they still have the task of heating and/or ventilating the nest - then they take on the role of guardians. The 'warrior' bees check who lands on the nest inlet, and if they don't like an individual, they have the right to use a weapon - i.e. a stinger. They watch the flight of approaching insects and, up close, recognise their scent. When the foraging is very intense, the bee becomes a collector just a few hours after taking on the role of guardian. It then begins its most dangerous and exhausting work - gathering food, water or balsamic substances. This task continues for about 15 days until the exhausted worker bee dies.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.1. BEE BIOLOGY

1.1.4. Interesting facts about bees

Can bees live in the ground?

Of course! In the bee family Apidae there are very many bees that live in the ground. The bumblebee, for example, but also bees from the families Anthophorinae and Eucera (some species of hornets form families). The following bees burrow in the Polish soil: the striped warbler, the cornflower, the red warbler, the wykowa and clover cornucopia, the lucerne drone and the clover bee. The depth of the nests varies from 8 to 28 cm and they are either straight channels located vertically or horizontally, or they fork.

Also living in the ground are bees of the genus Amegilla e.g. Amegilla davsoni found in Australia as well as Amegilla cingulata. The latter species is interesting in that it not only has dark stripes on the abdomen, but also blue stripes. The white and black bees of this genus live in southern Europe and northern Africa.

Why are not all flowers easily accessible to the honeybee?

To increase reproductive success, plants take different pollination strategies leading to fertilisation. Sometimes they produce readily available nectar in shallow, small flowers clustered in clusters of umbels, in other cases only insects heavy enough to spread the petals can reach the food, and sometimes plants produce a lot of small, light pollen, making them independent of the help of pollinators.

Do all flowers secrete nectar?

Secretion of nectar is a very energy-consuming process. And yet there is no guarantee that the flower will be visited by an insect. Therefore, some plants only produce pollen, which is also readily collected by bees. These include, for example, poppies, pasqueflower, mullein, rutabaga, anemone, marsh marigold, helleborine or St. John’s wort. These species form a colourful perianth that attracts bees but does not provide nectar. Bees also collect pollen from plants that do not care at all about visits from pollinators - that is, from wind-pollinated species. Willows or hazels are very important spring beneficials to ensure a good start to the season for the colony.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.1. Role in the environment

The work of bees is extremely important for the environment and for us as part of it. Albert Einstein said that after the extinction of bees, humans would still have 3-4 years of existence left. And this was not a nightmarish joke, but the result of observation and reflection. If more than 80% of plants depend on insect pollination for their existence, how will nature function without them? If bees die, they will probably be the last of the insects and no one will pollinate these plants any more. Such a break in the food chain will have a terrible effect on nature as a whole. Probably even the best computer simulation cannot show this, we still know too little about all the intricate connections between living organisms on our planet and between them and the rest of the environment.

The benefits of bees for agriculture are already appreciated, but less is said about their role in the environment not used agriculturally. Not all foresters understand that the presence of bees in the forest increases the amount of forest fruit and thus also improves conditions for wildlife. Proper pollination of plants contributes to maintaining biodiversity, which is very important for the proper functioning of ecosystems. This is increasingly important nowadays, when environmental degradation due to human activities is causing the rapid disappearance of many plant and animal species.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.1. Role in the environment

In the maintenance of insect-pollinated plant species, the bee is irreplaceable, as it has outstanding qualities as a pollinator. Above all, it is characterised by "floral fidelity", i.e. collecting food from the same plant species until it has finished flowering. Overwintering whole colonies allows it to pollinate flowering plants in early spring when other insects are scarce. The number of bees in an area can be easily regulated by transporting apiaries. The flight of bees to a particular plant can be managed to a certain extent (so-called bee training). The role of bees, despite the already visible effects of their scarcity, is still generally underestimated.

The association of human life and economy with the honeybee over thousands of years means that, in public opinion, the importance of bees is widely known and associated with the products obtained from the honeybee, namely honey, wax, pollen, propolis, royal jelly and sometimes the venom used in apitoxin therapy. This is justified because, before sugar was produced, in Poland as late as the beginning of the 19th century, honey was the only substance used to sweeten drinks, food and to make confectionery. Wax, on the other hand, was used to make candles and thus to light up homes even before the invention of electricity.

The honeybee and wild bee species, therefore the most important pollinators, perform a variety of functions, both in the natural environment, agriculture and in many industries and therefore the human economy. However, the most valuable asset that bees provide to the entire animated world on our globe is their contribution to plant pollination.

Among insects, only bees have adapted, or in fact become dependent, on floral food in the course of evolution, that is, nectar and pollen, which are the exclusive food of both imaginal forms and larvae. On the other hand, entomophilous plants have depended on pollinators for their ability to produce seeds and fruit, and therefore for reproduction. The cooperation and interdependence between these organisms is so far developed that one group cannot exist without the other. Bees get food from plants to enable the survival of the species, and plants get cross-pollination from bees, i.e. the ability to release seeds and develop successive generations. Both groups of organisms have often developed complex systems of attraction and attraction to the opposing group.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.1. Role in the environment

Based on data on the importance of the honeybee and other wild bees, it is pollination and not the products obtained from the honeybee that are of greatest importance to the human economy and environmental biodiversity.

Bees and other pollinating insects are an integral part of ecosystems. They play an extremely important role in the pollination of crops and wildlife. It is estimated that about 78% of all plant species found on earth are insect-pollinated (including more than 200 crop species). Thus, insect pollination primarily ensures the survival of most species of the living world.

The main pollinator of plants in Poland is the honeybee, which pollinates more than 90% of the flowers of insect-pollinated plants. The remaining flowers are pollinated by bumblebees, solitary bees, flies, butterflies, beetles and other insects.

Of the field crops in Poland, about 50 species benefit from pollination by bees and about 60 species of vegetables. Of the horticultural plants, bees pollinate about 140 species, including 15 species of fruit trees and shrubs, and more than 60 species of cultivated medicinal plants benefit from the help of bees. The work of the insects increases the quantity and quality of the crop, which is particularly important for plant species such as e.g. rape (up to 30%), apple (up to.90%), gooseberry (up to 70%), or strawberry (up to. 20%).

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.2. Effects of environmental change on bees

The natural environment in which bees have lived for thousands of years is undergoing huge changes as a result of human activity, and these changes are, unfortunately, unfavourable to bees. The development of agriculture and deforestation has changed the composition of the melliferous flora, as well as the timing of the so-called main forage, when bees obtain most of their food.

The natural adaptation of the annual rhythm of development of bee colonies no longer corresponds to such a modified forage base and forces beekeepers to apply special treatments to alter this rhythm in order to achieve greater honey production.

In recent years, there has been a reduction in the number of species of crops grown, and many plants that provide bees with benefits have also disappeared from cultivation. The cultivation of monocultures over large areas results in an excess of nectar in relation to the number of bees at certain times and at other times in an almost complete lack of nectar, which has a negative effect on the development of bee colonies.

Much more dangerous are the ill-considered and short-sighted actions of man aimed mainly at immediate profit. The most drastic example is the invasion of the Varroa destructor mite, which has posed the greatest threat to beekeeping worldwide since the 1950s. This mite parasitizes the eastern bee (Apis cerana) without causing major losses, as this bee species has developed mechanisms to limit the parasite's growth. The natural habitat areas of the eastern bee and our honey bee have not come into contact with each other. In order to obtain higher honey yields, the honey bee was introduced into the areas inhabited by the eastern bee. The parasite infected the honeybee, which was completely unsuited to fighting it, and a massive invasion began, first in the Asian continent, then in Europe, from where it was carried by man to the Americas. Globally, the losses in the number of bee colonies due to this are counted in the millions.

There are many similar examples, involving parasites as well as bacterial, fungal and viral diseases.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.2. Effects of environmental change on bees

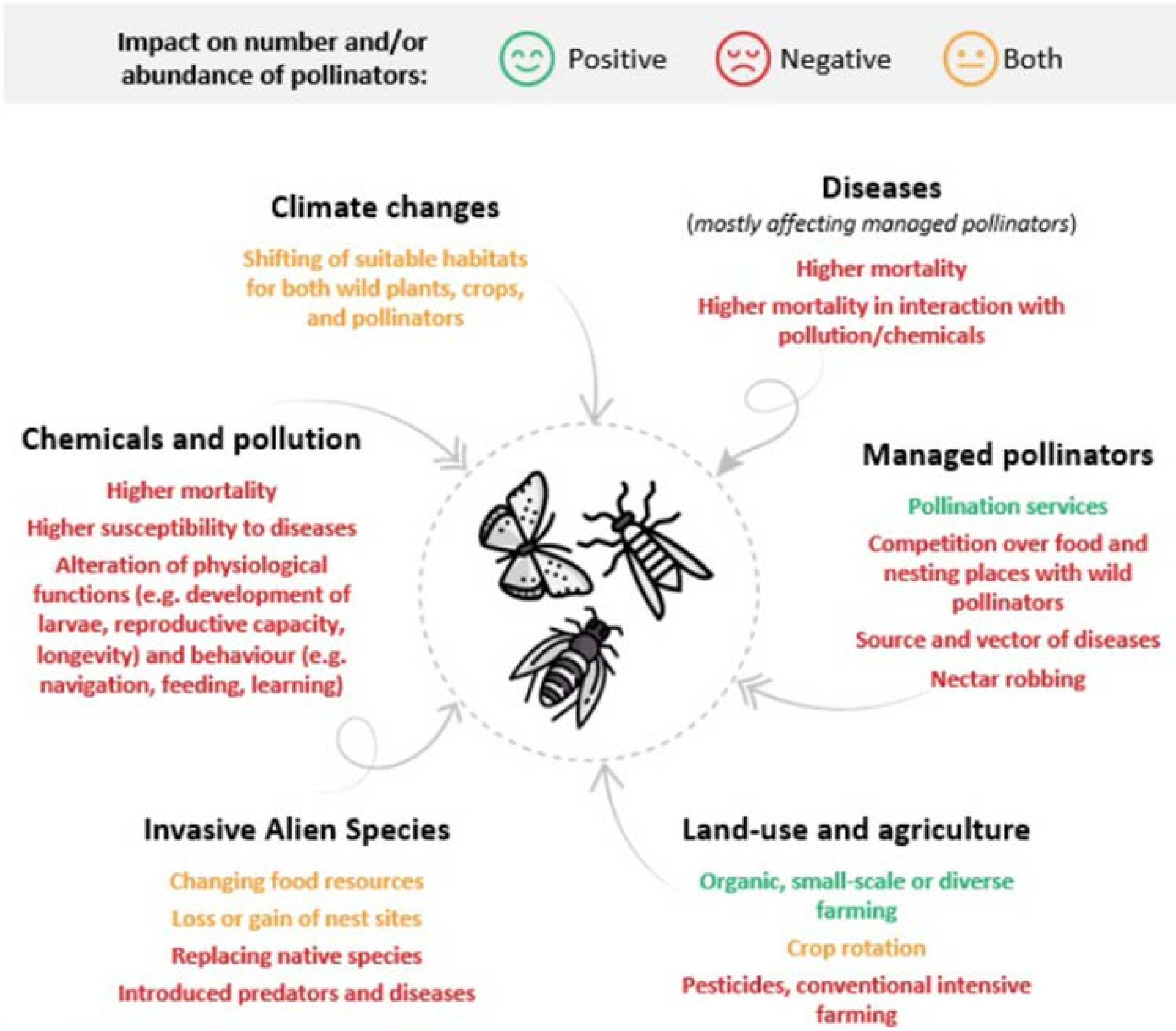
The natural environment in which bees have lived for thousands of years is undergoing huge changes as a result of human activity, and these changes are, unfortunately, unfavourable to bees. The development of agriculture and deforestation has changed the composition of the melliferous flora, as well as the timing of the so-called main forage, when bees obtain most of their food. Environmental chemistry has been a threat to bees for at least half a century, mainly due to the use of pesticides. In recent years, bee poisoning has been the cause of huge losses to apiaries in many parts of the world. Phenomena previously unknown to beekeepers have occurred: the mass disappearance of flying bees or entire colonies for unknown reasons. They were first reported in the United States and, in the absence of a discovered cause, were given the conventional name CCD (Colony Collapse Disorder). Studies have shown the multi-causal nature of CCD. The main factor is now thought to be the disruption of the bee's nervous system as a result of trace amounts of neonicotinoid pesticides (in nanogram doses per bee). An additional problem is genetically modified plants containing the Bt protein, which damages the digestive system and some glands of bees.

Such a changed environment is responsible for weakening the bees' natural resistance to various pathogens, which manifests itself in increased disease invasion.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.2. Effects of environmental change on bees



Source: ECA based on IPBES information.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.3. The role of bees in agriculture

For a long time, the role of bees in the agricultural economy was either completely overlooked or underestimated. It was not until the decline in yields of certain crops, despite correct agro-technical measures, that attention was drawn to the problem of flower pollination. Numerous research works have shown how important it is to have a sufficient number of pollinators, above all bees. The number of bee colonies used for pollination is generally insufficient, which has an impact on yields. This applies mainly to fruit crops. On a national scale, losses due to insufficient pollination of plants amount to more than PLN 2 billion, according to calculations by the Institute of Pomology and Floriculture. With the current concentration of agricultural production, only the use of bees as pollinators can give satisfactory results. The value of this 'service' is illustrated by the prices that growers in the USA pay for leasing one bee colony for the flowering period of a crop.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.4. Bees as natural bio-filters

Nowadays, man is well acquainted with the biology and ecology of the honeybee, and is thus able to use these pollinating insects not only to obtain bee products, but also to monitor the state of environmental contamination with heavy metals and pesticides. Bioindication is a method of assessing the state of the environment using living organisms. Bioindicators include animals, plants, fungi and even entire ecosystems.

There are a growing number of threats to which the honeybee is exposed in Poland and around the world, such as diseases and pathogens, and any environmental pollution, such as heavy metals, which can come from both natural and anthropogenic sources. Natural sources include the weathering of rocks, volcanic eruptions or soil formation processes [Sitarz-Palczak et al., 2015]. Man contributes to the pollution of the environment with heavy metals by consuming liquid and solid fuels, developing the metallurgical industry, etc. The

21st century has witnessed a dynamic development of motorisation, and earlier there was also the chemisation of agriculture, the delivery of industrial and municipal wastes to the soil, which resulted in the free penetration of dust and with it numerous impurities into the soil and directly into the nectar and pollen of flowers [Madras-Majewska, 2014; Kisała and Djugan, 2009; Spodniewska and Romaniuk, 2007]. The emitted pollutants become airborne and then spontaneously or with precipitation are deposited in the soil, plants and animals. In addition, bees are exposed to various types of harmful substances that enter their bodies with the food they take in, water and air they inhale [Stawarz and Masierowska, 2014]. The level of contamination of the natural environment is increasing year by year, thus disrupting the ecological balance [Banaszak and Izdebska, 1994]. Soil and water bodies at the site of coal and biofuel extraction are contaminated with heavy metals [Burden et al., 2019]. These elements are detected not only in bees and bee products obtained from plants located in the vicinity of industrialised and agricultural areas, but also in ecologically clean areas [Spodniewska and Romaniuk, 2007]. There is a hypothesis which assumes that all airborne impurities produced in cities and industrialised areas float in the air, in turn move long distances with air currents and either spontaneously or with precipitation settle and are deposited in the soil, among other things.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.4. Bees as natural bio-filters

Honey bees depend 100% on plants to provide them with nectar and pollen. They also benefit from the secretions of plant buds, which provide the raw material for the production of propolis [. Worker bees pollinate many plant species and visit thousands of flowers, through which they have direct and indirect contact with heavy metals and pesticides [Madras-Majewska et al., 2014]. Along with nectar, pollen and water, bees carry xenobiotics, pesticides and heavy metals into the hive [Kisala and Djugan, 2009]. A bee that lives in a clean environment dies after contact with even the lowest levels of heavy metals or pesticides. A worker bee that is in contact with a polluted environment from the first days after mating is characterised by increased resistance to polutants. A correlation between the diversity and abundance of pollinating insects and environmental pollution has been proven. The biodiversity of pollinating insects in the natural environment is reported to be higher than in the human-degraded environment. However, there are no studies verifying whether the efficiency of pollinated plants is higher, lower or unaffected [Moron, 2017]. Pollinating insects are able to adapt to the prevailing environmental conditions. Furthermore, the honeybee worker bee is able to learn to recognise the toxin and limit its consumption [Burden et al., 2019]. There has been preliminary research on bees that describes that honey bee workers, after eating nectar after which they became unwell, later avoided smelling the nectar of toxic flowers. Bees have a tendency to learn the characteristics of flowers, including colour and smell. Meeting these two conditions ensures good food.

Honey bees act as a biofilter as the honey raw material is cleaned of mechanical and chemical contaminants in the goitre. The excretory system of the insects is somehow imperfect, resulting in the accumulation of contaminants in the tissues of the worker bees [Roman, 2006]. The content of nickel, chromium, lead and selenium in the body of bees and drones from an industrialised area is higher than from an agricultural-forest region. Only the cadmium content in the tissues of bees from the agro-forestry region was higher than from the industrialised area. The explanation for this is that the farmers used mineral fertilisers and plant protection products. Furthermore, it has been proven that worker bees have a higher tendency to accumulate heavy metals than drones. This is further evidence that honey bee workers clean the honey raw material in the goitre and accumulate some of the heavy metals in their bodies. It has also been shown that the content of heavy metals in the nectar of plants growing at different distances from traffic routes is more than 20% higher than in honey extracted from these plants [Jablonski et al., 1995; Jablonski and Koltowski, 1996].

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.2. THE ROLE OF BEES IN THE ENVIRONMENT AND AGRICULTURE

1.2.4. Bees as natural bio-filters

In addition to the accumulation of heavy metals in bee tissues and bee products, pollinating insects are exposed to plant protection products. These agents, including insecticides, result in a reduced attention to nest cleanliness by the worker bees. Such frames quickly become a good place for the development of butterflies. The result is a lack of space for the bee colony to raise brood. The bee larvae are exposed to poisoned bees or insecticide in the food, which causes disorders in their development. Honeybee workers are not allowed to enter the nest after contact with herbicides or fungicides. This is because the active ingredient in the pesticides has a stronger odour than the bees' pheromones, so the insects' communication is disrupted. In addition, all chemicals cause the worker bees to reduce their food intake [Burdock, 2017].

In summary, bees have a mechanism for filtering the honey raw material contained in the goitre, so that the honey contains fewer heavy metals and dangerous chemical compounds. In addition, bees have many of the characteristics of a bio-indicator, so they can be used as alternative tools for environmental assessment.

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1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.1. Bee honey and Immunity

One of the important characteristics of bee products such as honey, propolis, pollen, bee bread and royal jelly is their immune-stimulating effect, i.e. increasing the activity of the human body's immune system. The systematic intake of these valuable natural products is the best guarantee against the infections to which we are exposed, especially during the autumn-winter and winter-spring periods.

Bee products mainly affect the body's non-specific immunity (innate or cell-mediated), which involves the capture and destruction of pathogenic microorganisms (bacteria, fungi, viruses and protozoa) that caused the infection. In response to the inflammatory response, specialised cells are produced as part of the body's defence: phagocytes, macrophages, monocytes, lymphocytes, neutrophils and eosinophils, and other body fluid factors such as antimicrobial proteins (interferon, lysozyme). The higher the level of these cells in the body, the higher the degree of non-specific immunity stimulated by honey and other products.

One component of honey's effect on the immune system is also its antiviral action. Therefore, it is characterised by its natural ability to prevent and counteract adverse side effects after COVID-19. Unlike synthetic drugs, it has multidirectional biological activity (antimicrobial, anti-inflammatory, expectorant, antitussive), is well tolerated and has no side effects. The ability of viruses to rapidly adapt and mutate is forcing scientists to search for new therapeutic strategies based on natural, safe and mildly acting products: such include plant raw materials and bee products, including honey.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.1. Bee honey and Immunity

The antiviral, antimicrobial, anti-inflammatory and immunomodulatory properties of honey were exploited in a clinical study conducted in Pakistan. A group of 313 patients infected with SARS-CoV-2 coronavirus were treated with nigella seeds and honey. Along with standard therapy, they received 1 g/kg body weight of honey and 80 mg/kg body weight of nigella seeds 2-3 times a day. As a result of the treatment, a significant improvement in the condition was observed, as well as a reduction in the time needed to relieve symptoms compared to the control group of patients.

The action of honey is further supported by other bee products contained in commercial preparations. It should be emphasised that the combined use of honey and other bee products shows synergism of action and makes it possible to achieve a better preventive and curative effect. It is therefore worth taking advantage of their beneficial effects, especially when we are particularly exposed to pathogenic agents. In this way, we can eliminate or significantly reduce upper respiratory tract infections and colds.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.2. Healing properties of beehives - Introduction to Apitherapy

Over the years, bee products have helped humanity treat and prevent a wide range of maladies, and apitherapy has been practiced in many nations as a supplemental treatment. This review sought to explore apitherapy, scientific research, and clinical trials involving bee products.

The Apimondia Standing Commission for Apitherapy defined Apitherapy as "a medical concept, based on scientific foundations corroborating traditional knowledge, including:

- bee production procedures aimed at medical development
- transformation of hive product procedures, alone, or in association with medicinal plants and their derivatives (apipharmacopoeia)
- clinical protocols incorporating the use of the api-pharmacopoeia and/or of the bees (api-medicine)."

Apitherapy is an alternative and complementary therapy that uses bee products such as honey, pollen, propolis, royal jelly and bee venom for disease prevention or treatment. It can also be described as "the science and art of using bee products to maintain health and assist the individual to regain health when disease or accident interferes."

Some of the conditions treated are: multiple sclerosis, arthritis, wounds, pain, gout, shingles, burns, tendinitis and infections.

Ancient cave art of early hunter-gatherers describes the bee as a source of natural medicine.

Bee venom therapy was practiced in ancient Egypt, Greece and China – three great civilizations known for their highly developed medical systems.

Hippocrates, the Greek physician known as the "Father of Medicine," recognized the healing properties of bee venom for treating arthritis and other joint problems. Today, growing scientific evidence suggests that various bee products promote healing by improving circulation, decreasing inflammation, and boosting the immune system.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.2. Healing properties of beehives - Introduction to Apitherapy

Some more history

Bees were painted on the walls of pharaohs' tombs, incorporated into the coat of arms of their kings, and the ancient Egyptians were already actively gathering honey. A paper from that time period also lists the use of honey as a treatment for kidney, stomach, and eye problems. Poultices, ointments, and other mixtures are also mentioned in the document.

It is obvious that the history of using honey as a health agent predates the history of medicine. The first known medical recipe dates back to Sumer circa 2000 B.C. and includes honey among other components. This recipe is also mentioned in religious texts. Additionally, honey is advised against plant, animal, and mineral poisonings in traditional Eastern medicine. In the Buddhist tradition, honey is regarded as a substance that extends life. Honey was advocated for use as a skincare product and to treat tooth decay during the Tang dynasty in ancient China. Roman, Indian, and Greek cultures, where Hippocrates and Aristotle outlined the health advantages of honey, also have records on suggesting honey and other bee products for therapy.

Since the beginning of scientific investigation into the effects of honey utilizing chemistry and technology, similar records have been discovered throughout history up to the present. Every day, more research are published regarding the beneficial impact of bee products on health. Inhaling the air in beehives is advantageous in addition to bee products, whose benefits depend on their composition and qualities.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.3. Healing properties - Effects and use of Apitherapy

Multiple sclerosis, osteoarthritis, rheumatoid arthritis, post-herpetic neuralgia, and bee sting desensitization are among the most prevalent conditions treated with apitherapy. Premenstrual syndrome (PMS), sulcoplasty, allergic rhinitis, enhancing sports performance, hyperlipidemia, and the common cold are additional conditions for which it is prescribed. Apitherapy is used topically and is typically used with honey to treat diabetic foot ulcers, burns, and wound healing.

Benefits of Apitherapy

Apitherapy can be used to treat a number of conditions:

Soothes arthritis pain: Bee venom therapy has been used since ancient Greece to help relieve pain from rheumatoid arthritis. This is due to its anti-inflammatory and pain-relieving effects.

Heals Wounds: Honey has long been used to treat wounds—including both open cuts and burns—due to its antibacterial, anti-inflammatory, and pain-relieving properties.

Treats Allergies: Wildflower honey can help treat allergies in several ways. Honey can soothe sore throats caused by allergies and act as a natural cough suppressant. At the same time, it can protect people from allergies. This is because local wildflower honey may contain traces of flower pollen, a known allergen. Eating local honey could slowly introduce this allergen into the body, potentially creating an immunity to it.

Treats Immune and Neurological Conditions: Bee venom can be used as a complementary treatment for diseases related to both the immune and neurological systems, including: Parkinson's disease, multiple sclerosis, Alzheimer's disease or lupus. Although bee venom should not be the only treatment method for these conditions, research has shown that bee venom has been able to boost the immune system and reduce some symptoms of these conditions in the body – partly due to the anti-venom of bees with inflammatory effects.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.3. Healing properties - Effects and use of Apitherapy

IMPORTANT to remember! Bee venom can be a double-edged sword. Bee venom can cause adverse reactions in many people, even if they are not allergic. Treatment should be carefully considered.

Reduces gingivitis and plaque: Propolis can have a number of health benefits. It can reduce gingivitis and plaque when added to a mouthwash.

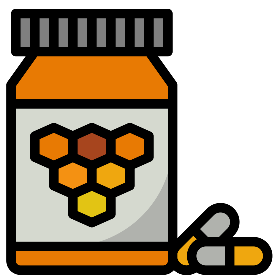
Mouthwash containing propolis may be able to naturally protect against oral diseases. Propolis can even help heal and prevent canker sores.

Source of multivitamins: Both royal jelly and propolis contain a large number of vitamins and nutrients. In fact, they can be taken as multivitamins to improve overall health, including the appearance of hair. Propolis is available as an oral supplement and extract. Royal jelly is available in soft gel and capsule form.

Practicing Apitherapy

Apitherapy should not be confused with the regular consumption, of course beneficial, of some bee products. The recommendation for the administration of apitherapeutics must be made only by specialists and only depending on sex, age, disease, body mass, the therapeutic target pursued, the stage of the disease, the values of laboratory analyses, other medical investigations, possible simultaneous or heredocollateral diseases, etc.

The apitherapist must also know the field of possible contraindications or side effects that some apitherapeutics present. Apparently harmless, some bee products, bee food supplements and even some standardized apitherapeutics, improperly administered, can have important side effects, ranging from allergies to triggering the onset of autoimmune diseases. The assertion of the lack of contraindications or side effects of apitherapeutics is nothing more than a legend.



1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.3. Healing properties - Effects and use of Apitherapy

It is known that medicines are, in fact, substances. If a drug contains a single substance or a complex of two or more substances, this depends on the therapeutic, pharmacokinetic valence with which it is invested by its manufacturer. The doses in which a certain drug, as well as its association with other drugs that support or moderate its actions in the human body, depending on the therapeutic target pursued, depend on the knowledge and experience of the doctor, but also on clinical knowledge and paraclinical of the patient, including holistic and hereditary. They are dedicated doctors who bring their profession to the level of art. These are the ones who treat the patient seen as a whole - body, mind and soul -, but also as part of another whole: the environment in which he lives (socio-familial, economic-occupational, his habit, diet, natural or urban environment, etc.). These people know well not only the medicine but also the patient. Always the clinician, when drawing up a therapeutic protocol, must know not only the indications, but also the contraindications, adverse and side effects of the prescribed medication.

Apitherapeutics, in most of them, especially the non-standard ones, are complexes of substances with therapeutic effects, and their prescription requires, in addition to medical knowledge, knowledge of their synergistic actions, as well as their antagonistic ones.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.3. Healing properties - Effects and use of Apitherapy

Principles, Guidelines and Precautions

1. Without the expert advice or close supervision of a licensed healthcare professional, it should not be used as a self-treatment.

2. It should only be used when conventional treatments have failed to help a patient or when they cannot be used as the initial course of treatment.

3. The diagnosis should be "holistic," encompassing not just conventional (allopathic) but also alternative therapies like homeopathy, acupuncture, and structural and energetic medicine.

4. Before delivering any api-product, but in particular before injecting bee venom, an allergy test should be conducted. The test should be performed by a licensed healthcare professional in a facility that is outfitted with the necessary supplies and authorized life-saving emergency procedures.

5. To get the most out of api-products, the primary recipient of the therapy should be willing to make dietary and lifestyle adjustments and be actively involved in the healing process.

6. The apitherapy treatment should be customized taking into account the principal recipient's overall health, the health condition to be treated, and the method of distribution of the appropriate api-product(s) for the condition. Every patient is different, and they all need to be treated differently!

7. Treatment schedules should be in harmony with various (bio)rhythms, which vary depending on the patient, the disease, the season, the time of day, etc.

8. Apitherapy should be used in conjunction with other natural therapeutic techniques such as phytotherapy, aromatherapy, acupuncture, organic diet, Ayurveda, etc. as it is not a "panacea." "Primum non nocere,"

9. Don't test your patient on anything! Utilize only secure procedures and superior materials!

10. It is crucial to increase blood flow using additional techniques such as massage, acupressure, gymnastics, taijiquan, qigong, and hatha yoga, among others.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.3. Healing properties - Effects and use of Apitherapy

11. The effects of bee products are enhanced by rest and relaxation.

12. A “positive-thinking“ family/friends group and a good environment (clean, organized, non-polluted) are also advantageous.

13. A “blitz“ approach is not apitherapy! Particularly when dealing with chronic illnesses, persistence and patience are required.

14. Educate your patients before, during and after treatments; make them genuine bee lovers and guardians! Each patient needs to eventually become his or her own apitherapist.

15. A good apitherapist must be at least a competent “amateur“ beekeeper and be well-versed in all aspects of bee colony life.

16. Finding the optimal medical plan for each individual can be aided by ongoing research, beneficial information sharing with other experts from other “Apitherapy related nations,“ and regular use of the Internet.

17. Before beginning apitherapy, the body must be “cleaned“ using several “detoxifying“ techniques: specific diets, fasting, and, if required, colon cleansing

18. The beneficial effects of a specific api-product may be slowed down or eliminated by medications that were prescribed before apitherapy under conventional care.

19. The duration of an apitherapy treatment is proportional with the severity of the treated health condition, the proper execution of therapy guidelines, the knowledge of the therapy provider and the necessary positive attitude, willingness and participation of the principle receiver.

20. Re-starting and continuing the apitherapy treatment may be necessary to maintain a better state of health that had not previously responded to conventional therapies after an indeterminate amount of time has passed after the onset of symptom alleviation

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.4. Products and techniques of Apitherapy

Honey

Honey is a viscous and aromatic product, with a variable composition depending on its botanical source. Bees use the therapeutic qualities of plants to produce honey; as a result, honey's identity is intimately tied to its botanical source. Sugars (including fructose, glucose, sucrose, maltose, isomaltose, maltose, trehalose, maltotriose, and melezitose), water, and enzymes (including invertase and amylase, glucose oxidase, and catalase) are the main ingredients of honey. Low levels of minerals (Na, K, Ca, Mg, Fe, Cu, Mn, and Zn), vitamins (mostly B and C), proteins, amino acids, pollen grains, and other phytochemicals are also present.

The anti-oxidant properties of honey, which are a result of the activity of polyphenolic components (phenolic acids and flavonoids), vitamins C and E, and enzymes, are one of the most studied characteristics of honey for medical purposes (catalase, peroxidase). Additionally contributing to honey's anti-inflammatory and anti-cancer properties are polyphenolic chemicals. Honey's low water content and the presence of glucose oxidase contribute to its antibacterial capabilities by inhibiting bacterial growth and even killing germs like methicillin-resistant Staphylococcus aureus (MRSA) isolated from infected wounds.

Clinical investigations showed that honey can help heal wounds. In a trial to determine the effectiveness of honey as a topical treatment for diabetic foot ulcers (DFU), diabetic participants with infected foot wounds were given honey dressings for three months. This led to significant healing of mild ulcers but not of ulcers with exposed bone and insufficient vascularity. This was linked to honey's antibacterial properties, which act as a barrier to stop microorganisms from entering, promote epithelialization, and speed up the absorption of edema from the wound and its surroundings. Due to the polyphenols in honey, it also has cardiovascular protective effects by enhancing endothelial function, preventing platelet aggregation, lowering inflammatory reactions and LDL oxidation, serving as an antioxidant, and lowering oxidative stress.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.3. BEE PRODUCTS AND THEIR HEALING PROPERTIES (APITHERAPY)

1.3.4. Products and techniques of Apitherapy

Honey not only has a potent healing effect but also has an antibacterial impact that helps with infectious conditions like mucositis. One of the most concerning side effects of radiation for head and neck cancer is oral mucositis. In 28 patients who had had radiation, it was examined the impact of honey (15 ml) on oral mucositis. After 4, 5, and 6 weeks, there was a discernible difference between the experimental and control groups in the severity of oral mucositis. Additionally, 7.14% of the experimental group experienced grade III oral mucositis compared to 64.28% of the control group.

Table: Clinical trials with honey: main approaches, types of trial, subjects and groups, types of intervention and main outcomes.

Approach	Trial	Number of subjects/ groups	Honey intervention	Main outcomes	Authors
Diabetic foot ulcer	Randomized	Honey dressing (n = 179) Saline dressing (n = 169)	Honey dressing 120 days	↑ healing efficiency	Imran et al. (2015)
Eyelid surgical wound healing	Randomized single-blind	n = 46 (29 women, 17 men)	Manuka honey twice a day 6 weeks	↓ tendency for skin distortion scar less palpable	Malhotra et al. (2017)
Cardiovascular parameters and anthropometric measurements of postmenopausal women	Randomized double-blind two-armed parallel	Tualang honey (n = 49) Honey cocktail (n = 49)	Tualang honey 20 g/day honey cocktail 20 g/day 6 and 12 months	↓ diastolic blood pressure ↓ fasting blood sugar	Ab Wahab et al. (2018)

Due to the polyphenols in honey, honey also has cardiovascular protective effects via enhancing endothelial function, preventing platelet aggregation, lowering inflammatory reactions and LDL oxidation, serving as an antioxidant, and lowering oxidative stress.

Data on honey's potential for ulcer and wound healing, treating oral mucositis, and protecting the heart are all related to its usage in apitherapy. Honey reduces swelling and stimulates tissue re-epithelialisation, hastening the healing process and providing pain relief. Honey has advantages for regulating the gut microbiota and can function as a substrate for probiotic microorganisms. Additionally, honey has been used to treat gastrointestinal disorders, piles, eczema, throat infections, coughs, bronchial asthma, tuberculosis, hepatitis, exhaustion, and dizziness. More recently, studies have shown that honey is effective in treating cancer, diabetes, and neurological disorders.

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1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

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1.3.4. Products and techniques of Apitherapy

Propolis

Bees produce propolis, a resinous substance derived from various plant components including tree bark and leaf buds and a combination of saliva and beeswax. Because bees use propolis to plug holes and defend their hives against invaders and water, the Greek term propolis literally translates to “protection of the city.“

Propolis has a wide range of biological activity based on its complex chemical makeup, which varies according on the botanical source and the region in which it was generated. Many plant species, including poplar, birch, palm, pine, alder, willow, Baccharis dracunculifolia, and Dalbergia ecastophyllum, have been identified as sources of propolis. Aromatic aldehydes, alcohols, amino acids, esters, diterpenes, sesquiterpenes, lignans, fatty acids, vitamins, and minerals may be present in its composition.

Since ancient times, propolis has been employed in traditional medicine for a range of ailments. Propolis was used by the Egyptians to embalm corpses and stop putrefaction.

Due to its antibacterial and therapeutic qualities, propolis was used by the Greeks and Romans to clean their mouths and to cure wounds. Propolis was used as an antipyretic by the Incas and as a remedy for myalgia, rheumatism, and eczemas by the Persians. Propolis was employed in the Second World War to mend wounds and cure tuberculosis.

Numerous propolis qualities, including antioxidant, antimicrobial (particularly its antibacterial effect), anticancer, anti-inflammatory, and immunomodulatory, were discovered through in vitro research utilizing cell culture assays. Propolis has recently been reported to have the potential to be used in the treatment of COVID-19, with several methods and perspectives.

Regarding in vivo studies, a wide variety of propolis activities has been described, e.g. antipsoriatic, estrogenic, antihypertensive, immunomodulatory, analgesic, hepatoprotective, antidiabetic and hypolipidemic, anti-inflammatory), antitumor anti-nephrotoxic, antidepressant and anxiolytic, anti-allergic, neuroprotective, antioxidant, anti-urolithiasis, wound and burn healing, photoprotective and others.

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Propolis has been also studied using different models of diseases or biological disorders, including asthma, insulin resistance, chronic gastric ulcers, sciatic nerve injury, lung damage, colitis, chronic apical periodontitis, ovary injury, cerebral injury, among others.

Due to its rich composition, propolis has been utilized in apitherapy to treat a wide range of ailments both internally and topically. The symptoms of the flu and cold, skin conditions (wounds, burns, and acne), psoriasis, otorhinolaryngologic, gynaecologic, obstetric, and proctologic problems, as well as for avoiding caries and treating gingivitis or stomatitis, have all been linked to propolis. In addition to other bee products, propolis is recommended to alleviate chronic inflammation. When combined with honey and saline solution, it can be inhaled. Propolis-containing medications are effective in treating infections brought on by microorganisms that are resistant to antibiotics.

Table: Clinical trials with propolis: main approaches, types of trial, subjects and groups, types of intervention and main outcomes.

Approaches	Trial	Number of subjects/ groups	Propolis intervention	Main outcomes	Authors
Type 2 diabetes mellitus	Randomized double-blind placebo controlled	Placebo (*n* = 30) Propolis (*n* = 30)	Capsules 1500 mg/day 8 weeks	↓ fasting blood sugar ↓ 2-hp, insulin, HOMA-IR and HbA1c ↑ antioxidant capacity ↑ GPx and SOD	Afsharpour et al. (2019)
COVID-19 (Hospitalized patients)	Randomized controlled open-label single-center	Propolis 400 mg + standard care (*n* = 40) Propolis 800 mg/day + standard care (*n* = 42) control (standard care alone – *n* = 42)	Capsules 400 mg/day or 800 mg/day 7 days (followed for 28 days after admission)	Both doses: ↓ length of hospital stay 800 mg: ↓ acute kidney injury	Silveira et al. (2021)
HIV-infected people under antiretroviral therapy	Randomized double blind parallel-group placebo-controlled	Placebo (*n* = 20) Propolis (*n* = 20)	Tablets 500 mg/day 3 months	↑ Foxp3 expression ↑ CD4+ T cell proliferation • Positive correlation: IL-10 and CD4⁺ T cell count • Negative correlation: IL-10 and IFN-γ	Conte et al. (2021)

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Bee Venom

Bee Venom is a clear liquid that is used to protect the hive. Molecules with biological activity, including melittin, apamin, phospholipase 2, histamine, dopamine, norepinephrine, and others, make up its makeup.

Due to its preventive effects on the pathological pathways involved in liver damage, airway inflammation, and inflammatory acne, bee venom has been shown to have an anti-inflammatory impact. This is likely because of its primary component, melittin. In actuality, melittin inhibits the activation of p38, ERK1/2, AKT, PLC1, and the translocation of NF-kB into the nucleus, influencing the signal pathways of Toll-like receptor (TLR)2, TLR4, CD14, NEMO, and PDGFR, reducing the release of pro-inflammatory cytokines and other mediators. But since melittin's toxicological consequences (mainly erythrocyte lysis) have previously been established, employing pure melittin in therapeutic therapy is less likely unless this molecule's structural makeup is altered. The low toxicity of apitherapy utilizing bee stings and BV various uses, on the other hand, may be explained by the harmless concentration of melittin and its synergism with other compounds in BV.

It's significant to note that BV can be utilized to treat or prevent COVID-19 in beekeepers. Despite treating patients who were afflicted, apitherapists at the SARS-CoV-2 pandemic's center avoided contracting the illness. While there is evidence supporting the beneficial impact of BV and other bee products against SARS-CoV-2 infection, a study carried out in Germany found conflicting results and the scientists did not support the protective benefits of BV against this virus. Similar to that, it was suggested that BV treatment may lessen the consequences of the H1N1 pandemic.

In apitherapy, BV may be injected directly by a bee sting or indirectly through the insertion of a needle into certain acupuncture sites (acupoints). The analgesic effect of acupuncture is attributed to the release of endogenous neuropeptides, which is a long-standing method of pain management that is approved on a global scale. BV is often applied to acupoints a few times per week, depending on the therapy objectives. The anti-inflammatory action in the treatment of arthritis, pain alleviation, and anticancer activity stand out among its many actions.

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However, some cautions are necessary due to the following factors:

- the concentration of BV compounds may vary depending on the season in which the bees produce them some isolated BV molecules may exert cytotoxic effects
- each individual allergic response must be carefully observed before beginning any treatment, following strictly the desensitization protocol (discussed in a section below)
- the application of BV (with bee sting or needles) may exert different These variations might account for the effectiveness or failure of BV treatment

By having an anti-inflammatory effect, the bee sting has been used in apitherapy to treat a variety of medical illnesses, including arthritis, autoimmune disorders (multiple sclerosis and systemic lupus erythematosus), and post-herpetic neuralgia. Malaria, rheumatism, arthritis, body aches, high blood pressure, headaches, and stroke have all been treated in Nigeria using BV. Additionally, it has been shown that BV plays a positive impact in disorders of the muscular system and skin conditions including psoriasis and dermatitis. However, as BV's ingredients may operate synergistically depending on their quantities in BV and through various pathways, it may be argued that BV itself can be helpful for treating specific inflammatory illnesses without having any negative side effects.

Table: Clinical trials with bee venom acupuncture: main approaches, types of trial, subjects and groups, types of intervention and main outcomes.

Approach	Trial	Number of subjects/ groups	Bee venom intervention	Main outcomes	Authors
Chronic low back pain	Randomized sham-controlled triple-blind	Control (*n* = 30) Bee venom (*n* = 30)	Injection of 0.1 ml/ point twice a week for 4 weeks	↓ chronic low back pain	Shin et al. (2012)
Recalcitrant localized plaque psoriasis (RLPP)	Randomized double-blind	Apitherapy (*n* = 25) Placebo (*n* = 25)	Injection of 0.05 to 0.1 ml of commercial BV (Epivac®) once a week for 3 months	↓ RLPP ↓ TNF-α	Eltaher et al. (2015)
Parkinson's disease (PD)	Prospective open-label study	*n* = 11 (7 men and 4 women) with idiopathic PD	0.1 ml diluted to 0.005% twice a week for 12 weeks	↑ gait speed ↑ Parkinson's disease quality of life questionnaire (PDQL) ↑ motor symptoms	Doo et al. (2015)

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Bee bread

Pollen, nectar, and saliva are combined to create bee bread, which is then packed into the hive where it is chemically altered over time by the activity of microorganisms' enzymes. This procedure aids in the transformation of the pollen that has been preserved, and the resultant substance is acidic (pH=4) and includes 40–50% simple sugars. Because the pollen envelope dissolves during processing, which favours vitamin absorption, bee bread is more effectively absorbed by the body than pollen. The pollen grain's ability to release nutrients and bioactive compounds is greatly influenced by the biochemical processes.

In addition to the important amino acids and vitamins (C, B1, B2, E, H, P, nicotinic acid, folic acid, and pantothenic acid), phenolic compounds serving as natural antioxidants, and colours, bee bread also includes about 20% protein, 3% fats, 24–35% carbs, 3% minerals, and 3% vitamins. Additionally, it includes a variety of biologically active substances, including hormones, phosphatase, amylase, flavonoids, and carotenoids.

Bee bread is a good vitamin supplement due to the amount of its ingredients. Bee bread has really been used as a diet supplement, and its flavonoid concentration may provide anti-tumor effects that aren't detrimental to normal cells. Consequently, apitherapy suggests bee bread because to its nutritious composition. Since bee bread is a source of probiotics that are intended to repair the intestinal microbiota, especially in patients who have undergone a colonoscopy or are taking antibiotic therapy, it can help with digestive and intestinal issues.

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Royal Jelly

The mandibular and hypopharyngeal glands of worker bees produce RJ. In contrast to workers who only receive it sometimes, the queen bee is fed exclusively with RJ, suggesting a substantial change in the bees' way of life. The queen bee is twice as big, has an anatomy tailored for reproduction, and lives up to 5 years, unlike worker bees, who only survive for a few weeks, even though they share the same diploid DNA. These findings show that RJ encourages health and lifespan; also, it is regarded as an anti-aging supplement that enhances fertility and body composition.

RJ is a thick, white material that is made up of around 60% water, 20%–40% protein, 15%–30% carbs, 3%–8% lipids, and 1.5–3% vitamins and minerals. RJ includes a variety of bioactive compounds, such as 10H2DA, sometimes known as "royal jelly acid," which has immunomodulatory properties. Several research have focused on royalactin, a functional component of RJ that is involved in the morphological transition from larva to queen. It works as a pluripotent gene network activator by modifying chromatin accessibility.

RJ has a wide range of health advantages in apitherapy because to the abundance of bioactive substances in it, including antioxidant, anti-inflammatory, neurotrophic, hypotensive, antidiabetic, anti-rheumatic, anticarcinogenic, antifatigue, anti-aging, and antibacterial effects. RJ has demonstrated effectiveness for osteoporosis, wound healing and tissue repair, immunomodulation, hormone regulation, increasing cognitive function, and lowering cholesterol levels. Additionally, it has been shown to aid in the treatment of diabetes, high blood pressure, cancer, skin conditions, hyperlipidemia, and neurological diseases including Alzheimer's and Parkinson's.

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Apilarnil

Apilarnil is a natural bee product, obtained from the drone larvae that constitute the main raw material. At the age of 7 days, they are fully harvested, thus obtaining apilarnil.

In the early stages of life, the drone larvae are homogenized, filtered, and lyophilized to produce apilarnil, which has a milky consistency, a grayish hue, and a bitter flavor. Proteins, carbs, lipids, the B complex vitamins, biotin, folic acid, inositol, choline, and a high concentration of micronutrients and macroelements are just a few of the nutritional components it includes (K, Mg, Na, P, Mn, Cu, Fe, Se). Apilarnil has a higher concentration of free amino acids than RJ. Apilarnil contains E-dec-2-enedioic acid, which is identical to the estrogenic fatty acids extracted from RJ, and other steroid hormones including testosterone, progesterone, estradiol, and prolactin. Apilarnil is used in alternative medicine to treat a wide range of illnesses and health issues, including thyroid and immune system abnormalities, male infertility, ovarian dysfunction, and infant malnutrition. Apilarnil may be used to treat male andropause issues since it appears to have an androgenic impact.

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Beeswax

Beeswax has been used extensively throughout history as a bartering tool, to prepare death masks and embalm corpses, to make writing tablets, and to make candles. Most accounts of beeswax come from Egypt, Greece, and Rome, proving its usefulness as a commodity. The wax glands in the abdomen of the worker bees release beeswax in a liquid state. Hydrocarbons, free fatty acids, esters of fatty acids, fatty alcohol, and exogenous materials including pollen, propolis, and floral components are the major components of beeswax. Because of their genetic makeup and food, bees can produce different types of beeswax.

Beeswax has a wide range of uses in the culinary sector, craft and industrial items, cosmetics, and industrial products because of its hydrophobic quality. The creation of dermo-cosmetics based on beeswax makes it easier for people to get natural and safe goods. In cosmetics, the emulsifying and hardening properties of beeswax can minimize trans-epidermal water loss from the skin, encouraging hydration and a moisturized skin, particularly for dry and chapped lips. Due to its biocidal abilities against mold, beeswax may be put into textiles, making it useful for avoiding cutaneous mycoses in patients from healthcare and social care facilities. Beeswax acts as a barrier against outside influences by producing a coating on the skin's surface.

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Beehive air

Currently, lung fibrosis, respiratory tract infections, bronchitis, and other conditions are all treated using beehive air treatment. This therapeutic method, which is permitted in developed nations like Germany, Hungary, Slovenia, and Austria, relies on breathing air from a beehive that has been saturated with volatile chemicals made from bee products.

The air in the hives is filled with natural compounds - the excellent anti-inflammatory, antibacterial, and natural antioxidant capabilities of propolis, honey's nutritional and antibiotic benefits, the relaxing effects of beeswax, etc. In addition, bee bread, royal jelly with great properties, air that bees breathe loaded with cytochrome protein, capable of eliminating chemical residues and hydrocarbons lodged in the body.

The air from beehives provides health benefits for both the mind and body. The immune system is strengthened, the respiratory system is favourably impacted, stress is reduced, and overall health is improved by spending a few hours at an apiary where you may breathe in the aerosol (air loaded with etheric fragrances of bees) and the positive energy charge. Inhaling beehive air has shown to be highly useful in treating respiratory ailments, but it has found to be particularly effective in treating immunological problems such allergies, infection susceptibility, and chronic sinusitis.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.1. Introduction

The bee colony health is crucial aspect of a properly managed beekeeping economy. No one needs to be convinced that this is one of the main factors affecting the profitability of beekeeping. As beekeeping developed, interest in the diseases and parasites of these beneficial insects grew. Over the past decade, beekeepers have faced new challenges such as new diseases, pests, the sudden collapse of bee colonies, parasitic fungi, or viruses. To maintain the health of bee families, knowledge of veterinary medicine and beekeeping practice are essential.

All kinds of pathological conditions cause significant losses to the beehive and potentially lead to their complete destruction. If a bee family gets sick, it is unpredictable to expect economic profits, and the number of individuals and the production of bee products decreases. What is more, sometimes it is necessary to liquidate the entire apiary.

In these cases, the apiary ceases to be profitable and may even require additional financial expenses – the purchase of preparations for the treatment of occurring diseases, the purchase of new bee families, the purchase of new unused hives, etc. Since prevention is better than cure, we should pay special attention to the diseases' prevention.

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1.4.2. Diagnosis of bee diseases and sampling for diagnostic tests

It is rarely possible to diagnose the disease based on the observed symptoms. Symptoms characteristic of this disease can occur in bagging and bee fruit calcification. Unfortunately, in most cases, it is necessary to send the appropriate biological material to the diagnostic station to make a correct diagnosis.

Available field diagnostic tests can also be used - such tests can be used to identify plague and brood rot. In diagnostic laboratories, diseases are diagnosed based on macroscopic and microscopic analyses of the examined material. Appropriate staining of microscopic preparations, inoculation on microbiological substrates, tests using diagnostic sera, or detection of the genetic material of pathogenic organisms is carried out in the laboratories. With the help of practice tests, it is possible to detect both the presence of pathogenic material and the degree of infection.

The purpose of laboratory diagnosis of the bees' death or bees with symptoms of the disease (30-50 pieces) or a closed brood should be sent to the diagnostic laboratory. Bees that have died in the winter should be removed from the hive at the beginning of the year before the start of the bee trip. Samples of dead bees or broods without honey should be individually wrapped in paper for each family and then placed in a strong box that has been additionally secured with pieces of paper. Do not use plastic packaging or bubble wrap. In some cases, the test material may be a live insect. Before shipping, they can be frozen or placed in a special frame designed for transporting queen bees. A honey-sugar dough is placed in the cage. The cage is placed in a perforated envelope labelled "Caution, Live Bees".

The material should be sent to bee disease diagnostic laboratories as soon as possible. A list of these devices can be found on the Internet. Each sample is described by indicating the number of the family, the location of the apiary, and the beekeeper name. The reason for sending the sample, the symptoms, and the duration of the first symptoms, the date of the sample collection, etc. will also be indicated.

In case of suspicion of notifiable diseases, e.g., plague of bee foetuses, material for laboratory tests is collected and sent by the relevant veterinarian.

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1.4.3. Legal hygiene and disinfection treatment

Hygienic and breeding treatments designed to control and prevent bee diseases include: frequent, preferably annual, replacement of combs; disinfection of tools used in the apiary; annual disinfection of bee colonies; prevention from robbing and flying bees, not to supply families with supplies and combs left after the death of another bee colony, to avoid catching unknown swarms and if inhabited, the hives should be quarantined for about six weeks outside the apiary.

Decontamination is a primary hygiene procedure included among the basic hygiene procedures necessary to maintain a bee colony's health. This treatment applies to the tools and the hives once a year. In the spring, bees should be relocated to disinfected hives. Among the methods of decontamination of equipment and tools, a flame (e.g., a gas burner) is the best. To disinfect the combs, you can use 80% acetic acid or acetic acid - the combs are placed on the extensions in sealed plastic bags or placed in sealed containers into which cotton wool or other material soaked in acid is inserted. Such treatment should last seven days, and the ambient temperature during this time should not be higher than 17°C. Sodium hypochlorite is another powerful disinfectant that destroys Penicilliums bacteria at a 1% concentration. An old disinfection method is to scrub equipment and tools with a 2-5% hot caustic soda solution, followed by rinsing with water and vinegar and finally with clean water.

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1.4. THE HEALTH OF BEES

1.4.4. The most important diseases of bees and methods of their control

1.4.4.1. Bacterial diseases

Important bacterial diseases include: a plague of bee brood and bee fruit rot.

A plague of bee brood

Occurrence - from spring to autumn, during the rearing of young, may increase in the warmest months.

The cause - larvae of the bacterium Peanibacillus larvae ssp. Bacterial endospores are characterized by high resistance to chemical and physical factors, particularly resistant are the endospores present in wax and honey, where they can remain viable for up to 30 years! Only the spores are contagious, and only the brood can become infected. Spores can be transmitted by bees while feeding the brood, endospores germinate in the intestine within 24 hours.

Symptoms - typical symptoms involve capped fruit and pupae. Sick, dying larvae darken, darken (cream-brown-coffee colour - dark brown) and turn into a mass with a soft, sticky structure. When they are pulled out, long threads are formed. The disease is accompanied by a specific smell of carpenter's glue. The body of the dead larva shrinks, resulting in closure inside the cell - a collapse of the lids. Bees trying to remove the dead larva may disturb the cell lids. It may also happen that the cells become filled with a liquid substance escaping through the holes in the lids. After a month, the mass dries up, and forms cinders containing infectious endospores. Bees affected by the plague may show increased aggression. Untreated families weaken and die.

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Treatment and prevention - it is a disease that is subject to legal notification and eradication obligations. Once diagnosed in an apiary, such an apiary is considered an outbreak, and a protection zone is designated within a radius of at least 6 km, and bee colonies in this area must be checked. The following steps can be applied to families of sick bees:

1. Burning of stem bees (bees with a nest and a hive) after killing the bees;
2. Burning the bee family and its nest after killing the bees earlier;
3. Relocating bees from a sick hive and burning their nest (combs and hive).

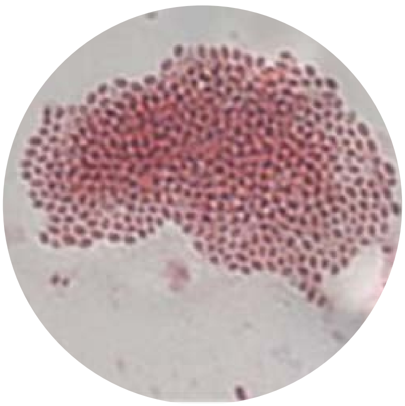
Methods of cleaning and sanitation in the fight against the plague of bee brood:

1. Tanning with a gas burner, wooden and metal equipment or burning in beehive straw to brown the walls;
2. Immersion of wooden elements in liquid paraffin wax at 160˚C for 10 minutes;
3. Scrub the hives with a biocidal preparation with sodium hypochlorite. The area in front of the contaminated beehives is disinfected with a preparation containing sodium hypochlorite and dug to a depth of 30 cm. Hot 6% caustic soda or 10 kGy gamma rays are also recommended for decontamination.

Rot of bee fruit

Occurrence - from spring to autumn, during breeding.

Cause - gram-positive granuloma Melissococcus plutonius, requiring the development of high concentrations of carbon dioxide. When infected with this bacterium, other infections often appear when the bacteria are involved, such as:
-Achromobacter euridice,
-Enterococcus faecalis,
-Peanibacillus alvei,
-Brevibacillus lanceolatus,
-Brevibacillus laterosporus.



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Symptoms - Symptoms of the disease appear most often during malnutrition of the larvae. If the disease is caused by M. plutonius only, the lesions involve the open brood. Infected larvae lie unnaturally arranged in the cells – they change their position from spiral to upright; they have a transparent cuticle, and the dead body acquires a grey-yellow colour. A characteristic feature is that the stomata are very visible, and the intestine is filled first with white and later darkening colonies of bacteria. The dead larva dries to form scum with a smooth, shiny surface and is easily removed. Most of the dead larvae are removed from the cells, causing cells with offspring to mix with empty cells. In a complication of the disease caused by E. faecalis, the dead larvae are decomposed by the bacterium and take the form of a shapeless mass with a creamy consistency and a sour smell. In the case of complicated P. alvei infection, the lesions can also affect the capped brood. The larva turns brown and then turns into a shapeless mass. The infection is accompanied by the characteristic smell of rotting meat. In the hive, the disease is spread by feeder bees, and the source of infection is sick or dead larvae, honey, bee bread, infected combs, beekeeping tools, and contaminated hives. The incubation period of the disease is 1.5-5 days.

Treatment and prevention - with a moderate severity of the disease and an uncomplicated form of bee fruit rot, the disease will disappear after a certain time without the help of a beekeeper. You need to remove and burn the combs with the changed fruit, feed the bees with warm syrup, and replace the queen with a young and healthy one that reproduces well. It is important to remember that susceptibility to infection varies between breeds or lines. If the disease is severe, all combs should be burned, and the bees moved to a new or decontaminated hive. In some countries, it is recommended to liquidate entire families. In addition to observing hygiene rules in the apiary, maintaining and wintering strong families in the apiary, ensuring constant access to fresh water for families, isolating nests, and ensuring access to food are significant for prevention. Limiting the spread of disease is prioritized by preventing robberies and defective bees. It is crucial to systematically change the combs and disinfect the hives before the start of the season. In terms of decontamination, it is possible to use the treatment of the plague of bee brood infection. In most European countries, there is a ban on the use of antibiotics to fight bee brood rot. The method of artificial swarming can be used during severe infections.

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1.4.4.2. Diseases caused by Fungi

Among the most important diseases caused by fungi are: nosematosis, bee brood calcification, and bee brood petrification.

Bee Brood Petrification

<u>Occurrence</u> - early spring when there is a contribution of pollen to the hive. It intensifies in rainy weather.

<u>Cause</u> - The origin is the fungus Aspergillus flavus, which multiplies in the intestines of the larva, overgrows the organs, and destroys them. The larva turns into a stone mummy.

<u>Symptoms</u> - mechanical and enzymatic damage to the brood. A white mycelium grows on the larva's body. The larvae then harden and are difficult to crush and pull out of the cells. In the later stage of the disease, depending on the species of Aspergillus, which determines the colour of the spores, a yellow-green or black coating appears. Infected adult bees behave unnaturally, run quickly on spots, eventually lose the ability to fly, fall from the combs, lie on the bottom and die. The body of dead bees is covered with mycelium and the abdomen becomes hard. Ridges may overlap with the mycelium. It is characteristic that when checking the beehive, spore dust can swirl in the air. Adult bees are victims more often than brood.

<u>Treatment and prevention</u> - with the low severity of the disease, the bee colony should be moved to a disinfected hive on a nodal frame and fed. There is no cure for this disease. Heavily affected families should be killed and burned with the combs, the hives should be properly disinfected, and if the infestation is less severe, the combs should be burned, and the bees transferred to a new disinfected hive for the new work. Wash the beehives of attacked bees, frames, and tools thoroughly with hot water, burn with a flame or hot air gun (600-1000˚C) after drying, or clean with 1% sodium hydroxide.

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Prevention consists in:

- compliance with hygiene rules at the apiary,
- maintaining strong families,
- mothers should be regularly replaced by young mothers from lines with a highly developed hygienic instinct, prophylactic disinfection of hives every spring.

The disease is not classified as a dangerous disease.

Bee Brood Calcification

Occurrence - from spring to autumn, during the breeding season.

Cause - the causative agent is the fungus Ascosphaera apis, which decomposes the tissue of the larva or pupa and destroys its organs. It is a relatively pathogenic species and only under favourable conditions for its development (regular lack of food, hypothermia of the nest, high humidity, poor ventilation) can it lead to disease changes. Its spores - axospores - are very resistant to environmental factors. The susceptibility of bee colonies to otorbial fungal disease is determined genetically. In Varroa mites, calichosis often occurs.

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Symptoms - occur in pupated erect larvae, larvae drastically reduce food intake. Larvae develop on white mycelium - they look like they are covered in cotton wool. The mycelium is saturated with calcium salts, causing the formation of so-called mummy-like chalk. When the mycelium appears, the larvae take on a grey-black colour. The initiating factors are the temperature in the hive (hypothermic brood areas encourage the development of moulds, so the brood is more often affected), the humidity of the air (hives located in a humid habitat are more likely to be infested with larvae), the greater temperature difference between inside and outside the hive during brood rearing (condensed water). Inbreeding also makes bees susceptible to fungal diseases. Also, the cleaning instinct, which decreases swarming or eases inbreeding, plays a significant role in the bees' susceptibility to brood calcification. A single colony may be able to cope with a light to moderate infestation of this fungus, but even with a light infestation, the laying performance of the colony declines. With a major infestation, the colony lacks worker bees. In the worst case, the colony will die.

Treatment and prevention - drug therapy is not carried out. Take care of hygiene and choose families with high hygiene instincts. Care should be taken to ensure the resilience of families by replacing mothers with well-reproducing individuals with highly developed hygienic behaviour. In case of high disease severity, remove the brood combs, remove mummies from the flyer and the hive bottom. The hive should be insulated, stand in a sunny location, and be well-ventilated. Ascospores retain their invasive ability for several years, so disinfection of the hive in spring is crucial as a preventive measure. Colonies are more susceptible to calcification after antibiotic treatment due to changes in the gastrointestinal microflora.

The disease is not classified as a dangerous disease and reporting is not mandatory.

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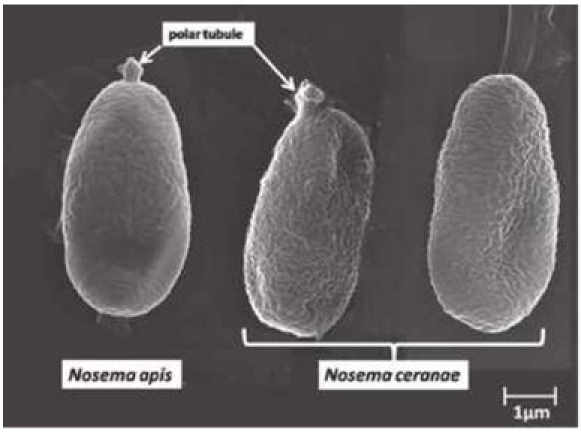
Terrestrial infections of type A and C

Occurrence - Nosema type A - winter and spring season, type C. - early autumn.

Cause - specialized parasitic fungi, Nosema apis, responsible for Nosema type A and Nosema ceranae, responsible for Nosema type C. These fungi take vegetative form only in the host organism, while in the environment they occur in the form of spores. The spores enter the middle intestine of bees with the food and germinate under the influence of digestive juices. It is believed that a large amount of food with a high protein content promotes the reproduction of the fungus. The disease most commonly affects bees that forage on the stores in the hive.



Symptoms - Nosema type A infection - diarrhea - spots visible on the front wall of the hive, on the fly side of the hive, you can observe crawling bees in front of the hive with an outstretched abdomen, from which smelly feces are ejected when squeezed.

There is an unpleasant smell in the hive and the inside of the hive is covered with excrement. Dead bees are also visible, stuck together with fecal masses. In heavily infected bees, the colour of the middle intestine changes - it turns a milky white colour and is swollen. Nosema type C infection - there are no symptoms of diarrhea (called dry nosematosis), causes rapid death of the insect due to dysfunction of the damaged gut - starvation death. Sick bees have impaired orientation and are unable to return to their own hive, often dying outside the hive.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.4. The most important diseases of bees and methods of their control

Treatment and prevention - there is no pharmacological treatment in the European Union. Various dietary supplements, probiotics, or plant extracts are often used. Hygienic and husbandry treatment is of key importance: disinfecting hives, changing combs, disinfecting beekeeping equipment, and not feeding honey from sick colonies - they are a source of spores. For treatment and prevention, you can use herbs such as sorrel (horse sorrel), and oak bark decoction (for winter feeding - 50 g of decoction per 25 l of ready-made syrup) for a very good effect. In spring, bees can be stimulated for intensive work by using essential oils such as anise, and eucalyptus.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.4. The most important diseases of bees and methods of their control

1.4.4.3. Diseases caused by viruses

A virus is a biological system infecting living cells in biological organisms belonging to non-cellular organisms (Acellullata). Viruses are obligatory intracellular parasites, meaning they can reproduce inside a living cell because they do not have their own biosynthetic apparatus.

A simplified way to describe the spread of viruses is larvae fed on food containing viruses, transmission by bodily contact through wounds, hives can be airborne, the bee mite by sucking the haemolymph of the bee or brood can also transmit viruses. When a bee is infected with a virus it usually dies. If it survives a viral infection, it is weak and does not fulfil its role in the colony. The whole colony can easily cope with a weak virus infestation if it is vital, has sufficient stores, a cleansing instinct, and plenty of brood.

Viral diseases of the brood are not classified as dangerous diseases and are not reportable.

The most important diseases caused by viruses are: Chronic paralysis of bees, Acute bee paralysis, Brood pox and Black queen virus.

Chronic paralysis of bees

Occurrence - late summer/early autumn; it often occurs after the hungry and eggless season. It may be endemic.

The cause - is chronic bee paralysis virus (CBPV). It is a pathogen of adult bees. The infection is often latent but can lead to the death of the bee colony if the infection is very severe. This virus may occasionally infect the brood but does not cause characteristic symptoms.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.4. The most important diseases of bees and methods of their control

Symptoms - occur in two forms - the first bees are observed to have body tremors, especially of the wings, loss of the ability to fly, and sick individuals crawling on the ground. They may congregate on top of the hive. The bees have an enlarged abdomen, diarrhea may occur, and the insects die within a few days. The second form, in addition to paralysis, is characterized by hair loss, and the sick bees look smaller and have a darker color (they may be black). Healthy bees show aggression towards sick individuals and are considered robber bees. Chronic paralysis causes increased bee mortality or mass die-off.

Treatment and prevention - Drug treatment is not used. Prevention and replacement of the queen with a young queen of good reproductive capacity from a distant colony are necessary. In areas where the disease has an endemic form, do not allow a situation where the bees are unemployed by laying and are in the hive for a long time - the bees can be relocated for grazing. Avoid overcrowding the hive.

Acute bee paralysis

Occurrence - late autumn or early winter.

Cause - the disease is caused by the acute bee paralysis virus (ABPV). The spread of the virus is promoted by the invasion of the Varroa destructor mite.

Symptoms - the beekeeper rarely observes the bees dying rapidly, and therefore many dead bees can be found before the hive emerges and at the bottom of the hive in the cold season. Colonies weaken and may even die. Normally the bees in the field die and the colony are left with a small number of dead or alive bees in the hive, the queen, and the rest of the brood with stores. In severe infection, open brood may die. Diseased bees lose the ability to fly, wings may be observed fluttering, and an unwillingness to forage.

Treatment and prevention - treatment with preparations is not used. Thorough control of varroasis and elimination of colonies with severe symptoms is recommended.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.4. The most important diseases of bees and methods of their control

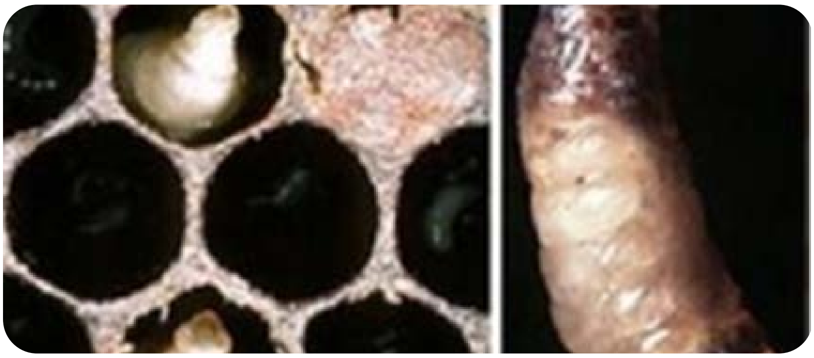
Baggyness of bee brood

Occurrence - spring/early summer, especially after long laying breaks or when there is a large decline of bees. May take the form of endemicity.

Cause - the causative agent is Sacbrood virus (SBVirus), also called Morator aetatulae. This virus can only reproduce in the brood, so it is dependent on brood rearing and is pathogenic especially to bee larvae and young bees. Very widespread in the world. Infection occurs because of feeding the brood with infected royal jelly.

Symptoms - infected individuals die most often after pupation of the cell - the caps are punctured by workers wanting to remove the dead larvae. The larvae take the form of a sac filled with a yellowish fluid, with the dead larva darkening over time, drying out and taking the form of a gondola-shaped appendage. As with other diseases of the fruit, the fruit is ruptured and partially removed. The individual dies in the erect larval stage. The diseased/dead brood is carried out by the bees and thus the virus spreads throughout the hive.

Treatment and prevention - brood pox is not a bee epidemic, it spreads slowly. Detection during a normal colony inspection is mostly accidental, it is only infested when the bees do not carry out all the dead brood. In the early stages, confusion with brood plague is possible. The treatment for bagworm is unknown, but it is recommended to remove the combs with dead larvae (melt). It is worth replacing the stock combs and replacing the queen. When we have unfavourable utility and climatic conditions, it is worth narrowing the hive space and feeding the bees. Care should also be taken to reduce the number of mites, as they are favourable to the disease.



1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.5. Bee Poisoning

The cause - chemical substances that are the active substances of various plant protection products (mainly insecticides), as well as substances found in the food of bees, that is, nectar, pollen and honeydew.

Symptoms - dying bees in or outside the hive. Poisoned bees lose their shyness, show signs of paralysis, lie on their backs with their tongues out and their abdomens shrunken.

Pollen poisoning

So-called May Pollen Disease: horse chestnut, red horse chestnut or Greenland butternut pollen (toxin: anemonol) can also be poisonous. Pollen poisoning mainly affects young bees consuming large quantities of pollen. The insects lose the ability to fly and crawl in front of the hive. Their abdomen is heavily distended, symptoms of constipation appear and when the abdomen is squeezed, thick faeces come out.

The violent course of poisoning is characterised by weakness and loss of flight, the bees have unpleasant movements, their wings flutter, they crawl on the ground, turn black (glitter) and give off an unpleasant odour. There are traces of dark diarrhoea in the hive. The brood and forager bees may also die.

Bee pollen:

- Field scabious (Delphinium consolida)
- Blue helmet bee (Aconitum napellus)
- White sneezeweed (Veratrum album)
- Snakeweed (Polygonum bistorta)
- Onion (Allium cepa)
- Horse chestnut (Aesculus hippocastanum i A. pavia)

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.5. Bee Poisoning

Nectar poisoning

Nectar contains alkaloids toxic to bees. Nectar that can cause poisoning:

- Gooseberry (Astragalus glycyphyllos)
- Glial (Asclepias sp.)
- Poison ivy (Daphne mezereum)
- Corn lily (Veratrum californicum)
- Black elm (Hyoscyamus niger)
- Andromeda polifolia (Andromeda polifolia)

The acute course of nectar poisoning mainly threatens foraging bees, which then lose their ability to fly and congregate on the poisonous plant.

Honeydew poisoning

Honeydew poisoning occurs when undigested complex sugars and mineral salts present in honeydew damage the bee's intestinal epithelium and toxins, bacteria, viruses, and polysaccharides enter the haemolymph.

Poisoning by plant protection products

Plant protection products pose a major risk to bees. In the case of such poisoning, the colonies are restless and may become greedy, and may fight as in the case of robbery. The bees are still cleaning themselves; they may have unnaturally twisted wings. Bees die in convulsions in front of the hive. In milder poisoning, general weakness of colonies is a symptom.

Treatment and prevention - poisoning is transmitted by bees in contact with a plant protection product. If the poisoning occurs regularly and the cause is not identified, appropriate samples should be taken for analysis to identify the active substance responsible for the poisoning.

1. KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

1.4. THE HEALTH OF BEES

1.4.6. Good beekeeping practice for healthy bees

Every beekeeper should observe the following principles:

- Strong colonies are more resilient than small and weak colonies, therefore weak colonies should be strengthened or cancelled in time. Do not build too weak brood or brood rearing colonies. Do not join sick colonies with healthy ones.
- Take care when buying bees or queens, buy from recognised queen breeders.
- Allow the bees, especially in spring, to build up as many combs as possible so that the old combs can be replaced and moulded a minimum of 30% comb renewal per year is needed! Old combs (dark brown to black) encourage the development of the honeycomb borer.
- Clean dirty, dung-covered, or mouldy hives thoroughly (hot water, sodium hydroxide).
- If there is no suitable source of clean water nearby, construct watering troughs and clean and disinfect them regularly.
- Protect stored honeycombs from the honeycomb borer, but do not store old ones. The honeycomb hive can be described as a 'friend of the bees', as it 'frees' the bees from the old combs that the beekeeper 'fills' them with every year.
- It prevents robbing, which also transmits diseases and pests between colonies. Honeycomb, honey and forage should be stored dry and inaccessible to the bees.
- Never feed foreign honey - diseases can be transmitted, e.g. honey from a region with a high incidence of honey bee plague is likely to contain its spores, foreign honeys may contain the causative agent of a disease that may be a new unknown scourge for our bees. Do not feed poor quality sugar, or sugar with additives that clog the bees' digestion.
- Consistently implement a reliable bee mite control regimen all season long.
- ·Once a year, have the forage taken from the comb (from the store wreath) laboratory tested for the presence of honeybee brood moth. Visual inspection can only detect or rule out an acute condition.
- In the event of a laying failure, keep an eye on the stock situation and either supply the combs with stores or feed them. Abandon the unsuitable position or nomad. Layers need good pollen laying, and all colonies must have enough pollen in late summer to raise vigorous long-lived winter bees.

Chapter 2

THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES

2. THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES

The chemicalization of the environment is a current problem affecting all economic sectors and activities, including agriculture where the use of different plant protection products and chemical fertilizers has become a fundamental part of all modern large-scale agricultural production. In most countries worldwide, it is impossible to achieve strategic food self-sufficiency without the use of agrochemicals.

Globally, agriculture in the 21st century faces, among other multiple challenges, the need to produce more food to feed a growing population with a smaller labour force. It is predicted that the population will continue to grow at a rapid pace, that urban areas will account for 70% of the world's population by 2050 and that the rural population will continue to decrease.

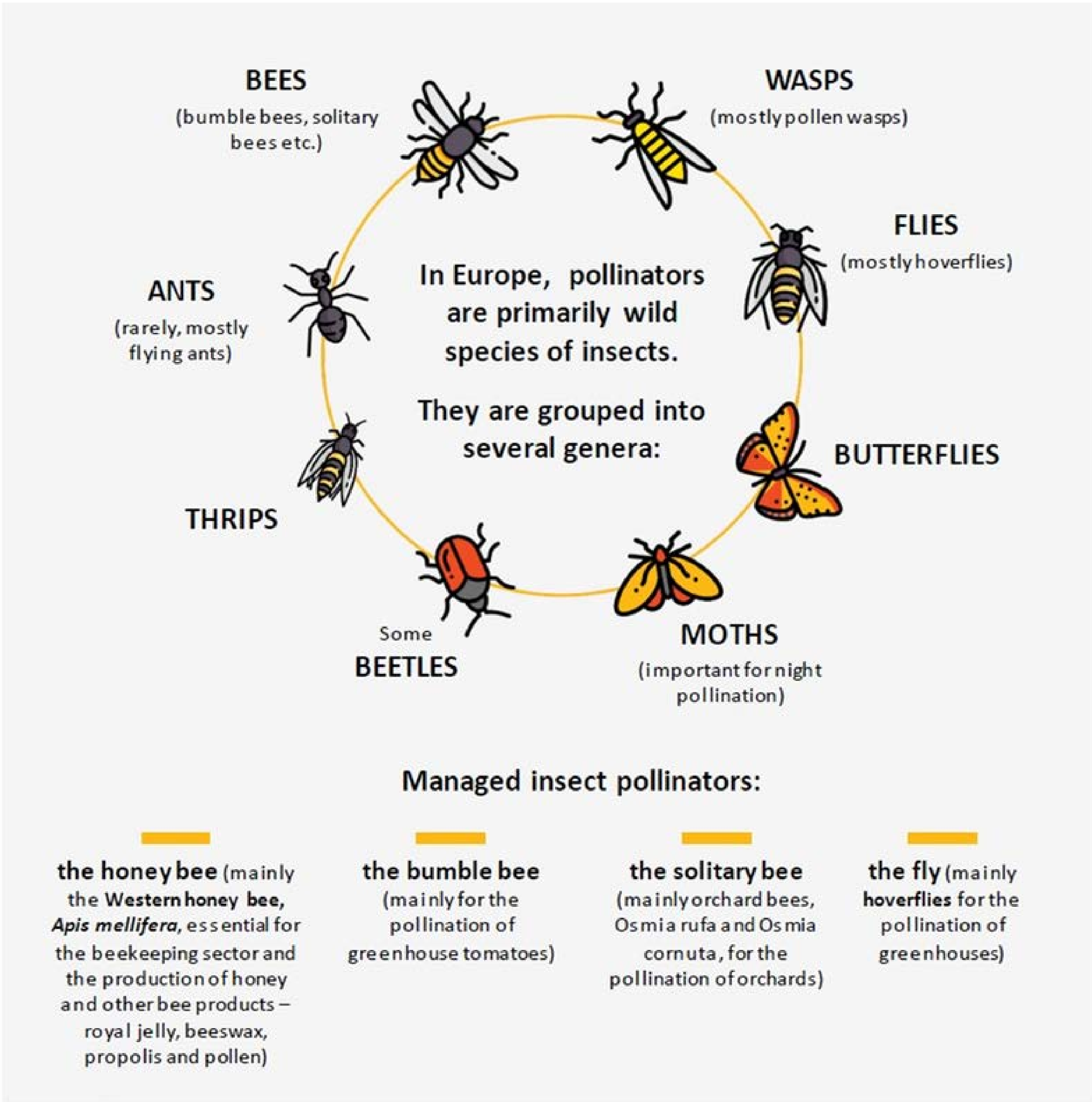
Plant protection products are used in today's agricultural production to control and eliminate various types of harmful organisms. The use of these pesticides has an irreplaceable role in the modern structure of primary agricultural production, as they effectively replace the expensive labour that would be necessary to eliminate weeds or crop pests; it is impossible to replace the effectiveness of modern pesticides with large-scale manual labour.

Contamination by plant protection products and fertilizers on intensively cultivated land is a dangerous phenomenon because these products accumulate in vegetation, water and soil and cause damage to beneficial organisms such as bees. The excessive and inappropriate use of agrochemicals, in general, affects bees and other beneficial insects, as they can cause their death by contact, direct ingestion or ingestion of nectar, pollen, resins and contaminated water.
We must keep in mind that one third of food production depends on pollinators, including bees.

In recent years, bee populations have declined significantly on a global scale, so there is growing concern about the environmental and economic consequences. If the number of pollinators is reduced, the performance of many of these crops could drop by 50%.

In Europe, pollinators are mainly insects, such as bees (including bumblebees, honeybees and solitary bee species), wasps, hornets, butterflies, moths, beetles and others.

2. THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES



Source: ECA.

Bees are one of the most effective pollinator groups in agro-ecosystems so the threats they face have been more extensively studied than other pollinator groups. Most of the environmental risk assessment procedures carried out prior to the authorization of plant protection products are carried out with the honey bee (Apis mellifera, Apidae).

The death of bees and other pollinators has a very important environmental impact as it directly affects the pollination of a large number of wild and agricultural species, resulting in significant imbalances that are very detrimental to biodiversity and ecosystem health.

2. THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES

On the other hand, beekeeping is an important activity in the European Union (second largest honey producer in the world, after China according to source: Eurostat). Beekeeping is practiced in all countries of the European Union, as an activity deeply rooted in rural areas, starting to have more and more effect in urban areas. The main producing countries are: Germany, Spain, France, Greece, Hungary, Italy, Poland and Romania. In the European Union 650,000 beekeepers care for some 18 million hives. From an economic, environmental and cultural perspective, all these hives play a vital role in the social fabric of the regions where they are located.

The use of plant protection products, a major threat to bee conservation, encompasses a wide range of compounds, including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, growth regulators and others. Among them, insecticides, being designed to control pest insect populations, pose a greater risk to non-target insects that come into contact with them, such as bees. In particular, the use of certain insecticides such as neonicotinoids has been identified in a large number of scientific studies as a major threat to bee health and as a consequence their application has been restricted in the European Union.

Exposure to mixtures of compounds could pose a greater threat to pollinator health than the action of a single active substance, as synergies between them can multiply their harmful effects. But more studies are needed to learn more about the possible negative effects of these combinations.

The risk of some pesticides lies not only in their high toxicity, but also in their persistence in the environment and in their particular mechanism of action. For example, certain sub-lethal doses of neonicotinoids have been shown to have a negative effect on several aspects related to learning, larval development, the ability of queens to lay eggs and initiate colonies under laboratory conditions, drone fertility, orientation and navigation, pollinating ability, colony hygienic behavior and reproductive capacity of bees.

All these alterations in the behavior and physiological aspects of bees do not lead to immediate death of the animal, or to colony collapse, but have negative consequences on their long-term survival and conservation.
Certain fungicides can increase the toxicity of insecticides by reducing the bees' ability to detoxify.

2. THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES

Herbicides do not have acute toxicity to pollinating insects, although their use has also been reported on occasions as a threat to them, for example, by altering the learning and navigational ability of bees or interfering with the development of their larval stages. The use of herbicides often indirectly affects pollinators because they eliminate numerous wild plants and reduce floral diversity in agricultural areas.

The effect of fungicides has been less studied but it is known that residues of these compounds in hives are related to the prevalence of diseases in bees.

In order to find a balance between nature and the use of chemical products on agricultural crops, we must learn to use plant protection products and fertilizers properly and efficiently to minimize as much as possible the negative impact they have on the environment.

In the case of pesticides applied in aerosol form, their use should be limited to times when the risk of contact with pollinators is lower, such as at night. Also, aerosol application should be avoided as much as possible during the flowering season of cultivated plants and wild plants growing in the surroundings.

Finally, the effects of exposure to mixtures of pesticides should be included in risk assessments of plant protection products, as the simultaneous application of compounds that may present interactions or synergies in the pollinators' organism should be avoided.

It is important to have a good knowledge of the different types of plant protection products and fertilizers used in agricultural production, their different forms of presentation and application, the possible routes of exposure of pollinating insects to the residues of these products, the basic principles to be respected in the storage, handling and application of these products so that the risk and impact on bees, wildlife and the environment in general are as low as possible.

It is difficult to establish intervention criteria or phytosanitary regulations that are excessively rigid and generally valid or lasting over time. But it is vital to know how to apply a series of agricultural practices in relation to the use of this whole series of agricultural chemicals.

2. THE USE OF AGRICULTURE CHEMICALS AND RISKS ON BEES

These aspects will be discussed in more depth in the following chapters: classification and formulation of plant protection products, basic principles of working with plant protection products, how they affect bees and other pollinator species, toxicity of different types of pesticides, risk assessment of plant protection products for pollinators, most common mistakes when applying treatments on crops, effects on bees, how to reduce risks to bees and other non-target pollinators, plant protection products that are authorized for organic agricultural production, the importance of integrated pest management, among other general aspects. In addition, the specific issues of each type of specific product will be studied in detail, including the different plant protection products and fertilizers.

It is essential to respect and develop the practices established in Integrated Pest Management (IPM), i.e. the careful consideration of all available methods of plant protection and the subsequent implementation of measures that prevent the development of pest populations and keep the use of plant protection products at economically and environmentally justified levels to minimize the risk to human health and the environment.

Finally, ecological practices in agricultural production and beekeeping will be studied, because although prevention measures and correct management are fundamental, other tools such as biological control and ecological production are also of great importance, helping to significantly reduce especially important phytosanitary problems and thus contributing to greater sustainability of agricultural ecosystems.

Increased investment in research on mechanisms to reduce the use of pesticides and in independent advice programs for farmers on how to apply Integrated Pest Management would be very beneficial, not only for bees, but also for the conservation of the biodiversity of agroecosystems and their long-term productivity.

Chapter 3

PLANT PROTECTION PRODUCTS

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.1.Introduction to plant protection products

Agricultural production is one of the most important economic areas in Europe and ensuring quality and healthy agricultural production is a priority public interest. Crop production itself has an important position within agricultural production and its functioning requires good quality basic inputs, including plant protection. One of the most important ways of protecting plants and plant products from harmful organisms, including weeds, and a means of improving agricultural crop production is the use of plant protection products. The advantage of their use in plant protection is that large areas can be treated in a short space of time and thus the necessary interventions can be carried out in a timely manner and often only locally, thus preventing the further spread of weeds, diseases or pests. Plant protection products also have the advantage over mechanical interventions that they are usually simpler in terms of performance.

The term pesticide is a broad term and includes chemicals as well as micro-organisms or other substances of biological origin.

The use of pesticides in crop production, forestry but also in other areas is a necessity, especially under changing agro-climatic conditions and the associated increasing pressure of an expanding number of pests. What is important, however, is how these pesticides are used, what substances are applied and in what way. It should be borne in mind that the application of mainly chemical pesticides is more demanding in terms of skilled use and protection of health and the environment from the possible adverse effects of these substances. Of course, pesticide control is only successful if it is appropriately complemented by other control methods within an integrated pest management system, including relevant preventive measures.

Plant protection products are mixtures used in plant protection, consisting of active substances, safeners or synergists and co-formulants, and intended for one of the following uses:

a)the protection of plants or plant products against harmful organisms or the prevention of the action of such organisms, unless the main purpose of these preparations is to serve hygienic purposes rather than to protect plants or plant products,

b)influencing plant life processes, such as substances affecting plant growth, other than nutrients or plant biostimulants,

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.1.Introduction to plant protection products

c)preservation of plant products, unless such substances or products are covered by specific EU provisions on preservatives,

d)the destruction of unwanted plants or plant parts, excluding algae, where the products are not applied to soil or water for the purpose of plant protection,

e)the prevention or control of unwanted plant growth, excluding algae, where products are not applied to soil or water for the purpose of plant protection..

Active substances are approved at EU level, i.e. common to all EU Member States, and information on them can be found in the EU Pesticide Database.

Safeners are substances or preparations that are added to a plant protection product to remove or reduce the phytotoxic effects of the plant protection product on certain plants.

Synergists are substances or preparations that show no or only weak effect as plant protection products but may improve the efficacy of the active substances in plant protection products.

Coformulants are substances or preparations which are used or intended for use in a plant protection product or adjuvant but are not active substances, safeners or synergists.

Adjuvants are substances or preparations which consist of co-formulants, or preparations containing one or more co-formulants, in the form in which they are supplied to the user and placed on the market for mixing by the user with the plant protection product and which enhance its efficacy or other pesticide properties.

In the following chapters we will deal more specifically with selected types of plant protection products such as:

- Insecticides
- Fungicides
- Acaricides
- Herbicides
- Rodenticides
- Others

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.1.Introduction to plant protection products

The benefits of plant protection products in plant protection are evident in several areas, both in crop cultivation and for the protection of plant production in warehouses, they are used in the protection of forest stands, in fruit and forest nurseries, in the protection of ornamental plants and trees, from non-agricultural uses we can mention the maintenance of golf courses and sports grounds, public greenery.

As pollinators of flowering crops, bees play an indispensable role in primary food production. The use of agricultural chemicals such as fertilisers or plant protection products brings bees into direct contact with them or their residues are regularly detected in the bee hive environment.

Insect pollinator intoxication is a serious adverse consequence of the use of plant protection products on crops, as honey bees pollinate up to 80% of crops (fruits, vegetables, legumes and oilseeds).

When collecting nectar, pollen, propolis and water, bees can come into contact with residues of plant protection products through various routes, the most common being:

Exposure by contact - either by spray application (e.g. spray drift) or from dust particles when bees forage for food on the treated crop, weeds in the treated field, plants on the edge of the treated field and flowering neighbouring crops.

Oral exposure, such as through consumption of pollen from the treated crop/weed in the field and/or field margin, adjacent crop or subsequent crop/perennial crop in the following year; consumption of nectar from the treated crop/weed in the field and/or field margin, adjacent crop or subsequent crop/perennial crop in the following year; and through consumption of water, such as dew, surface water and puddles on and/or near the treated crop.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.1.Introduction to plant protection products

In addition to these two routes of exposure, there is the inhalation route of exposure.

From the point of view of toxicology (especially chronic exposure), substances with persistent and cumulative properties are hazardous to living organisms. Persistence refers to individual environmental compartments, whereas accumulation refers to living organisms. The ability of bees to share nectar, pollen and water within a community is called trophallaxis and should be taken into account when assessing bee intoxication.

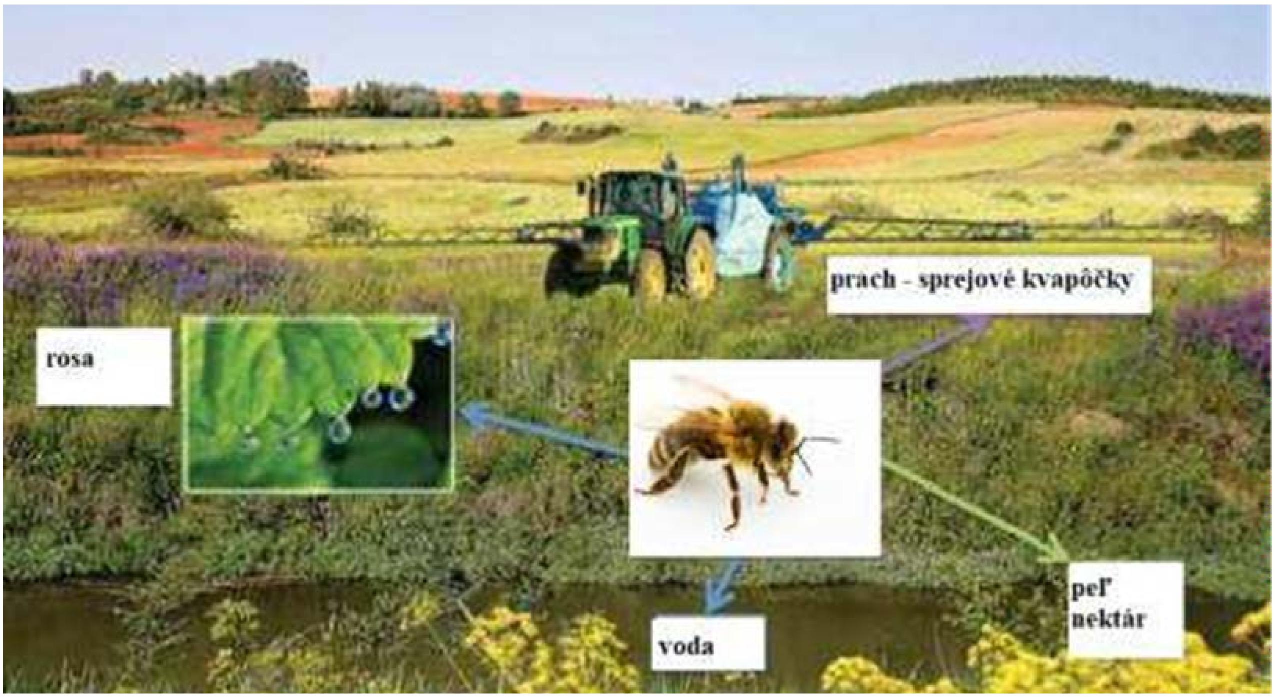


Figure: Possible routes of exposure of pollinators to pesticide residues (adapted from Sanchez-Bayo and Goka (2016); doi: 10.5772/62487)

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.1.Introduction to plant protection products

The use of plant protection products is only one of the factors affecting the health of pollinators in nature. In practice, pollinators are exposed to a number of synergistic, negatively acting factors, such as climate change, the degradation of individual species communities and the associated occurrence of different types of diseases, as well as the impact of invasive species. For example, in the absence of a diversity of flowering plants, as is common in intensive monocultures that produce only one type of flower while all flowering at the same time, bees are unable to sustain themselves and their offspring throughout their life cycle. In this case, the negative indirect effect of herbicides on pollinators applies. Unjustified herbicides or over-application of herbicides in the ecosystem reduces the diversity of wild plants on and near farmland. In addition, climate change is altering flowering patterns and shifting the occurrence of plants that were important food sources for bees from one area to another, or causing a 'seasonal shift' where flowering no longer coincides with the spring foraging trip of bees.

Figure: Extensive monocultures pose the greatest threat to pollinators

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.2.Division of plant protection products

Pesticides are divided into contact and systemic in terms of their mode of action. While contact products act preventively and only at the site affected, systemic pesticides are distributed throughout the plant and act even at sites where they have not been directly applied.

In the case of contact plant protection products, efficacy is dependent on direct contact of the spray liquid with the pest. The active substance does not penetrate into the interior of the plant, but remains localised on the surface, where it protects only those areas directly affected by the application. The contact mode of action implies the need to treat the surface of the plant evenly and as thoroughly as possible. The disadvantage of contact preparations is that they are subject to weathering or are washed away by rain and do not protect the unaffected areas of the plant.

The product with systemic action penetrates the plant tissues and is distributed in the plant translaminarly (from the top of the leaf to the underside of the leaf) and also vertically through the vascular system, even to the newly growing parts of the plant, which is particularly important during periods of intensive crop growth. These products have the advantage over contact products in that they are less dependent on the weather, since once the active substance has penetrated the plant, the rainfall that occurs ½ - 2 hours after application no longer affects the effectiveness of the product. The active substances of plant protection products with systemic action penetrate into the plant either through the underground organs of the plant (roots) or through the aboveground organs (leaves, stems and flowers). If applied to the seed as a seed protection coating, the product may penetrate the seed through the seed coat or may be dispersed in the soil where it is then absorbed by the roots. The different pesticides differ in their mode of penetration into the plant, which is linked to the physico-chemical properties of the seed coat. Penetration through the roots is passive and systemic products follow the same pathway as water and other soluble substances. Absorption by lateral roots is at the same level as absorption by the main root. With systemic preparations there is a greater risk of the pest developing resistance to the active substance.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.2.Division of plant protection products

Plant protection products are divided into four basic groups according to the pest identified:

a) fungicides (bactericides, virocides, soil fumigants, protection of stored products),

b) herbicides, desiccants and defoliants,

c) zoocides (insecticides, acaricides, nematicides, rodenticides, molluscicides, soil fumigants, insecticide attractants, repellents, protection of stored products),

d) growth regulators (plant hardiness improvers, germination inhibitors, post-harvest preparations for the protection of plants or parts of plants).

According to the method of use, plant protection products can be divided into:

- soil (with soil incorporation, without soil incorporation),
- foliar (sprays),
- seed and seedling treatments (seed prototective coating).

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.3. Formulation of plant protection products

Plant protection products can be solid, liquid, volatile, non-volatile, soluble or insoluble in their natural state. They must therefore be prepared in forms that are both effective and safe for use in the field. The manufacturer formulates plant protection products by combining the pesticide active substance or substances with other components of the products, such as solvents, inert carriers, surfactants, stabilisers, etc.

Requirements for the formulation of the plant protection product:
-To obtain a formulation with physical properties suitable for use in different types of application equipment and under different conditions.
-To prepare a preparation that is biologically effective and economically viable for use.
-Prepare a preparation that is suitable for storage in local conditions.

Types of formulation

G.I.F.A.P.	
AE	Aerosol dispenser (using propellant)
AL	Liquid concentrate for application without dilution
AP	Powder for application without dilution
CB	Concentrate (solid, liquid) for bait preparation after dilution
CG	Capsulated granules with a coating that controls the release of the active substance
CS	Suspension of capsules in liquid for use after dilution with water
DC	Dispersible concentrate
DP	Dust or powder
DS	Powder for dry seed treatment
EC	Emulsion concentrate
ED	Concentrate for electrodynamic application
EG	Emulsifiable granules
EO	Emulsifiable concentrate - oil water : oil emulsion
ES	Emulsifier in emulsion form for direct use or after dilution
EW	Water oil : water emulsion
FD	Smokebox - can
FK	Smokebox - candle (smoke generator form)
FP	Smokebox – cartridge (form of smoke generator)
FR	Smokebox - stick (smoke generator form)
FS	Seed treatment in the form of a stable suspension
FT	Smokebox - tablet (smoke generator form

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3.1.3. Formulation of plant protection products

CODE G.I.F.A.P.	Formulation
FU	Smokebox - (flammable pesticide)
FW	Smokebox - pellet (smoke generator form)
GA	Gas in a pressure vessel
GB	Granulated bait
GE	Gas is produced by a chemical reaction
GF	Gel for seed protection
GR	Granules
GW	Gel water soluble (gelatine for application as an aqueous solution)
LN	Net impregnated with long-acting insecticide
LS	Seed treatment liquid for direct use or after dilution with water
ME	Microemulsion aqueous concentrate
OD	Suspension oil-based concentrate
OL	Liquid concentrate for dilution with organic solvents
PA	Paste consistency coating
PB	Plate for spreading glue (bait)
RB	Bait for direct use
SC	Liquid suspension concentrate for dilution with water
SE	Suspension emulsion
SG	Water soluble granules
SL	Liquid concentrate for dilution with water
SP	Powder or water-soluble solid concentrate
SS	Water soluble powdered seed treatment
SU (ULV)	Special formulation for very low dose application (suspension)
TB	Tablets
UL (ULV)	Specially formulated formulations for very low dose application (liquid)
VP	Preparation (strips, plates, vaporizers) releasing the active substance in the form of vapour
WG	Water dispersible granules
WP	Dispersible (wettable) powder
WS	Water dispersible powdered seed treatment
XX	Other
ZC	Mixture of liquid suspension concentrate and capsule suspension, for dilution with water

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Many chemical preparations are defined as hazardous chemical agents to humans that can cause short-term, long-term or repeated damage to health or even death if inhaled, ingested or absorbed through the skin. They may be classified according to Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures. 1907/2006 as corrosive, irritant, sensitising, very toxic, toxic, harmful, as well as carcinogenic, mutagenic or toxic to reproduction, according to the content and concentration of the active substances so classified or according to the classification of other relevant components of the preparation. Many of them are hazardous to the environment.

Preparations must be stored in their original intact packaging in separate warehouses, which must be free of foodstuffs, medicines, feed, disinfectants, seeds, planting materials, fuels and similar substances and their packaging.

The general conditions for storage of plant protection products:

The warehouse must have:

·a concrete floor with a gutter leading to a catch basin (must not be connected to a public sewer),
·an area for handling the preparations, e.g. a table with equipment for casting or weighing the quantities needed for treatment, a source of water (tap) and adequate lighting,
·first aid kit with basic necessities, fire extinguishers, absorbent material to remove spillages (e.g. dry sand), Spare packaging (e.g. 3 times rinsed used preparations), a section reserved for empty packaging, thermometer and hygrometer,
·racks made of non-absorbent material (metal). Marked entrances and exits (e.g. with a sign saying 'Plant protection product store' and warning symbols),

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3.1.4. Basic principles when working with plant protection products

and must be:

- ventilated (opening window or fan),
- equipped with personal protective equipment, large enough for the expected volume of stored preparations, lockable (or the preparations are stored in a lockable cabinet),

Preparations labelled as highly toxic must be stored in a separate part of the warehouse specifically secured against access by unauthorised persons or in fixed, lockable cabinets in the preparation warehouse.

Prior to application, it is important to select the appropriate plant protection product, focusing on the pest species, its developmental stage and resistance management. In addition to chemical, biological plant protection products are also available, which are generally more environmentally friendly.

For the safe use of plant protection products it is necessary to:

- Mapping of land adjacent to sensitive areas (bee habitats, water reservoirs, watercourses, residential areas, private land, etc.) Compliance with regulations on setbacks from sensitive areas,
- Reading the product label, monitoring of weather conditions and forecasts (wind force max. 5m/s or max. 10m/s for low-flying nozzles and 12m/s for air-assisted application), temperatures max. 25˚C, humidity min. 60%)
- Use of low drift technologies and choosing the appropriate time of application (morning, early evening),the correct settings for the application device, adherence to drift reduction principles before and during application,
- use of tested and calibrated application equipment.
- Personal protective equipment must be used when applying plant protection products. Pesticides can enter the human body in four different ways; by mouth, inhalation, skin contact or through the eyes.

Personal protective equipment is regulated by National Regulations on minimum requirements for the provision and use of personal protective equipment.

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Spray liquid preparation:

Chemical resistant protective work clothing, rubber/PVC apron, chemical resistant gloves, face shield or goggles, respirator for respiratory protection and rubber work boots must be worn when preparing the spray liquid. The use of contact lenses is not recommended when preparing the application fluid.

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3.1.4. Basic principles when working with plant protection products

Application:

Protective full body work clothing, gloves suitable for working with chemicals, face shield or goggles, respirator for respiratory protection and rubber work boots should be used when applying the spray. Contact lenses are not recommended for application. Working with the product is prohibited for pregnant women, minors and is unsuitable for persons suffering from allergic diseases.

Workers entering treated crops:

They must wear appropriate protective work clothing covering the whole body, sturdy closed shoes, protective gloves and may enter treated areas only after the spray has dried on the plants, at the earliest 24 hours after spraying.

When applying the product, the application rate, concentration, number of applications according to the label instructions must be observed, as the biological efficacy and risk assessment of the product always refers to the authorised application rate

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Chemical plant protection products are generally toxic chemical mixtures with a specific mode of action, meaning that they are designed to specifically control a target group of organisms by interfering with certain metabolic pathways of living organisms. Thus, insecticides and acaricides kill insects and mites by interfering with their neuronal activity, the molting process or other specific metabolism of these arthropods; herbicides and algaecides kill plants and algae by interfering with their photosynthetic capabilities or the synthesis of essential organic compounds; and fungicides kill fungi by inhibiting the formation of their cell membranes or other specific metabolism of these organisms.

Pesticide substances represent a diverse range of chemical classes with different modes of action on the organism, and therefore the study of the effects of pesticides on bees is not straightforward. A further complication is that honey bees often encounter many different chemicals (xenobiotics) simultaneously due to their “ubiquity“ in their pollination activity in nature, their specific foraging strategy during which they may cover hundreds of square kilometres. These different chemicals, together with adjuvants and other additives in applied plant protection products, can interact with each other to produce additive or sometimes synergistic effects on bees and other insects.

However, the toxicity of each type of pesticide is not exclusive to the target group of organisms: other species with similar metabolism are also affected, although usually to a lesser extent.

The efficacy of a plant protection product on any species is defined by the dose of the toxic chemical that is lethal to 50 % of the test individuals of that species (LD50), such dose varying from species to species. Doses below the LD50 are considered ’sublethal’ but may also cause the death of a proportion of the population of a species, i.e. 20 or 30 % of individuals may die. In general, sublethal doses cause toxic effects that do not kill the organisms but still affect their physiology and behaviour.

Scientists often focus their research on investigating the acute toxicity of pesticides, as such assessments are required by national regulatory authorities when authorising products, but bees and other pollinators often encounter pesticides in their environment at a variety of sub-lethal doses and in combinations with each other. Even these lower doses can cause a variety of harmful effects in bees and other pollinators, including behavioural, learning and memory, longevity and immune function impairments.

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3.1.5.1 Toxicity of different types of pesticides to bees

In practice, most insecticides are applied in the form of sprays to treated crops, but sprays of herbicides and fungicides are often applied directly to the soil before planting or sowing agricultural crops. In all these cases, droplets and dust from the applications may fall directly on bees flying over or near the treated fields, as the wind can carry the tiny droplets and dust particles hundreds of metres away from the crop. A single droplet of insecticide may be enough to kill a bee because spray solutions contain concentrated doses of these chemicals - this is the most common cause behind cases of bee poisoning. Granular pesticides that are incorporated into the soil (e.g. herbicides) do not have a direct effect on bees (possible exposure through the crop).

So-called systemic insecticides are usually applied as a seed mordant. The treated seeds are sown into the soil using pneumatic sowing machines and the friction of the seeds in the machines produces dust particles that can theoretically affect flowering weeds or agricultural crops in their vicinity. Systemic insecticides are taken up by plants during growth and their residues are present in all parts of the treated plant, including flowers, pollen and nectar. Not only the crop plants themselves are affected, but also weeds, agricultural crops and shrubs growing in their vicinity or the year after treatment, as they also take up small amounts of residues through contaminated groundwater or are contaminated through dust/spray drift during the actual sowing process. In addition, some plants may produce 'guttation dew drops' in the early morning (e.g. maize, strawberries) and systemic insecticides appear in such drops in elevated concentrations that are capable of killing bees.

Exposure of bees to residues of plant protection products occurs mostly through pollen and nectar from contaminated plants, either from crops or from weeds in the vicinity of fields. It is important to note that bees look for food sources everywhere during the season, targeting the most suitable flowers that produce pollen and nectar in abundance. In addition, the sugar content of the nectar is also important for pollinators. This is why some crops are more attractive than others; for example, the yellow flowers of oilseed rape, sunflowers and many weeds that grow around crops are more attractive to bees than potato flowers. Pesticide residues in pollen and nectar are carried by honey bees to their hives and remain in stored pollen and honey for quite a long time.

These residues are then fed to the larvae, drones and queen, which are affected in a similar way to worker bees.

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In addition to food, bees and other pollinators also carry water to feed the brood and keep the hive temperature under control. Pesticide residues in the soil eventually make their way into surface water (puddles, streams, rivers and ponds) in agricultural areas and beyond, which are thus contaminated with a mixture of different agrochemicals (pesticide and fertiliser residues.

Not to be overlooked are the pharmaceuticals used worldwide in beekeeping, the so-called acaricides used to control Varroa destructor and other bee parasites. In this case, the bees come into contact with high doses of residues present on the wax cells of the combs, which particularly affect the developing brood.

Given the vast array of agrochemicals used in crop production, it is not surprising that so far residues of up to 173 different compounds have been detected in honey bee colonies at any one time (Mullin et al., 2010). In this context, it is important to note that bees are many times exposed to mixtures of plant protection products, so-called pesticide residue cocktails. The effects of the combinations have not been studied in detail, so scientific research is currently focusing on this area.

All animals, including bees, are equipped with detoxification mechanisms that transform and remove most toxic chemicals out of the body. Currently, most organic pesticides are degradable either in the organisms themselves or in the environment. Exceptions are organochlorine pesticides (e.g. insecticides such as DDT and lindane), which are very persistent. As they have been used quite frequently in the past decades, their residues are still present in the soil, albeit at low levels. Their use in agriculture is currently banned - due to their low water solubility, organochlorine residues are not taken up by plants growing in contaminated soil and therefore do not appear in pollen or nectar of flowers.

The persistence of pesticides is assessed by their half-life (t1/2), which is defined as the time it takes for half the amount of a chemical to disappear from the environment, i.e. from water, soil, air or biological tissues. A half-life longer than 90 days indicates that the pesticide may accumulate in living organisms, as more than 5% of the applied amount will remain in the environment after one year. Residues of persistent pesticides found in pollen or nectar will therefore remain in beeswax throughout the honey production season.

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Systemic insecticides such as neonicotinoids (e.g. imidacloprid) and fipronil are more toxic and persistent than most organophosphorus (e.g. malathion), carbamate (e.g. formetanate, pirimicarb) and pyrethroid (e.g. cypermethrin, deltamethrin) agents. Due to their high water solubility, their residues are also found in the surface waters of agricultural areas and in the rivers into which they flow. As they are still in use in some countries of the world (mostly applied as seed treatments), their residues can remain in the soil for years and are taken up by crops and weeds, entering the nectar and pollen of all plants in the treated landscape. This poses a risk to bees and other pollinators not only because of their high toxicity and availability, but also because of their specific mode of action. For example, neonicotinoids show delayed toxicity at low doses, so that in addition to the various sub-lethal effects they cause, they will eventually kill bees if they are exposed to their residues over a long period of time. Neonicotinoids also cause immunosuppression in honey bees and, as a result, predispose bees to Nosema spp. infections and outbreaks of viral diseases commonly transmitted by Varroa mites. As a consequence, honey bee colonies may succumb to the combined effects of chemicals and diseases.

Figure: Bee dead in a swarm

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The toxicity of some insecticides may be increased in the presence of ergosterol-inhibiting fungicides (e.g. conazole fungicides, e.g. difenoconazole), which act synergistically. This type of compounds inhibits the detoxification system of bees, so that residues of insecticides and acaricides are not metabolised or eliminated as quickly as they should be. In addition, the toxicity of insecticides and acaricides used for Varroa control is often additive or synergistic. Since the food that honey bees collect is usually contaminated with a mixture of both insecticides and fungicides, and since most managed colonies are treated with acaricides, the combined toxicity and synergism of all these chemicals poses a real threat to the health and survival of honey bee colonies and all other pollinator species.

Sub -lethal exposure to pesticides, including fungicides and some herbicides, often causes stress in animals as organisms try to rapidly metabolise and get rid of toxic chemicals using large amounts of energy. In addition to stress, exposure to sublethal doses of pesticides has other negative effects on bees. For example, under conditions of chronic exposure, honey bees fed pollen contaminated with chlorpyrifos (recently banned from use in the EU) have produced very few viable mothers. Solitary bees (Osmia bicornis) exposed to sub-lethal levels of thiamethoxam and clothianidin had a 50% reduction in reproduction; the bumblebee community (Bombus terrestris) exposed to sub-lethal levels of thiamethoxam produced 85% fewer queens than the control group. Sublethal doses of neonicotinoid insecticides also cause disorientation and memory loss in honey bees, contributing to lower pollen and nectar collection efficiency. Sublethal doses of the acaricide coumaphos also cause abnormal motility in exposed honey bees. All these effects undoubtedly impair the performance of individual bees and the colony as a community.

Finally, the indirect effects caused by herbicides cannot be ignored. Herbicides are usually not directly toxic to bees, but they do disrupt the environment in which bees and other pollinators live. It has been scientifically proven that plant biodiversity and associated arthropod communities have been reduced in areas that have been treated with herbicides for many years. The lack of certain plant species, especially weeds, means an impoverishment of the natural environment that supports pollinators, including honey bees. As a result, it is more difficult for bees to collect the diverse pollen that is needed for a healthy bee diet. Poor bee nutrition due to lack of flowers is an indirect consequence of the continuous application of herbicides in agricultural and forest areas over many decades.

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3.1.5.2. Risk assessment of plant protection products for pollinators

The main risk of using plant protection products in practice arises from the acute toxicity of the chemicals to bees, causing bee mortality in the short or medium term. Other risks include sub-lethal effects that can damage colony performance and the long-term viability of bee colonies, as discussed above.
The risk assessment system for honeybees, bumblebees and solitary bees is uniform across the EU and a risk assessment guidance document, the EFSA BEE GUIDANCE DOCUMENT (developed in 2013 and revised in 2023), has been developed.

Plant protection products may only be authorised and used within the European Union if a risk assessment has been carried out and it has been confirmed that they do not have unacceptable effects on the environment, including honey bees, solitary bees and bumblebees. The European Food Safety Authority (EFSA), in collaboration with the Member States, published this guidance document in 2013. In 2019, at the initiative of the European Commission, the 2013 guidance document was revised based on the collection of new data on bee mortality, a review of the individual requirements for field studies and a review of the attractiveness of crops. The risk assessment methodology has also been revised and, unlike in the original document, a maximum allowable level of colony size reduction, the so-called SPG (Specific Protection Goal), has been agreed for honey bees with a value of 10%. As regards solitary bees and bumblebees, the definition of this value is still under discussion and examination.
The current EFSA document, taking into account the latest scientific knowledge and methodologies, was published on 15 May 2023.

The basis of the document is a risk assessment for the above pollinator groups exposed to plant protection products in normal agricultural practice. In contrast to the original version, the revised document now includes a so-called multi-level approach for exposure estimation and effect assessment. The aim is to cover or capture as many possible scenarios and aspects of exposure as possible. Exposure via contact exposure, where bees come into direct contact with the product, and exposure via dietary exposure, where bees consume affected/contaminated pollen and nectar, are assessed under different exposure scenarios. As this is a multi-tiered approach, individual exposure levels as well as effect levels have been defined. The assessment focuses on time scales (acute and chronic) and on different stages of bee development (adult, brood - larvae).

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For this purpose, four basic risk cases have been defined:

1.Acute contact

2.Acute dietetic

3.Chronic dietary

4.Larval dietary

In addition, the document also calls for an assessment of increasing toxic effects due to long-term exposure to low doses of the product and sub-lethal effects. The so-called higher level of testing consists of types of studies such as semi-field and field studies and studies aimed at monitoring the colony as a whole. It is the field trials that represent the highest experimental form of testing in real-life ecological as well as agricultural practice settings.

Not only the impact within the treated area, Its peripheral parts, but also the impact on organisms in adjacent areas is monitored. The guidance document provides a scheme for the assessment of metabolites and mixtures of products and also considers possible risk mitigation measures.
The authorisation process for each individual plant protection product itself requires an expert assessment of the potential adverse, harmful effects of the active substance as well as the product itself on the environment (air, surface water and groundwater, soil) and non-target organisms (human life and health, terrestrial animals such as birds, mammals, aquatic animals (fish, invertebrates), phytoplankton, earthworms, soil macro-organisms and micro-organisms, non-target plants and bees and other non-target (beneficial) arthropods).

In the process of authorisation of preparations, the following are assessed:

- the content of the active substance in the preparation,
- the method of application of the product to the crop and the time of application,
- attractiveness of the treated crop to bees (watch out for flowering weeds),
- the prescribed application rate per hectare (quantity, number of applications and application interval),
- the physicochemical properties of the active substance under consideration (e.g. persistence in the environment), the mechanism of action and the actual toxic effect on non-target insects, including honey bees.

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3.1.5.3.The most common mistakes when treating crops with plant protection products

It is imperative that when applying plant protection products, gardeners or farmers follow the directions for use and restrictions on the product label. The most common mistakes in practice are:

- Failure to respect the level of risk classification to bees and the resulting restrictions on the use of the products, failure to respect the special precautions 'when using the products,
- Non-compliance with the instructions for use, including maximum authorised application rates, timing of application in relation to flowering of honey bees crops,
- Use of unauthorised tank-mix combinations: two or more plant protection products (tank-mix combination of 3 or more products) and/or combination of plant protection product + fertiliser,
- Application in windy or hot weather - increased drift or evaporation of the applied liquid, poor technical condition of the application equipment.

3.1.5.4. Bee poisoning

The residual activity of an insecticide is an important factor in determining its safety for pollinators. An insecticide that evaporates within a few hours of application can generally be used with minimal risk when bees are not actively foraging. If bees visit the crop during the period of residual activity of the insecticide (especially when using insecticides with prolonged residual activity, i.e. > 8 h), it is difficult for humans to prevent damage to bees and other pollinators. Therefore, insecticides with prolonged residual activity require additional precautions to avoid exposure to bees. If the target crop is not flowering or is not attractive to bees, insecticide drift can cause significant bee poisoning if it reaches neighbouring flowering crops or weeds. In general, products should not be applied if wind speeds in excess of 4 m/s encourage drift towards flowering crops or weeds. Chemical poisoning of honey bees can overshadow all other colony problems, including bee diseases. Highly toxic insecticides with residual toxicity of more than 8 hours are responsible for most cases of bee poisoning in the world, especially those from the following chemical groups:

- Organophosphates (such as chlorpyrifos, dimethoate, malathion and methamidophos), N-methylcarbamates (such as carbaryl),
- Systemic neonicotinoids (for example, clothianidin, imidacloprid and thiamethoxam),

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- Pyrethroids (such as cyfluthrin, deltamethrin and lambda-cyhalothrin), with some pyrethroids such as esfenvalerate and permethrin being repellent to bees when used in dry climates.

The repellent effects reduce the possibility of bee poisoning by these insecticides in dry conditions, but they are likely to pose a danger to bees when used in humid areas.

In general, bee poisoning is most commonly observed in flying bees that are actively foraging for food during the day. Bees forage from a relatively large area around the hive, most commonly 7 km2 if they fly within 1.5 km of the hive. Different forms of plant protection products containing certain insecticides often vary considerably in their toxicity to bees. For example, insecticides in granular form are generally not dangerous to bees. Dusts that can potentially form when sowing seed with protective coating are more dangerous to bees than emulsified concentrates because the dust particles adhere to the hairs of the bees' bodies and are carried back into the hive. Wettable powder and liquid formulations can dry to a dusty form and thus be carried back into the hive by the flies. Exposure of honey bees to an insecticide that kills leafhoppers directly in the field (acute course of intoxication) can immediately reduce honey production, but colonies usually recover when replaced by young bees. In some cases, residues of various pesticides may remain active in the hive for several months (chronic intoxication) and prevent the colonies from recovering from the damage. Pesticide poisoning is not always obvious and may be associated with other factors. Delayed and chronic effects, such as poor laying progress, are difficult to link to specific pesticides, but occur when stored pollen, nectar or wax combs become contaminated with pesticide residues.

As a result, severely weakened colonies or queenless colonies may not survive the winter.

Temperature can have a significant effect on the course of bee poisoning. If temperatures are unusually low after application of an insecticide, residues of that insecticide may remain toxic to bees for much longer than when normal temperatures prevail. In addition, if high temperatures occur in the late evening or early morning hours, flying bees may still be present in the treated crop at this time. Pesticide applications by aircraft over bees in flight are more dangerous than applications by ground equipment because the chemical compounds are spread over large areas. However, if pesticide applications by aircraft are made at night when bees are not flying, losses to bee colonies are greatly reduced (due to the fact that the pesticide used has more time to degrade and become less toxic to bees).

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3.1.5.5.Symptoms of bee poisoning

Bees can be killed by insecticides by direct contact through the cuticle, through the gastrointestinal tract (per os) or through the respiratory system (per respirationem). Some products kill by a single effect, while others kill by combinations of different effects. Bees absorb contact toxicants through the cuticle. Ingested residues of toxic substances are absorbed through the digestive tract when they enter the body during feeding or cleaning.

Fumigants are absorbed through the bee's tracheal system. All anticholinesterase insecticides do not act in the same way, e.g. carbamates, which are ionised at physiological pH, are inactive or less active than expected from their anticholinesterase activity. This results from the relative impermeability of the insect nerve sheath to ionized substances and from the absence of cholinergic neuromuscular junctions in insects.

The anatomy, physiology and behaviour of the honey bee are such that if it is exposed to a chemical, its behaviour deviates from normal. Honey bees tend to retain nectar in their honey sacs when exposed to a poison and carry it to the hive where it is fed or stored as stores. If the bees return to the hive with a load of exposed nectar or with a spray odor, the guard bees will prevent them from entering or remove them from the hive. This partially prevents contamination of the honey stores. In cases where contamination with pesticide residues does occur, the resulting detected concentrations are low enough to cause acute poisoning of the bees or larvae. With some fast-acting toxicants, honey bees may die in the treated field; other bees may return and die in the hive or climb in front of the flyer and die nearby; still others will be lost between the treated field and the hive. Bees may also be poisoned by water they drink from treated fields, at watering points or even by dew present on treated plants. If the bees are affected by water-carrying leafhoppers, not only are the water-carrying bees lost, but the whole colony then suffers from the lack of water. If the bees are unable to use food and water, they die of starvation and desiccation very quickly in 6 to 8 hours (cannibalism is observed in the affected colony before collapse).

The first sign of pesticide poisoning is the appearance of large numbers of recently dead or dying bees on the ground near the hive flyer. The natural physiological mortality rate in strong colonies is up to 100 adult bees per day. If this rate is higher, poisoning may be suspected. If poisoning is severe, dead or affected bees accumulate on the hive bottom faster than unaffected cleaner bees can remove them.

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As the colony population declines, younger, then older larvae begin to die off. Likewise, the pupated brood begins to die off while the cell caps darken. As the bee population becomes increasingly disorganized and shrinks, honeycombs in hives unprotected from sunlight may begin to melt and honey leaks out of the hive flyer and mixes with dead bees on the ground in front of the flyer. The female hoverflies quickly discover the weakened colony, lay eggs in it, and their larvae soon destroy the remaining combs.

The number of bee deaths due to pesticide residues is usually much higher than those found in the most serious cases of adult bee diseases. Another symptom of acute poisoning is a significant reduction in the flight activity of the affected colonies on the apiary and a reduction in the need to swarm.

Some of the typical symptoms of bee poisoning:

- Excessive number of dead and dying bees in front of the hives, reduced defenses of the colony (most insecticides), Lack of supplies for bees on a normally attractive flowering crop (most insecticides),
- Numbness, paralysis and abnormal jerky, zigzagging or rapid movements of exposed bees; turning on their backs (organophosphates and neonicotinoids), disorientation in foraging and reduced foraging efficiency (neonicotinoids),
- Immobile, lethargic bees unable to leave the flowers (many insecticides),
- Regurgitation of honey stomach contents and ejection of the sucker (organophosphates and pyrethroids), unusual communication dances, struggle or confusion at the entrance to the hive (organophosphates), occurrence of “crawlers“ (bees unable to fly),
- Bees slowing down and behaving as if they were hypothermic (carbaryl),
- Poor brood development, with adult bees unaffected (novaluron and spirodiclofen),
- Dead brood, dead newly emerged workers or abnormal queen bee behaviour such as spaced oviposition (carbaryl), queenless colonies (acephate, carbaryl, malathion),
- Poor hatching of young queens in hives used for queen production, with adult bees unaffected (coumaphos).

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.5. Can plant protection products affect bees and other pollinator species? How to reduce risks to wildlife and bees?

3.1.5.6. How to reduce risks to non-target pollinators, including bees?

Prevention is also preferable in this case and therefore:

- the right choice of habitat for bee colonies and solitary bees (so-called insect hotels) is important - outside intensively used agricultural landscapes, establishing green biobelts sown with bee-loving flowers,
- It is always important to find out in spring the crop mix of the bee colonies and to check with the farmers about the expected time of the planned chemical crop protection,
- It is equally important to inform farmers about the habitat of bee colonies,
- In the external environment, mark the location of the beehives - an equilateral triangle of yellow colour (1 m) visible from the air and from the ground, it is necessary to mark the apiary with a plate with the beekeeper's name, registration number and contact details,
- The need for cooperation and mutual information between growers and beekeepers.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.6. Studies on the effects of pesticides on bees

Herbicides and fungicides, very often used for plant protection, are not designed to kill insects and their acute toxicity to adult bees is generally low. These pesticide s are usually not subject to application restrictions to reduce bee exposure, so bees may come into direct contact with the application rate concentration when applied during flowering of the crop. Fungicides are detected extensively in honey bee colonies. The effects of fungicide exposure are generally observed in brood rather than adult bees (Johnson 2015). Therefore, we can consider them as a potential risk to affect the reproductive cycle of the bee colony. Tests determining the larval toxicity of these substances are needed to better understand their effect.

Although herbicides and fungicides are not usually toxic to insects, it is not clear exactly whether they pose a risk to bees and other pollinators. Only the effects of direct poisoning, which are not usually observed with fungicides and herbicides, are taken into account when legislative restrictions on pesticide use are drawn up. However, damage caused by acute toxicity is not the only threat to bees. Therefore, sub-lethal effects of fungicides and herbicides on bees, such as paralysis, disorientation or behavioural changes, both short- and long-term, are increasingly being investigated (Rortais et al. 2005). Thus, sublethal doses pose a threat to the survival of the entire colony (Wu-Smart and Spivak 2016), hive contamination (Rortais et al. 2005), and cause a reduced ability to pollinate plants (Gill et al. 2012). Emerging evidence suggests that herbicides can affect bee navigation, learning, and larval development, while fungicides can affect bee food consumption, metabolism, and immune response when bees are directly exposed to these compounds by contact during or after application or by oral exposure - contaminated nectar and pollen (Cullen et al. 2019).

Several recent scientific studies from the European environment have been devoted to monitoring the presence of pesticide residues in components of the hive environment, including beeswax. In a recent study by López et al. (2016) collected honeycomb wax directly from 60 randomly selected hives and examined the pesticide residue load of honeycomb wax from these samples. They performed multiresidue analysis to detect 120 pesticides, detecting 31 different pesticide species in the samples. The following pesticide residues were detected: amitraz degradation products (DMPF and DMF combined) at concentrations of 5 - 464 µg.kg-1 , organophosphate insecticides 1 - 464 µg.kg-1, acaricides at concentrations > 9 µg.kg-1, fungicides at concentrations of 1 - 23 µg.kg-1. Herbicides were detected, as expected, in a small number of samples and at low concentrations (1 - 5.9 µg.kg-1).

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.6. Studies on the effects of pesticides on bees

Neonicotinoid insecticides were found in 4-6% of the samples analysed. Analyses by García et al. (2017) confirmed the presence of pesticide residues in all 50 honeycomb wax samples collected and analysed at different apiaries in Spain (2-11 pesticide residues were detected in each sample). Thirty-two different pesticide residues (14 insecticides/acaricides, 10 insecticides, 6 fungicides, 2 herbicides) were detected out of 160 analytes tested, at concentrations between 69 and 9557 μg.kg-1, giving an average concentration of 2262 μg.kg-1. As expected, compounds such as tau-flauvalinate and coumaphos were present at the highest concentrations (approximately 100-fold) as a result of use in beekeeping treatments. It is difficult to conclude whether the presence of pesticide residues in wax comb samples represents recent or historical contamination, as these chemicals resist the wax melting temperature and can therefore accumulate over decades (García et al. 2017).

The aim of the French scientific work by Daniele et al. (2018) was to assess the exposure of bees by studying the pesticide residue content in the hive environment (in bees, brood and beeswax). They focused on the analysis of pesticide substances contained in plant protection products. They used sensitive analytical methods to detect and quantify 13 pesticides belonging to neonicotinoids and pyrethroids, some of their metabolites and the fungicide boscalid. Perga was the most contaminated with 77 % positive samples out of 276 samples examined, with an average of 2 pesticides detected per positive sample (max. 7 pesticides per sample). The highest concentrations of pesticide residues were detected in wax, up to 302.3 ng/g boscalid and up to 106.5 ng/g thiamethoxam, which is related to the fact that wax remains in the bee colony for several years during which time pesticide residues accumulate. Of the 87 beeswax samples analysed, 61 % contained at least one of the pesticides of interest. A combination of 2 pesticides was detected in 21% of the positive samples and 3 pesticides in 2% of the positive samples. Neonicotinoids (especially thiacloprid) and boscalid were the most frequently detected pesticides. Pyrethroid insecticides were surprisingly less frequently detected in wax due to their lipophilic nature, which may be explained by high LOD (limit of detection of the analytical method) values in wax or by their metabolisation. The LOD and LOQ (limit of quantification of the analytical method) values in wax are generally higher compared to those in bees and perga due to its complexity and the content of many lipophilic components. Deltamethrin was detected in one wax sample at a concentration of 28.3 ng/g.

These results indicate a high contribution of pesticides from agriculture to bee exposure within the hive environment itself.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.6. Studies on the effects of pesticides on bees

Several studies have shown that neonicotinoids have adverse effects on honey bee brood development. In addition, delays in larval hatching and adult development have been observed in bees fed food contaminated with imadocloprid. The same effect was also observed in solitary O. lignaria bees.

Different results were obtained in field studies compared to laboratory studies. In some cases, no adverse side effects were observed in bees grazing on clothianidin-treated oilseed rape (B. napus) flowers. The same results were also found with imidacloprid. It was also found that bees responded to the change caused by ingestion of pesticide-treated food by subsequently refusing to accept the contaminated food, resulting in a significant reduction in foraging activity. This protective behaviour of bees avoiding contaminated food may reduce the risk of exposure to pesticides and associated consequences.

Recently, it has also been shown that bees come into contact with insecticides used for seed mordanting, by way of excretion of guttaceous fluids from plants (guttaceous water), where no mortality was observed in foraging bees after ingestion of dew from plant leaves, in contrast to the high mortality observed in bees that came into contact with guttaceous fluids. Also, bees exposed to dust originating from stained seeds (from incorrectly set seed drills) showed high mortality. However, high bee mortality was only observed under higher humidity.

Neonicotinoids act as neurotoxins on the nervous system of insects. These insecticides are systemic, so they are imported throughout the vascular system of plants. The use of these products potentially leads to exposure of bees and other pollinators to residues in nectar and pollen. After many comparisons, it has been found that neonicotinoids containing a nitro group (imidacloprid, clothianidin, thiamethoxam) are more toxic to honey bees than those containing a cyano group (acetamiprid and thiacloprid). Furthermore, metabolites of neonicotinoids have been shown to contribute to toxicity, where again metabolites of neonicotinoids with a nitro group are the most dangerous.

It has been found that certain combinations of pesticides can act synergistically to increase toxicity to pollinators, this is particularly true for neonicotinoids containing a cyanocotyl group. For example, the insecticide piperonylbutoxide combined with the fungicides triflumizole and propiconazole increased acute toxicity more than sixfold. For insecticides such as imadicloprid almost twofold. The toxicity of acetamiprid increased 6-84-fold after the addition of the fungicides triadimefon, epoxiconazole and uniconazole-P, according to different combination ratios.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.7. How attractive are different plant protection products to bees?

The choice of products in plant protection can significantly affect the attendance of bees and other pollinators in canola stands. Additives have been shown to have a significant effect on the attractiveness or repellency of products to bees. It can be hypothesised that a targeted change in the composition of the additives in a pesticide could make treated plants highly repellent to pollinators and thus prevent not only poisoning but also the occurrence of pesticide residues in pollen and honey. Repellency of pesticides for bees is an important property that partially limits the visitation of treated stands and reduces the transfer of residues of these pesticides to the hive. The direct attraction method was used to detect bee repellency under laboratory conditions. The amount of product that would realistically fall on 1 flower, i.e. 1 cm2, was mixed into treated honey, which had a similar consistency and composition to the nectar of canola flowers, and converted to a concentration according to the usual amount of nectar in the flowers. These honey and preparation solutions were poured into ependorfs (= plastic resealable tubes), where each ependorf contained 2 ml of solution. As a control, the honey was selected as modified according to the parameters of rapeseed nectar. The plates holding the ependorfs were made of yellow plastic to make them conspicuous to the bees. All the ependorfs from one variant were opened at once and the bees started sucking the attractive solutions. By the time all the solution had been sucked out of the most attractive ependorf, the amount of solution remaining in the other ependorfs was recorded. Among the attractive preparations for bees, Mospilan 20 SP (Gazelle) can be included.

The fungicide Pictor was even the only preparation that bees often drank rather than pure treated honey. These preparations were taken preferentially by the bees, so it can be said that the active substances of these preparations are more frequently introduced into the hive by the bees. Little repellency was shown by the Karate Zeon preparation. Trebon OSR (Magma) was highly repellent.

It was also found that all commercially formulated products were significantly more repellent than the pure active ingredients tested. The greatest difference was found for the pure active ingredient etofenprox. The commercial insecticide Trebon OSR was 12 times less attractive to bees than its pure active ingredient.

3. PLANT PROTECTION PRODUCTS

3.1. GENERAL ASPECTS

3.1.7. How attractive are different plant protection products to bees?

The smallest difference of the tested active substances was found for the pure active substance acetamiprid. The attractiveness of the most common formulation Mospilan 20 SP was only 1.4 times lower compared to the pure active substance acetamiprid. Thus, the repellency of plant protection products is mainly due to the additives that are precisely specified in the individual formulations of the products. Different variants of formulations with the same active ingredient have different levels of repellency and therefore different risks to bees and other pollinators. This should be borne in mind when purchasing products on the black market or from unknown suppliers, where the content of the product is unknown and often contains high-risk solvents or impurities with unknown content.

Since insecticide and fungicide control is often combined in canola and the products are applied as a tank-mix, the effect of the insecticides under study was also evaluated with the frequently used fungicides Pictor and Prosaro. When the insecticide Pictor was added to the insecticides, also a minimally repellent fungicide for bees, the repellency of the mixture was increased. The highly repellent fungicide Prosaro increased the repellency of all tested mixtures even more. The tank-mix of insecticides with Prosaro fungicide was unattractive to bees in all cases.

3. PLANT PROTECTION PRODUCTS

3.2. PLANT PROTECTION PRODUCTS AUTHORISED FOR ORGANIC AGRICULTURAL PRODUCTION

Plant protection products may be used in organic agricultural production if they comply with the conditions of Annex I of Commission Implementing Regulation (EU) No 2021/1165 authorising certain products and substances for use in organic production and establishing lists thereof. This means that they may only contain active substances listed in that Annex, namely:
·Basic substances (Basic substances listed in Part C of the Annex to Implementing Regulation (EU) No 540/2011 which are of plant or animal origin and are food-based or listed in Annex I of Regulation (EU) No 2021/1165), e.g. whey, sucrose, fructose, certain plant extracts, etc.

·Low-risk active substances (substances listed in Part D of the Annex to Implementing Regulation (EU) No 540/2011a are listed in Annex I of Regulation (EU) No 2021/1165), e.g. cerevisan, laminarin, ferric phosphate, etc.

·Micro-organisms (All micro-organisms listed in Parts A, B and D of the Annex to Implementing Regulation (EU) No 540/2011 may be used in organic agricultural production, provided that they do not originate from genetically modified organisms - GMOs).

·Other substances such as spinosad, copper compounds, sulphur, vegetable oils, repellents, pheromones, etc.

3. PLANT PROTECTION PRODUCTS

3.3. INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is the careful consideration of all available methods of plant protection and the subsequent implementation of appropriate measures that prevent the development of pest populations and maintain the use of plant protection products and other forms of intervention at levels that are economically and environmentally justified and reduce or minimise the risk to human health and the environment. IPM emphasises the production of healthy crops with the least possible disruption to agro-ecosystems and promotes natural mechanisms to regulate harmful organisms. Pursuant to Section 43 of Act No 405/2011 Coll., every professional user of plant protection products is obliged to apply the provisions of IPM from 1 January 2014.

IPM is multilevel and based on four basic approaches:

- Prevention
- Monitoring
- Identification (observation) and determination of the degree of threat
- Control using an appropriate method

The main IPM measures include:

- preventive measures
- protection and promotion of beneficial organisms
- monitoring of harmful organisms
- preference for biological, physical and other non-chemical methods,
- selection of products as specific as possible for the target species with minimum side effects on human health, non-target organisms and the environment,
- use of preparations at the necessary level
- checking the success of the measures used

3. PLANT PROTECTION PRODUCTS

3.3. INTEGRATED PEST MANAGEMENT

3.3.1. How to reduce risks to wildlife and bees when using POR?

1. Preventive measures:

- Crop rotation
- Suitable cultivation techniques, sowing of the crop mixture, timing and density of sowing
- Resistant or tolerant varieties
- Certified seed and propagation material
- Balanced fertilization and irrigation
- Prophylactic measures to prevent the spread of harmful organisms
- Protection of beneficial organisms

2. Monitoring of harmful organisms:

- Conducting field observations.
- Early warning, forecasting and diagnostic systems. Determination of threshold levels of harmful organisms

3. Qualified professional advice

4. Where possible, biological, physical and other non-chemical methods shall be preferred.

5. The plant protection products applied must be specific to the target organism and with the least possible side-effects for human, animal and environmental health.

6. The dosage of plant protection products shall be minimised to the necessary level: e.g. by reducing doses (if authorised), reducing the frequency of application or split applications with an acceptable level of risk to vegetation and not increasing the risk of resistance in pest populations.

7. Where there is a risk of resistance to certain active substances and the level of harmful organisms requires repeated applications of plant protection products to treat crops, anti-resistance strategies are applied. This involves the use of several plant protection products with different modes of action

8. The effectiveness of the phytosanitary measures applied shall be monitored and evaluated.

3. PLANT PROTECTION PRODUCTS

3.3. INTEGRATED PEST MANAGEMENT

3.3.1. How to reduce risks to wildlife and bees when using POR?

In addition to plant protection products, living invertebrate macroorganisms, also called biological predators or bioagents, are also used against pests. There are no harmonised rules for bioagents at EU level and in the Slovak Republic they are regulated by Act No 387/2013 Coll. on auxiliary preparations in plant protection and Decree No 477/2013 Coll. of the Ministry of Agriculture and Rural Development of the Slovak Republic.
When selecting plant protection products, the preference is to use products authorised in organic arable production, e.g. sulphur and copper, approved basic substances such as baking soda can also be used.
Sulphur is probably the oldest fungicide in use. It prevents the growth of fungal spores. If applied early enough (before disease progression), it can prevent many types of fungal infections. However, there are certain plants, such as raspberries, that should not be treated with sulphur. In addition, sulfur applied in hot weather can cause damage (scorching) to plants.
Copper is also used as a fungicide, applied before the plants are infected by fungi. However, copper can also be phytotoxic, so it is important to formulate the product and follow the application rate and other instructions on the product label.

Bicarbonate of soda (sodium bicarbonate) is used as a basic substance with fungicidal effect in the cultivation of vegetables, fruit and vines.
Biological control against rodents is based on the support of predators such as birds of prey (hawks, falcons, owls) as well as ravens, as well as weasels, weasels, foxes, wild pigs and domestic cats. Biological protection consists in creating conditions for their reproduction by maintaining shrubs and trees at the edges of the land, installing boxes and placing T-shaped perches for raptors.

Predators of the field vole are Mustela nivalis, Mustela erminea, Vulpes vulpes, Mustela putorius, Mustela eversmannii, Martes martes, Martes foina, Felis silvestris f. catus, Canis lupus f. familiaris, Sus scrofa, Falco tinnunculus, Buteo buteo, Buteo lagopus, Milvus migrans, Milvus milvus, Pernis apivorus, Circus aeruginosus, Falco vespertinus, Asio otus, Tyto alba, Athene nuctua, Strix aluco, Asio flammeus, Larus ridibundus, Corvus frugilegus, Ciconia ciconia, Ardea cinerea, Corvus monedula, Corvus corax, Phasianus colchicus, Corvus corone, Lanius collurio, Lanius excubitor.

3. PLANT PROTECTION PRODUCTS

3.4. INSECTICIDES

The division of active substances of plant protection products into groups, categories and chemical classes is provided for in COMMISSION IMPLEMENTING REGULATION (EÚ) 2023/1537 of 25 July 2023 laying down rules for the application of Regulation (EU) 2022/2379 of the European Parliament and of the Council as regards statistics on the use of plant protection products to be transmitted for the reference year 2026 during the transitional regime 2025-2027 and as regards statistics on plant protection products placed on the market.

What are insecticides?
An insecticide is a chemical intended primarily to kill insects. It is used primarily in agriculture against pests in field conditions that damage cultivated plants or threaten the population by transmitting certain infectious diseases.

The benefits of pesticides are not only effective in field conditions but also in warehouses, where the elimination of animal storage pests in particular has brought enormous economic as well as humanitarian benefits.

The effectiveness and importance of insecticides in many high-risk areas, where the spread of dangerous insect-borne human diseases (e.g. malaria, sleeping sickness, etc.) has been suppressed, should also be highlighted.
When selecting a plant protection product, the growth stage of the crop, the developmental stage of the pest and the prevention of resistance are taken into account.

By limiting the number of applications of a plant protection product in a given season, selection pressure will be reduced and the risk of resistance will be reduced. Applications should be made in seasons, crop growth stages or pest stages that are critical for optimum control. Pest warning (signalling) systems are used to predict the development of pest populations and thus the optimal timing of product application.

3. PLANT PROTECTION PRODUCTS

3.4. INSECTICIDES

Increasing the application dose above the level of the highest authorized application dose is prohibited Decreasing the application dose without reducing efficacy (e.g. through optimal timing), this may be useful in preventing target resistance. However, if reducing the application rate results in a larger pest population surviving, this may lead to the development of resistance.

When insecticides are applied, the development of resistance is monitored in some target insect species. This is due to the fact that the insects that survive will reproduce and establish another population. Resistance refers to a previously susceptible insect population that can no longer be controlled by the recommended dose of the insecticide. Hundreds of species of harmful insects have acquired resistance to various synthetic and organic pesticides, and strains that have become resistant to one insecticide may also be resistant to a second insecticide that has a similar mode of action to the first. Insecticides can have a negative effect on bioagents, i.e. natural enemies of pests, therefore, when classifying products, the effect on beneficial arthropods is also taken into account (e.g. if the product is harmful to bioagents, it is labelled as 'The product is harmful to populations of beneficial arthropods. Consult your supplier for information on the safety of using this product in combination with the use of a specific species of beneficial arthropod." Where appropriate, individual bioagents shall be listed "The product is harmful to populations of Typhlodromus pyri, Aphidius rhopalosiphi and Orius laevigatus". If the product is not harmful to beneficial arthropods, it shall be indicated as 'The product is of acceptable risk to populations of beneficial arthropods'.

3. PLANT PROTECTION PRODUCTS

3.4. INSECTICIDES

The new herbicides were ground-breaking because, due to their high toxicity, they could effectively control weeds at doses as low as 1 to 2 kg per hectare. These are much smaller doses compared with sodium chlorate, which required doses of around 112 kg per hectare, and carbon bisulphide, which required doses of up to 2 242 kg per hectare. Some of these early herbicides, such as 2,4,5-T, eventually proved to be harmful to both humans and the environment, and in many countries were prohibited. Herbicides that work continue to be produced and some, such as glyphosate, are widely used around the world.

Herbicide-resistant crops (HRCs) are agricultural plants that have been genetically modified since the mid-1980s to resist a particular group of chemical herbicides, particularly glyphosate. Since only HRC plants can survive in fields sprayed with the herbicide in question, these genetically modified organisms (GMOs) allow for effective chemical weed control. Such crops have been shown to be particularly beneficial for no-till farming, which reduces soil erosion. However, these crops remain controversial in terms of their impact on the environment and general safety, as they stimulate more rather than less chemical use. In addition, farmers need to use different weed control techniques to reduce the danger of selecting weeds that are resistant to herbicides.

3. PLANT PROTECTION PRODUCTS

3.5. FUNGICIDES

Fungicides are a specific group of pesticides that kill or restrict the development of fungi that damage plants, wood, leather, paper and other organic matter. Fungicides generally act on fungi by preventing the germination of spores or by destroying or limiting the growth and development of fungal mycelia. If fungicides can effectively kill pathogenic fungi, we speak of a fungicidal effect. If they can restrict the growth of fungi this is a fungistatic effect.

Some fungicides are also bacteriostatic, meaning that they slow down the growth and development of bacteria under certain circumstances.

3. PLANT PROTECTION PRODUCTS

3.5. FUNGICIDES

3.5.1. Division of fungicides

The division of fungicides is:

·Fungicides with a preventive effect prevent infection and must be applied before it occurs.

·Fungicides with a curative effect are able to stop an infection that has already occurred, usually just after its onset, when even macroscopic symptoms are not yet observed.

·Fungicides with eradicative effect have the ability to stop the development of the disease even at the first observable symptoms.

Curative and eradicative modes of action cannot be fully relied upon in most cases, so the principle that most fungicides are applied preventively, i.e. before the outbreak of disease, applies. This is because the effectiveness of fungicides is higher at this time, even though they are also curative or eradicative.

Combination fungicides contain both a systemic and a contact component, combining the benefits of both systems and making the resulting mix more effective than solo applications of individual components. The use of these compound (two- or three-component) products avoids the disadvantages of so-called single-position active substances (interfering with the metabolism of the pathogen at one or two sites), to which resistance often develops.

3. PLANT PROTECTION PRODUCTS

3.6. ACARICIDES

Acaricides are used to kill mites, which are agricultural pests,and ticks, which can transmit encephalitis to humans and pets.

Most insecticides are also effective in controlling mites, but acaricides have more specific and particular uses. Because they were controlled by predatory mites and insects until the mid-20th century, mites (Acari: Tetranychidae)and other mites that attacked cultivated plants were only minor pests of agricultural crops.The increase in mite populations far beyond economic thresholds was due to improvements in agricultural productivity after World War II based on increased use of synthetic pesticides and fertilizers, irrigation, and other cultural practices. When plants were grown under ideal conditions, they became high quality food reservoirs for mites, causing population declines and allowing them to compensate for losses caused by predators. In addition, the widespread use of organochlorine, organophosphorus and carbamate pesticides decimated mite predator populations.

Most first and second generation acaricides are no longer sold on the international market. A few organophosphorus and carbamate chemicals are still available for the control of mite pests of plants, although almost all organochlorines for previously used broad-spectrum insecticides have been severely restricted or banned, mostly due to toxicological and environmental problems.

In addition to chemical acaricides, significant acaricidal activity has been demonstrated in the essential oils of several plants including basil, cumin, citronella, cloves, lemon eucalyptus, mint, peppermint, rosemary, oregano and thyme. Among the constituents of essential oils, carvone, carvacrol, cineole, cinnamaldehyde, cuminaldehyde, eugenol, geraniol, limonene, linalool, menthol, and thymol are known to be useful against mites. The citronellol and farnesol-based formulations act as attractants, thereby increasing mite activity and exposure to the synthetic acaricide applied simultaneously. Other plant extracts and oils (e.g. pyrethrum, rotenone, fatty acids, rapeseed oil, soybean oil, potassium salts of vegetable oils) as well as fermentation by-products also contain commercial preparations with acaricidal activity (polynactins).

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

Herbicides are chemicals used to kill or inhibit the growth of unwanted plants such as invasive species and weeds in residential or agricultural areas. The advantage of chemical herbicides is that they are much easier to apply than mechanical weed control, often resulting in labor cost savings. Although most herbicides are considered safe for both humans and animals, they can significantly harm non-target plants and insects that depend on them, especially when aerial sprayed.

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

History of the use of weed killers

Sea salt, industrial waste and oils were the first substances used in the process of chemical weed control. After its discovery in France at the end of the 19th century, selective control of broadleaf weeds in cereal fields spread rapidly throughout Europe. Copper and iron sulphates and nitrates were used, but sulphuric acid worked much better. Spraying was used for application. Soil sterilisers and sprays containing sodium arsenate soon gained popularity. This hazardous substance was used in huge quantities on miles of railway lines as well as on sugar cane and rubber plantations in the tropics, commonly harming animals and occasionally humans.

The first major organic chemical herbicide, Sinox, was created in France in 1896. As a result of research carried out during the Second World War, new herbicides were developed in the late 1940s, ushering in the era of 'miracle' weed killers. In less than 20 years, more than 100 new compounds were created, produced and used.

Chemical weed control has surpassed the control of plant diseases and insect pests in terms of economic effect. The discovery of selective chemical weed control was particularly important in 1945. At that time, 2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and IPC (isopropyl-N-phenylcarbamate) were introduced. The first two were introduced as foliar sprays against broadleaf weeds and the third was introduced as a soil application that was selective against grass species.

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

The new herbicides were ground-breaking because, due to their high toxicity, they could effectively control weeds at doses as low as 1 to 2 kg per hectare. These are much smaller doses compared with sodium chlorate, which required doses of around 112 kg per hectare, and carbon bisulphide, which required doses of up to 2 242 kg per hectare. Some of these early herbicides, such as 2,4,5-T, eventually proved to be harmful to both humans and the environment, and in many countries were prohibited. Herbicides that work continue to be produced and some, such as glyphosate, are widely used around the world.

Herbicide-resistant crops (HRCs) are agricultural plants that have been genetically modified since the mid-1980s to resist a particular group of chemical herbicides, particularly glyphosate. Since only HRC plants can survive in fields sprayed with the herbicide in question, these genetically modified organisms (GMOs) allow for effective chemical weed control. Such crops have been shown to be particularly beneficial for no-till farming, which reduces soil erosion. However, these crops remain controversial in terms of their impact on the environment and general safety, as they stimulate more rather than less chemical use. In addition, farmers need to use different weed control techniques to reduce the danger of selecting weeds that are resistant to herbicides.

3.7.1. Classification of herbicides

Various characteristics are used to categorise herbicides, such as mode of action, site of action, chemical groups, time of application, selectivity, translocation, etc. It is very important to realise that, given the appropriate amount and application rate, certain weeds that are otherwise resistant to herbicides may also be sensitive to a particular herbicide. However, excessive use of herbicides can cause crop damage and breed resistance in those weeds that the herbicides were intended to eradicate or control. To achieve the best and greatest effect, it is essential to strike a balance between these tactics and select the ideal product.

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

3.7.1. Classification of herbicides

1) Based on the method of application:

- Soil-applied herbicides
- Foliar herbicides

2) Based on the mode of action:

- Selective herbicide: A herbicide is considered selective if, in a mixed stand of plant species, it kills some species without harming others
- Non-selective herbicide: kills most treated vegetation

3) Based on mobility:

- Contact herbicide: contact herbicide kills those parts of the plant with which it comes into direct contact
- Translocated herbicide/systemic herbicide: Herbicide that tends to move from the treated area to untreated areas through xylem/phloem tissues depending on the nature of its molecule

4) Based on the time of application:

- Application before planting: Application of herbicides prior to planting or seeding of crops.
- Pre-emergence: Application of herbicides prior to crop or weed emergence.
- Postemergence: herbicide application after the crop or weed has emerged is referred to as a postemergent application. If weeds emerge before the crop plants appear in the soil and are killed by the herbicide, then it is called an early postemergent application.
- Early postemergent: next herbicide application in slow-growing crops such as potatoes, sugarcane, 2-3 weeks after sowing with classified as early post-emergence.

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

3.7.2. Effects of exposure of bees to herbicides

Exposure to herbicides has been found to adversely affect several components of honey bee life, including drones sperm counts and adult worker survival.

Exposure to single herbicides or combinations of herbicides and metal compounds has also been shown to impair the metabolic functions of honey bees. The effects of glyphosate on honey bee drones sperm were tested and the results showed an LD50 of 0.31 mg/ml, with the amount of dead sperm increasing dramatically with length of exposure and glyphosate concentration. Intake of bentazone and metamitron by honey bees from sugar syrup for 168 h resulted in daily herbicide uptake of 16.16 and 13.87 mm3/bee, respectively.Exposure to bentazone resulted in a daily mortality of 3.21 bees/cluster and increased aggressiveness, while exposure to metamitron resulted in a daily mortality of 13.00 bees/cluster and low to slightly increased aggressiveness and motility of the bees.

Chronic in vitro exposure of larvae to traces of glyphosate (1.25-5.0 mg/l food) resulted in reduced litter weight and delayed hatching. Similarly, exposure to technical grade glyphosate resulted in significantly lower larval weight (doses of 0.08 and 4 mg/l) and survival (doses of 4 and 20 mg/l).

Numerous studies have also shown how herbicides affect learning, sensory perception and navigation in honey bees, for example, learning was negatively affected by prolonged exposure to imidacloprid + glyphosate, with reduced response to sucrose and impaired olfactory learning. Honey bees fed sugar syrup spiked at 10 mg/L (0.500 g per bee) in the feeder spent more time flying home than control bees or bees fed lower concentrations of 2.5 and 5 mg/L (0.125 and 0.250 g per bee), sublethal concentrations of glyphosate affected foraging and home-hive navigation of honey bees. In addition, honey bees given sugar syrup with higher doses of glyphosate made more indirect flights. After the second release, the proportion of direct flights homeward increased in control bees, but not in bees that were treated. This finding reveals that the honey bee's ability to handle a navigational task, such as flight back to the hive, may also be impaired by oral exposure to field-realistic amounts of glyphosate (simulating the amounts present in nectar).

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

3.7.3. Glyphosate - the world's most famous herbicide

The most popular pesticide used today is glyphosate. In 2014, the estimated global sales volume was 825,804 t, of which the agricultural sector used 746,580 t (or 90%) and the remaining t was used by non-agricultural regions. According to the Food and Agriculture Organization (FAO) and the Organisation for Economic Co-operation and Development, this volume represented 18% of the 4,105,783 t of pesticide active ingredients and 92% of the 814,614 t of herbicide active ingredients sold to the agricultural sector worldwide in 2014. (OECD).

Sales of glyphosate, which was first sold in 1974, have steadily increased over the years. In 1994, the agricultural sector was estimated to have consumed 56 296 t of the active ingredient glyphosate, in 2000 this figure had increased to 155 367 t and in 2010 it reached 578 124 t. The introduction of glyphosate-tolerant crop varieties, the increasing number of approved uses of glyphosate in different crops, the introduction of no-till and conservation tillage systems that rely on herbicides (especially in USA and South America), the declining market price of glyphosate and new application techniques are just some of the factors that have contributed to the increase in glyphosate use worldwide. Glyphosate is now widely used in both annual farming techniques and perennial crops.

Glyphosate is a chemical that is widely used in plant protection products (PPPs). Glyphosate-based plant protection products - i.e. products containing glyphosate, adjuvants such as anti-foaming agents and possibly other chemicals - are mainly used in agriculture and horticulture to control weeds that compete with cultivated crops.

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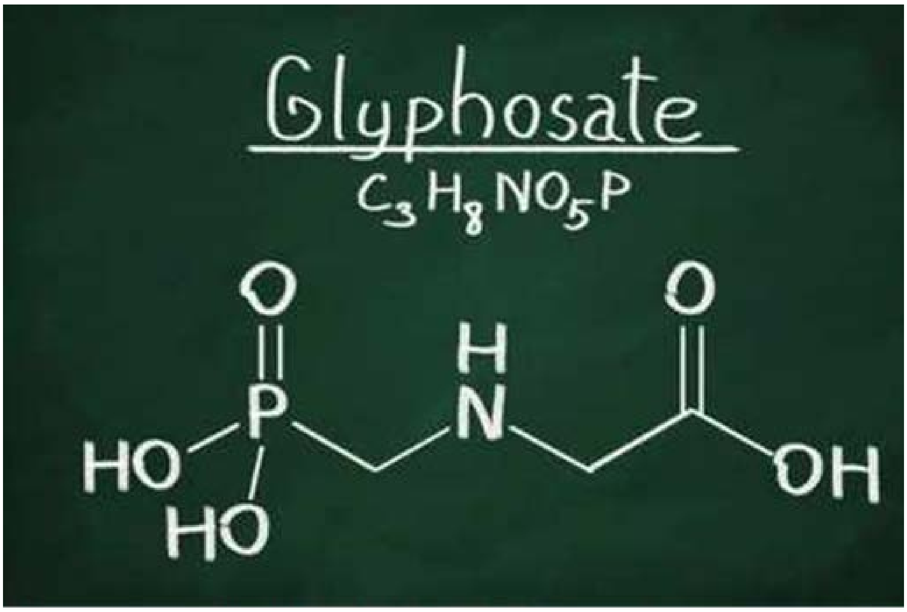

3. PLANT PROTECTION PRODUCTS

3.7. HERBICIDES

3.7.3. Glyphosate - the world's most famous herbicide

At the time of writing, in August 2022, glyphosate is currently approved for use in the EU until 15 December 2022. This means that it can be used as an active substance in plant protection products until that date, provided that each product is approved by national authorities on the basis of a safety assessment.

According to a report by Environmental Sciences Europe, glyphosate is most commonly used in agriculture. Farmers use the handy herbicide to eliminate weeds that compete with crops for sunlight, water and nutrients in the soil. With an estimated 8.6 billion kilograms sprayed since 1974 to help grow crops from peppers to oranges, glyphosate is used more than any other agricultural means.

According to Ramdas Kanissery, a weed expert at the University of Florida in Immokalee, when a chemical is sprayed on a plant, it often penetrates the plant through the leaves. Glyphosate can then spread from these cells to the stem and roots, infecting the entire plant. Plant cells treat glyphosate as if it were an amino acid, because glyphosate is made from the amino acid glycine. Through a process known as amino acid synthesis, plants use amino acids to make the proteins and enzymes they need to thrive. However, if glyphosate enters the plant's amino acid synthesis cycle, it destroys everything. Since glyphosate disrupts the basic enzyme synthesis pathway, preventing the plant from producing essential proteins, the plant will die two to three weeks after exposure to glyphosate. Glyphosate is also used by homeowners to control weeds, and some cities spray herbicide on parks and other green spaces to control exotic species that could crowd out native vegetation. However, because of growing public concerns about the safety of the chemical, several city governments, such as the city of Seattle, Washington, have stopped the practice.

In 2017, glyphosate accounted for 33% of the volume of herbicides placed on the market in Europe. Glyphosate was applied annually to a third of the area used for annual cropping systems and to half of the area used for perennial crops. At least eight agronomic uses of glyphosate are common, including weed control, crop desiccation, cover crop eradication, temporary grassland eradication and permanent grassland regeneration. The use of glyphosate can be divided into two categories: repeated use, which is a frequent practice embedded in farming systems and for which other agronomic solutions may be available but are not used frequently, and occasional use, which is an exceptional use conditioned by meteorological conditions or specific farm constraints.

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

Rodenticides are plant protection products that are used in crop protection against harmful rodents such as:

- Mouse (Mus musculus),
- Brown rat (Rattus norvergicus)
- Dark rat (Rattus rattus)
- Field vole (Microtus arvalis)
- Water bittern (Arvicola terrestris)

In Europe, we regularly record extreme overpopulation of rodents (especially the field vole), which has resulted in significant economic damage to crops in many regions. Field vole populations are cyclically graduating every 5 years, currently 4.5 years due to climate change (no winters).

In 2014/2015, agricultural operators in Slovakia spent tens of thousands of euros on the purchase and application of rodenticides to eradicate voles in agricultural areas. In 2019, there was another calamitous overpopulation of the field vole and, despite preventive measures, there were significant crop losses, up to 80% in some locations. According to information from the Slovak Chamber of Agriculture and Food and the Slovak Chamber of Agrarian Affairs, damage caused by the field vole was reported on an area of at least 63 000 ha and the damage caused amounted to more than EUR 14.5 million.

Due to the mild and dry winter of 2019/2020, there was no natural decline in vole populations and so vole damage did not stop during the winter period and damage to winter crops (winter cereals and winter rape) as well as to perennial forage crops persisted and had significant economic impacts.

Effective control should be ensured by the application of rodenticidal plant protection products (for application on agricultural and non-agricultural land) or biocides (for application in drains, indoors and outdoors around buildings).

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

Season	Abundance(number of burrows used/ha)		
	weak	medium	strong
Spring	10-40	50-200	210 and more
Summer	10-200	210-600	610 and more
Autumn			
winter cereals, winter rape and this year's sowings of lucerne, clover and grasses	10-200	210-600	610 and more
two-year and older sowings of lucerne, clover and grasses, meadows and pastures and other crops	10-400	410-2 000	2010 and more

Due to the mild and dry winter of 2019/2020, there was no natural decline in vole populations and so vole damage did not stop during the winter period and damage to winter crops (winter cereals and winter rape) as well as to perennial forage crops persisted and had significant economic impacts.
Effective control should be ensured by the application of rodenticidal plant protection products (for application on agricultural and non-agricultural land) or biocides (for application in drains, indoors and outdoors around buildings).

Before rodent control can be implemented, it must be certain that rodents are a problem (calamitous occurrence of the field vole). The first step is to identify target areas (plots) and mark the start of rodent elimination.

The limit values for determining the calamitous occurrence of the field vole per 1 ha area are :

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.1. Main types of rodenticides

Anticoagulant rodenticides (overview of approved as well as unapproved active substances)

These rodenticides are the most widely used group of rodenticides for rodent control.

They are used in the form of grains, granules, pellets and paraffin blocks. Their mechanism of action is to inhibit the synthesis of vitamin K-dependent clotting factors, thereby causing death by bleeding into internal cavities or organs.

Roedenticide in pellet form

Rodenticide in paraffin blocks

Symptoms resulting from the anticoagulant effect are: ecchymosis (spotty bleeding on mucous membranes, blood bruising), epistaxis (nosebleeds), subconjunctival hemorrhage (bloodshot eye), gingivorrhagia (bleeding gums), hematemesis (vomiting of blood), haematuria (blood in the urine), anaemia, massive gastrointestinal bleeding, intracranial haemorrhage (bleeding in the brain) and hypovolaemic shock (reduced intravascular blood volume), etc. Vitamin K is used as an antidote.

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.1. Main types of rodenticides

Anticoagulant rodenticides are divided into two groups according to their effect:

- First-generation anticoagulants: chlorophacinone, diphacinone and warfarin,
- Second-generation anticoagulants: difenacoum, brodifacoum, bromadiolone and difethialone. Second-generation anticoagulants are more advanced, more effective and more toxic when ingested once.
- In the European Union, anticoagulant rodenticides can only be used as biocides for rodent control. As plant protection products for the control of agricultural pests in the fields, they are banned on the grounds that, following the placement of anticoagulant baits in agricultural areas, poisoning of wildlife has also occurred, therefore anticoagulant rodenticides are considered to be extremely harmful to wildlife animals (especially birds and mammals). Poisoning of non-target wildlife by these rodenticides has been reported worldwide, e.g. in Denmark, France, the UK and Italy. Long-lasting residues of anticoagulant pesticides have also been documented in soil and field crops.

Non-anticoagulant rodenticides (overview of approved as well as unapproved rodenticide active substances)

- Zinc phosphide: used in baits with a concentration of 1 to 5 %, the most common concentration is 2 %. Zinc phosphide forms hydrogen phosphide gas in the stomach, which, when it enters the bloodstream, damages the central nervous system and causes heart failure. There is no specific antidote against its action
- Alfachloralose: a fast-acting narcotic that slows brain activity, heart rate and breathing, causing hypothermia and death. This substance is only used to kill mice indoors.
- Calciferols: cholecalciferol (vitamin D3) and ergocalciferol (vitamin D2) have also been used for many years to eradicate rodents. They act by facilitating the mobilization of calcium from the bone skeleton, causing hypercalcemia and calcification of soft tissues, especially in the large arteries and kidneys. The use of cholecalciferol has not been included in the biocidal uses of TP14 because the use of this rodenticide may cause direct and secondary intoxication in non-target animals (rodent predators).

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.1. Main types of rodenticides

- Bromethalin: considered effective against many rodent species. After ingestion of an effective dose, anorexia (reduced appetite and non - acceptance of food) occurs in the affected individual. Symptoms include tremors, convulsions, prostration (general body weakness) and paresis to paralysis of the hind limbs. Bromethalin is used in the United States and other countries around the world, but is not approved for use in any EU country.

- Corn husk powder: As a biocidal rodenticide, it is used in granular form.

- Aluminium phosphide: it is inserted into the burrows of rodents in the form of small black, attractive pellets, and when ingested and in c o n t act with hydrochloric acid in the stomach, it releases hydrogen phosphide, which kills the rodents. It is also converted by humidity into phosphine gas, which is very toxic and can poison the rodents present, but in this way the poisonous pellets become non-toxic in a short time due to humidity.

- Dead rodents as well as uneaten pellets do not induce primary or secondary toxicity in predatory and necrophagous mammals and birds. Sodium fluoroacetate: a crystalline powder with no odor or taste, soluble in water. This substance blocks cell metabolism by inhibiting the Krebs cycle enzyme.

- Strychnine: has been used in the past for therapeutic and medicinal purposes in humans, but its main use has been as a rodenticide. Strychnine was withdrawn from use as an active substance in plant protection products by Commission Decision of 30 January 2004.

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.2. Toxicity of rodenticides

Most rodenticides are applied orally, only some are applied in the form of a gas. Unskilled application, as well as leaving rodenticides loose in places frequented by rodents, can cause intoxication of other non-target species. The most common means of poisoning of domestic and wild animals is ingestion of baits containing anticoagulant rodenticides (primary poisoning), but secondary poisoning is also frequently encountered in cats and dogs, or in wild farting birds - birds of prey, storks, etc. Occasionally there are also published reports of poisoning of humans, especially children.

In terms of the degree of toxicity to humans, rodenticides can be divided into the following categories:

a. Low risk: no significant negative impact.
b. Harmful: cause risks of limited severity.
c. Toxic: may cause serious acute or chronic danger and even death.
d. Very toxic: may cause extremely serious acute or chronic hazards, including death.

Examples of toxicity of some selected rodenticides:

NAME	DEFINITION	EFFECTS	HAZARD CLASSIFICATION
Brodifacoum	It is an anticoagulant rodenticide that reduces the blood's ability to clot by inhibiting prothrombin and blocking vitamin K1.	Death comes a few days after ingesting a lethal dose.	Noxious N
Bromadiolone	It is an anticoagulant rodenticide that causes a reduction in the prothrombin rate.	Death occurs from internal haemorrhage some time after ingestion.	Noxious
Bromethalin	It is a fast-acting neurotoxin that affects the brain and liver.	Increases intracranial pressure due to accumulation of cerebrospinal fluid. This causes paralysis, seizures and death.	Very toxic
Chlorophacinone	Fast-acting, indanedione-derived anticoagulant raticide. Highly toxic to rodents, with lower toxicity to humans and other non-target species.	It acts by rendering the blood of rodents that have ingested it uncoagulable. Absorption of these compounds begins after 12-24 hours.	Toxic
Coumatetralyl	It is an anticoagulant rodenticide used mixed with cereal.	Inhibits the production of prothrombin in the liver leading to internal haemorrhages resulting in the death of all types of rodent pests....	Noxious

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.2. Toxicity of rodenticides

NAME	DEFINITION	EFFECTS	HAZARD CLASSIFICATION
Difenacum	Active substance in anticoagulant rodenticides. Declared as potentially persistent, bioaccumulative and toxic, or very persistent and very bioaccumulative. It is a risk to health, animals and the environment.	Its potency is related to its higher affinity for vitamin K epoxide reductase.	Very toxic
Strychnine	An alkaloid obtained from plants of the genus *Strychnos*. It can be absorbed by aerosol inhalation and by ingestion.	Causes central nervous system effects such as convulsions, muscle twitching and respiratory failure.	Very toxic
Flocoumafen	It is an anticoagulant rodenticide that depletes the supply of vitamin K1 and blocks the formation of prothrombin.	The substance can be absorbed by inhalation, through the skin and by ingestion. Effects may be delayed.	Very toxic
Aluminium phosphide	Used as a rodenticide, insecticide and for fumigating stored grain. Nerve, respiratory and metabolic poison. This product may only be used by professional pest control technicians.	Aluminium phosphide is solid, and in contact with air humidity generates phosphamine. It produces a decrease in erythrocytes, haemoglobin, haematocrit, increase in platelets...	Very toxic
Powdered corn cob	It is composed of alpha-cellulose which, when ingested, is deposited in the intestine and disrupts water absorption. It causes severe dehydration of the animal. It affects rodents and not other mammals, which makes it safe for humans and other animals. It is a biodegradable product with a very low environmental impact.	Physiological digestive pathways are disrupted, preventing normal regulation of water and salt levels, leading to reduced blood volume and blood pressure, blood oxygen deprivation and ultimately death.	Low hazard
Warfarina	It is odorless and tasteless and is effective when presented mixed with food, because the rodent returns to the site to continue feeding on the bait until the lethal dose is accumulated.	It is an anticoagulant that reduces the prothrombin content of the blood and predisposes the animal to massive internal bleeding.	Toxic

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.3 Protection of field crops against plagues of field vole

Protection against filed voles is divided into three groups:

A) Preventive

B) Biological

C) Chemical

A) Preventive protection

It consists in adhering to the principles of conventional tillage, sowing practices and agronomic discipline in their application. The main principles are:

• Regular monitoring of field vole on plots in the spring months of March-April and after the second cutting of perennial fodder crops, no-till system for increased field vole incidence, not leaving post-harvest plant residues on the land after harvest (straw, beet leaves, etc.)

• Application of chemical intervention as soon as possible after harvesting of the crops and detection of the presence of field vole populations on these plots

• Carrying out the spraying as soon as possible after harvesting of the crops

• Adherence to traditional tillage practices, including deep ploughing. Deep ploughing can eliminate up to 80-90% of individuals, adapting the crop rotation so that successive crops do not create suitable breeding conditions for the field vole

• Adherence to agronomic discipline in any intervention on land with field vole (sowing practices, soil tillage, chemical protection)

• Increasing the proportion of mature trees on the boundaries and edges of plots and creating suitable conditions for the permanent presence of predators, which are able to effectively regulate vole populations in times of low abundance.

B) Biological protection

Biological control of the field vole is based on the control of the field vole population by natural predators (birds of prey, weasels, etc.). Biological control is not very effective when the field vole over-breeds, because predators react to an increase in the field vole population with a time lag.

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.3 Protection of field crops against plagues of field vole

C) Chemical protection

Zinc phosphide-based preparations are authorised in the Slovak Republic for the chemical protection of field crops against the field vole. The success of chemical control depends on:

- from knowing the life of the pest
- the correct application
- coordinated action

The following principles must be observed in chemical protection:

- study the label and dosage of the product thoroughly, do not apply the product on the surface of the land without vegetation, apply the product in dry and stable weather (do not apply before rain, snow or in heavy dew),
- apply the product as soon as possible after harvesting the crop before any agrotechnical intervention, to treat the edges of the land - borders, ditches, etc.,
- when applying to burrows, apply appropriately to burrows, not to piles around burrows,
- it is forbidden to use anticoagulant rodenticides in the eradication of the field vole, as they are highly toxic to humans and all warm-blooded animals (field animals, non-target organisms) and leave residues in the environment, enter the food chain as residues in plants and are deposited in the body of dead rodents and subsequently kill their natural predators.

The main principles for the successful use of zinc phosphide-based preparations:

- Do not use the product on land without vegetation, in snow and in rain,
- apply in dry sunny and windless weather,

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.3 Protection of field crops against plagues of field vole

Conditions for the application of rodenticidal products in the event of calamitous occurrence of the field vole:

1. The preparation used must be authorised for this purpose in the Slovak Republic.

2. Products can only be applied deep into active burrows, or poison stations can be used, or good results can also be achieved by using brick drainage pipes. Within a single vole colony, we recommend applying the product to 3-5 burrows.

3. A maximum of 30g (in the burrow) or 60g (in the poison station or in the drainage pipe) of bait can be placed per application site, provided that the dosage per hectare (max. 10 kg per hectare) is observed.

4. Under no circumstances should larger doses be placed loose in the field!

5. Collect the dead voles and bury or burn them in a pre-designated place.

6. Any application of rodenticides under field conditions must be reported, together with the date of application, to the relevant Hunting Association for the purpose of wildlife protection.

7. In order to minimise the risk of application to wild predators, it is recommended to carry out the eradication of field vole in the early dry pre-spring or late autumn period.

3.8.4. Impact on wildlife. Can bees and other pollinator species be affected?

In the case of deployment of anticoagulant rodenticide baits in agricultural areas, poisoning of wildlife occurs, therefore anticoagulant rodenticides are considered to be particularly harmful to wildlife (especially birds and mammals). Poisoning of non-target wildlife by these rodenticides has been reported. The long persistence of second-generation anticoagulants in the tissues of rodents and non-target species makes these poisons more dangerous to these organisms than first-generation anticoagulants. Therefore, the use of anticoagulant rodenticides under field conditions is PROHIBITED!

Few studies exist, so further research is needed on the impact of rodenticides on bees and other pollinator species. According to the National University of Costa Rica, we only know the effect of some substances, such as chlorophacinone, which has a moderate effect on bees, while aluminium phosphide has a high ecotoxicological effect on these pollinators if the correct application or good agrotechnical practice is not followed.

3. PLANT PROTECTION PRODUCTS

3.8. RODENTICIDES

3.8.3 Protection of field crops against plagues of field vole

Only by strict adherence to good agrotechnical practice can we prevent possible secondary intoxication of animals and eliminate the risk to human health and the environment.

Zinc phosphide-based preparations are authorised in the Slovak Republic for the chemical protection of field crops against the field vole.

The use of other rodenticidal biocidal products, e.g. based on warfarins or superwarfarins (bromadiolone, brodifacoum, difenacoum, chlorophacinone, difethialone, etc.) or other active substances is strictly forbidden under field conditions. These pose enormous acute and enormous chronic risks to non-target organisms. Their toxicity ranges from 0,2 to 6 mg/kg live weight. These active substances hardly degrade in the environment and their application to fields or non-agricultural land almost invariably results in the death of birds, birds of prey and other wildlife. In addition, residues of these active substances can be found in the soil and in plants even several years after application. Residues of these substances thus pose a risk to humans via the plant food route.

3.9. OTHER PESTICIDES

Nematicides

Nematodes are microscopic non-segmented worms that inhabit most habitats on Earth. There are bacterivorous nematodes, fungivorous nematodes, predators of other nematodes, parasites of insects, and herbivores or parasites of plants that cause damage to crops. Nematicides are used to protect plants against these pests. Nematicides are chemical pesticides used to kill nematodes.

Molluscicides

Molluscs are soft-bodied animals in which a cephalothorax or head, a visceral mass and a muscular leg can be recognised. With the exception of some groups, they have a calcareous shell that protects the visceral mass, which have no or an internal shell. Some species of molluscs, such as snails and slugs, are considered pests in agriculture, especially in leafy vegetables, as they can cause considerable damage to crops.

Crop damage caused by slugs and slugs can be controlled by the use of molluscicides, which are chemicals that act as repellents, eliminate pests or prevent their development.

Commonly used molluscicides were highly toxic metaldehyde-based formulations that could be harmful to other non-target animals and even to humans who handled them.

3. PLANT PROTECTION PRODUCTS

3.9. OTHER PESTICIDES

The newer products are based on ferric phosphate, which occurs naturally in soil and is approved under Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market as a low-risk substance. Ferric phosphate does not dissolve in wet weather and is not a pollutant as it is a mineral that is used as a nutrient by many micro-organisms. It is a helicid molluscicide that, when ingested by snails and slugs, disrupts their metabolism, attacks their intestines and causes them to stop feeding immediately. It is compatible with the environment.

Growth regulators

Growth regulators are plant protection products that act as structural analogues of plant hormones or as agonists or antagonists of their action.

Seed treatment

Seed treatment is an important part of an integrated pest management system.

The need for seed protection has been addressed by growers since ancient times. The first attempts at seed treatment date back to the 17th century, when researchers were interested in protecting seed against the wheat weevil (Tilletia caries). In the period after the Second World War, seed treatment became a common part of agricultural production. Nowadays, the practice is intensively used mainly for fungicide or insecticide treatment, which makes production more efficient, reduces economic costs and also reduces the burden on the environment.

The most widely used are fungicides targeting a group of pathogens causing rotting of sprouts and germinating plants and a group of seed-borne fungi that do not directly attack the seed but cause infections at later growth stages.

Insecticidal seed treatments are mainly used on plants where it is necessary to reduce their damage by animal pests in the initial stages of vegetation.

The third group of seed treatments that have their justification in intensive crop production are biostimulators. These contain very small amounts of nutrients, plant hormones or other substances beneficial for growth, which provide germinating seeds and emerging plants with energy for more even germination, emergence or more intensive rooting.

The quality of treatment is important to achieve the desired biological treatment efficiency but also in relation to environmental protection.

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Chapter 4

FERTILIZERS

4. FERTILIZERS

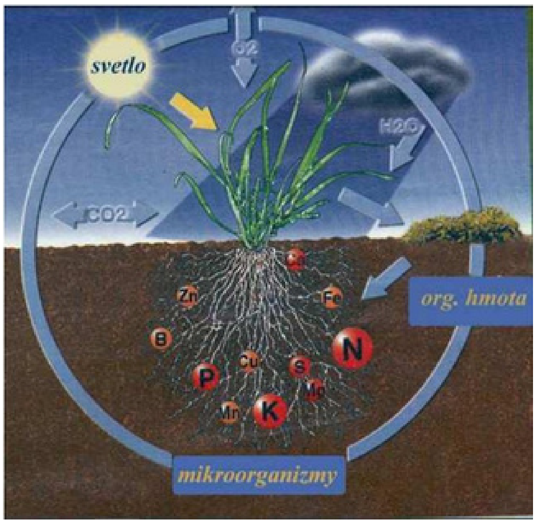
4.1. INTRODUCTION

All plants need a certain amount of essential nutrients and trace elements for their growth and fertility from spring to autumn, which need to be supplied to the soil before or during the growing season.

Agricultural plants, like all green plants, are autotrophic organisms that make the organic substances necessary for building their bodies from inorganic compounds. In doing so, they use light energy and convert it into potential energy latent in the organic matter.

Elements necessary for the growth and normal development of plants and irreplaceable in their function by other chemical elements are called plant nutrients. They are substances that the plant organism needs to sustain its life. Plant nutrients are inorganic in nature, which makes plants significantly different from animal organisms, whose food is mainly organic substances produced by plants. The tissues of a plant organism consist of water and dry matter.

Although the mineral content of the plant body is small, it allows plants to form organic matter through photosynthesis.



Water has several functions in the plant:

- supplies the plant with hydrogen and oxygen,
- is a solvent of mineral nutrients,
- mediates the transport of soluble assimilates,
- swelling of organic colloids of cell plasma,
- participates in physiological processes in plants.

4. FERTILIZERS

4.1. INTRODUCTION

Plants produce dry matter from CO2 in the air, water and mineral salts from the soil. The dry matter contains on average 45% C, 42% O, 7% H and 6% other elements.

Of this, about 1.5% is nitrogen and 4.5% is fly ash. Without the participation of nitrogen and ash, as well as sugars and other non-nitrogenous organic substances, protein formation is not possible. The basic biologically most important biological elements involved in the formation of plant organic matter are divided into:

Macronutrients:

a: C, H, O, N,

b: P, S, Ca, K, Mg, Fe,

- C-H-O: are mainly taken up from the air through photosynthesis, respiration and water, although they can also be taken up from organic matter available in the soil or through fertilisation. It is not necessary to provide them in fertiliser, although their contribution can be very beneficial.
- Major or primary macronutrients (N-P-K): these are the essential macronutrients that the plant needs in the greatest quantity and, with the exception of legumes, which are able to absorb nitrogen from the air in conjunction with nitrogen-fixing micro-organisms, are essential in agriculture to provide them in fertilisers. Nitrogen (N) contributes to the growth of leaves and the vegetative development of all the aerial parts of the plant (it is essential to apply it without excess, as it would be detrimental to the development of flowers, fruits or bulbs); phosphorus (P), the development of roots, flowers, seeds, fruits. Phosphorus strengthens plant resistance; Potassium (K), strong stem growth, water movement in plants, promotion of flowering and fruiting (potassium is found in wood ash).
- Secondary macronutrients (Ca-Mg-S): these are essential macronutrients that the plant needs in smaller quantities, although still much more than micronutrients.

Micronutrients:

- B, Mn, Cu, Zn, Co, Mo,
- Elements useful: Si, Al, Cl, Na.

The period during which plants take up nutrients from the external environment is called the plant nutrition period. The length of the plant nutrition period does not coincide with the length of the growing season. The nutrient requirements of plants vary and are closely related to the biological peculiarities of the species and cultivars.

4. FERTILIZERS

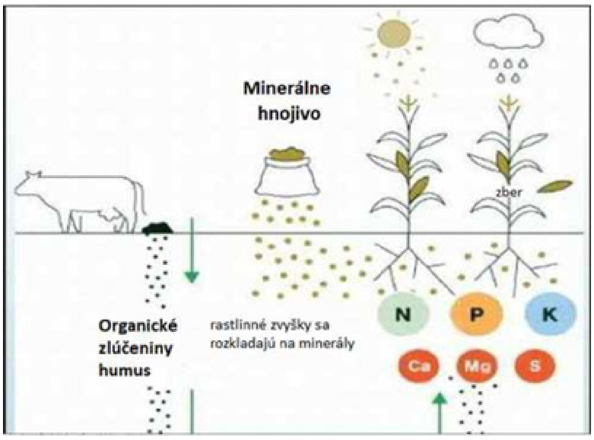
4.1. INTRODUCTION

The nutrient requirement of plants depends on the dynamics of the intensity of nutrient demand during vegetation (quantitative aspect of nutrition) and changes in the ratios of nutrients taken up (qualitative aspect of nutrition).

Carbon is taken up by plants from the air as CO2, together with water taken up by the plant roots with the help of chlorophyll and solar energy to form organic matter in photosynthesis.

Nutrients are mainly taken up by plants from the soil environment. Plants are only able to take up all the substances necessary for life in mineral form. Nutrients found in organic matter, in humus or in organic fertilisers can only serve as nutrition for plants after prior mineralisation, i.e. after decomposition of the organic matter.

The intensity of plant growth depends, among other things, on the amount of mineral nutrients taken up. The amount and ratio of nutrients that most favourably influence the yield and quality of the crop must be determined with regard to the growth state and development stage. For normal growth and development, the plant needs ten basic elements, which we call biogenic - essential for life. These are oxygen, hydrogen, carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and iron. If any of these elements were lacking in the diet, the plant would live only as long as the supply was sufficient. When these are exhausted, it would perish. In addition to these basic elements, it would die. other elements are still present in the plant, but only in minute quantities in trace amounts, and are therefore also called trace elements. These are boron, sodium, silicon, zinc, copper. Plants take up nutrients either from the air (oxygen, carbon) or, to a large extent, from the soil (nitrogen, phosphorus, potassium, magnesium, calcium and others). In doing so, plants do not take up elements in pure form, but in the form of various chemical compounds. For example, phosphorus is taken up in the form of phosphates, nitrogen in the form of ammonium cations or nitrates, etc. All nutrients must be in balance. Liebig's law of minimum states: "If one of the basic biogenic elements (N,P,K,Ca) is present in the soil in insufficient quantities, the plant can only use the other three nutrients in a limited form, even though they are abundant in the soil".



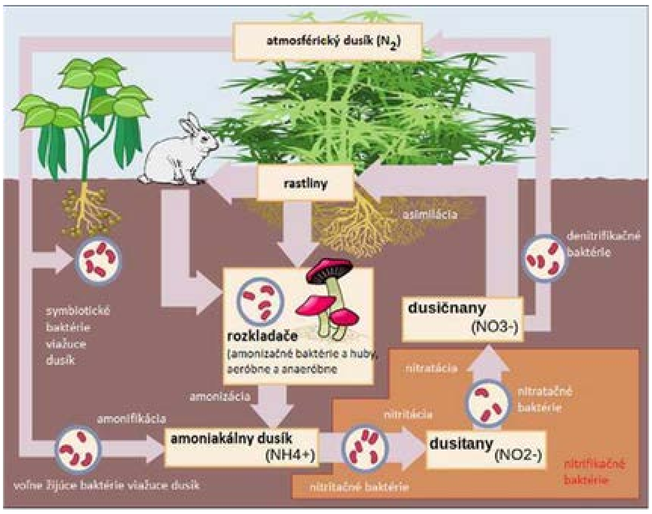
4. FERTILIZERS

4.2. THE IMPORTANCE OF INDIVIDUAL ELEMENTS

Plants consist of four main elements: hydrogen, oxygen, carbon and nitrogen. The first three are widely available in the form of water (H_2O) and carbon dioxide (CO_2). Nitrogen, although it makes up most of the gaseous composition of the atmosphere, is in a form that is not available to plants. Nitrogen is the most important nutrient because it is present in proteins, DNA and other essential plant components such as chlorophyll. For nitrogen to be nutritious for plants, it must be available in a 'fixed' form. Only some bacteria and their host plants (especially legumes) can fix atmospheric nitrogen (N_2) by converting it to ammonia. Phosphate is needed for the production of DNA and ATP, the main energy carrier in cells, as well as some lipids.

Oxygen, carbon and hydrogen are the basic building blocks of a plant. Plants take up oxygen and carbon from the air. Man cannot influence their supply, except perhaps by making sure that the plants are not dusty. The plant gets hydrogen by the decomposition of water in photosynthesis.

Nitrogen - this i s one of the most important elements in plant nutrition, and its content in the soil can vary greatly over a short period of time. Nitrogen, although it makes up most of the gaseous composition of the atmosphere, is in a form that is not available to plants. Nitrogen is the most important nutrient because it is present in proteins, DNA and other essential plant components such as chlorophyll. For nitrogen to be available to plants, it must be available in mineral form. Only some bacteria and their host plants (especially legumes) can fix atmospheric nitrogen (N_2) by converting it to ammonia. Plants take it up in the form of ammonium cation or nitrate. The nitrogen that is not taken up by the plants remains in the soil as nitrate and enters the groundwater under the influence of rain or melting snow. Nitrogen is the only nutrient that is not used to fertilise the soil, but the plant. Therefore, care must be taken to give plants only as much nitrogen as they are able to consume.



Source:
cs.wikipedia.org/wiki/Kolobeh_dusíka

4. FERTILIZERS

4.2. THE IMPORTANCE OF INDIVIDUAL ELEMENTS

Phosphorus: This element is an important building block for the cell nucleus, supports the formation of flowers, fruits, seeds and roots, and is therefore most needed by plants at the time of fruit set. Phosphorus acts in the opposite way to nitrogen - it shortens the growing season. Excess leads to growth disorders. Iron supply is blocked and further nutrient deficiencies (manganese, boron, zinc and copper) occur.
Calcium: It ensures a good soil structure and is needed for the formation of cell walls. Unlike other nutrients, the plant stores calcium in its system permanently. Plants in acidic, often waterlogged and poorly aerated soils suffer from calcium deficiency. Such soils need to be limed or drained.
Excess calcium prevents plants from taking up phosphorus, iron magnesium and other elements. Both deficiency and excess of calcium show up in the same way on the outside - chlorosis (fading of the plants' weeds).

Magnesium: It is the most important building block for foliage and protein production, and is particularly needed by plants for chlorophyll production, as it is an essential component of foliage. When magnesium is deficient, green plants turn pale or even yellow. Compared to other elements, plants do not need very large amounts of magnesium. Most of the time, the natural supply in the soil is sufficient for them. Magnesium deficiency usually manifests itself in the typical chlorosis. If we remove the excess calcium in the soil, this will usually adjust the normal uptake. Magnesium is of great importance in the formation of flowers, fruits, seeds. Seeds have a high magnesium and phosphorus content. Mature seeds of some plants contain even 3 times more magnesium than calcium.

Potassium: Strengthens plant cell walls, regulates water supply and promotes frost resistance. Plants are weakened and leaves wither from the inside out if not watered properly. Excess inhibits growth and can lead to plant death because the salt content of the soil is high.

Sulphur: Plants have different sulphur requirements. Fruit plants need a tiny amount. Celery, onion, garlic, tomato have high requirements. These crops are fertilized with sulphate, which contains sulphur in addition to the main nutrient.

Iron: required for chlorophyll formation and other plant life processes. However, plants need only a very small amount of it, which is usually enough to cover the natural supply in the soil. A deficiency is manifested by a lack of leafy green foliage, so that the plants turn pale. Fe deficiency sometimes manifests itself when there is an excess of calcium in the soil. I can supply iron, especially to fruit plants, by top dressing with a 1% solution of green lily of the valley.

Trace elements: of the trace elements, boron is particularly important, especially for legumes and potatoes, but also for the proper development of other plants. Boron deficiency in woody plants is manifested by drying of the vegetative tops, poor flower set and small, leathery, curled leaves.

4. FERTILIZERS

4.2. THE IMPORTANCE OF INDIVIDUAL ELEMENTS

Boron deficiency also promotes the development of some diseases, e.g. apple scab. Silicon is important as a building substance and, together with Ca, is important in the formation of stone and woody parts. As for chlorine, some plants need it (celery) but for most plants it is harmful, so it reduces the usefulness of the plants. The most sensitive to chlorine are grape vines, berries, potatoes. Aluminium is involved in the formation of flower colour. Copper is of similar importance to aluminium for plants, with white spots forming on leaves when copper is deficient. Plants usually need a tiny amount of molybdenum and its deficiency is hardly noticeable. Only cauliflower does not form florets when it is deficient in molybdenum. Plants need such minute amounts of trace elements that the natural supply in the soil is usually sufficient. It is, however, advisable to occasionally supplement the plants with some trace elements in the form of various fertilisers. So - the right fertiliser should be chosen according to what it is intended for - to produce flowers, leaves, to encourage further flowering or to give the leaves a nice colour. If you read carefully the article on the different elements, you will find out which fertiliser is right for your plants. The period during which plants take up nutrients from the outside environment is called the plant nutrition period. The length of the plant nutrition period does not coincide with the length of the growing season. The nutrient requirements of plants vary and are closely related to the biological peculiarities of the species or even the cultivars. The nutrient requirements of plants depend on the dynamics of the intensity of nutrient demand during the growing season (the quantitative aspect of nutrition) and changes in the ratios of nutrients taken up (the qualitative aspect of nutrition).

Intensification tools in crop production clearly include plant nutrition, which should be targeted and focused on the type and method of crop production. Plant nutrition is applied by means of fertilisers based on soil analyses, the crops grown and the use of optimal techniques.

Fertilisers are substances that either provide nutrients for plants or improve plant nutrition, acting directly or indirectly on plant growth and development, yield and quality, and soil fertility and aeration. Nutrients necessary for healthy plant development are classified according to elements, but these elements are not used as fertilisers; instead, compounds containing these elements are the basis of fertilisers.

In the past, natural or organic sources were used for fertilisation, including compost, manure, crop rotation and by-products of certain industries. In the 19th century, following innovations in plant nutrition, an agricultural industry based on chemically produced fertilisers developed. This transition was important in the transformation of the global food system, as it allowed for a larger-scale industrial agriculture with high crop yields. Chemical nitrogen fixation processes became very important in the 20th century (with an 800% increase between 1961 and 2019), when they were a key component of the increased productivity of conventional food systems

4. FERTILIZERS

4.3. CLASSIFICATION AND TYPES OF FERTILISERS

Fertilisers are divided into:

A: by efficiency:

- Direct
- Indirect

B: by composition:

- Inorganic:

1. produced by chemical means
2. derived from natural sources

- organic:

1. produced by chemical means
2. from natural sources

- organic- mineral:

1. produced by chemical means
2. derived from natural sources

C: by aggregate

- Solid
- Liquid

Fertilisers are usually classified according to the nutrients they provide:

- Primary nutrients: we know single-component fertilisers and multi-component fertilisers. We call fertilisers NPK if they contain all three nutrients. Otherwise, we call nitrogen, phosphate, potassium, NP, NK or PK fertilisers.

- Secondary nutrients: fertilisers to correct calcium, magnesium or sulphur deficiencies.

- Primary and secondary fertiliser mixtures: for example, NPK (Mg) with formula 7-12-40 is a fertiliser with 7% N, 12% P O25 , 40% K2 O and 2% MgO.

- Micronutrients: deficiency correctors for Fe, Mn, Mo, Cu, B, Zn, Cl, etc. They can be marketed as correctors of a single micronutrient, of several micronutrients and even in combination with any of these substances.

4. FERTILIZERS

4.3. CLASSIFICATION AND TYPES OF FERTILISERS

Two sets of enzymatic reactions are very important for the effectiveness of nitrogen fertilizers. The first is hydrolysis, or the reaction of water with urea. Many soil bacteria have the enzyme urease, which catalyzes the conversion of urea to ammonium ion (NH_4^+) and bicarbonate ion (HCO_3^-). On the other hand, there is oxidation of ammonia by some bacteria, such as species of the genus Nitrosomonas, which oxidize ammonia to nitrite, a process called nitrification, or nitrite-oxidizing bacteria, especially species of the genus Nitrobacter, which oxidize nitrite to nitrate, which is extremely mobile and is one of the main causes of eutrophication.

Recently, nitrogen fertilisers have been used in combination with inhibitors that slow down their decomposition and thus prevent their nitrogen loss to the air or leaching into groundwater.

Secondary nutrients and micronutrients are usually present in sufficient quantities in the soil and are only added when they are deficient. Plants have a need for relatively large amounts of primary elements. Nitrogen, phosphorus and potassium are the elements that are absorbed in the greatest quantities and often require addition in the form of fertilisers. NPK fertilisers form the basis of most fertilisers sold today. Nitrogen is the most important and controversial of these because of the high solubility of nitrates in water and their contamination of groundwater when misused.
According to nutrient availability:

Slow-release fertilisers deliver nutrients slowly and evenly. This makes nutrients available to the crop for a longer period and minimises nutrient losses. The fertiliser granules are coated with a polymer that protects the soluble fertiliser and controls the rate of nutrient release.

There are also controlled-release fertilisers that use a different coating technology, such as polymer matrices. They are coated with polymer or inorganic materials such as sulphur. When using the polymer matrix technique, the matrix is dispersed in the fertiliser and slows down its dissolution. Materials used as matrix include rubber, polyolefins or gel-forming polymers.

The release of nutrients from slow-release fertilisers is difficult to predict because it is influenced by many factors including soil moisture, temperature, pH or microbial fauna, whereas the release of nutrients from controlled-release fertilisers can be better predicted because it is not strongly influenced by soil conditions but rather by soil temperature and the properties of the packaging materials.

4. FERTILIZERS

4.3. CLASSIFICATION AND TYPES OF FERTILISERS

According to their solubility in water:

- Solid fertilisers can be water soluble or water insoluble.
- Water soluble fertilisers. Some are considered very soluble in water and can be used in 'fertigation'. Solubility also varies between fertilisers depending on the temperature of the water.
- Water-insoluble fertilisers last longer in the soil and are less prone to leaching.

According to the time of application of plant nutrients, the following types of fertilization can be distinguished:

- Ameliorative - application of plant nutrients to achieve a major modification of their content in the soil, or to achieve a major modification of other soil properties (e.g. reduction of soil acidity by liming). It is a one-off measure with a long-term effect. It is usually carried out in connection with the preparation of the land for planting.
- Pre-fertilisation - fertilising with a nutrient several years in advance, and generally not fertilising with that nutrient in subsequent years.
- In soil preparation - usually the full dose of phosphate and potassium fertiliser is applied, possibly some secondary and micronutrients. However, in the case of nitrogen, only part of it is applied.
- Per leaf - fertilize throughout the growing season.

We know fertilisers according to the method of application of plant nutrients:

- Soil - the fertiliser is worked into the soil and the plants take up nutrients from the soil exclusively through the roots. Off-root - so-called foliar - fertilization on the above-ground part of the plant (leaves), in order to take advantage of the plant's ability to take up nutrients through the leaf surface.
- Irrigation - fertiliser is applied at the same time as the application of water used for watering or irrigation (drip irrigation, sub-irrigation, etc.). In fertigation, fertilizers are applied in the irrigation water, so that nutrients are distributed over the entire area, i.e. both green and soil.
- Special - nutrients are applied to take into account the specific requirements of plant cultivation (soilless so-called hydroponic or aeroponic cultivation, etc.), or to take into account the specific requirements of the cultivated plants to the maximum extent possible (submerged cultivated plants).

4. FERTILIZERS

4.3. CLASSIFICATION AND TYPES OF FERTILISERS

According to the function of the fertilizer in the nutrition of the crop, we know fertilization:

- Amelioration - pre-plant (see above);
- Basic - fertilization before the start of the growing season;
- Regeneration - fertilisation with an appropriate nutrient (usually nitrogen) or a complex foliar fertiliser to improve the condition of the crop (fertilisation of winter crops in spring, fertilisation of waterlogged crops, fertilisation of perennial crops in spring after a severe winter, etc.);
- Optimisation - application of nutrients on the leaf or by irrigation to optimise the nutrient content of the soil in relation to other nutrients (based on diagnosis of the nutritional status of the plants (leaf diagnostics, soil analyses, etc.);
- Prophylactic - application of nutrients (usually to the leaf) when nutrient deficiency is not established but an exceptionally high yield is expected and other vegetative factors are in a very favourable physiological relationship;
- Preventive - application of plant nutrients regardless of their specified content, usually according to the known requirements of the crop being grown;
- Maintenance - application of approximately the amount of nutrients that are removed from the soil each year by agricultural activity (harvesting).

Other special types of fertilizers are:

- Biofertilizers - fertilizers for plants containing living microorganisms. Similar to organic fertilizers, they are also used in organic farming because they are environmentally friendly and provide for the soil microbiome;
- Biostimulants - also contain microorganisms, but the difference with biofertilizers is that microorganisms do not promote nutrient uptake from biofertilizers but stimulate plant growth and counteract abiotic stresses.

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4. FERTILIZERS

4.4. ORGANIC FERTILISERS

Organic fertilisers are a very important group, especially in recent times.

Organic fertilisers are a very diverse group of products. Their properties and benefits depend on their origin, their processing and how they are used or combined in specific conditions. Compared to inorganic fertilisers, they maintain soil quality - increasing soil organic matter as well as improving the physical and chemical properties of the soil, including aeration, permeability, water holding capacity and nutrient retention capacity. In general, their main common denominator is that organic fertilisers provide a sustainable option to avoid the negative impacts of chemical fertilisers on long-term soil fertility, reduce vulnerability to climate stress and weather variability, and at the same time reduce the negative impact of agriculture on the environment.

Their benefit depends on the exact type of organic fertiliser used as well as on the soil properties. Organic fertilisers can be used alone or in combination with other fertilisers. Types of organic fertilisers that contain organic matter contribute directly to increasing the organic carbon content of the soil, but the fungi and microbes contained in certain types of organic fertilisers, as well as the effect of pH and the proportion of other nutrients and micronutrients, will affect the dynamics of soil biota and ecosystems. Soil organisms are essential for soil fertility by making nutrients available to crops. A healthy soil ecosystem decomposes organic matter, makes nutrients available, prevents nutrient leaching and fixes nitrogen. It also protects plants from pathogens, improves soil structure and promotes well-functioning root systems. Soil microbial activity benefits crops and supports agricultural productivity, but can also lead to a net increase in greenhouse gas emissions, depending on the balance and conditions. Tillage will also increase microbial activity, which contributes to emissions. Total global average net GHG emissions ($CO2$, CH 4 and $N2O$) across all sectors in 2007-2016 are estimated at 52.0 ± 4.5 $GtCO2eq$ per year, of which agriculture directly contributes 17-22%. In terms of net $CO2$ between the soil and the atmosphere, there is considerable uncertainty. Soil waterlogging and compaction also contribute to $CH4$ emissions.

The use of organic fertilisers seems particularly interesting under conditions of stress and weather variability. The use of organic fertilisers alone is not sufficient to address these challenges, but in combination with other sustainable agricultural practices it can be an important component of farmers' climate change adaptation and mitigation strategies. Combinations of approaches lead to synergies, not only in terms of nutrient bioavailability, but also in terms of water balance, erosion prevention, pest and pathogen control and resilience to other stress factors.

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4. FERTILIZERS

4.4. ORGANIC FERTILISERS

Organic fertilisers can therefore play a key role in supporting soil biota and soil fertility. Improved yields, availability and relatively low cost make organic fertilisers an attractive alternative for farmers. In semi-arid areas, improving soil quality is an important aspect, which in turn affects soil water retention, while better root development helps crops withstand heat and water stress. Organic fertilisers thus support adaptation to climate change and regional food security. Soil quality is critical for carbon sequestration, while increased nutrient and water retention reduces the impacts of agricultural runoff on groundwater and water bodies. Degraded soils have poor water retention capacity, require more fertiliser and are less able to contribute to carbon sequestration.

The transition to sustainable farming with organic fertilisers should also consider the selection of appropriate cultivars that retain the ability to take full advantage of improved soil health. The carbon sequestration capacity of soils is expected to decrease as a result of global warming. Soil quality is critical for carbon sequestration, while increased nutrient retention reduces the impact of agricultural runoff on groundwater and water bodies.

In recent years, the quality and health of soils fertilised with e.g. exogenous organic matter from waste, which is part of the principles of sustainable development and circular economy, has been widely recognised and of great interest to a wide range of scientists from all over the world. There is a pressing need to use the abundance of organic fertilizer sources as a substitute to reduce the use of inorganic fertilizers. Research should focus, for example, on the use of organic fertilisers (including waste material) in new products (e.g. biochar, compost) and their impact on soil quality. Fertiliser selection cannot be seen in isolation, but as part of overall soil management practices.

Given the numerous factors that influence the outcomes of organic fertiliser use, the recommendations move towards a combination of approaches to improve soil health and sustainable land management. However, there is still a lack of sufficiently detailed data on how different management practices affect yields and environmental impacts depending on local conditions.

The need to increase the use of organic fertilisers, in terms of ensuring good soil quality, the ever-decreasing supply of conventional fertiliser sources and the need to mitigate the increase in waste generation, it is essential to take all these aspects into account in order to achieve a positive outcome.

4. FERTILIZERS

4.4. ORGANIC FERTILISERS

When classifying fertilisers into the "Organic fertilisers" group, we can base our classification on a number of factors and the different groups will differ from each other accordingly. For example:

- Organic fertilisers are fertilisers with organically fixed carbon,
- Organic fertilizers are fertilizers with organically fixed carbon that does not come from fossil sources,
- Organic fertilisers are fertilisers made from biodegradable materials and by-products of production or by-products of animal production processed by non-chemical methods,
- Organic fertilisers are fertilisers made from biodegradable materials and by-products of production or by-products of animal production, also processed by chemical methods,
- Organic fertilisers are fertilisers that, by their nature, affect the organic matter content of the soil.

Organic fertilisers certainly include farm fertilisers (farmyard manure, slurry, slurry, slurry and poultry manure), the production of which is directly related to the size of livestock holdings. Green manure and the use of straw applications, composts and digestate as a by-product of anaerobic digestion must certainly not be overlooked.

4.5. APPLICATION METHODS

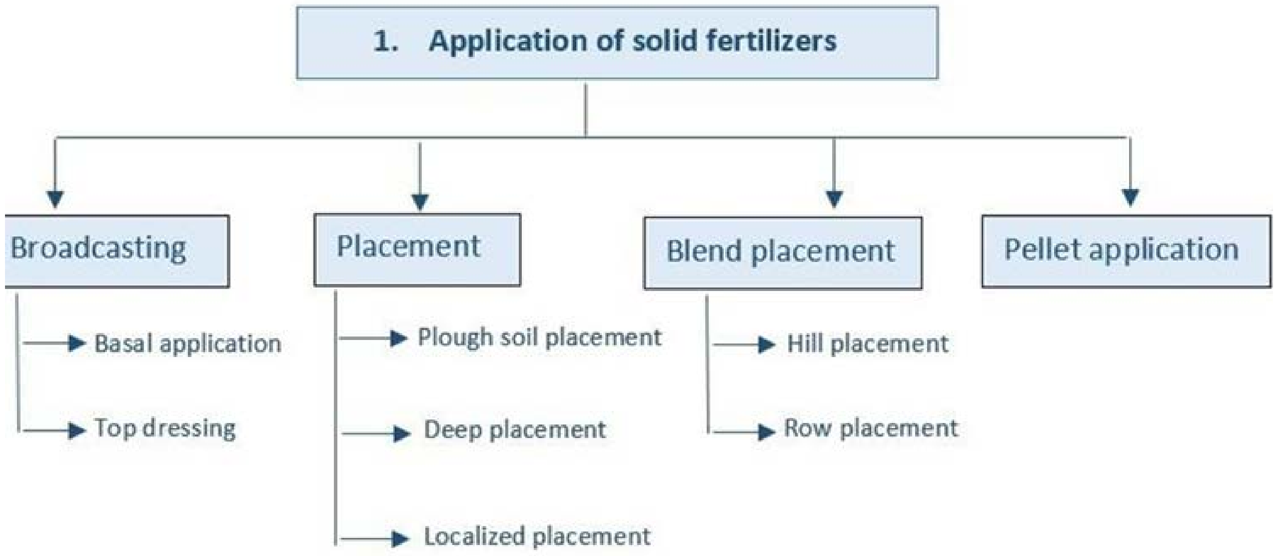
Farmers apply fertilizers in a variety of ways, through different application methods, using manual methods and, more commonly, through large farm equipment. Among others, there are dry, granular or liquid application methods.

4. FERTILIZERS

4.5. APPLICATION METHODS

4.5.1. Application of solid fertilisers

The most common methods are:



I) Broadcasting

Spread fertiliser evenly over the entire field. This method is suitable for crops with dense growth where the roots of the plants penetrate the entire soil volume. Large doses of fertiliser are applied and insoluble phosphate fertilisers such as rock phosphate are used. Fertiliser spreading is of two types.

A) Basal application (spreading at sowing or planting)

The main objective of fertiliser application at the time of sowing is to distribute the fertiliser evenly over the entire field area and to mix it with the soil.

B) Top dressing.

It is the application of fertilisers, particularly nitrogen fertilisers, to closely sown crops such as wheat to supply the growing plants with nitrogen in a readily available form.

4. FERTILIZERS

4.5. APPLICATION METHODS

4.5.1. Application of solid fertilisers

The main disadvantages of fertiliser application by spreading are:

- The nutrients cannot be fully utilised by the plant roots as they move laterally over long distances. Weed growth is stimulated throughout the field.
- Nutrients are fixed in the soil because they come into contact with a large mass of soil.

II) Placement

Refers to the application of fertilisers in the soil at a specific location with or without regard to the location of the seed. Fertiliser placement is usually recommended when the amount of fertiliser to be applied is small, root development is poor, the soil has a low level of fertility, as well as for the application of phosphate and potassium fertilisers. The most common methods of placement are as follows:

A) Plough soil placement

The fertiliser is placed on the bottom of the furrow in a continuous strip during the ploughing process and each strip is covered when the next furrow is turned. This method is suitable for areas where the soil is relatively dry up to several cm below the soil surface, as well as for soils with a heavy clay pan just below the topsoil.

B) Deep placement.

This involves the application of ammoniacal nitrogen fertilizers to the soil reduction zone, especially in rice fields where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of the fertilizer in the root zone of the soil and prevents nutrient loss through runoff.

C) Localized placement.

Application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:

4. FERTILIZERS

4.5. APPLICATION METHODS

4.5.1. Application of solid fertilisers

- Drilling: In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

- Side dressing: Spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are: placement of nitrogenous fertilizers by hand in between the rows of crops to apply additional doses of nitrogen to the growing crops or placement of fertilizers around the trees like apple, grapes, etc.

III) Band placement

It refers to the placement of fertilizer in bands. Band placement is of two types:

A) Hill placement.
It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of --the crop.

B) Row placement.
When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

IV) Application of pellets

Application of nitrogen fertiliser in the form of pellets 2.5 to 5 cm deep between the rows of the rice crop. The fertilizer is mixed with the soil in a 1:10 ratio and small pellets of the appropriate size are made for placement in the mud of the rice fields.

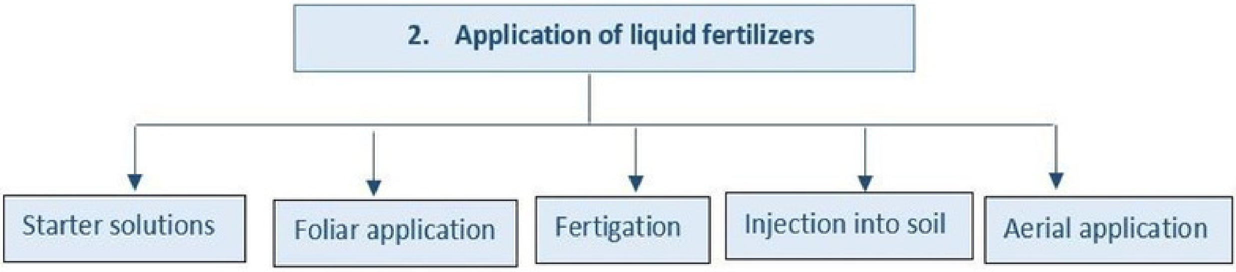
Local application of fertilisers has many advantages. When fertiliser is applied, there is minimal contact between the soil and the fertiliser, thus significantly reducing nutrient fixation. Nitrogen losses through leaching are reduced and phosphate, which is immobile, is better utilised by topical application. In addition, weeds cannot utilize fertilizers throughout the field, while fertilizer utilization by plants is higher.

4. FERTILIZERS

4.5. APPLICATION METHODS

4.5.2. Application of liquid fertilisers

The most common methods are:



I) Starter solutions: This involves the application of a solution of N, P2O5 and K2O in 1:2:1 and 1:1:2 ratios to young plants at the time of transplanting, especially in the case of vegetables. The starter solution helps the seedlings to take root and grow quickly. The disadvantage of starter solutions is the need for additional labour and higher phosphate fixation.

II) Foliar application: Sprays of fertiliser solutions containing one or more nutrients directly onto the leaves of growing plants. Several nutrients are readily absorbed by the leaves when dissolved in water and sprayed on them. The concentration of the spray solution must be controlled, otherwise serious damage may occur due to leaf scorch. Foliar application is effective for minor nutrients such as iron, copper, boron, zinc and manganese. Sometimes insecticides are applied along with fertilizers.

III) Fertigation:Fertigation is an application through irrigation water. It is the application of water-soluble fertilisers. The nutrients are thus introduced into the soil in solution.

IV) Soil injection: Liquid fertilisers intended for injection into the soil can be pressurised or non-pressurised. Non-pressurised solutions can be applied either to the surface or into the furrow under most conditions without significant loss of plant nutrients. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and immediately covered to prevent loss of ammonia.

V) Aerial application: In areas where ground application is not possible, fertiliser solutions are applied by aircraft, especially in hilly areas, forest land, grassland, etc.

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4. FERTILIZERS

4.5. APPLICATION METHODS

4.5.3. Slow-release and controlled-release fertiliser

Crops absorb nutrients at a certain rate throughout their growth cycle. Applying a large dose of fertiliser early in the crop cycle can result in nutrients being lost before the crop has time to use them. Therefore, to avoid losses and to meet the nutritional requirements of the crop, quick-release fertilisers should be applied in split doses.

As an alternative to split applications, slow-release and controlled-release fertilisers can be used. Slow release improves nutrient use efficiency by prolonging nutrient availability and minimising potential losses. Ideally, the rate of release should match the rate of nutrient uptake by the crop so that nutrients are available exactly as the crop needs them

Slow-release and controlled-release fertilisers are compounds designed to supply nutrients to crops in quantities that exactly match their nutrient requirements. Unlike fast-release fertilisers, which are rapidly released in the soil and provide nutrients in a relatively short period of time, slow-release and controlled-release fertilisers release nutrients over a longer period of time.

Their advantages are: higher nutrient use efficiency; less nutrient leaching and nitrogen loss through evaporation, reducing the risk of environmental contamination; fewer applications are required. Although more expensive than conventional fertilizers, reducing the frequency of fertilizer application saves labour and energy costs.

4. FERTILIZERS

4.6. ENVIRONMENTAL IMPACT OF NUTRIENT POLLUTION FROM FERTILIZERS

As inputs to agricultural production, fertilisers play an important role in increasing global crop yields, contributing to food security and providing a range of other benefits. However, the improper or excessive use of fertilisers, as well as pesticides, can impose significant costs on the environment and human health, depending on factors such as toxicity, mobility and persistence in the environment.

Under certain climatic and soil conditions, nutrients and especially nitrogen can be lost through leaching, evaporation, runoff and denitrification. These losses not only have an impact on overall crop production but also represent a major environmental problem. Water pollution by nitrates and nitrous oxide emissions to the atmosphere are considered to be a serious environmental risk.

Most fertilisers are still inorganic in nature, the result of chemical production, the use of which in very high quantities poses a risk to the cultivated land and the environment as a whole. They have several drawbacks, including soil degradation, water pollution and food safety impacts. Today, the urgent need to offset these negative environmental impacts has opened the way for the use of organic and products produced from alternative sources that can help restore soil structure, micro-organism communities, nutrient elements and, in some cases, positively increase soil carbon sequestration.

There are currently major concerns about the effects of inorganic fertilisers on the environment, but also on human and animal health (e.g. the presence of toxic elements such as heavy metals or metalloids). Cadmium, uranium and other potentially toxic elements are components of phosphates, which means that fertilisers produced from such raw materials contain potentially toxic elements due to the original phosphate rock deposits. These contaminants present in phosphate fertilisers, such as cadmium, can pose a risk to human, animal or plant health, food safety and the environment by accumulating in the environment and entering the food chain.

Nutrient pollution due to improper and excessive use of fertilisers has several negative consequences for ecosystems. These include direct toxicity to organisms (high concentrations of N can be toxic to organisms that take up elements directly from the environment, such as algae, lichens or bryophytes) and indirect impacts through factors such as nutrient enrichment, oxygen depletion in aquatic ecosystems, soil and water acidification or amplification of the impact of other stressors such as pathogens, invasive species and climate change.

4. FERTILIZERS

4.6. ENVIRONMENTAL IMPACT OF NUTRIENT POLLUTION FROM FERTILIZERS

The main consequence of phosphorus (P) pollution is eutrophication of freshwater. N pollution leads to a variety of impacts including eutrophication of coastal and marine waters, groundwater pollution, changes in species composition, increases in atmospheric concentrations of N2O (an important greenhouse gas and also a stratospheric ozone depleting substance), increases in NOx , leading to atmospheric smog and ozone, and acidification of soils and freshwaters.

Nutrient runoff from fertilizers has contributed to the creation of many hypoxic zones due to eutrophication worldwide. Global trends point to the continued deterioration of coastal waters due to pollution and eutrophication. Of the 63 large marine ecosystems assessed by the Transboundary Waters Assessment Programme, 16% of ecosystems are in the 'high' or 'highest' risk category for coastal eutrophication due to nutrient runoff (UN ECOSOC 2017).

Potential human health impacts of nutrient pollution include skin, respiratory, cardiovascular diseases and cancers resulting from particulate matter and ground-level ozone (formed when Nitrogen oxides react with organic compounds), blooms of potentially toxic cyanobacteria and nitrate toxicity in drinking water.

Nutrient balance (the difference between nutrient inputs into the farming system, mainly manure and fertilizer, and nutrient outputs from the system - nutrient removal for crop production and grazing) and nutrient use efficiency (the ratio between the amount of N removed by the crop and the amount of N applied by the fertilizer) are important ways of analyzing the impact of nutrient pollution.

“It is estimated that around 50% of phosphate fertilisers and 60% of nitrogen fertilisers applied globally exceed the required amount and contribute to nutrient pollution. Phosphorus (P) is a potentially dwindling resource as global phosphate rock reserves are limited and concentrated in a few countries. Although there is no consensus on the size and longevity of remaining phosphate rock reserves, the current situation is unsustainable given the environmental impacts associated with phosphorus use for food production, the unequal access and geopolitics associated with the uneven distribution of phosphate resources, and the finite nature of phosphate rock.

4. FERTILIZERS

4.6. ENVIRONMENTAL IMPACT OF NUTRIENT POLLUTION FROM FERTILIZERS

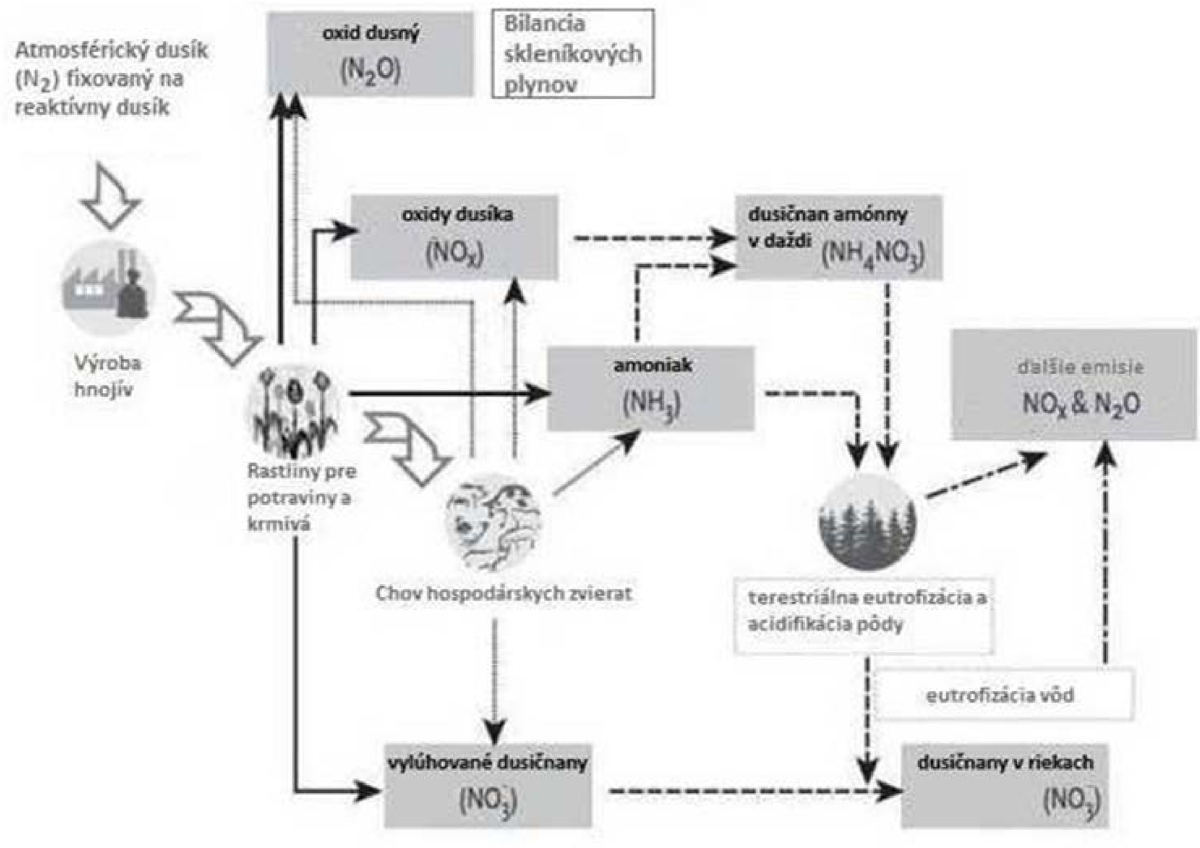
Increasing the efficiency of the use of these reserves in crop production is essential to maintain current and future agricultural productivity. P uptake by crops is generally only 10-30 % of the P fertiliser applied in the first year, but a substantial part of the applied P accumulates in the soil as residual P, which is released to the crop in subsequent years. The accumulation of soil P fertility as a result of significant inputs of organic and mineral P fertilisers in the past in several regions of the world has reduced the required inputs of P. In other words, when sufficient available P is built up in the soil, crop yields can increase despite decreasing P application, and increasing the level of application is not only harmful to the environment but very likely uneconomic. For example, between 1965 and 2007, cumulative P fertiliser and manure application rates in Europe far exceeded cumulative P uptake by crops. Since the 1980s, P application rates have decreased in much of Europe and consumption continues to increase due to the supply of plant-available P from the residual soil P pool.

Unlike P, N does not accumulate in the soil. Together with its natural leaching nature, this makes N management more difficult. Fertiliser requirements and their impact depend on soil type, crop type, rate applied, method and timing of application and other factors. Therefore, data on fertiliser consumption are not sufficient to assess impacts. A better picture of potential environmental impacts is provided by nutrient balance data. The OECD indicators on nutrient balances in agriculture are gross balances, which are calculated as the difference between the total amount of nutrient inputs into the agricultural system (mainly fertiliser, manure) and the amount of nutrient outputs from the system (mainly nutrient uptake by crops and grasslands). In the case of nitrogen, the gross nutrient balance includes all emissions of environmentally harmful nitrogen compounds from agriculture to soil, water and air; the net balance does not include emissions to air. For phosphorus, as there are no emissions to air, the gross balance is identical to the net balance (OECD/EUROSTAT 2012)."

Nitrogen fertilisers used in agriculture and manure are now a global source of gas emissions without proper controls, although they are also a direct cause of the climate crisis. The scientific journal Nature has published the first global assessment of nitrous oxide (N2O), one of the main greenhouse gases responsible for global warming. The combination of its strong warming potential and its long residence time in the atmosphere makes nitrous oxide the third most important greenhouse gas after carbon dioxide and methane. Of all human-related emissions, agricultural production has accounted for nearly 70% of N2O generation in the last decade, leading to a rapid accumulation of N2O in the atmosphere.

4. FERTILIZERS

4.6. ENVIRONMENTAL IMPACT OF NUTRIENT POLLUTION FROM FERTILIZERS



Strategies for controlling nitrogen emissions from agriculture: regulatory, voluntary and economic approaches. Source: Sutton, Erisman and Oenama (2007)

Nitrous oxide emissions from agriculture occur during the "nitrification and denitrification" processes of nitrogen contained in synthetic fertilisers and manure.

The report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources for the period 2016-2019 concludes:

- The implementation and enforcement of the Nitrates Directive has reduced nutrient losses from agriculture over the last 30 years. Evidence suggests that without the Directive, water pollution levels in the EU would be significantly higher. Data on nitrate concentrations at EU level show that groundwater quality has improved since the Directive was adopted, but further improvement has been very slow since 2012. A high percentage of groundwater monitoring stations still show values above the maximum value of 50 mg nitrate/l in Malta, Germany, Luxembourg, Spain, Portugal and Belgium (Flanders region).

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- Water quality monitoring from Member States has improved for both eutrophication and saltwater assessments. Eutrophication is a serious problem for all types of surface waters, as inland, transitional, coastal and marine waters are still severely affected. Member States with a large number of eutrophicated waters include the Czech Republic, Finland, Denmark, Luxembourg, Belgium, Germany, Latvia, Poland and Belgium. Despite the considerable efforts of most Member States and farmers who have proposed and implemented measures to mitigate nitrate depletion in waters, water quality data show that the level of implementation and enforcement is still not sufficient to achieve the objectives of the Directive

30 years after its adoption and despite some progress:

- Some Member States experience poor water quality throughout their territory and a systemic problem in managing nutrient losses from agriculture: Belgium (Flanders region), the Czech Republic, Denmark, Germany, Finland, Hungary, Latvia, Luxembourg, Malta, the Netherlands, Poland and Spain.

- Some Member States must therefore urgently take additional measures to achieve the targets of the Nitrates Directive, in particular Belgium, the Czech Republic, Luxembourg, Spain, the Netherlands and Germany, which are the furthest away from these targets.

4. FERTILIZERS

4.7. IMPACT ON BEES AND OTHER POLLINATOR SPECIES. HOW TO REDUCE RISKS TO BEES

Honey bees, as well as other pollinators (solitary bees, thrips, bumblebees, butterflies, ants, wasps and others), are an important part of our global ecosystem. Pollinators, both known and lesser known species, have an irreplaceable position within the ecosystem that greatly influences not only the diversity of wild plants but also crop production within global agriculture. As pollinators of flowering crops, bees play an indispensable role in primary food production.

For this reason, it is also important to rethink stereotypes in the use of various agricultural chemicals such as plant protection products (PPPs), adjuvants and various types of fertilisers. Fertilisers or fertiliser substances, whether natural, organic or inorganic, are a source of nutrients needed by plants or serve to support plant nutrition. Where the use of organic or inorganic fertilisers cannot be restricted or eliminated, it is important to act extremely responsibly when using them. Many of them present potential ecotoxicological risk to pollinators. Pollinators come into direct contact with them, or their residues are regularly identified in the hive environment of honey bees as well as in the environment of solitary pollinators.

Insect pollinator intoxication is a serious adverse consequence of the use of crop protection products, adjuvants as well as fertilizers because, for example. the honey bee pollinates up to 80% of agriculturally important crops (fruits, vegetables, legumes and oilseeds). When collecting nectar, pollen, propolis and water, bees can come into contact with chemical residues in a variety of ways. Contact and oral exposure are the most common. In addition to these, there is also the so-called inhalation exposure route.

4. FERTILIZERS

4.7. IMPACT ON BEES AND OTHER POLLINATOR SPECIES. HOW TO REDUCE RISKS TO BEES

4.7.1. Toxicity of fertilisers to bees and other pollinators

With regard to fertilisers, there is often a misconception that the use of organic fertilisers, for example, is almost risk-free for the organisms, and also that organic fertilisers are much safer for bees than inorganic ones. However, there are many organic fertilisers that can pose a potential risk to bees, and some of them may even be more harmful than inorganic ones or those produced by a chemical process. Many of the so-called organic fertilisers are prepared synthetically. In addition, some organic fertilisers contain heavy metals that pose a high toxic risk to pollinators.

Toxicity is influenced not only by the specific type of fertiliser, but also by the actual content of the active ingredient within the product; the physicochemical properties of the fertiliser; the amount of fertiliser applied to the crop; the attractiveness of the treated crop to bees; the presence of other flowering plants within the treated field as well as in its surroundings (presence of flowering weeds); the method of application; the timing of the application as well as the number of applications per season and the inter-application interval.

In addition, one of the things to consider when applying fertilisers is the possible mixing of fertilisers and plant protection products. Some fertilisers contain insecticides or herbicides in their list of ingredients. This means that although the aim is to promote plant health through fertilisation, the additives in these synthetic products can subsequently harm plants and insects, including bees. As a result of the inclusion of herbicides or insecticides, these fertilizers are considered potentially toxic to pollinators. In general, tank-mix combinations of bee-friendly products with an acceptable risk at the prescribed dose or concentration (Aph 3) are classified as bee-harmful (Aph 2) from the point of view of bee protection.

The above formulation is used when applying a tank-mix in combination of two plant protection products, however, there is also a potential risk when using a plant protection product together with a specific fertiliser. This combination does not reduce the risk. In particular, the use of non- treated tank-mix combinations is a problem. These combinations have not been studied in detail, so scientific research is currently focusing on this area. It is also important to note that if pesticides are mixed with fertilisers, the rainfall may result in these products reaching the groundwater, which will affect all life forms in the area, including bees.

4. FERTILIZERS

4.7. IMPACT ON BEES AND OTHER POLLINATOR SPECIES. HOW TO REDUCE RISKS TO BEES

4.7.1. Toxicity of fertilisers to bees and other pollinators

Finally, any fertiliser, whether organic or inorganic, that contains any form of pesticide will directly or indirectly affect bees. Fertilisers that contain pesticides will most often affect bees directly, even within the treated field. For example, herbicide fertilisers harm bees indirectly, mainly by damaging the growth of flowering plants, including flowering weeds, which are also attacked by various other pollinator species. In this case, the negative indirect effect of herbicides on pollinators applies. Unjustified or excessive application in the ecosystem reduces the diversity of wild plants on agricultural land. Moreover, damage to flowering weeds does not only occur within the treated area, but also adjacent and field margin communities are often affected. The diversity of plant communities, not only of fields but also of meadows and pastures, is also adversely affected by the use of nitrogen fertilisers, which, with the advent of intensive farming, have displaced leguminous crops from the rotation.

These fertilisers encourage grasses to grow, to the detriment of flowering plants. This also indirectly affects the availability and quality of 'bee forage'. In order to minimise the risk when treating crops, it is most important that both the consumer and the farmer follow the instructions for use and the recommended restrictions or risk mitigation measures that are given within the label (instructions) for the use of the product.

4.7.2. Risk of spray application of fertilisers on bees

Some fertilisers are applied as a spray to the leaves of the plants. Although it is not the primary intent that this spraying be harmful to bees, the formulation has been formulated specifically to kill insects. If bees in the area come into contact with the pesticide in the air or on the leaves, it can affect their behavior or even cause colony mortality. Fertilisers, especially inorganic fertilisers, designed specifically for foliar application, are potential contributors to a decline in pollination. Experts have found significant effects of copper sulphate on bees when used as a spray fertiliser. Some types of fertiliser traditionally used in organic farming can be as toxic to bees as other types of agrochemicals. In the Journal of Economic Entomology, researchers investigated the effects of copper sulphate, a fertiliser and pesticide that is approved for use in organic farming in many countries and is applied as a spray on crop leaves. The study found a negative effect, particularly on stingless neotropical bees such as the species Friesella schrottkyi.

4. FERTILIZERS

4.7. IMPACT ON BEES AND OTHER POLLINATOR SPECIES. HOW TO REDUCE RISKS TO BEES

4.7.2. Risk of spray application of fertilisers on bees

Summer and sub-lethal effects of foliar fertilizers containing heavy metals on behavior were studied in the bee species F. schrottkyi, a pollinator of ecological importance in the Neotropics. Two foliar fertilizers, copper sulphate (24 % Cu) and a micronutrient mixture (Arrank L: 5 % S, 5 % Zn, 3 % Mn, 0.6 % Cu, 0.5 % B and 0.06 % Mo), were used in oral and contact bioassays. The biopesticide spinosad and water were used as positive and negative controls.

Sub-lethal exposure to both foliar fertilizers at their field rates also caused a significant effect in exposed workers. Copper sulphate improved the emergence of worker bees, in contrast to worker bees exposed to the micronutrient mixture. Foliar fertilizers had no significant effect on the overall activity and movement behavior of the worker bees. No significant effect was observed on the respiration rate of worker bees during contact exposure, but worker bees orally exposed to the micronutrient mixture showed reduced respiration rate. Thus, foliar fertilizers have an effect on F. schrottkyi , which may also occur in other stingless bees, potentially compromising their pollination activity, which deserves attention.

From the point of view of the protection of bees and other pollinator species, if a risk is found in the testing of such a copper-containing product, the application of the product shall be restricted. In this case, application during the flowering period of the crop is not recommended; application in the evening, during the off-flight time of the bees, is recommended. It is also not recommended to apply the product in areas where bees are actively foraging for food.

Apart from chemical toxicity, little is known about the impact of agrochemicals on plant-pollinator interactions. Leaf applications of agrochemicals are common practice in horticulture as well as in large-scale farming. Many chemicals carry a charge or electrostatic additives designed to effectively adhere to plants and increase their exposure to particular types of chemicals and, therefore, just such spray applications can increase the moisture in the vicinity of the plant, altering the conductivity and permittivity of both its surface and the surrounding air. It has been shown that E-fields (electric fields) around flowers can change as a result of spray application. Scientists have found that commercially available fertilizers can alter the electric field of flowers for up to 25 minutes, which is significantly longer than the effect of natural phenomena such as wind. The latter causes only short-term fluctuations in signals and has little effect on pollination ability.

4. FERTILIZERS

4.8. LEGISLATION

It is necessary to ensure that products used in plant nutrition or soil improvement do not have harmful effects on health and the environment.

Key EU regulations
Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules for making EU fertiliser products available on the market, amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003, repealing the previous Regulation (EC) No 2003/2003, which is directly applicable in all EU Member States.

Although this Regulation repeals EP and R (EC) Regulation 2003/2003 on fertilisers, according to Article 52, EU Regulation 2010/1009 does not prevent the making available on the market of products which were placed on the market as fertilizers labelled 'EC fertilizer' in accordance with Regulation (EC) No 2003/2003 before 16 July 2022.

There is a growing interest in the market and in the agricultural sector to move towards a model of sustainable agriculture with low external inputs, which also uses alternative sources for the production of EU CE-marked fertiliser products. In addition to inorganic fertilizer s and some exceptions of organic fertilizers produced chemically with a precise composition as specified in the EP and R Regulation (EC) 2003/2003 on fertilizers, organic and organic-mineral fertilizers, liming preparations, growing media, soil conditioners, inhibitors, plant biostimulants and mixtures made up of the previous categories can be placed on the EU market for the first time by Regulation 2019/1009.

This Regulation lays down common rules on safety, quality and labelling requirements for fertiliser products and introduces for the first time limits for contaminants, including limits for pathogens in products where relevant. This ensures a high level of soil protection and reduces health and environmental risks, while producers must adapt their production process to comply with the new limits if they wish to market their products under the Regulation.

The regulation focuses on defining the minimum nutritional requirements and maximum levels for contaminants (Annex I), on defining the component materials that are suitable for the production of EU fertiliser products (Annex II). Annex III lays down labelling requirements, which are planned to be extended with the possibility of digital labelling. Annex IV lays down the conditions for the placing on the market of EU fertiliser products according to the conformity assessment modules. Conformity assessment of EU fertiliser products must be carried out in a reliable and reproducible manner.

4. FERTILIZERS

4.8. LEGISLATION

It shall not apply to animal by-products or derived products which are subject to the requirements of Regulation (EC) No 1069/2009 when they are made available on the market and to plant protection products falling within the scope of Regulation (EC) No 1107/2009.

Maintaining optional harmonisation does not prevent non-harmonised fertilisers from being made available on the internal market in accordance with national law and general rules on free movement. Regulation (EU) 2019/515 on the mutual recognition of goods lawfully placed on the market in another Member State and repealing Regulation (EC) No 764/2008 has been developed to remove barriers to trade in fertilisers from different countries.

On the other hand, the number of Member States adopting national measures for new sub-sectors of fertilisers is also increasing. This situation creates new barriers to trade that can only be addressed by measures taken at European level.

In 1991, 91/676/EEC introduced the Nitrates Directive (EEC Directive of 12 December 1991 on the protection of waters against pollution caused by nitrates from agricultural sources), which aimed to reduce water pollution caused or induced by nitrates from agricultural sources. The Directive requires Member States to apply the measures of the agricultural action programme throughout their territory or within separate nitrate vulnerable zones, called vulnerable areas. The action programme measures must promote good practice in the use and storage of fertilisers and manure through four key measures:

- Limiting the application of inorganic fertilizers to crop requirements.
- Restrictions on the use of farmyard manure.
- Seasonal restrictions on the application of slurry, urea and manure on sandy and shallow soils.
- Keeping farm records that include crop production, livestock numbers and fertiliser management.

The Nitrate Directive is transposed into Act No. 364/2004 Coll. on Water and on Amendments to Act No. 372/1990 Coll. of the Slovak National Council on Offences, as amended (Water Act) and the Action Programme is set out in Sections 10b and 10c of Act No. 136/2000 Coll. on Fertilisers, as amended.

Chapter 5

GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.1. INTRODUCTION

Our lives depend on science. We rely on research, knowledge and experience, but also on observation, to be able to influence the reality around us. In order to achieve benefits, we increasingly rely on the administration of external substances.

In this way, we try to combat the smaller organisms while causing as little damage as possible to the beneficial ones. However, the effect is not always as previously anticipated. As Paracelsus - the eminent physician and naturalist, called the father of modern medicine - once said: "Everything is poison and nothing is poison, for only the dose makes the poison".

The presence of pests in crops can lead to a reduction in yield quantity and quality, which is why the first attempts to control and eradicate them were made nearly 200 years ago. Measures based on nicotine, plant extracts and grey soap were supposed to be the solution to the presence of these organisms.

Even then, the conclusion was put forward that the use of an active substance together with a detergent has a much better effect.

It seemed that chemicals would rid agriculture of pests and the yield volume would steadily increase.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.1. INTRODUCTION

In addition to nicotine, other active substances were used whose toxicity was increasing.

Meanwhile, efficacy in pest control translated unnoticed into increased risks for bees and organisms living on or near crops: wild pollinators, small vertebrates and others. The plant protection products of the time were certainly not indifferent to humans either.

A prime example is dichlorodiphenyltrichloroethane, or DDT. The agent was synthesised in 1874. At the time, its insecticidal properties were not yet known. It was not until 1939 that it was discovered by Paul Müller, for which he was awarded the Nobel Prize less than 10 years later.

DDT production in Poland began in 1947 under the name Azotox. This agent is well remembered by our grandparents, who used it on crops by powder application. At the beginning of the 1980s, the search for less environmentally harmful substances began on a larger scale than before. Over time, successive generations of plant protection products were developed, although much safer for bees, still causing colony losses of 30-50%. These included organophosphates, carbamates, polychlorines and pyrethroids. Some of them had very long withdrawal and prevention periods.

The grace period is the time it takes for an active substance to break down in an agricultural product into non-hazardous derivatives. Prevention, on the other hand, is the time after the application of a given product during which humans and animals should not be in the area of the crop. The precautionary period for some measures was as long as 21 days, which was virtually impossible to maintain in bees.

With the development of science and advances in research, many substances in the above-mentioned groups were found to be highly toxic. Consequently, they were withdrawn from the market and their use was banned. Others were subjected to further testing, both for efficacy against undesirable organisms and for their effects on bees, small vertebrate animals and humans.

The desire to minimise the negative environmental impact of agro-swales led to the conclusion that they should be planned and carried out thoughtfully and appropriately. Therefore, education was to be the next solution. On the basis of the Act on Plant Protection Products, of 8 March 2013. (Journal of Laws 2013, item 455), pesticide users were divided into professional and non-professional users.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.1. INTRODUCTION

Photo by Jerzy Górecki

A professional user is a natural person who uses plant protection products for purposes other than his/her own, non-commercial needs. Particularly in the context of a business or professional activity in agriculture, horticulture, horticulture, forestry, landscaping services.

They were subjected to mandatory qualification training and verification at the time of sale starting in November 2016.

From 1 January 2014, professional users are obliged to apply the principles of integrated pest management, aiming to reduce the use of chemicals to the minimum necessary, e.g. by limiting the number of treatments or reducing the doses.

Integrated plant protection

According to the accepted definition, it is a way of protecting plants against harmful organisms by using all available plant protection methods, especially non-chemical ones, minimising the risk to human and animal health and to the environment.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.1. INTRODUCTION

Directive 2009/128/EC recommends:

- use of crop rotation,
- use of proper agro-technology,
- the use of resistant or tolerant varieties and seed and planting stock assessed in accordance with seed legislation,
- the use of balanced fertilisation, liming, irrigation and land reclamation,
- the application of measures to prevent the introduction of harmful organisms, protecting and creating conditions conducive to beneficial organisms,
- the use of phytosanitary hygiene measures (such as regular cleaning of machinery and equipment used in plant cultivation) to prevent the spread of harmful organisms,
- the use of plant protection products in such a way as to reduce the risk of resistance in harmful organisms.

In practice, this means using appropriate methods and tools based on field monitoring, warning, forecasting and early diagnosis systems. Meanwhile, the dissemination of knowledge of the correct legal procedure for dealing with bee poisoning among beekeepers able to make a report and the staff responsible for receiving them in local authorities still leaves much to be desired.

According to the Law on Plant Protection Products, a non-professional user is defined as an individual who applies pesticides exclusively for his or her own non-commercial use with a sprayer smaller than 30 l.

However, it is not uncommon that the preparation of the spray in a small sprayer may favour exceeding the permissible doses. The method of application, left to the will, skill and knowledge of the person applying, can also favour exceeding recommended doses. Manual application can result, for example, in an uneven distribution of the spray over a given area.Despite the tenets of integrated pest management, practice is often quite the opposite. Pesticides are often used like medicines rather than as a necessity dictated by a conscious choice of the last option to protect against crop loss.

The pattern is as follows: “I see a disease symptom - I treat immediately, I observe a pest - I control immediately“, often without sufficient analysis of the risk to the crop or assessment of the aesthetic value of the garden.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.2. POLLINATORS AND PESTICIDES

There are 470 species of bee-eating insects in Poland, among which there is one species of honeybee. The smallest bees (smugglers) have bodies about 4 mm long. The majority of bee species have a very limited range of distribution, linked to their ability to forage in a very small area.They most often live in the ground, forming nest forms characteristic of their species. They are mainly insects with a solitary lifestyle.

Due to their small flight range of 30 to 500 m and dependence sometimes on only one host plant, wild bee insects have little chance of rebuilding populations in the event of poisoning. As a rule, one inappropriate treatment wipes out the entire population in a given area. It takes time for this ecological niche to become repopulated again.

As creatures that fly completely uncontrollably and are guided only by the smell of nectar, bees are unable to perceive or identify danger. Various pesticides and their residues contained in nectar, pollen and water can therefore enter the hive. Absolutely indefinable are their proportions and impact on the life, health and resilience of the bee, both in an individual and colony context.

The choice of pesticide and its application is entirely up to the person carrying out or commissioning the treatment. In practice, this means that within the flight range of the bees, several fields of the same crop may have different preparations applied at the same time. Honey bees characterised by floral fidelity may therefore bring to the hive forage from different fields with different 'additives'. The same pickers may be exposed to further substances on subsequent days.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.2. POLLINATORS AND PESTICIDES

The synergistic effect of different compounds mixed together can have an effect that is difficult to predict. It is assumed that acute poisoning can be induced by a mixture of preparations which, if used alone, would not show such high toxicity. This also applies to substances belonging to different groups (insecticides, herbicides, fungicides, repellents and adjuvants) used in parallel on different crops. This significantly increases the possibility of combinations and effects on bees.

Most worrying, however, is the arbitrary combination of different pesticides and fertilisers in one working solution - a so-called tank-mix. Integrated pest management allows the use of such mixtures for reasons of economy and improved work organisation. This is particularly convenient when several treatments overlap. However, there are no precise instructions on how to combine agrochemicals with each other. Apart from a few strictures on what not to mix, all that remains is a 'jar' test of the reaction between the ingredients. After mixing the samples in the jar, we visually assess whether or not a reaction is taking place. There can, of course, be no question of determining the efficacy or toxicity of the mixture thus created.

There is also no information on how to combine them on the labels. In the principles of good plant protection practice, you can only read in which order they should be mixed, namely: fertilizers first, then suspensions, emulsions, solutions and finally adjuvants.

Pre-harvest crop re-drying (desiccation) is also a very serious threat to bees. This applies to cereals, oilseed rape and buckwheat and potatoes. Non-selective herbicides with a total effect, often with the addition of ammonium sulphate, are used for desiccation. The purpose of this treatment is to even out the moisture content of the grain and, in the case of cereals and oilseed rape, also to prevent the grain from spontaneously spilling out of the ears and pods.

This treatment is particularly dangerous for bees in August and September on late buckwheat crops. During this time, the bees are raising generations of winter bees that live 8-10 months. Such prolonged exposure of these worker bees to harmful substances brought into the hive in late summer can prove lethal to the entire colony.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.3. BEE POISONING

The condition of the bee colony, its size, the number of gatherers and the distance from the crop are factors that significantly affect the course of bee poisoning. At greater distances, the most destructive effect of pesticides can be observed in colonies that are large and strong, with a preponderance of flight bees over hive bees.

Families that are very well prepared for nectar collection, with correspondingly high pollen needs, reach numbers close to 80,000 insects, of which up to 70% are active gatherers. This structure makes it possible to obtain larger quantities of honey. That is why the beekeeper manages his colonies very intensively from early spring in order to achieve such a number and structure for the main forage.

If the nectar is contaminated with pesticides, such a large population of bees from a colony is able to bring a large amount of pesticides directly into the hive. If the content of the substances is low and relatively safe for the bees, the symptoms of poisoning will not be acute and a large amount of the toxins will be taken away with the honey.

The gradual loss of bees may even go unnoticed by the beekeeper or be treated as a normal phenomenon. If, on the other hand, the toxin content is higher or the poisoning is contact, a large proportion of the bees will remain on the crop or die dispersed along the crop-hive path. It can also happen that the pickers suddenly stop flying and that there is virtually no accumulation of poisoned bees on the den and in front of the hive. Such a situation is very troublesome because it makes it impossible to take a representative sample of bees for toxicological testing. If, however, the bees manage to return to the hive, and the poisoning is acute, there will be a very large swarm of poisoned bees on the den and in front of the hive.

5. GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

5.3. BEE POISONING

The shorter the distance to the source of poisoning, the more bees return and die in and just outside the hive. Toxic substances can accumulate and their effects intensify during periods of worsening weather when bees cannot collect their next forage. Intensive feeding of pre-harvested nectar and pollen with 'additives' can result in symptoms typical of acute poisoning. There may therefore be a time lag between the application of agrochemicals and the symptoms of bee poisoning.

While partial poisoning of bee colonies with an immediate effect is easy to spot (bees suddenly stop flying), the effect of poisons in the long-term aspect is difficult to recognise - the colony weakens over time.

Weaker families are equally disadvantaged when faced with poisoning. Such families, being close to its source, lose most immediately. In them, poisoning of all life stages is most common, since any food brought in is immediately managed for the family's current needs.

First the flight bees die, then the hive bees and the larvae, and finally the brood dies under the combs as a result of cold resulting from the hive bees leaving the combs. The whole colony is most often unsalvageable.As can be seen, the course of bee poisoning can vary greatly and is correlated with environmental factors and colony size. Each bee colony is driven by economic profit. It tries to match its dynamics with the development of the plants that are foraging for them.

The availability of food allows the bees to develop intensively leading to the division of the hive to acquire new territories. For their own sustenance, bees need 25-50 kg of pollen and 80-100 kg of honey each year. Such high needs force the bees to take every possible opportunity to bring as much food as possible into the hive.

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5.3. BEE POISONING

Therefore, of all the variety of plants, bees are most likely to choose those offering them the highest sugar content in nectar, growing over a large area and as close to the hive as possible. The closer, the greater the honey yield for the bee colony. When there are no such plants nearby, the compactness of the sugars becomes the most important criterion.

The larger it is, the more it compensates the bees for the effort of flying further distances. This is why bees are very keen to collect nectar from oilseed rape grown as far as 3 km from the hive.

The highest incidence of pollinator poisoning is observed precisely during rapeseed flowering, particularly during the period of control of the rapeseed strawberry, as well as in orchards and in potato and cereal plantations where control is carried out during the flowering period of weeds. If flowering weeds or honeydew are present in a plantation, the crop should be treated as a flowering crop.

The causes of bee poisoning are mainly due to mistakes made by treatment contractors, the most serious of which are:

- failure to comply with the provisions of the application label,
- incorrect selection of plant protection products and doses,
- incorrect timing of chemical protection treatments,
- incorrect treatment technique,
- use of plant protection products not authorised for the crop in question
- lack of preparation of treatment contractors,
- use of non-recommended mixtures of plant protection products.

In order to avoid and prevent bee poisoning:

- treatment should only be carried out where the harmful organisms exceed the economic damage thresholds and, where possible, treatment should be limited to marginal strips or areas where the harmful organisms occur,
- Strictly comply with the provisions of the plant protection product label,
- where scientific results are available, use reduced doses and split doses to reduce the chemicalisation of agriculture,
- to carry out treatments in areas where bees are likely to be foraging, choose selective agents that are non-toxic to bees or have a short precautionary period,
- treatment should be carried out in the evening, after the bees have finished flying over the crop,

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5.3. BEE POISONING

- many flowering weed species already provide food for bees from early spring onwards, e.g. common starflower, and treatments carried out in this situation must be treated in the same way as treatments when the crop is in flower, do not spray honeydew-covered plants,
- with highly toxic and bee-toxic products, do not treat crops that may flower before the end of the prevention period,
- prevent spray drift, especially onto neighbouring flowering crops and areas where pollinators may be foraging, do not spray when there is too much wind,
- inform beekeepers about the plant protection treatments being carried out,
- do not pollute waters, such as drainage ditches, mid-field reservoirs and others with plant protection products, as these can provide a source of water for pollinators,
- comply with the legislation.

The holder of land or premises where treatments with plant protection products are carried out by a professional user is obliged to keep records of the plant protection products used on that land or premises for a period of 3 years.

Plant protection is that special field of agricultural practice where a number of decisions and choices have to be made, on which depend not only the health of the plants and the economic effect, but also the safety of the treatments carried out for humans and the environment. Despite the development of various methods of plant protection, chemicals are still the most important tool in reducing the population of organisms harmful to crop plants. The widespread use of these preparations in agriculture over the past few decades has made it possible not only to better exploit and stabilise the yield potential of increasingly productive plant varieties, but also to recognise the risks and take measures to minimise the negative effects of their use. One such action is the implementation of the principles of good plant protection practice. The term 'good plant protection practice' is defined by the European Commission in Regulation No 1107/2009. This definition emphasises the use of plant protection products in accordance with the conditions for authorised use, i.e. in accordance with the label, as well as the use of the minimum necessary amount of chemical plant protection products and the combination of chemical methods with other methods (e.g. mechanical and biological), where possible and economically justified.

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5.3. BEE POISONING

The State Plant Protection and Seed Inspectorate, in cooperation with the Veterinary Inspectorate, takes official action when a suspicion of bee poisoning with plant protection products is reported. For this purpose, a commission may be set up to authenticate and clarify the fact. The commission may be made up of an employee of the Plant Protection and Seed Inspection Service, an employee of the Veterinary Inspection Service or a free practice veterinarian, the owner of the apiary and a representative of the beekeeping organisation. The committee may optionally also be appointed by the municipality or the local authority responsible for the incident of bee poisoning or by the person who is to be part of the committee.

The committee's task is to immediately collect the material for testing, secure and send the samples to the laboratory. In addition, the members of the committee acting within their competence:

- determine the number of bee colonies with symptoms of poisoning,
- assess the health of the apiary,
- determine the estimated amount of damage to the apiary,
- verify that plant protection products have been used on neighbouring crops where poisoning may have occurred in a way that poses a risk to animal health,
- determine the owner of a plantation where plant protection products have been applied that could be a likely source of bee poisoning.

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5.4. GOOD PRACTICES

Good plant protection practice is intended to ensure not only the acceptable efficacy of the treatments carried out, but also to minimise risks to human, animal and environmental health. A basic prerequisite for following the principles of such practice is to have an adequate body of knowledge. A minimum of expertise in this area is provided by training courses, which cover advice on plant protection products and their use, as well as issues relating to integrated crop production and sprayer performance testing. These trainings, with the exception of equipment health checks, include basic and supplementary training. Lists of entities authorised to conduct training can be found on the website of the State Plant Protection and Seed Inspection.

Among pollinators of crop plants, the honeybee is the dominant species, and its contribution to pollination is estimated at 86.8% of the total labour input of all pollinators (SANJEREHEI 2014), which translates into 9.5% of global agricultural production (GALLAI AND WSP. 2009). Sixty agricultural and 140 horticultural species, more than 80% of the species cultivated in Poland, depend on pollination for a profit of between 4.1 and 7.4 billion PLN (NIK 2017). The widespread participation of bees in the pollination process of chemically protected crop plants means, at the same time, that bee colonies are intensively exposed to fungicides, used during the flowering period against infections of the generative organs of plants, but also to insecticides used against insect pests. An important result of the honeybee's exposure to pesticides is also the contamination of bee honey, which is widely recognised as healthy and safe, not only for the consumer, but also for the entire bee colony, for which honey is the primary source of energy, ensuring the survival of the colony during the winter.

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5.4. GOOD PRACTICES

For products that may come into contact with honeybees in the recommendations for use, the label provides information on the specific recommendations to be followed when planning and carrying out the treatment. These include the toxicity and the precautionary period for honey bees, as well as specifying conditions under which the product should not be applied, e.g. flowering crop, flowering weeds, presence of honeydew. The label of a plant protection product is therefore a source of a lot of valuable information that is helpful and even necessary for the correct and safe planning and execution of a plant protection treatment. Thanks to this information, mistakes resulting in a decrease in the effectiveness of the treatment or the creation of risks for human and animal health and environmental safety can be avoided. The labels of plant protection products contain (as defined by legal regulations) phrases concerning the protection of the honeybee and other bee species. In Poland, compliance with the label is mandatory.

The set of basic recommendations whose observance will guarantee the effectiveness of the treatments and their safety for the environment and for man and in relation to plant protection is called Good Plant Protection Practice. The DPOR principles were first issued in 1994 and contained 10 recommendations. Nowadays, the number has been increased to 14, taking into account the progress and focus of plant protection development.

Familiarisation with and adherence to the DPOR principles is the basis for the effective and safe use of plant protection products and therefore also for pollinator safety.

The State Inspectorate for Plant Protection and Seed Inspection is responsible for controlling the correct use of plant protection products and should be approached if any irregularities are found. If you suspect that bees in your apiary have been poisoned by plant protection products, follow the guidelines of the Polish Beekeeping Association. On the PZP website (http://www.zwiazek-pszczelarski.pl) there is information on the Code of Good Production Practice in Beekeeping, as well as on how to proceed in the event of a suspected poisoning, and it is possible to download model protocols according to which evidence should be collected.

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5.4. GOOD PRACTICES

In accordance with the principles of good agricultural practice, it is imperative to remember that measures, even those with a low risk to bees, should only be applied in the evening and after their flights have ceased, as:

- spraying bees with liquid causes them to wet their wings, which prevents them from returning to the hive,
- bees treated with the liquid take on the smell of the liquid and are treated as strangers when they return to the hive, and the guard bees keep them out and then sting them,
- drought and high ambient temperatures at the time of treatment are an additional threat to bees, which, in their search for water, siphon off spray droplets contaminated with the product from the plants, which can lead to bee poisoning.

Properly applied insecticides should not cause bee poisoning, but poisoning or poisoning of bees is very common in Europe. The reason for this situation is primarily a lack of awareness of the effects of incorrectly applied plant protection products and, consequently, the disregard for regulations by those carrying out chemical treatments. It should be stressed that the use of all plant protection products therefore requires a great deal of knowledge and responsibility on the part of those carrying out chemical treatments, observance of the regulations governing their use and cooperation with and concern for apiary owners. It is worth remembering that a farmer who has contributed to the poisoning or poisoning of bees is obliged to compensate for the resulting damage. Damage, in the Civil Code, is "the loss of property due to a certain event". The damage caused by bee poisoning is the actual loss and the lost expected benefits that the beekeeper could have achieved. The injured beekeeper has the right to claim compensation, but in any case the beekeeper is obliged to collect and provide evidence of the losses suffered.

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5.4. GOOD PRACTICES

In protecting bees, attention should be paid to the following issues:

- A plant protection treatment carried out on non-flowering plants is considered harmless to bees. This fact is not always justified, as such a treatment creates the possibility for toxic substances to penetrate the nectar or pollen after the flower buds have developed. The toxic effects of the active substance of the pesticide may only become apparent after the bees have taken up nectar or pollen containing such chemical compounds.

- In spring, the dynamic development of bees requires a higher demand for water. Very often, bees can be observed collecting the liquid used for chemical plant protection on the crop being flown. Then, even low-toxic pesticides brought into the hive with the collected liquid or after penetration into the nectar and pollen can be very dangerous toxic agents in the form of direct and indirect harm.

Bees feeding on food from plants heavily sprayed with pesticides develop symptoms of biological dysfunctions of the organism, namely:

- a decrease in bee activity,
- reduced ability to raise offspring,
- reduced maternal reproductive activity,
- a decrease in the bees' defensive activity and immune capacity.

Prevention periods are very important. The prevention period is the time that must elapse from the application of the product until it is safe for the bees to come into contact with the treated plants, i.e. there is no risk of them being poisoned. During this time, the active substance of the preparation should be broken down into compounds that are inert to the bee organism. The longer the precautionary period, the higher the toxicity of the preparation concerned, and can last from several days to one hour. Before using any plant protection product, it is essential to read the label (instructions for use) carefully so that the chemical treatment can be carried out effectively and safely for the environment.

Bees are pollinating insects that can be protected from poisoning by plant protection products, and the risk of their poisoning is minimised by, among other things:
- not using products toxic to bees during the flowering period of plants,
- avoid spraying plantations where flowering weeds are present,
- selecting preparations that are low in toxicity to bees,

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5.4. GOOD PRACTICES

- compliance with prevention periods,
- preventing spray drift during treatment,
- carrying out treatments in the evening after insect flights have ended.

It has been found that even minimal doses of measures can:

- disrupt memorisation, learning and the bee dance,
- influence the lack of orientation,
- interfere with breathing, which affects the ability to fly,
- make it difficult to maintain nest temperature, which in turn affects disease infestation,
- lower the immune system (by up to 4 times), significantly increasing susceptibility to disease,
- if winter stocks are contaminated even with small amounts, we may have to deal with chronic bee poisoning,

It has been proven that lower doses and with prolonged contact between bees and the substance are significantly more harmful than in the case of acute poisoning.

In addition, when carrying out chemical plant protection, in particular:

- use only plant protection products authorised for marketing and use on the basis of permits or parallel trade permits issued by the Minister of Agriculture and Rural Development,
- apply plant protection products in accordance with the conditions specified on the label and observe the prohibitions and restrictions (phenological stage of the plant, time and period when the product must not be applied),
- use plant protection products in such a way as to minimise the negative effects of chemical treatments on non-target organisms, do not apply preparations toxic to bees during the flowering period of crops and in crops where flowering weeds are present, carry out treatments after pollinating insect flights have ended (in the evening or at night),
- check for the presence of pollinating insects, with particular attention to bees, in the protected crop before treatment, maintain minimum distances from apiaries (i.e. a minimum of 20 m for field and orchard sprayers),
- observe the prevention periods,
- do not carry out the treatment under conditions conducive to spray drift during the treatment (wind speed higher than 4 m/s).

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5.4. GOOD PRACTICES

Plant protection is an integrated set of measures, not just chemical treatments. The Code of Good Agricultural Practice defines it as follows: “ (...) integrated pest management consists of combining effective, environmentally safe and socially acceptable biological, agrotechnical and chemical methods of plant protection that keep the population of agrophages below harmful thresholds“.

As recent years have taught us, everyone loses out on the conflict between beekeepers and farmers. Current legislation, Integrated Pest Management and the current principles of Good Plant Protection Practice clearly define how to do it safely - but they must be ruthlessly applied and enforced. The farmer must not be paid to break the law, and the beekeeper must have the tools to quickly identify the real culprit if there are losses in the apiary.

In fact, there are three sides to solving the problem:

- farmers who need to improve their working methods and treat beekeepers as important partners,
- beekeepers who, despite negative experiences, need to gain cooperation,
- as well as administrations and authorities, which must organise a way of identifying the causes of, and those responsible for, the losses caused by the use of agricultural chemicals without delay and in a reliable manner.

The introduction of the obligation to protect all crops in accordance with the principles of integrated pest management in all EU Member States from 1 January 2014 has had a significant impact on the protection of the agricultural environment and thus pollinators. Given in Annex III to Directive 128/2009, as well as in the Regulation of the Minister of Agriculture and Rural Development of 18 April 2013, the general requirements for integrated plant protection read that integrated plant protection includes ’the protection of beneficial organisms and the creation of conditions favourable to their occurrence, in particular pollinating insects and natural enemies of harmful organisms’ (extract from the Regulation of the Minister of Agriculture and Rural Development). This strong emphasis on the need to reduce the possible effects of the use of chemical plant protection products is characteristic of the European Union’s actions and already in the preamble of Directive 91/414 we read: “The protection of human, animal and environmental health takes precedence over the improvement of agricultural production“.

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5.4. GOOD PRACTICES

In Polish legislation, too, we find many provisions guaranteeing that the side effects of the use of chemical plant protection products are minimised to the point of complete elimination:

- to authorise the marketing and use of products which, when used correctly, do not present a risk to humans, animals or the environment,
- obligation for technical inspection of sprayers,
- an obligation for plant protection contractors to complete training,
- and supervision of the correct use of plant protection products by employees of the State Plant Protection and Seed Inspection Service.

Thus, on the regulatory side, pollinator safety is very much assured. However, the possibility of new developments or changes in the range of plant protection products used, which may require additional and new measures, must be taken into account.

Key legislation related to good plant protection practice:
- Regulation No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC (OJ L 309, 24.11.2009, p. 1, as amended).
- Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ L 309, 24.11.2009, p. 71).
- Act of 8 March 2013 on plant protection products (Journal of Laws 2017, item 50)
- Regulation of the Minister of Agriculture and Rural Development of 18 April 2013 on the requirements of integrated plant protection (Journal of Laws 2013, item 505)

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- Ordinance of the Minister of Agriculture and Rural Development of 31 March 2014 on conditions for the use of plant protection products (Journal of Laws 2014, item 516)
- Regulation of the Minister of Agriculture and Rural Development of 22 May 2013 on the procedure for the use and storage of plant protection products (Journal of Laws 2014, item 625).

5.5. SUMMARY

The positive impact of bees on agriculture, the environment and, consequently, the national economy is not in the slightest doubt. Furthermore, bees are a kind of marker of environmental purity. Where bees live and do well, this environment, this surroundings, is also human-friendly.

The increasing decline of bee colonies in Poland, Europe and the rest of the world in recent years should give food for thought to policymakers, as it is thanks to them that we can stop the destructive human activities that we learn about thanks to bees. What are the benefits of bees' work? The work of bees is valued at over €1,200. Therefore, when considering the problems of beekeeping, it should be viewed as an asset to be supported and strengthened legally, economically and organisationally.

Plant protection products and bee poisoning caused by them are second only to apiary diseases among the important factors threatening beekeeping. This problem in Poland affects between 5 and 20% of bee colonies each year (poisoning and sub-poisoning). Where does the problem lie? First and foremost in the farmers, there is a lack of knowledge regarding the biology of the bee, the safe use of plant protection products and the season of application of APCs.

When beekeepers report bee poisoning, municipalities do not always know how to deal with the problem. Unnecessary conflicts arise between beekeeper and farmer. However, despite these problems, we have to realise that neither farmers will abandon the use of chemicals in agro-technology and plant protection, nor will beekeepers stop taking bees out to forage in arable plantations.

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5.5. SUMMARY

Today it is the beekeepers who are the biggest environmentalists, they are the ones who report on the excessive use of chemicals in agriculture. However, in order to avoid poisoning, they must step up their efforts to raise awareness among farmers carrying out chemical plant protection treatments. This is the most effective method of preventing bee poisoning. Currently, this awareness-building takes place during so-called 'chemisation courses'. However, according to farmers, not all chemical training companies include pollinator protection in their training programmes. It would seem eminently justified to make these issues an obligatory part of such training courses. Such provisions were demanded by beekeepers during the writing of the Law on Plant Protection Products and later during work on amendments to this law. However, this is what farmers' organisations should be striving for, so that there is as much training and information campaigns as possible, followed by enforcement of the knowledge acquired, especially in the periods before and during periods of intensive use of PPPs.

APCs are powerful poisons whose irresponsible use exposes us and our environment to damage, the effects of which we may feel for years and may take a very long time to remedy. Farmers often mix APCs or fertilisers on their own to reduce the cost of treatments, without realising what effects the synergy of these agents can have.

If the bees are doing well, it means that the environment is clean; if there is irresponsible use of plant protection products, it affects the bees first and then people.

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5.5. SUMMARY

What does the PZP Board need to do about this?

- Bring about legislation such that there is more about pollinator protection and their beneficial role in the environment in chemistry training for farmers.
- Introduce a simplified procedure for dealing with damage caused by poisoning by plant protection products.
- Convince farmers' organisations that it is they who must take care to educate farmers, provide training among their members on pollinator protection and their useful role in the environment.
- Lead to the creation of a compensation fund. Plant protection product distributors must set up a compensation fund for beekeepers harmed by the incorrect use of plant protection products. A beekeeper who loses bees in an oilseed rape plantation is left without a livelihood for the next year, the farmer pays a small fine, while the APesticide distributor is satisfied that he has sold poison and is only counting his profits.
- Legal aid for affected beekeepers.

The sale of pesticides and the widespread use of pesticides, despite measures to minimise environmental impacts, should prompt us to take action to reduce their use in the near future. Statistical data (e.g. 1,462 acute poisonings, 11,177 sub-poisonings were reported in 2018) do not always show the scale of insect poisoning and the impact of pesticides on the environment, especially in the synergistic effects of the substances they contain.

The number of bee colonies is gradually increasing year on year. Many cases of poisoning go unrecorded. Beekeepers often fail to report the occurrence of poisoning. This contributes to the under-reporting of poisoning statistics to the detriment of us all. Furthermore, we only have data on bee poisonings for the honeybee.

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5.5. SUMMARY

Will analogous surveys of the remaining almost 470 species be carried out? This can hardly be considered possible or certain. In any case, the scale of their difficulty and cost will be high. So it remains for us to keep a close eye on and support the remaining wild pollinators as much as possible. To talk and discuss constructively.

Exchange views and stay in touch, rejecting all antagonism and stereotypes. Every step of this kind taken locally will be for the sake of both bees and crops, orchards and gardens... and all of us.

The countries of the Union place great emphasis on restoring damaged ecosystems, from arable land to forests, seas and urban environments. We seem to forget that Europeans live on a continent with very little biodiversity (compared to the rest of the world), which adversely affects ecosystems that may not cope under climate change conditions. Meanwhile, people depend on nature, even if they forget this on a daily basis. If we restore wetlands (probably no one needs reminding that Poland has been in a state of permanent drought for seven years, and farmers are already warning that this year (2022) it will significantly contribute to an increase in the price of food products), secure rivers, forests, grasslands, marine ecosystems and protect the species living in these environments, the investment will pay off in the form of food security, increased resilience of ecosystems to climate change, improved human health and enhanced general well-being. It will also secure the food supply within the Union.

As humans, we depend on nature. We need the air we breathe, the water we drink, the food we eat - throughout our lives. Our economy also relies on natural resources. The climate crisis and the biodiversity crisis threaten the very foundations of our life on Earth. We have made progress in tackling the climate crisis and today we have added two pieces of legislation to the rulebook that represent a huge step forward in tackling the spectre of ecocide. By restoring natural resources, we can continue to provide clean air, water and food, and protect ourselves from the worst of the climate crisis. Restricting the use of pesticides also helps to rebuild natural resources and protects the people who work with these chemicals," said Frans Timmermans, Vice-President of the European Commission.

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5.5. SUMMARY

Objectives include:

- Increase the population of pollinating insects and reverse the decline in their numbers by 2030.

- zero net loss of urban green spaces by 2030, a 5% increase by 2050, tree canopy density of at least 10% in every European city, town and suburb, and a net gain of green spaces integrated with buildings and infrastructure;

- in agricultural ecosystems, an overall increase in biodiversity and a positive trend in grassland butterfly populations, farmland birds, organic carbon stocks in mineral soils of farmland and landscape elements of high diversity on farmland; rehabilitation and re-wetting of drained peatlands used for agriculture and peat extraction sites;

- in forest ecosystems, an overall increase in biodiversity and a positive trend in forest connectivity, deadwood, uneven-aged forests, forest birds and organic carbon stocks;

- the restoration of marine habitats, such as seagrass or sediment beds, and the recovery of the best-known marine species, such as dolphins and porpoises, sharks and seabirds;

- removing river barriers so that at least 25,000 km of rivers are transformed into free-flowing rivers by 2030.

Approximately €100 billion will be allocated for these purposes.

Chapter 6

ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

6. ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

6.1. INTRODUCTION

Organic agriculture is defined as the application of a set of cultural, biological, and mechanical practices that support the cycling of on-farm resources, promote ecological balance, and conserve biodiversity. It aims to produce and process a system that focuses on the food of optimum quality, free of waste, minimizing the human impact on the environment. Moreover, it uses natural resources optimally, helping to preserve plant and animal biodiversity, and betting on promoting sustainable local development in the area. That means using nature without breaking its biological cycle, extracting from the earth what the earth is capable of giving without over-exploiting it with the use of polluting substances.

Organic agriculture includes maintaining or enhancing soil and water quality, conserving wetlands, woodlands, and wildlife, and avoiding the use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering.

The standard regulates the production of life, or non-processed, agricultural products (vegetables, animals, aquaculture animals, and algae), processed agricultural products intended to be used for human consumption, feed, vegetative reproductive material, and seeds, as well as yeasts.

Through Organic Agriculture, it is intended to achieve the following objectives:

- produce food of the highest quality, sanitary and organoleptic,

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6.1. INTRODUCTION

- preserve food security,
- be environmentally sustainable and economically profitable,
- promote rural development,
- work in an integrated way with ecosystems,
- increase or maintain soil fertility,
- make the most of renewable and local resources,
- avoid the forms of contamination that may result from agricultural techniques,
- maintain the genetic diversity of the agrarian system and its environment.

6.2. KEY POINTS OF THE ORGANIC AGRICULTURE

Biodiversity | Chemical Additives | Soil tillage

Biodiversity

A combination of different crops and plant varieties (crop association) is grown in the same field, fleeing from monocultures that are used in industrial agriculture. In this way, many synergies between crops are achieved.

Agricultural biological diversity increases the resistance of plants to climate change. It has been scientifically proven that, both in nature and in agriculture, biodiversity offers a natural insurance policy against extreme weather events.

Boosting natural biodiversity, wild plants, beneficial insects, and predators ... is another way of guaranteeing a fundamental balance for agricultural exploitation

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6.2. KEY POINTS OF THE ORGANIC AGRICULTURE

Chemical Additives

Pest control is done naturally by enhancing natural control systems, for example, by introducing beneficial insects and birds that feed on pests and plants that repel pests, and attract beneficial insects. The use of hazardous chemicals or the use of transgenics is not allowed.

Natural fertilizers are also keys to organic farming. Fertile soil is achieved with green manures by, for example, the cultivation of legumes. The incorporation of animal manure and compost also enrich the soil. These are just some ways to increase organic matter and soil fertility without synthetic fertilizers. The use of natural fertilizers also allows savings for farmers and eliminates the need for artificial inputs. With natural fertilizers, the soil is rich in organic matter, better able to retain water, and allows better protection against erosion. The use of chemical fertilizers is not allowed.

Soil Tillage

In Organic Agriculture, the soil assumes vital importance and is not mere support of plants but a complex web of life that must be enhanced and pampered. It is the only method of agriculture that seeks to harmonize the functioning of natural systems with the interests of the human being, obtaining healthy food with sustainable yields and ensuring the conservation of natural resources, the health of people, and contributing to mitigating the effects of global warming.

The soil is the main protagonist, it is treated as what it is: a very complex living entity, respecting the infinity of organisms that make it up, working to maintain fertility. For this, it is essential to carry out the minimum possible tillage, even none in some cases, so as not to alter its intrinsic complexity and not lose the layers (horizons) with a greater amount of organic matter.

Another fundamental point in organic farming is the rotation of crops so that the soil is not impoverished. On the contrary, it is enriched to prevent the appearance of pests.

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6.3. BENEFITS OF THE ORGANIC AGRICULTURE

Organic farming allows communities to produce the food they need to feed. This type of agriculture favors a future with respectful agriculture and healthy food for all people. Ecologically grown foods taste better and are healthier. A recent study in California shows that ecologically grown strawberries are sweeter than those produced conventionally. The organic variety also contains 10% more antioxidants, related to the prevention of many diseases.

Organic farming systems produce lower yields compared with conventional agriculture. However, they are more profitable and environmentally friendly and deliver equally or more nutritious foods that contain less (or no) pesticide residues, compared with conventional farming. Moreover, initial evidence indicates that organic agricultural systems deliver greater ecosystem services and social benefits. By not using synthetic chemical inputs that are also very polluting, there is a significant saving for farmers.

It is also the best way to mitigate the effects of climate change and help the world population adapt to the changes that global warming entails.

Organic Farmers

Currently, 2.6 billion people (about 40% of the world's population) are small farmers. These are the farmers who produce most of the food we consume.

Millions of farmers around the world practice organic farming. They demonstrate that it is possible to produce enough food with cost-effective organic methods.

Organic Agriculture in the world

Spain is the country that, for the fourth consecutive year, has been at the head of the platoon in the European Union in terms of the area devoted to organic farming, already reaching the figure of more than 1,845,039 hectares representing a growth in recent years. It is a clear example that organic farming is viable and is the only solution to save agriculture and allow rural development, especially during the deep socio-economic and ecological crisis.

6. ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

6.4. ORGANIC AGRICULTURE IN EUROPEAN UNION

European Union (EU) organic farming rules cover agricultural products, including aquaculture and yeast. They encompass every stage of the production process, from seeds to the final processed food. This means that there are specific provisions covering a large variety of products, such as seeds and propagating material such as cuttings, rhizome etc. from which plants or crops are grown living products or products which do not need further processing feed products with multiple ingredients or processed agricultural products for use as food

EU regulations on organic production exclude products from fishing and hunting of wild animals but include harvest of wild plants when certain natural habitat conditions are respected. There are specific rules for wine and aquaculture.

EU eco-labelling and logo

The EU organic logo on food products ensures that EU standards on organic production are respected. It is mandatory for pre-packaged foods. In the case of processed foods, it means that at least 95% of the ingredients of agricultural origin are organic. Supermarkets and other retailers can label their products with the term “organic“ only if they comply with the rules.

6. ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

6.5. ORGANIC MANAGEMENT PRACTICES

The complex interactions among structural factors and tactical management strategies on a diversified organic farm producing food, fibre and fuel for human and livestock use and consumption. Structural factors, represented by circles, are the foundation of organic management, with diverse crop and livestock rotations at the centre. Tactical management decisions are used to supplement the structural factors and include the use of:

- biological controls;
- supplementary lime, organic fertilizers and compost;
- hedges, margins and other habitat areas;
- species, variety and breed selection;
- temporal and spatial patterns;
- physical weed management.

Organic producers use natural processes and materials when developing farming systems—these contribute to soil, crop nutrition, pest and weed management, attainment of production goals, and conservation of biological diversity.

The tools and practices listed below can be addressed by organic agriculture:

Crop Rotation

Crop rotation is a system of growing different kinds of crops in recurrent succession on the same land.

Green Manures and Cover Crops

Green manures and cover crops are grown primarily for reasons other than short-term economic gain. In other words, they are not produced for sale, but rather for the benefits they provide to the production of subsequent cash crops. Cover crops are so-called because they protect otherwise bare soil against erosion; green manures improve soil fertility. Because a cover crop is inevitably added to the soil, it becomes a green manure, so the terms are reasonably interchangeable.

Manuring and Composting

Manure and compost not only supply many nutrients for crop production, including micronutrients, but they are also valuable sources of organic matter.

6. ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

6.5. ORGANIC MANAGEMENT PRACTICES

Intercropping and Companion Planting

Intercropping is the growing of two or more crops in close proximity to promote beneficial interactions. Companion planting refers to the establishment of two or more species in close proximity so that some cultural benefit, such as pest control or increased yield, may be achieved between them.

Biological Pest Control

Biological pest control is the use of one or more beneficial organisms, usually called natural enemies, to reduce the numbers of another type of organism, the pest.

Sanitation

Sanitation can take on many forms including removal, burning, or deep plowing of crop residues that could carry plant disease or insect pest agents, the destruction of nearby weedy habitats that shelter pests, cleaning accumulated weed seeds from farm equipment before entering a new, and sterilizing pruning tool.

Tillage

Merely maintaining soil organic matter levels is difficult if soil is intensively tilled (such as with annual use of a mouldboard plow.) Reducing tillage means leaving more residue and tilling less often and less intensively than conventional tillage. No-till is the most extreme version of reduced tillage but is not desirable on some soils and is not the only way to conserve soil organic matter.

Mulching

Organic mulches, such as straw or spoiled hay, can reduce the need for cultivation, protect soil from erosion and crusting, and replenish organic matter.

Supplemental Fertilization

Organic farming management relies on developing biological diversity in the field to disrupt habitat for pest organisms, and the purposeful maintenance and replenishment of soil fertility. Organic farmers are not allowed to use synthetic pesticides or fertilizers.

6. ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

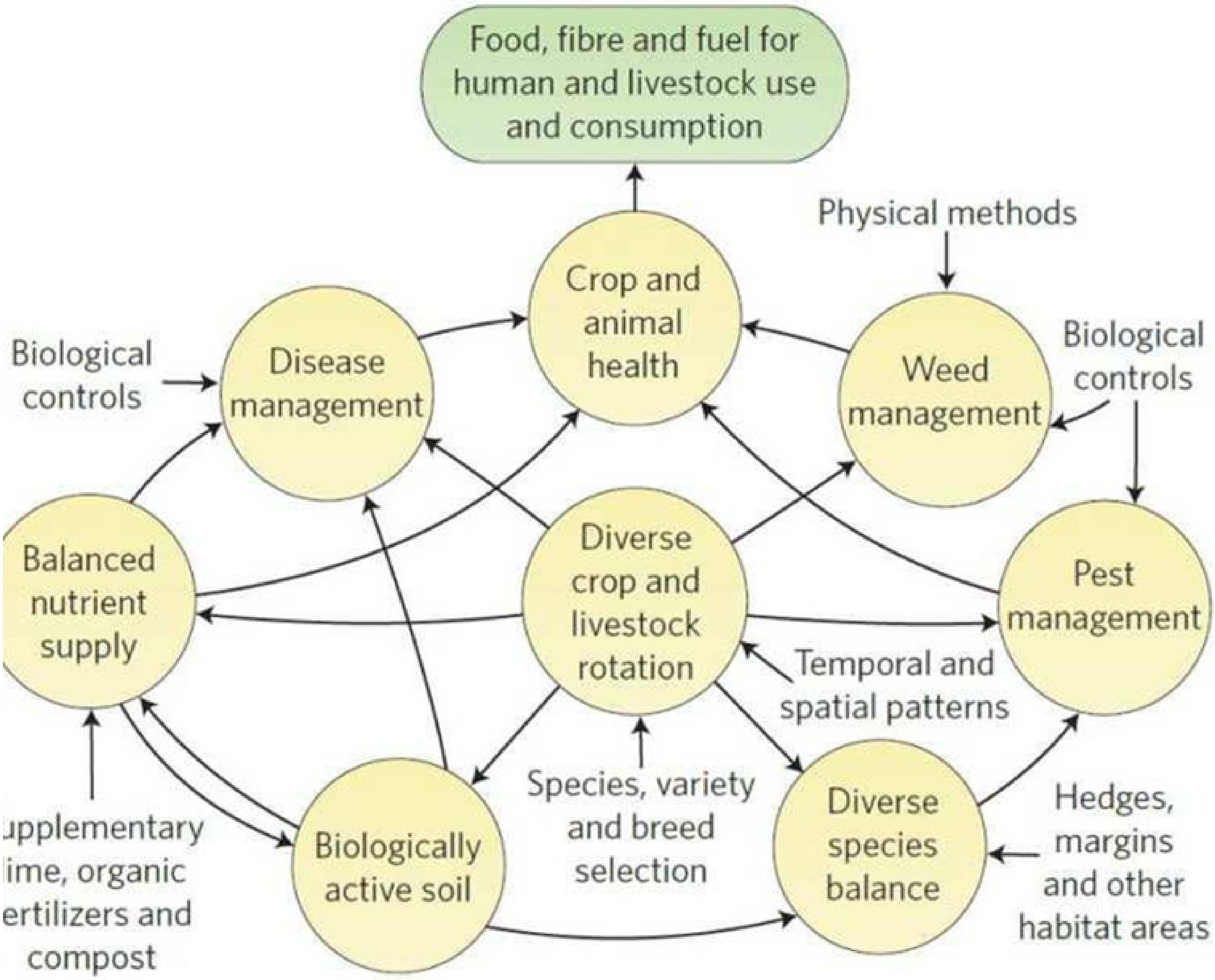
6.5. ORGANIC MANAGEMENT PRACTICES

Biorational Pesticides

This term refers to synthetic, organic, or inorganic pesticides that are both low toxicity and exhibit a very low impact on the environment. “Biorationals“ also have minimal impact on species for which they are not intended (called non-target species). Biorational pesticides include oils, insecticidal soaps, microbials (such as Bacillus thurengienesis and entomopathogenic nematodes), botanicals (plant-based) and insect growth regulators.

Buffers and Barriers

In the context of organically managed systems, buffer and barriers are required under NOP rules if there is a risk of contamination, via drift or flow, of substances not allowed under organic regulations.



The complex interactions among structural factors and tactical management strategies on a diversified organic farm producing food, fibre and fuel for human and livestock use and consumption. (Source Reganold, J., Wachter, J. Organic agriculture in the twenty-first century. Nature Plants 2, 15221 (2016).)

Chapter 7

ORGANIC BEEKEEPING

7. ORGANIC BEEKEEPING

7.1. IMPORTANCE OF BEES

Bees pollinate plants, which is vital for ecological balance in agriculture and forestry. To pollinate their crops, many farmers rely on a variety of bees. Beekeeping is an essential activity for preserving a variety of plant species, especially those that are used for human nutrition. Bees are considered responsible for more than 80% of all insects that pollinate plants.

Unfortunately, the population of honey bees decreased by 40% from 2018 to 2019, and the yearly rate of decline for the winter of 2019 to 2020 was likewise 40%, according to experts. These decreases are “unsustainable.“

News, A., & Jaboco, J. (2021, August 21). National Honey Bee Day: These foods could disappear if pollinator populations continue to dwindle - ABC News.

People might be concerned about the use of chemicals in hives, such as insecticides. Organic beekeeping allows bees to live in a natural environment which is free of pollution, toxins, and other dangerous substances. Simply said, organic beekeepers, provide bees with the opportunity to live their lives as they did many years ago. That is why organic beekeeping has such tight regulations. However, organic beekeeping will allow us to combat bee population decline caused by human activity.

Our course will cover the basics of organic beekeeping, as well as how to put them into practice and the essential steps.

7. ORGANIC BEEKEEPING

7.2. PRINCIPLES AND REGULATIONS

7.2.1 Principles

Organic apiculture aims to manage systems with minimal intervention and healthy methods that protect the environment and sustain diversity and do not utilize synthetic compounds like pesticides.

The method of raising bees without the use of pesticides, herbicides, or other artificial or harmful substances is referred to as "organic beekeeping." The overall structure of organic beekeeping is making sure that the products and substances that have been used in hives are both safe for the bees and the consumers. This method of beekeeping is respectful of bees and their way of life. Various controls are implemented to ensure healthy production, and the standards are extremely precise. Synthetic molecules are strictly prohibited in organic beekeeping, which encourages the use of natural remedies against diseases that can affect the colony. Organic beekeeping requires keeping bee colonies in species-appropriate conditions, using resistant bee varieties, providing housing made of natural materials with residue-free honeycombs and middle walls of wax from organic production units, and using organic acids or essential oils to handle varroa mite disease. The hives need to be located in such a way that the nectar and pollen supplier plants within the bee colonies' flying radius are organically farmed land or from cultures or wild plants that do not threaten the organic quality of the beekeeping products.

7. ORGANIC BEEKEEPING

7.2. PRINCIPLES AND REGULATIONS

7.2.1 Principles

Achieving the minimum organic criteria is one thing, but many organic beekeepers prefer to do so much more. After all, if you believe in the value of an organic approach, you'll want to do everything necessary to ensure that your honey is as pure as possible. In general, the organic approach is aimed at caring for the bees, not just producing as much honey as possible. According to the Research Institute of Organic Agriculture (FIBL) and IFOAM-Organics International, in 2019 (FIBL&IFOAM- ORGANICS INTERNATIONAL, 2021), there were 3 million organic beehives, accounting for nearly 3.4 percent of the world's beehives. Europe (47%) has the highest proportion of organic beehives, followed by Latin America (30%), Africa (14%), Asia (9%), North America (1%), and Oceania (0.2%). Brazil has the most organic beehives (629.939), followed by Zambia (368.274) and Bulgaria (368.274). (264.069). Organic beekeeping is quite difficult due to stringent requirements. Most organic beekeepers face challenges such as location regulations and disease control.

7.2.2. Pest & Disease Treatment

The purpose of organic management is to keep honey bee colonies healthy and productive without using synthetic treatments or antibiotics. For an organic management system, there are parasite and disease control solutions. Natural chemicals or compounds are frequently used in organic pest and disease control.

- Organic varroa mite treatments include formic acid, oxalic acid, and thymol. These treatments can be considered organic.
- Reduce varroa mites by removing drone brood and using screened bottom boards.
- Remove old frames from the hive to help lower disease levels.

7. ORGANIC BEEKEEPING

7.2. PRINCIPLES AND REGULATIONS

7.2.2. Pest & Disease Treatment

Organic pest management adopts the same methods as any other Integrated Pest Management (IPM) system but does not use synthetics or antibiotics. Organic beekeeping might be difficult due to the lack of antibiotic usage. Applying for the IPM program to organic management controls can assist in the success of organic beekeeping. It is critical to understand pests and diseases, how they develop, how they may be managed, and what solutions are available to control them. The four basic components of an IPM system are awareness, monitoring, treatment thresholds, and solutions.

Awareness:

The same disease threats are inflicted on colonies regardless of the type of management strategy used by a beekeeper. All beekeepers must be aware of current problems and new developments in honey bee pests and diseases.

Monitoring:

Monitoring should be done more often for organic beekeeping practices. This is especially critical for some diseases because no antibiotics are given. As a result, the only defense against foulbrood is to physically recognize the problem at its inception, remove the diseased colony as soon as possible, and follow the approved foulbrood treatment, which excludes the use of antibiotics. Monitoring for varroa is also essential. Because organic varroa treatments can be influenced by environmental factors, it is crucial to check not only before, but also after the treatment to ensure efficacy.

Treatment Thresholds:

These remain the same for all beekeeping operations. The procedure should be followed for Honey Bee Disease and Mite Control.

Solutions:

In an organic IPM system, a variety of options are available. Synthetic treatments and antibiotics, as previously stated, are not permitted. When considering which organic treatments to apply, please check the European Regulations for a list of authorized compounds for honey bee colonies.

7. ORGANIC BEEKEEPING

7.2. PRINCIPLES AND REGULATIONS

7.2.3. Regulations

European Commission announced COMMISSION REGULATION (EC) No 889/2008 on 5 September 2008 and established detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labeling of organic products with regard to organic production, labeling, and control.

- Considering the importance of pollination of the organic beekeeping sector it should be possible to grant exceptions permitting the parallel production of organic and non-organic beekeeping unit on the same farm.
- For bees, preference shall be given to the use of Apis mellifera and their local ecotypes.
- For the renovation of apiaries, 10 % per year of the queen bees and swarms may be replaced by non-organic queen bees and swarms in the organic production unit provided that the queen bees and swarms are placed in hives with combs or comb foundations coming from organic production units.
- The siting of the apiaries shall be such that, within a radius of 3 km from the apiary site, nectar and pollen sources consist essentially of organically produced crops and/or spontaneous vegetation and/or crops treated with low environmental impact methods equivalent to those as described in Article 36 of Council Regulation (EC) No 1698/2005 (12) or in Article 22 of Council Regulation 1257/1999 (13) which cannot affect the qualification of beekeeping production as being organic. The above mentioned requirements do not apply where flowering is not taking place, or the hives are dormant.
- The Member States may designate regions or areas where beekeeping complying with organic production rules is not practicable.
- The bees wax for new foundations shall come from organic production units.
- The hives shall be made basically of natural materials presenting no risk of contamination to the environment or the apiculture products.
- Without prejudice to Article 25, only natural products such as propolis, wax, and plant oils can be used in the hives.
- The use of chemical synthetic repellents is prohibited during honey extractions operations.
- The use of brood combs is prohibited for honey extraction.
- Mutilation such as clipping the wings of queen bees is prohibited.
- In the case of bees, at the end of the production season hives shall be left with sufficient reserves of honey and pollen to survive the winter.

7. ORGANIC BEEKEEPING

7.2. PRINCIPLES AND REGULATIONS

7.2.3. Regulations

- The feeding of bee colonies shall only be permitted where the survival of the hives is endangered due to climatic conditions and only between the last honey harvest and 15 days before the start of the next nectar or honeydew flow period. Feeding shall be with organic honey, organic sugar syrup, or organic sugar.
- For the purposes of protecting frames, hives, and combs, in particular from pests, only rodenticides (to be used only in traps), and appropriate products listed are permitted.
- Physical treatments for disinfection of apiaries such as steam or direct flame are permitted.
- The practice of destroying the male brood is permitted only to isolate the infestation of Varroa destructor.
- If despite all preventive measures, the colonies become sick or infested, they shall be treated immediately and, if necessary, the colonies can be placed in isolation apiaries.
- Veterinary medicinal products may be used in organic beekeeping in so far as the corresponding use is authorised in the Member State in accordance with the relevant community provisions or national provisions in conformity with Community law.
- Formic acid, lactic acid, acetic acid, and oxalic acid as well as menthol, thymol, eucalyptol, or camphor may be used in cases of infestation with Varroa destructor.
- If a treatment is applied with chemically synthesised allopathic products, during such a period, the colonies treated shall be placed in isolation apiaries and all the wax shall be replaced with wax coming from organic beekeeping. Subsequently, the conversion period of one year laid down in Article 38(3) will apply to those colonies.
- Beekeeping products can be sold with references to the organic production method only when the organic production rules have been complied with for at least one year.
- The conversion period for apiaries does not apply in the case of application of Article 9(5) of this Regulation.
- During the conversion period, the wax shall be replaced with wax coming from organic beekeeping.

7. ORGANIC BEEKEEPING

7.3. ECOLOGICAL (BEE-FRIENDLY) METHODS OF PLANT PROTECTION

Integrated Pest Management (IPM)

IPM is one of the sustainable methods commonly used by people. In order to reduce risks to the economy, human health, and the environment, IPM integrates biological, cultural, physical, and chemical solutions into one sustainable pest management strategy. IPM encourages organic methods of pest management and puts a focus on crop health while causing the least amount of harm to agricultural ecosystems as is humanly possible. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. Both agricultural and non-agricultural environments - such as the home, garden, and office, can use the IPM strategy. In contrast, the production of organic food applies many of the same principles as IPM but limits the use of pesticides to those derived from natural sources rather than synthetic chemicals. IPM is a set of pest management evaluations, decisions, and controls rather than a single approach to pest control.

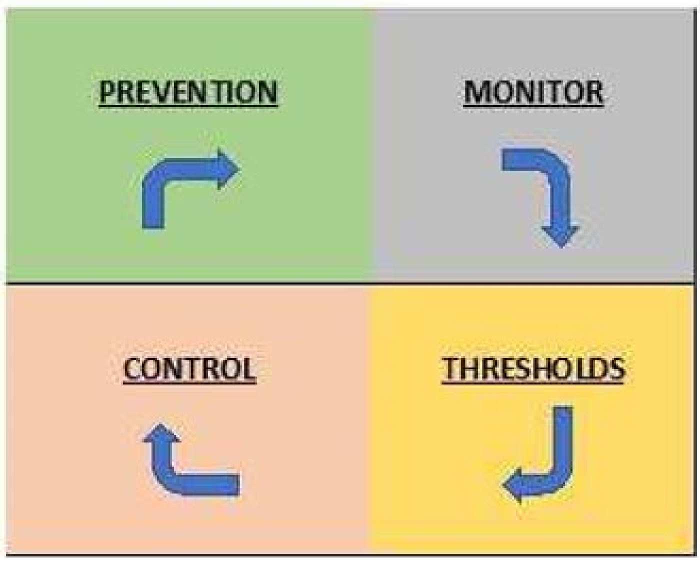
Generally, a four-step approach is followed:

1. Prevention: Avoiding circumstances where the pest or disease could become a threat is the first line of defense against pests.To this aim, make a plan to prevent, decrease, and avoid pest and disease threats.

2. Monitor: Not all diseases and pests need to be controlled. Proper classification enables the implementation of effective control measures. This eliminates the possibility of using pesticides improperly or unnecessarily.

3. Set action thresholds: Set action thresholds: When pest and disease populations reach a critical level or when environmental conditions are becoming a threat, action should be taken to avoid financial loss.

4. Control: Appropriate control methods can be used when monitoring, identification, and thresholds of pests or diseases indicate that action is required. The first approach to choose should be non-chemical solutions. Targeted pesticide application should be used if non-chemical approaches are unsuccessful.



7. ORGANIC BEEKEEPING

7.3. ECOLOGICAL (BEE-FRIENDLY) METHODS OF PLANT PROTECTION

Benefits of Integrated Pest Management:

1. Financial: Pesticides usually cost a lot of money to apply and manage pest populations. IPM implementation would reduce the financial burden. Additionally, IPM's various strategies are more sustainable and have long-lasting advantages.

2. Environment: The use of pesticides is frequently associated with environmental damage, which results in certain additional concerns. IPM is an environmentally friendly method, and before implementing any treatments, the consequences on the environment are always taken into account. The soil's fertility won't be impacted by using fewer pesticides.

3. Minimize Pesticides: IPM program will drastically reduce the use of pesticides, which effectively reduces the risks associated with pesticide residue.

4. Anti-Resistance: The anti-resistant mode of pest control is the IPM model itself. Chemical use is discouraged, which results in fewer cases of anti-resistance. Only when no other options are available are pesticides applied.

IPM is one of the most environmentally friendly methods of plant protection, however, it also has some limitations. IPM must be properly planned. It also needs more dedication and commitment. IPM application takes time, and it could take a while to see the desired outcomes. Lack of support from the government and policies is another IPM limitation.

7. ORGANIC BEEKEEPING

7.4. ALTERNATIVE ORGANIC METHODS OF PEST MANAGEMEN

Organic Pest Management

There are different methods of managing pests than IPM. Pesticides are never used in organic pest management because it is totally natural. This process entails seven steps.

1. Natural predation: The pest in concern will be managed by luring nearby populations of any specific pest's natural predators. Garden pest populations, such as aphids and slugs, can be effectively reduced by ladybirds, lacewings, frogs, hedgehogs, and birds.

2. Hand-picking: Infested areas will be taken out by hand. Even if it takes a long time and requires a lot of work, clearing up areas of infestation by hand might be good for the remainder of the plot.

3. Water Spraying: Aphids and related species can be eliminated from plants by spraying them with water or a light soap solution.

4. Organic deterrents: Numerous plant oils and other organic compounds utilize the natural resistance of plants to attack while having a preventative or fatal effect on particular garden pests. As a result, they are completely eco-friendly.

5. Biological Control: Encarsia, a parasitic wasp, can attack whiteflies. This works by paralyzing the whitefly nymph, limiting the population of whiteflies and their negative effects on sensitive plants.

6. Companion planting:The impact on crop species can be lessened by planting closely together with species that entice predatory insects or disguise vulnerable plants as pests are less likely to find their food plants.

7. Deterrents and Barriers: Numerous possible garden pests are sensitive to certain elements. Slugs, for instance, do not like copper pipes or the jagged edges of eggshells, thus placing such things around plants may prevent a variety of species. Placing straw and plastic bottles at the base of plants is another solution to prevent pests.

CASE STUDIES

BEECONNECTED

Innovative smartphone software is now available to Australian farmers and beekeepers to assist in ensuring the protection of bees during typical farming practices. BeeConnected, an innovative geomap-based, user-driven communication and coordination platform to help safeguard Australia's honey bee population, was established by CropLife Australia.

BeeConnected allows farmers and agricultural service providers to record the date, time, and location of specific application activity for a crop protection product. By using the same alert and messaging system, they are then linked up with beekeepers in that particular location. BeeConnected is a Google Maps-based software with GPS functionality that enables farmers to simply log the location of their farms.

The same features can be used by beekeepers to record the current or future locations of their beehives. Both users receive automated notifications and have the option to communicate more about their actions over a secure internal messaging service when a beehive is spotted close to a farmer's property.

To assist in defending Australia's honey bee population during typical farming operations, Google Maps-based BeeConnected is a world-first user-driven communication and coordination platform. Many of Australia's crops are pollinated by Australia's honey bee populations.

BeeConnected Website: https://beeconnected.org.au/

BEE PROTECTIVE- BEYOND PESTICIDES

BEYOND PESTICIDES

Beyond Pesticides is a non-profit organization based in Washington, D.C. that collaborates with partners in public health and environmental protection to lead the transition to a world free of toxic pesticides. Beyond Pesticides (originally known as the National Coalition Against the Misuse of Pesticides) was founded in 1981 as a non-profit membership organization because the founders believed that without the existence of such an organized, national network, local, state, and national pesticide policy would become increasingly unresponsive to public health and environmental concerns due to chemical industry pressure. Beyond Pesticides believes that people should have a participation in issues that directly affect them.

Beyond Pesticides informs the general public about pesticides and alternatives to their use. With this awareness, individuals can and do protect themselves and the environment against the potential negative public health and environmental effects of pesticide use and misuse. Beyond Pesticides has two main approaches to the pesticide problem, identifying the risks of conventional pest management approaches and promoting non-chemical and least toxic pest management alternatives.

The organization's main objective is to effect change through local action, aiding individuals and community-based organizations in stimulating discussion about the dangers of toxic pesticides while providing knowledge about safe alternatives.

In order to protect pollinators and the environment, Beyond Pesticides promotes the wide adoption of organic management practices. The organization has long advocated for a market transition to organic practices that forbids the use of dangerous synthetic pesticides and promotes a systems-based strategy that is safe for people and the environment.

Beyond pesticides website: https://www.beyondpesticides.org/

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PESTICIDE ACTION NETWORK (PAN)

The Pesticide Action Network (PAN), established in 1982, is a global network of over 600 non-governmental organizations, institutions, and individuals operating in more than 60 countries who are dedicated to minimizing the harmful effects of dangerous pesticides and promoting the use of environmentally friendly alternatives.

Five independent Regional Centers independently manage their actions and programs. Europe's regional center is PAN Europe. PAN works to reduce reliance on chemical pesticides and to support safe, sustainable pest management strategies.

PAN Europe is dedicated to significantly reducing pesticide use across the continent. Reducing pesticide use (including biocides) is a requirement for improving worker and public health as well as environmental protection, and its strict implementation is consistent with the precautionary principle. The use of pesticides should be minimized. PAN Europe focuses on advocacy, policy analysis, networking, and campaigning actions related to pesticides in order to achieve this vision. It coordinates NGO advocacy and public involvement in EU pesticide policy and works closely with members of the European Parliament, the Commission, and the Council to influence key decision-makers to reduce the use of dangerous pesticides. Working with academics, retailers, trade unions, farmers, scientists, and scientists is another one of their initiatives.

Examples of PAN campaigns are listed below:

- Ban Toxic 12
- Low Impact Farming
- Save the Honey Bees
- Pesticide Free Towns
- Voice of Pesticides

Pesticide Action Network Website: https://www.pan-europe.info/about-us/who-we-are

BEELIFE

BeeLife
European Beekeeping Coordination

A European non-governmental organization (NGO) called BeeLife European Beekeeping Coordination focuses on environmental problems that have an impact on pollinators, especially bees, and consistently campaigns for their protection. Beekeepers and beekeeping organisations started to strengthen their partnerships as colony mortality and the collapse of insect populations expanded throughout Europe. This was done to combat some of the causes and lessen the impacts. Together with some experts, they came to the conclusion that beekeeping-specific difficulties like parasites and infections were frequently a cover for the true environmental challenges. However, a major problem for bees and other pollinators in general has been and continues to be the high environmental toxicity carried on by extensive pesticide usage and other unsustainable farming practices. As a result, collaborators from many European nations established the NGO BeeLife in 2013 to promote their cooperative efforts to improve environmental conditions for bees and biodiversity. It has been working at the European level to improve conditions for bees and pollinators in general since its registry.

Bees have a vital role in culture and identity, in addition to pollinating and being necessary for our food security and healthy ecosystems. Over 20 beekeeping and farming groups from various European nations present the Coordination. Since its creation, it has worked on several critical dossiers for bees, including pesticide authorisation and use, GMOs or veterinary product authorisation, Common Agricultural Policy developments, defending the 2013 neonicotinoid partial ban in the Bayer and Syngenta vs European Commission case, and even co-organizing Bee Week at the European Parliament, among other activities. BeeLife has been working to improve the pesticide authorisation procedure since 2009, even before it was officially established. BeeLife primarily advocated for evaluating pesticide impact on bees and including it as a criterion during pre-market evaluation. BeeLife is working on a variety of projects and increasing awareness to safeguard bees and biodiversity.

BeeLife Website: https://www.bee-life.eu/

NATIONAL APICULTURE PROGRAMMES

Running for three-year periods, the national apiculture programmes for 2020-22 are co-funded by the European Union.

The budgets for the national apiculture programmes are only provisional and need to be approved by the European Commission, they will be adjusted based on the allocation granted to each EU country.

EU countries also produce annual implementation reports on the application of the national apiculture programmes during the previous year.

National apiculture programmes- official EC website:

https://agriculture.ec.europa.eu/farming/animal-products/honey/national-apiculture-programmes_en

NATIONAL PESTICIDE INFORMATION CENTER (NPIC)

Oregon State University and the US Environmental Protection Agency established the National Pesticide Information Center (NPIC) to provide independent and objective, factual information about pesticides, the detection and management of pesticide poisonings, toxicology, and environmental chemistry. It is funded through a cooperative agreement that is competitively awarded to an eligible applicant every 3–5 years.

The program was initially established in 1978 as a toll-free telephone service at the Texas Tech University Health Sciences Center to help medical professionals identify and treat pesticide poisonings. [3] The service was successively made available to the general public. The National Pesticide Telecommunications Network (NPTN) was formed in the middle of the 1980s after the NPIC relocated to Texas Tech University.

The program was transferred to Oregon State University (OSU) in 1995, and in 2001 the name was changed to the National Pesticide Information Center. The Ecological Pesticide Incident Reporting portal was created by NPIC. This portal provides a method to report ecological incidents that are known to be related to pesticide exposures. Ecological incidents occur when adverse field effects affect non-target species like plants, bees, birds, fish, shellfish, and wildlife (including non-crop damage from dicamba or other herbicide use). This portal's data can be sent directly to the US Environmental Protection Agency. Information from this portal can be used to inform decision-making in federal pesticide regulation.

NPIC Website: http://npic.orst.edu/index.es.html

MEDÍK-ŠEDÍK (Slovakia)

The bee farm project "MEDÍK-ŠEDÍK" follows the growing trend of keeping bees in cities to popularize bees and their products (honey, pollen, propolis, wax, royal jelly, and bee venom). Peter Šedík, a keen beekeeper, keeps bees in 4 locations in Nitra and the surrounding area:

- directly under the Nitra castle,
- Čermáň,
- Lívia organic orchard in Kolíňany,
- orchard near Nitra.

In his apiaries, he:

- produces true honey of high quality
- treats bees organically and WITHOUT chemistry
- does not feed the bees with sugar during the season
- regularly tests the quality parameters of the honey

In addition to beekeeping itself, he also organizes various lectures on beekeeping, bee products, and their use in apitherapy (healing with bee products).

The bee farm project "MEDÍK-ŠEDÍK" follows the growing trend of keeping bees in cities to popularize bees and their products (honey, pollen, propolis, wax, royal jelly, and bee venom). Peter Šedík, a keen beekeeper, keeps bees in 4 locations in Nitra and the surrounding area:

Adopt a Queen

Peter Šedík launched a new project "Adopt a Queen" a few years ago. Each hive is ruled by one queen bee (mother), so he decided to put this symbolism into a new project to support the bees through adoption. Bees are the guardians of the environment and the balance of nature. By pollinating, they contribute to the sustainability of the whole ecosystem and increase the yield of fruit and vegetables in our gardens. The "Adopt a Queen" project creates an opportunity to support the bee population in Nitra and its surroundings. Moreover, it guarantees quality bee products.

Website Medík-Šedík: https://www.medik-sedik.sk/

BEEKEEPING Geraldína (Slovakia)

Geraldína s. r. o. was founded on 12 September 2009 in Oponice, Topoľčany district. It takes its name after Geraldine, the Albanian queen, from Oponice. For more information about Queen Geraldine, visit the Château Appony in Oponice. The company owns the trademark "Slovenský med" and the brand Regional product PONITRIE, which are the mark of quality.

The beekeeping is located approximately 1 km from the foothills of the Tríbeč Mountains. The mixed forest provides plenty of grazing for bees, with a considerable representation of acacia, linden, and bird cherry. There is also a chestnut tree. The edges of the forests are lined with blackthorn and hawthorn. Along the watercourses grow important bee-keeping trees such as willow, willow, alder, and poplar. The cultivation of agricultural plants, particularly oilseed rape, sunflowers, clover, lucerne, and buckwheat, is also a significant contribution to beekeeping.

Thanks to the varied flora in its surroundings, the apiary produces spring flower honey, acacia honey, lime honey, honeydew honey, summer flower honey, and sporadically other types of honey.

Geraldína is also involved in the downstream processing of bee products. From the obtained propolis, it prepares propolis ointment and tincture. Both have beneficial effects on various health problems. Honey with pollen is a valuable nutritional supplement containing all the vitamins, minerals, enzymes, and amino acids substantial for the human body. It achieves its full effect by fermenting the collected pollen in honey, which guarantees its digestibility and maximum utilization of all the valuable substances contained in the pollen. It also focuses on combining honey with royal jelly, thus creating a very effective natural product, helpful for various health problems. Another product is beeswax, which is used to make beautiful, themed candles. Also worthy of attention are products from the honeycomb vine, containing the enzyme crease, which is very beneficial for health.

The hives are housed in a log-paneled apiary with a shingled roof, which protects them from inclement weather. Furthermore, hives protected in this way do not need to be treated with coatings, which guarantees an ecological approach to rearing and the high quality of honey and other bee products.

Beekeeping is also engaged in rearing queen bees and rearing new colonies in the form of detachments, thanks to which a stable number of bee colonies is ensured at the level of 50 to 70 bee colonies. When treating the colonies against pests, the apiary emphasises the use of organic products.

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ECOCOLMENA (Ecohive) - Social Innovation in Beekeeping (Spain)

This organization is a social innovation NGO that also works to protect the environment, help bees, beekeeping and wild pollinators. Mainly, they try to involve citizens, companies and governments in the protection of bees and beekeeping, as well as wild pollinators; they also regenerate ecosystems and favour the social economy.

On the other hand, their programs include beekeeping courses, work with schools, field visits, online talks to companies and programs like:

Sponsor a Beehive

This NGO offers to sponsor a hive, visiting the sponsored hive and getting a reward. Anybody can help protect the environment and the balance of the ecosystem, and support the work of organic beekeepers.

https://www.ecocolmena.org/sponsor-a-beehive-and-help-a-beekeeper/?lang=en

Be a Beekeeper For A Day

It allows to live the unforgettable experience of caring for one of the most important insects on the planet, learning how bees live and why they are so important to us. People only need to choose the Host Beekeeper nearest the, select the date to visit the apiary and send the request questionnaire

The activity is aimed at environmental education and raising awareness about the protection of all pollinators and their ecosystems; showing in a practical way how bees make honey and how beekeepers work; teaching the secrets of bees, how they live, organize themselves and work and the diseases and problems they are currently suffering.
https://www.ecocolmena.org/para-ti/apicultor-por-un-dia/?lang=en

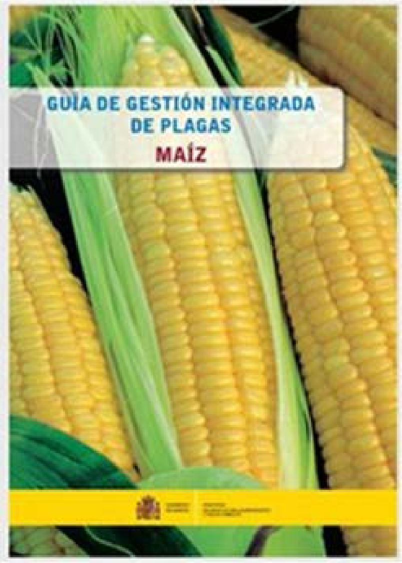
Pollination Islands

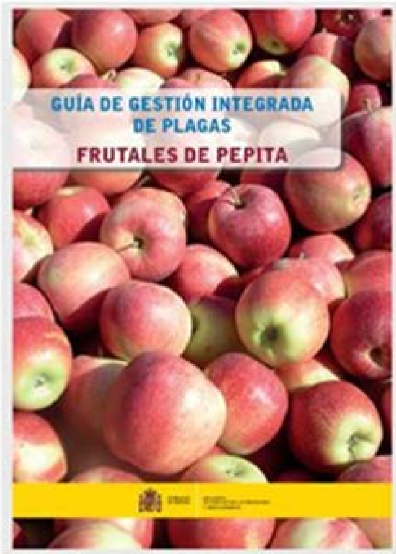
The pollination islands are regenerated spaces and corridors in areas degraded by agricultural, residential, industrial or extractive use. In addition, this way they establish a permanent research shelter on the feeding and health of honey bees, Apis mellifera, and other solitary bees and wild pollinators. Similarly, they provide farmers with ecological focus areas to meet the 'greening' quota of the European Union's Common Agricultural Policy and they provide an Environmental Education Centre for schoolchildren to promote the protection of bees and other pollinators.

https://www.ecocolmena.org/isla-de-polinizacion/?lang=en

HANDBOOKS TO INTEGRATED PEST MANAGEMENT (Spain)

The purpose of the Integrated Pest Management (IPM) guides is to provide guidance to farmers and advisors in order to implement the principles of integrated pest management throughout the national agricultural production, one of the requirements for all farms operating in Spain, according to Royal Decree 1311/2012, of 14 September, which establishes the framework for action to achieve a sustainable use of plant protection products.





The National Action Plan for the Sustainable Use of Plant Protection Products, approved in 2012, foresees to combine cultural measures, the use of chemicals and alternative measures (such as biological control through the use of natural predators, traps and pheromones). The use of pesticides must be carried

out with proper advice, adequate training of the farmer, appropriate safety measures and the establishment of protection areas in the crops fields.

They are focused to specific agricultural sectors to be more practical and useful. They are technical documents that set out the measures to be applied to treat the pests that may appear in the crop in the most sustainable way possible.

https://www.mapa.gob.es/es/agricultura/temas/sanidad-vegetal/productos-fitosanitarios/guias-gestion-plagas/default.aspx

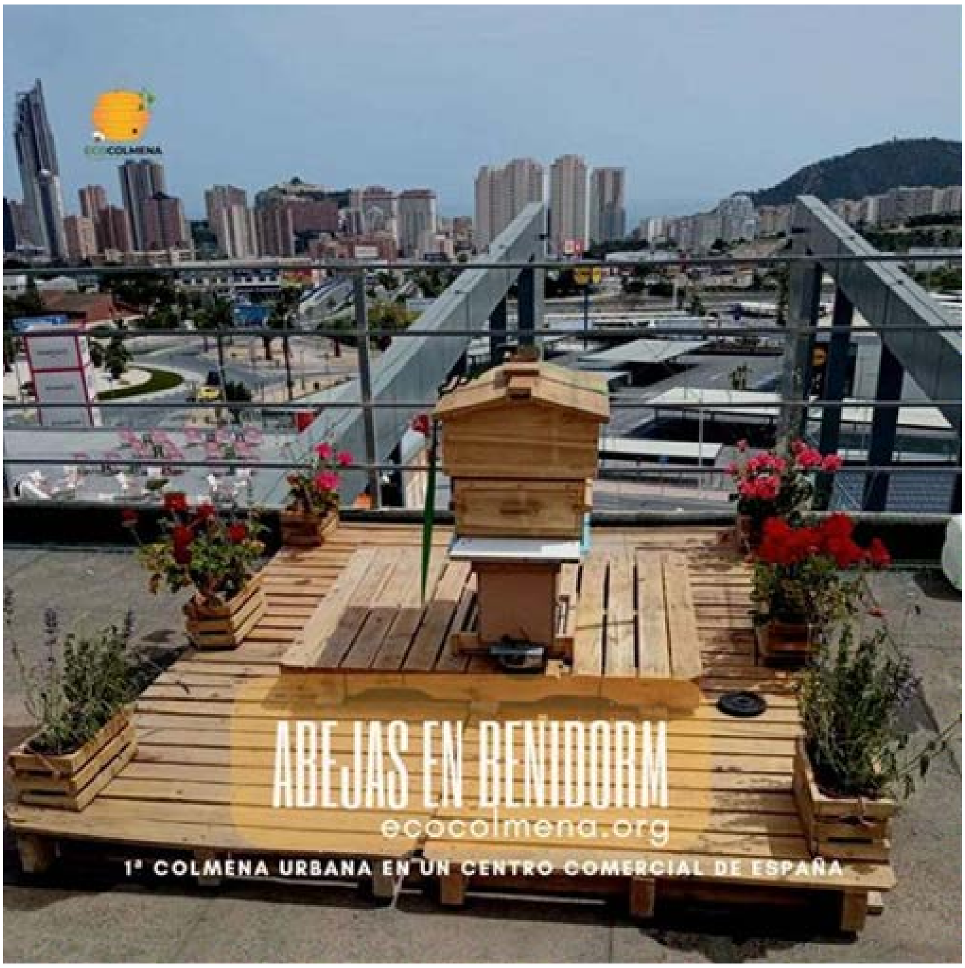
FIRST URBAN BEEHIVE IN A SHOPPING CENTRE (Spain)

Urban beekeeping can revitalize local bee populations. Bees are safe in an urban environment. Ultimately, hives located in cities produce healthier bees. The reason is that urban bees have access to greater biodiversity, resulting in a more varied diet and stronger immune systems.

While it may seem natural for hives to thrive better in rural environments, modern monoculture agriculture sequesters a diverse diet for bees and exposes them to more pesticides.

The NGO "Ecocolmena" offers urban beekeeping with bees in companies. They can install different types of observatory beehives, as a way to connect employees or customers with nature.

https://www.ecocolmena.org/apicultura-urbana-con-abejas-en-tu-empresa/



APIARY IN THE HEART OF CITY (Poland)

Bees have taken up residence in the very centre of Rzeszów. A Apiary in the Heart of City has been created!

Five bee colonies have taken up residence on the roof of Galeria Rzeszów. This is up to half a million bees, who will not only prepare delicious Rzeszów honey, but above all a valuable lesson in understanding the role of bees in our environment. Apiary in the Heart of City is being launched - a joint project of the Rafał and Maciej Szela brothers, beekeepers who create the authorial programme TAKdlaPszczół (YES to Bees), Galeria Rzeszów and the City of Rzeszów.

Apiary in the Heart of City in Rzeszów's downtown stands out for its mission and innovative approach to the subject of the permanent presence of bees in the city. The apiary will serve as a beekeeping recording studio - on the roof of Galeria Rzeszów, surrounded by bees, beehives and melliferous plants, educational films will be created, sensitising us to the presence of bees in our surroundings, teaching and inspiring us. Thanks to this cooperation, it is possible to build new strategies for education and the return of nature to the city. Rzeszów is thus not only joining the European trend of building apiaries in metropolises, but also entering it with its own innovative approach. The opening of the Apiary in the Heart of the City is the first step towards creating a complete strategy for bees and wild pollinators in the city.

The space prepared by the organisers on the roof of Galeria Rzeszów is unique. It has been planned down to the smallest detail. It is a kind of comfortable 'hotel' for bees. Not only do they have comfortable hives at their disposal, but they can also enjoy the greenery specially adapted to their needs. The bees also enjoy the clean water available in the permanently installed drinking trough. The honey-giving plants have been selected so that the insects can enjoy them during the season.

These are mainly plants typical of green roofs such as sedums, but also flowers with a more garden-like character - rudbeckia, myrobalan or coneflower. The landscaping of this space was designed by landscape architects Zuzanna and Rafał Szel. The beehives are situated on a wooden structure made by Galeria Rzeszów. It allows the bees to take off and land freely. The high attic of the roof is not an obstacle for them. This solution limits the accumulation of high temperatures, ensuring that the bees can work during the day.

WILDFLOWER MEADOW FLOWING WITH HONEY (Poland)

Flower meadows attract many residents, who return the favour of a safe place to live by supporting the proliferation of colourful plants. Promoting biodiversity is cited as one of the greatest benefits of establishing such spaces in urban areas. In turn, when planted close to agricultural areas, they can help to increase crop yields, as the insects living in them will pollinate the vegetables and fruit being grown.

Bracia Sadownicy is a Polish company that produces healthy apple-based products and has been looking after the welfare of bees, other insects and birds in its orchard in Śmiłowice. The activities it undertakes are not only in harmony with the environment, but also with concern for it. So far, the activity for pollinating insects has mainly focused on the company's own orchard; the brand has also undertaken cooperation with beekeepers or local schools. In June 2021, Brothers launched a nationwide campaign, and invited floral expert Maja Popielarska to participate.

OBJECTIVES

The Brothers and May for Bees campaign aimed to raise awareness of the significant role of bees in the ecosystem and to draw attention to problems and changes that affect the welfare of pollinating insects. One way to help is by sowing flower meadows, which was encouraged by the Orchard Brothers during the campaign.

ACTIONS

One of the activities undertaken by the Brothers was the planting of ten million different flowers in the form of a flower meadow, which provides food for the bees. The campaign was promoted through short spots on websites, banners and social media posts and competition.

The campaign also had an extensive message on Instagram, not only in the form of posts and testimonials on the brand's profile, but also thanks to the collaboration with influencers undertaken. As part of the action in support of the bees, selected influencers received baskets of limited edition products, but also field flowers and seeds to plant their own small flower meadow.

WILDFLOWER MEADOW FLOWING WITH HONEY (Poland)

Replacing traditional lawns with flowering meadows is an interesting solution for preserving biodiversity that has been successfully introduced in several cities across the country. Urban meadows are already flourishing in Warsaw, Krakow, Bialystok, Gdynia and Gdansk. In the Kujawsko-Pomorskie region, they can be admired in Bydgoszcz, Inowrocław and Włocławek. Interestingly, in Włocławek, an apiary is planned in a flower meadow in the Słodów Municipal Park, covering an area of over 3,500 square metres. The city wants honey to become its new symbol.

It is worth noting that conditions suitable for bees are increasingly being created in urban spaces. Already since 2016, an apiary of five beehives (each populated by around 40-50 000 individuals) has been operating on the roof of the Marshal's Office in Toruń.

URBAN BEE - ADOPT A HIVE (Romania)

Adopt a hive – story from the founders

We have thought for a long time to give people the opportunity to have a beehive without any other worries. For us, love for bees was love at first sight.

Sometimes you don’t even trust organic products because you think that you have no way to control their quality or how they were produced. We thought it would be best if you could oversee the production process from start to finish. Said and done!

I came up with the “adopt a hive“ idea by accident. Talking with friends, I realized that many times you find yourself in a situation where you want to buy something healthy for yourself or your family and you don’t realize how to make the best choice; you want a natural product, which does not contain food additives, sugars, or who knows what other harmful substances.

What do you get if you adopt a hive?

- Promotional package
- Free delivery
- 10% discount on the following orders
- Owner Certificate “Adopt a hive“
- We personalize the hive with your name

What does it mean to “Adopt a Hive“?

A financial investment of 500 lei (100 EUR), which represents the cost of the hive, its preparation and maintenance to be populated.

CONCLUSIONS

CONCLUSIONS

- Honeybees constitute an interesting and complex group of insects whose biology, social organization and the roles of the different members of the colony (breeding queen, drones and workers) are important to be known in order to understand their importance, interest and the risks they face.

- Bees are among the most important pollinators of both agricultural crops and wild plants. Bees provide many benefits in the form of cross-pollination essential for environmental conservation and play an important role in nature and agriculture production. We need to be aware of how vital honeybees are and that our lives probably could not exist without them.

- Beekeeping is a very important economic activity in the European Union and in the world. The interest of the great variety of bee products (honey, propolis, bee venom, pollen, royal jelly, apilarnil, bee air...) is unquestionable, with enormous therapeutic properties that have been exploited since ancient times and are more and more valued.

- The use of plant protection products and pesticides is considered one of the greatest threats to the conservation of bees, which are particularly susceptible to the action of certain plant protection products, so the loss of bees has become a major problem.

- Bees and other pollinators face different threats. The use of plant protection products is only one of the factors affecting the health of pollinators in nature. They are also exposed to a series of synergistic factors that act negatively, such as climate change, the degradation of individual communities, the appearance of different types of associated diseases, the impact of invasive species or the lack of diversity of flowering plants due to monocultures, among others.

- Bees are one of the most effective groups of pollinators in agro-ecosystems, so the threats they face can have serious consequences for the agricultural production needed to supply the world's population, as they directly affect the pollination of a large number of species.

- The decline of bee and other pollinator populations also has environmental consequences and imbalances that are highly detrimental to biodiversity and ecosystem health in general.

- The quality of honey, pollen and bee viability is an excellent measure of the quality of the environment. The health of bee colonies and their development are negatively affected by any mixture of pesticides in the food (honey, pollen) accumulated in the hive.

CONCLUSIONS

- Agrochemical products play an irreplaceable role in the modern structure of primary agricultural production, and it is impossible to achieve strategic food self-sufficiency without the use of plant protection products in the face of the challenge facing agriculture in the 21st century of having to produce more food to feed a growing population with a smaller workforce.

- Agricultural production is one of the most important economic sectors in Europe and ensuring a healthy and quality agricultural production is a priority public interest.

- Training of the different professionals involved in the use of plant protection products and fertilizers should be spread in an adequate and effective way in order to find a balance between nature and the use of chemical products on crops and minimize as much as possible the negative impact these products have on the environment.

- More scientific studies are needed to better understand the specific negative effects of the variety of pesticides and chemical products used in agriculture, as well as the effects of combinations of these plant protection products, since synergies between them can multiply their harmful effects.

- It is important to expand training on the different types of plant protection products and fertilizers used in agricultural production, their different forms of presentation and application, the possible routes of exposure of pollinating insects to the residues of these products as well as the basic principles to be respected in their storage, handling and application so that the risk and impact on bees, wildlife and the environment in general are as low as possible.

- It is important to choose the right habitat for bee colonies and solitary bees (the so-called insect hotels) outside of intensively used agricultural landscapes, establishing green surrounding areas planted with flowers.

- Cooperation and information between farmers and beekeepers is essential. It is important to know in spring the crop mix of bee colonies and to consult with farmers on the planned timing of planned chemical crop protection, as well as to inform farmers about the habitat of bee colonies.

- Insecticides, because they are designed to control pest insect populations, pose a greater risk than other plant protection products to bees and other non-target insects that come into contact with them.

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CONCLUSIONS

- In particular, the use of certain insecticides such as neonicotinoids has been identified in a large number of scientific studies as a major threat to bee health and as a consequence their application has been restricted in the European Union.

- The risk of plant protection products lies not only in their high toxicity, but also in their persistence in the environment and in their mechanisms of action, which can affect physiological aspects, learning capacity, larval development, fertility and reproductive capacity or behaviors such as orientation and navigation that affect their pollinating capacity. All these alterations, although they do not lead to immediate death or collapse of the hive, do have negative consequences on its survival and conservation in the long term.

- Herbicides do not have acute toxicity to pollinating insects, although their use has also been reported on occasions as a threat to them, for example, by altering the learning and navigational ability of bees or interfering with the development of their larval stages. The use of herbicides often indirectly affects pollinators because they eliminate numerous wild plants and reduce floral diversity in agricultural areas.

- The effect of fungicides has been less studied but it is known that residues of these compounds in hives are related to the prevalence of diseases in bees.

- It is essential to know and follow the instructions for use and application of plant protection products in agriculture, among others: respecting the level of risk classification for bees and the consequent restrictions on the use of the products, respecting special precautions when using the products, complying with the maximum authorized application rates and the application calendar in relation to the flowering of honeybee crops, not using unauthorized combinations of mixtures of two or more plant protection products and/or combination of plant protection product + fertilizer, and not applying in windy or hot weather, among others.

- The use of pesticides applied in aerosol form should be limited to times when the risk of contact with pollinators is lower, such as at night. Also, spray application should be avoided as much as possible during the flowering season of cultivated and wild plants growing in the vicinity.

- The effects of exposure to mixtures of pesticides should be better studied and included in risk assessments of plant protection products. The simultaneous application of compounds that may present interactions or synergies in pollinator organisms should be avoided.

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CONCLUSIONS

- It is essential to respect and develop the practices established in Integrated Pest Management (IPM), i.e. the careful consideration of all available methods of plant protection and the subsequent implementation of measures that prevent the development of pest populations and keep the use of plant protection products at economically and environmentally justified levels to minimize the risk to human health and the environment.

- The introduction of the obligation to protect all crops according to the Integrated Pest Management principles in all EU Member States (January 1, 2014) has had a significant impact on the protection of the agricultural environment and thus pollinators.

- Organic agricultural production uses natural processes and materials in the development of its farming systems, which contribute to the conservation of biological diversity. It uses the following ecological practices: crop rotations, green manures and cover crops, organic fertilizers such as manure and compost, intercropping of crops and associated crops, biological pest control, preventive sanitation mechanisms, reduced tillage, use of organic mulches and low-toxic pesticides and low impact on the environment, among others.

- Only plant protection products that meet the conditions of Annex I of Commission Implementing Regulation (EU) No. 2021/1165 authorizing the use of certain products and substances in organic production and establishing lists thereof may be used in organic agricultural production.

- Agriculture has to increasingly adopt efficient and sustainable production methods and be adapted to climate change and other new challenges of this century.

- Organic beekeeping aims to manage bee production with minimal intervention and healthy methods that protect the environment and maintain diversity and do not use synthetic compounds such as pesticides or other artificial chemicals, ensuring that the products and substances used in the hives are safe for both bees and consumers.

- Organic beekeeping encourages the use of natural remedies against diseases that may affect the colony, maintains the hives in appropriate conditions, uses resistant bee varieties, provides housing made of natural materials with residue-free comb and wax mid-walls from organic production units and the nectar and pollen supplying plants within the flight radius of the bee colonies must be organically grown or from wild plants that do not threaten the organic quality of the bee products.

ANNEXES

ANNEX 1. USEFUL REFERENCES

CHAPTER 1 - KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

Bee biology and the role of bees in the environment and agriculture

- Banaszak J., Izdebska B., Effects of environmental contamination on wild bees, honey bees and bee products. Cosmos, 43, 2, 285-302, 1994.
- Burden M., C., Morgan O., M., Hladun R., K., Amdam V. G., Trumble J., J., Smith H., B., Acute sublethal exposure to toxic heavy metals alter honey bee (Apis mellifera) feeding behaviour, Scientific Reports, 9, 4253, 2019.
- Jabłoński B., Kołtowski Z., Marcinkowski J., Rybak-Chmielewska, Szczęsna T., Warakomska Z., The content of heavy metals (Pb, Cd and Cu) in nectar, honey and pollen from plants growing along transport routes. Pszczelnicze Zeszyty Naukowe, XXXIX, 2, 129-144, 1995.
- Kisała J., Dżugan M., Influence of environmental condition and bee management on honey quality. Zeszyty Naukowe, 11, 115-120, 2009.
- Lopuch S., Effects of toxic substances on bee behaviour, Rural and Advisory, 4, 94, 2017.
- Lopuch S, Tofilski A. Importance of wing movements for information transfer during honey bee waggle dance. Ethology. 2017a, 123: 974-980.
- Lopuch S, Tofilski A. Direct visual observation of wing movements during the honey bee waggle dance. Journal of Insect Behavior. 2017b, 30: 199-210.
- Łopuch S, Tofilski A. Use of high-speed video recording to detect wing beating produced by honey bees. Insectes Sociaux. 2019, 66: 235-244.
- Lopuch S, Tofilski A. Impact of the quality of food sources on the wing beating of honey bee dancers. Apidologie. 2020, doi: 10.1007/s13592-020-00748-3.
- Literature: 1. CSO, 2010 - Production of agricultural and horticultural crops in 2009. 2. Majewski J., 2010 - Rocznik Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, t. XII, z.1, 122-127. 3. Majewski J., 2010 - Rocznik Nauk Rolniczych, t. 97, z. 4, 127-134. 4. Prabucki J. (ed.), 1998 - Pszczelnictwo. Wyd. Promocyjne "Albatros", Szczecin.
- Madras-Majewska B., Jasinski Z., Zajdel B., Gąbka J., Ochnio M., Petryka W., Kamiński Z., Ścięgosz J., Content of selected toxic elements in bee products, Przegląd hodowlany, 3, 49-51, 2014.
- Moron D., The effect of environmental pollution by heavy metals on insect pollination of floricultural plants, Countryside and Advisory, 4, 94, 2017.
- Ptaszyńska A., Gancarz M., Wiącek D., Nawrocka A., Borsuk G., Strachecka A., Wójciak H.,Załuski D., Paleologist J., Infection of honey bees by Nosema cernae can increase heavy metal accumulation in their organisms, Abstract from the Scientific Beekeeping Conference, Kazmierz Dolny, 44-45, 2018.

ANNEX 1. USEFUL REFERENCES

CHAPTER 1 - KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

- Roman A., Content of selected elements in bee products from the Lower Silesia region. Food, 4, 37, 368-378, 2003.
- Sitarz-Palczak E., Kalembikiwiecz J., Galas D., Evaluation of the content of selected heavy metals in Samales of polsih honeys, Journal of Ecological Energineering, 16, 3, 130-138, 2015.
- http://www.pszczoly.zielonaakcja.pl/platforma-edukacyjna/materialy-merytoryczne/item/50-biologia-rodziny-pszczelej.html
- https://beego.pl/rodzina-pszczela-struktura-podzial-rol
- https://beego.pl/rosliny-wybitnie-miododajne-ktore-warto-uprawiac
- https://beego.pl/7-niesamowitych-faktow-o-pszczolach
- https://pasieka24.pl/index.php/pl-pl/pasieka-czasopismo-dla-pszczelarzy/196-pasieka-4-2020/2605-komunikacja-wibroakustyczna-pszczoly-miodnej
- http://www.pszczoly.zielonaakcja.pl/platforma-edukacyjna/materialy-merytoryczne/item/50-biologia-rodziny-pszczelej.html

Bee products and their healing properties (Apitherapy)

- Metod Šuligoj (2021) Origins and development of apitherapy and apitourism, Journal of Apicultural Research, 60:3, 369-374, DOI: 10.1080/00218839.2021.1874178 (2021)
- A.M. Moghazy, M.E. Shams, O.A. Adly, A.H. Abbas, M.A. El-Badawy, D.M. Elsakka, S.A. Hassan, W.S. Abdelmohsen, O.S. Ali, B.A. Mohamed, The clinical and cost effectiveness of bee honey dressing in the treatment of diabetic foot ulcers, Diabetes Res. Clin. Pract., 89 (3) (2010)
- J.L. Jayalekshmi, R. Lakshmi, A. Mukerji, Honey on oral mucositis: a randomized controlled trial, Gulf J. Oncolog., 1 (2016)
- G.A. Burdock Review of the biological properties and toxicity of bee propolis (propolis) Food Chem. Toxicol., 36 (1998)
- J.M. Sforcin Biological properties and therapeutic applications of propolis Phytother. Res., 30 (6) (2016)
- V. Bankova, D. Bertelli, R. Borba, B.J. Conti, I.B.S. Cunha, C. Danert, M.N. Eberlin, S.I. Falcão, M.I. Isla, M.I.N. Moreno, G. Papotti, M. Popova, K.B. Santiago, A. Salas, A.C.H.F. Sawaya, N.V. Schwab, J.M. Sforcin, M. Simone-Finstrom, M. Spivak, B. Trusheva, M. Vilas-Boas, M. Wilson, C. Zampini Standard methods for Apis mellifera propolis research J. Apic. Res., 58 (2) (2016)
- V.C. Toreti, H.H. Sato, G.M. Pastore, Y.K. Park Recent progress of propolis for its biological and chemical compositions and its botanical origin. evid.-based complement Alternat. Med., 2013 (2013)

ANNEX 1. USEFUL REFERENCES

CHAPTER 1 - KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

- A. Braakhuis Evidence on the health benefits of supplemental propolis Nutrients, 11 (2019)
- F.L. Conte, K.B. Santiago, B.J. Conti, E.O. Cardoso, L.P.G. Oliveira, G.S. Feltran, W.F. Zambuzzi, M.A. Golim, M.T. Cruz, J.M. Sforcin Propolis from southeastern Brazil produced by Apis mellifera affects innate immunity by modulating cell marker expression, cytokine production and intracellular pathways in human monocytes J. Pharm. Pharmacol., 73 (2021)
- A.A. Berretta, M.A.D. Silveira, J.M.C. Capcha, D. De Jong Propolis and its potential against SARS-CoV-2 infection mechanisms and COVID-19 disease Biomed. Pharmacother., 131 (2020)
- N. Ripari, A.A. Sartori, M.S. Honorio, F.L. Conte, K.I. Tasca, K.B. Santiago, J.M. Sforcin Propolis antiviral and immunomodulatory activity: a review and perspectives for COVID-19 treatment J. Pharm. Pharmacol., 73 (2021)
- M.A.D. Silveira, D. De Jong, A.A. Berretta, E.B.S. Galvão, J.C. Ribeiro, T. Cerqueira-Silva, T.C. Amorim, L.F.M.R. Conceição, M.M.D. Gomes, M.B. Teixeira, S.P. Souza, M.H.C.A. Santos, R.L.A. San Martin, M.O. Silva, M. Lírio, L. Moreno, J.C.M. Sampaio, R. Mendonça, S.S. Ultchak, F.S. Amorim, J.G.R. Ramos, P.B.P. Batista, S.N.F. Guarda, A.V.A. Mendes, R.H. Passos Efficacy of Brazilian green propolis (EPP-AF®) as an adjunct treatment for hospitalized COVID-19 patients: a randomized, controlled clinical trial Biomed. Pharmacother., 138 (2021)
- N. Ledón, A. Casacó, R. González, N. Merino, A. González, Z. Tolón Antipsoriatic, anti-inflammatory, and analgesic effects of an extract of red propolis Zhongguo Yao Li Xue Bao, 18 (3) (1997), pp.
- Y.S. Song, C. Jin, K.J. Jung, E.H. Park Estrogenic effects of ethanol and ether extracts of propolis J. Ethnopharmacol., 82 (2–3) (2002)
- S. Mishima, C. Yoshida, S. Akino, T. Sakamoto Antihypertensive effects of Brazilian propolis: identification of caffeoylquinic acids as constituents involved in the hypotension in spontaneously hypertensive rats Biol. Pharm.Bull., 28 (10) (2005)
- J.M. Sforcin, R.O. Orsi, V. Bankova Effect of propolis, some isolated compounds and its source plant on antibody production J. Ethnopharmacol., 98 (3) (2005)
- H. Fokt, A. Pereira, A. Ferreira, A. Cunha, C. Aguiar How do bees prevent hive infections? The antimicrobial properties of propolis Curr. Res. Technol. Educ. Top. Appl. Microbiol. Microbial. Biotechnol., 1 (2010)
- C. Habryka, M. Kruczek, B. Drygaś Bee products used in apitherapy World Sci. News, 48 (2016)
- M.A.A-S.M. Ali Studies on bee venom and its medical uses IJOART, 1 (2012)
- N. Oršolić Bee venom in cancer therapy Cancer Metastasis Rev, 31 (2012)

ANNEX 1. USEFUL REFERENCES

CHAPTER 1 - KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

- J.H. Park, Y.S. Kum, T.I. Lee, S.J. Kim, W.R. Lee, B.I. Kim, H.S. Kim, K.H. Kim, K.K. Park Melittin attenuates liver injury in thioacetamide-treated mice through modulating inflammation and fibrogenesis Exp. Biol. Med., 236 (2011)
- J.H. Park, K.H. Kim, W.R. Lee, S.M. Han, K.K. Park Protective effect of melittin on inflammation and apoptosis in acute liver failure Apoptosis, 17 (2012)
- M.S. Choi, S. Park, T. Choi, G. Lee, K.K. Haam, M.C. Hong, B.I. Min, H. Bae Bee venom ameliorates ovalbumin induced allergic asthma via modulating CD4+CD25+ regulatory T cells in mice Cytokine 61, (2013)
- W.R. Lee, K.H. Kim, H.J. An, J. Kim, Y.C. Chang, H. Chung, Y.Y. Park, M.L. Lee, K. Park The protective effects of melittin on Propionibacterium acnes-induced inflammatory responses in vitro and in vivo J. Investig. Dermatol., 134 (2014)
- W. Yang, F.L. Hu, X.F. Xu Bee venom and SARS-CoV-2 Toxicon, 181 (2020)
- H. Männle, J. Hübner, K. Münstedt Beekeepers who tolerate bee stings are not protected against SARS-CoV-2 infections Toxicon, 187 (2020)
- J. Block High risk COVID-19: potential intervention at multiple points in the COVID-19 disease process via prophylactic treatment with azithromycin or bee derived products J. Biomed. Res. Rev., 3 (2020)
- W.G. Lima, J.C.M. Brito, W.S.C. Nizer Bee products as a source of promising therapeutic and chemoprophylaxis strategies against COVID-19 (SARS-CoV-2) Phytother. Res., 35
- R. Singla, V. Bhat Honey bee sting and venom offering active as well as passive immunization could reduce swine flu pandemic A (H1N1) Med. Hypotheses, 74
- B. Denisow, M. Denisow-Pietrzyk Biological and therapeutic properties of bee pollen: a review J. Sci. Food Agric., 96 (2016)
- M.G.R. Campos, C. Frigerio, J. Lopes, S. Bogdanov What is the future of bee-pollen? JAAS, 2 (2010)
- G. Kroyer, N. Hegedus Evaluation of bioactive properties of pollen extracts as functional dietary food supplement Innov. Food Sci. Emerg. Technol., 2 (2001)
- A. Vásquez, T.C. Olofsson The lactic acid bacteria involved in the production of bee pollen and bee bread J. Apic. Res., 48 (3) (2009)
- S. Bogdanov Antiviral properties of the bee products: a review Bee Product Sci., 2020

The health of bees

- Topolska G., Gajda A., Imińska U. 2018. Atlas chorób pszczół najbardziej istotnych dla polskich pszczelarzy. Powszechne Wydawnictwo Rolnicze i Leśne. Warszawa.

ANNEX 1. USEFUL REFERENCES

CHAPTER 1 - KNOWING THE BEES AND THEIR IMPORTANT FUNCTIONS

- W. Ritter. Zdrowie pszczół. 2016. Zapobieganie chorobom, ich rozpoznawanie i leczenie. Wydawnictwo RM. Warszawa.
- Chorobiński P. Choroby i szkodniki pszczoły miodnej. ISBN 978-83-940543-1-1
- Bienenkrankheiten - Dr. F. Pohl (Kosmos-Verlag, 2005)
- Die Honigbiene aus tierärztlicher Sicht - Prof. Hartmut Hoffmann (Amman, 1998)
- http://windowbee.com
- https://pl.wikipedia.org
- https://sk.wikipedia.org/wiki/Vírus

CHAPTER 2 - THE USE OF AGRICULTURE CHEMICALS AND THEIR RISKS TO BEES

- Sánchez-Bayoa, F., Wyckhuys, K.A.G. Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation 232 (2019). https://insect-respect.org/fileadmin/images/insect-respect.org/Rueckgang_der_Insekten/2019_Sanchez-Bayo_Wyckhuys_Worldwide_decline_of_the_entomofauna_A_review_of_its_drivers.pdf
- World Economic Forum. The Global Risks Report 2020. 15th Edition.
https://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf
- Kazda, J., Stejskalová, M. Atraktivita a repelence pesticide
https://vcelstva.czu.cz/o-postricich/atraktivitapesticidu

CHAPTER 3 - PLANT PROTECTION PRODUCTS

Insecticides, fungicides and plant protection products in general

- Bártová, K. 2020. Vliv pesticidů na včely se zaměřením na jejich endokrinně disruptivní účinek. Influence of pesticides on bees with focus on their endocrine disruptive effect. Bakalářská práce, UNIVERZITA KARLOVA, Přírodovědecká fakulta, Praha, 46 pp.
- Bokšová, A., Kazda, J., Stejskalová, M. 2022. Vlastnosti ovlivňující včely u pesticidů aplikovaných v období květu řepky. Agromanual 7, 2022.
- Böhme F, Bischoff G, Zebitz CPW, Rosenkranz P, Wallner K (2018) Pesticide residue survey of pollen loads collected by honeybees (Apis mellifera) in daily intervals at three agricultural sites in South Germany. PLoS ONE 13(7): e0199995. https://doi.org/10.1371/journal.pone.0199995
- Brown, P.R., Tuan, N., Singleton, G.R., Ha, P.T., Hoa, P.T., Hue, D.T., Tan, T.Q., Tuat, N.V., Jacob, J., Müller, W.J., 2006. Ecologically based management of rodents in the real world: applied to a mixed agroecosystem in Vietnam. Ecol. Applic. 16, 2000–2010.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- Charter, M., Meyrom, K., Leshem, Y., Aviel, S., Izhaki, I., Motro, Y., 2010. Does nest box location and orientation affect occupation rate and breeding success of Barn Owls Tyto alba in a semi-arid environment? Acta Orn. 45, 115–119.
- Cullen, M.G., Thompson, L.J., Carolan, J.C., Stout, J.C. & Stanley, D.A., Fungicides, herbicides and bees: A systematic review of existing research and methods, PLOS ONE, 14, 12, 2019, 1-17.
- Cagáň, Ľ. a kol. (ed.): Choroby a škodcovia poľných plodín. SPU, Nitra, s. 39-129. ISBN 978-80-552-0354-6
- Cagáň, Ľ., Hudec, K. 2003. Chemická ochrana rastlín proti chorobám a škodcom. Nitra. SPU, 130 pp. ISBN 80-8069-177-0
- Čermáková, T. (2016). Riziko používania pesticídov pre včely a ostatný užitočný myz. In: Ekologie chovu včel. Pavel Mervart, 151-163, ISBN 978-80-7465-215-8.
- Daniele, G., Giroud, B., Jabot, C., & Vulliet, E. (2018). Exposure assessment of honeybees through study of hive matrices: analysis of selected pesticide residues in honeybees, beebread, and beeswax from French beehives by LC-MS/MS. Environmental Science and Pollution Research, 25(7), 6145-6153.
- Debach, P., Rosen, D. 1991 (second edition) Biological control by natural enemiesCambridge University Press, Cambridge, UK xiv + 440 pages ISBN 0-521-39191-1
- Fargallo, J.A., Martinez-Padilla, J., Viñuela, J., Blanco, G., Torre, I., Vergara, P., De Neve, L., 2009. Kestrel-prey dynamic in a mediterranean region: the effect of generalist predation and climatic factors. PLoS ONE 4, e4311.
- García, M. G., Duque, S. U., Fernández, A. L., Sosa, A., & Fernández-Alba, A. R. (2017). Multiresidue method for trace pesticide analysis in honeybee wax comb by GC-QqQ-MS. Talanta, 163, 54-64.
- Gill, R. J., Ramos-Rodriguez, O., & Raine, N. E. (2012). Combined pesticide exposure severely affects individual-and colony-level traits in bees. Nature, 491(7422), 105.
- Iwasa, T., Motoyama, N., Ambrose, J. T., & Roe, R. M. (2004). Mechanism for the differential toxicity of neonicotinoid insecticides in the honey bee, Apis mellifera. Crop Protection, 23(5), 371-378
- Jänsch S, Frampton GK, Römbke J, Van den Brink PJ, Scott-Fordsmand JJ. 2006. Effects of pesticides on soil invertebrates in model ecosystem and field studies: A review and comparison with laboratory toxicity data. Environ Toxicol Chem 25: 2490– 2501.
- Johnson, R.M. (2015). Honey bee toxicology. Annual Review of Entomology, 60, 415–434.
- Kazda, J., Stejskalová, M. Atraktivita a repelence pesticide https://vcelstva.czu.cz/o-postricich/atraktivitapesticidu

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- Krupke CH, Hunt GJ, Eitzer BD, Andino G, Given K. Multiple routes of pesticide exposure for honey bees living near agricultural fields. PLoS One. 2012;7(1):e29268. doi: 10.1371/journal.pone.0029268. Epub 2012 Jan 3. PMID: 22235278; PMCID: PMC3250423.
- Kvorková, V., Pastierová, A., Michálek, J. 2020. Pesticídy a ich dopad na životné prostredie. Pesticides and their impact on the environment. Recenzovaný zborník z X. medznárodnej vedeckej konferencie , 17.1.2020, Bratislava, SSŽP et Strix, 154 pp, ISBN 978-80-973460-6-5.
- Labuschagne, L., Swanepoel, L.H., Taylor, P.J., Belmain, S.R., Keith, M., 2016. Review:Are avian predators effective biological control agents for rodent pest management in agricultural systems? Biol. Control 101, 94–102.
- López, S. H., Lozano, A., Sosa, A., Hernando, M. D., & Fernández-Alba, A. R. (2016). Screening of pesticide residues in honeybee wax comb by LC-ESI-MS/MS. A pilot study. Chemosphere, 163, 44-53.
- Lunaa, A. P., Bintanelc, H., Viñuelad, J., Villanúae, D. 2020. Nest-boxes for raptors as a biological control system of vole pests: High local success with moderate negative consequences for non-target species. Biological Control 146, 104267 10p.
- Machar, I., Harmacek, J., Vrublova, K., Filippovova, J., Brus, J., 2017. Biocontrol of common vole populations by avian predators versus rodenticide application. Pol. J. Ecol. 65, 434–444.
- Martin-Culma, N. Y., & Arenas-Suárez, N. E. A.-S. E. (2018). Daño colateral en abejas por la exposición a pesticidas de uso agrícola. Entramado, 14(1), 232-240. https://doi.org/10.18041/entramado.2018v14n1.27113
- Meyrom, K., Motro, Y., Leshem, Y., Aviel, S., Izhaki, I., Argyle, F., Charter, M., 2009. Nestbox use by the barn owl Tyto alba in a biological pest control program in the Beit She'an valley, Israel, Proc 4th World Owl Conf, October–November 2007, Groningen, The Netherlands, ed. By Johnson DH, Van Nieuwenhuyse D and Duncan JR. Ardea 97(4), 463–467.
- Muñoz-Pedreros, A., Gil, C., Yanez, J., Rau, J.R., 2010. Raptor habitat management and its implication on the biological control of the Hantavirus. Eur. J. Wildl. Res. 56, 703–715.
- Nikonorew, M. et al. 1983. Pesticídy a toxicita prostredia. Bratislava, Príroda. 20 pp.
- Obenberger, J., Trojan, V. Príručka chemické ochrany rostlin. Praha. SNTL, 1971, 246 pp.
- Ojwang, D.O., Oguge, N.O., 2003. Testing a biological control program for rodent management in a maize cropping system in Kenya. In: Singleton, G.R., Hinds, L.A., Krebs,
- C.J., Spratt, D.M. (Eds.), Rats, Mice and People: Rodent Biology and Management. Australian Centre for International Agricultural Research, Canberra, Australia, pp. 251–253.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- Paz, A., Jareño, D., Arroyo, L., Viñuela, J., Arroyo, B., Mougeot, F., Luque-Larena, J.J., Fargallo, J.A., 2013. Avian predators as a biological control system of common vole (Microtus arvalis) populations in north-western Spain: experimental set-up and preliminary results. Pest Manag. Sci. 69, 444–450.
- Peterková, V., Iľko, I. 2020. Pesticídy okolo nás. Pedagogická fakulta Trnavskej univerzity v Trnave, 74 pp. ISBN: 978-80-568-0295-3.
- Pilling, E. D., & Jepson, P. C. (1993). Synergism between EBI fungicides and a pyrethroid insecticide in the honeybee (Apis mellifera). Pest Management Science, 39(4), 293-297.
- Raučinová, Ľ., Vargová, Z. 2000. Metodická příručka pre ochranu rastlín. AT publishing. 117 pp. ISBN 80-88954-08-8
- Rortais, A.; Arnold, G.; Halm, M. P.; Touffet-Briens, F.: Modes of Honeybees Exposure to Systemic Insecticides: Estimated Amounts of Contaminated Pollen and Nectar Consumed by Different Categories of Bees. Apidologie 36, 71–83 (2005).
- Sanchez-Salinas, E. & Ortiz-Hernandez, L. (2011). Riesgos y estrategias en el uso de plaguicidas. Inventio. 7. 21-27.
- Staroňová, D. 2018. Hodnotenie rizika rezíduí pesticídov vo včeľom vosku. Risk assessment of pesticide residues in beeswax. NPPC – Výskumný ústav živočíšnej výroby Nitra, Ústav včelárstva Liptovský Hrádok, 44 pp., ISBN: 978-80-89738-14-4.
- Stejskalová, M., Kazda, J. 2019. Nejčastější rezidua pesticidů v medu a pylu z lokalit s intenzivním hospodařením. Agromanual, 9, 2019.
- Stenersen, J. 2004. Chemical insecticides. CRC Press. 296 pp. ISBN 0748409106
- Tóth, J., Lazor, P. 1998. Cudzorodé látky v poživatinách. Nitra. SPU, 82 s. ISBN 80-7137-609-4.
- Valchev, I.; Binev, R.; Yordanova, V.; and N. Yordan (2008) "Anticoagulant Rodenticide Intoxication in Animals – A Review," Turkish Journal of Veterinary & Animal Sciences: Vol. 32: No. 4, Article 1. Available at: https://journals.tubitak.gov.tr/veterinary/vol32/iss4/1
- Wu-Smart J, Spivak M. 2016. Sub-lethal effects of dietary neonicotinoid insecticide exposure on honey bee queen fecundity and colony development. Nature Sci. Rep. 6, 32108; doi: 10.1038/srep32108.
- Zaluski R, Kadri SM, Alonso DP, Martins Ribolla PE, de Oliveira Orsi R. Fipronil promotes motor and behavioral changes in honey bees (Apis mellifera) and affects the development of colonies exposed to sublethal doses. Environ Toxicol Chem 2015; 34(5): 1062–9.
- Zbirovský, M., Myška, J. 1959. Insekticídy, fungicidy, rodenticidy, Praha, SPN, 563 s.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- Paz, A., Jareño, D., Arroyo, L., Viñuela, J., Arroyo, B., Mougeot, F., Luque-Larena, J.J., Fargallo, J.A., 2013. Avian predators as a biological control system of common vole (Microtus arvalis) populations in north-western Spain: experimental set-up and preliminary results. Pest Manag. Sci. 69, 444–450.
- Peterková, V., Iľko, I. 2020. Pesticídy okolo nás. Pedagogická fakulta Trnavskej univerzity v Trnave, 74 pp. ISBN: 978-80-568-0295-3.
- Pilling, E. D., & Jepson, P. C. (1993). Synergism between EBI fungicides and a pyrethroid insecticide in the honeybee (Apis mellifera). Pest Management Science, 39(4), 293-297.
- Raučinová, Ľ., Vargová, Z. 2000. Metodická příručka pre ochranu rastlín. AT publishing. 117 pp. ISBN 80-88954-08-8
- Rortais, A.; Arnold, G.; Halm, M. P.; Touffet-Briens, F.: Modes of Honeybees Exposure to Systemic Insecticides: Estimated Amounts of Contaminated Pollen and Nectar Consumed by Different Categories of Bees. Apidologie 36, 71–83 (2005).
- Sanchez-Salinas, E. & Ortiz-Hernandez, L. (2011). Riesgos y estrategias en el uso de plaguicidas. Inventio. 7. 21-27.
- Staroňová, D. 2018. Hodnotenie rizika rezíduí pesticídov vo včeľom vosku. Risk assessment of pesticide residues in beeswax. NPPC – Výskumný ústav živočíšnej výroby Nitra, Ústav včelárstva Liptovský Hrádok, 44 pp., ISBN: 978-80-89738-14-4.
- Stejskalová, M., Kazda, J. 2019. Nejčastější rezidua pesticidů v medu a pylu z lokalit s intenzivním hospodařením. Agromanual, 9, 2019.
- Stenersen, J. 2004. Chemical insecticides. CRC Press. 296 pp. ISBN 0748409106
- Tóth, J., Lazor, P. 1998. Cudzorodé látky v poživatinách. Nitra. SPU, 82 s. ISBN 80-7137-609-4.
- Valchev, I.; Binev, R.; Yordanova, V.; and N. Yordan (2008) "Anticoagulant Rodenticide Intoxication in Animals – A Review," Turkish Journal of Veterinary & Animal Sciences: Vol. 32: No. 4, Article 1. Available at: https://journals.tubitak.gov.tr/veterinary/vol32/iss4/1
- Wu-Smart J, Spivak M. 2016. Sub-lethal effects of dietary neonicotinoid insecticide exposure on honey bee queen fecundity and colony development. Nature Sci. Rep. 6, 32108; doi: 10.1038/srep32108.
- Zaluski R, Kadri SM, Alonso DP, Martins Ribolla PE, de Oliveira Orsi R. Fipronil promotes motor and behavioral changes in honey bees (Apis mellifera) and affects the development of colonies exposed to sublethal doses. Environ Toxicol Chem 2015; 34(5): 1062–9.
- Zbirovský, M., Myška, J. 1959. Insekticídy, fungicidy, rodenticidy, Praha, SPN, 563 s.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

Acaricides

- Marchetti, S., Barbattini, R., D'Agaru, M., 1984. Comparative effectiveness of treatments used to control Varroa jacobsoni Oud. Apidologie 15 (4), 363–378. doi:10.1051/apido:19840401.
- Davies, T.G.E., Field, L.M., Usherwood, P.N.R., Williamson, M.S., 2007. DDT, pyrethrins, pyrethroids and insect sodium channels. IUBMB life 59 (3), 151– 162. doi:10.1080/15216540701352042.
- Rinderer, T.E., DeGuzman, L.I., Lancaster, V.A., Delatte, G.T., Stelzer, J.A., 1999. Varroa in the mating yard:: I. The effect sof Varroa jacobsoni and Apistan on drone honey bees. American Bee Journal 139 (2)
- EU (2008) Comission Regulation (EC) No 889/2008. Official Journal of the European Union, 51, L 250
- EU (2009) Regulation (EC) No. 1107/2009 of the European Parliament and of the Council of 21 October 2009. Official Journal of the European Union L 309
- EU (2011) EU Pesticides Database: Active substances http://ec.europa.eu/sanco_pesticides/public/index.cfm
- Badawy MEI, El-Arami SAA, Abdelgaleil SAM (2010) Acaricidal and quantitative structure activity relationship of monoterpenes against the two-spotted spider mite, Tetranychus urticae
- Bakker FM, Jacas JA (1995) Pesticides and phytoseiid mites– strategies for risk assessment. Ecotoxicol Environ Saf
- Beers EH, Martinez-Rocha L, Talley RR, Dunley JE (2009) Lethal, sublethal, and behavioral effects of sulfur-containing products in bioassays of three species of orchard mites.
- Blu¨mel S, Baker F, Grove A (1993) Evaluation of different methods to assess the side-effects of pesticides on Phytoseiulus persimilis
- Blu¨mel S, Matthews GA, Grinstein A, Elad Y (1999) Pesticides in IPM: selectivity, side-effects, application and resistance problems. In: Albajes R, Gullino MA, van Lenteren JC, Elad Y (eds) Integrated pest and disease management in greenhouse crops. Kluwer Academic Publishers, Dordrecht
- Marcic, D. Acaricides in modern management of plant-feeding mites. J Pest Sci 85, 395–408 (2012). https://doi.org/10.1007/s10340-012-0442-1
- Tihelka, Erik. (2018). Effects of synthetic and organic acaricides on honey bee health: A review. Slovenian Veterinary Research. 55. 10.26873/SVR-422-2017.
- Kunz SE, Kemp DH. Insecticides and acaricides: resistance and environmental impact. Rev Sci Tech. 1994 Dec;13(4):1249-86. doi: 10.20506/rst.13.4.816. PMID: 7711312.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- Humberto Boncristiani, Robyn Underwood, Ryan Schwarz, Jay D. Evans, Jeffery Pettis, Dennis vanEngelsdorp, Direct effect of acaricides on pathogen loads and gene expression levels in honey bees Apis mellifera, Journal of Insect Physiology, Volume 58, Issue 5, 2012, https://doi.org/10.1016/j.jinsphys.2011.12.011
- Johnson RM, Dahlgren L, Siegfried BD, Ellis MD (2013) Acaricide, Fungicide and Drug Interactions in Honey Bees (Apis mellifera). PLOS ONE 8(1): e54092. https://doi.org/10.1371/journal.pone.0054092
- de Mattos, I.M., Soares, A.E.E. & Tarpy, D.R. Effects of synthetic acaricides on honey bee grooming behavior against the parasitic Varroa destructor mite. Apidologie 48, https://doi.org/10.1007/s13592-017-0491-9

Herbicides

- Britannica, T. Editors of Encyclopaedia (2019, March 19). herbicide. Encyclopedia Britannica. https://www.britannica.com/science/herbicide
- Retzinger, E., & Mallory-Smith, C. (1997). Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. Weed Technology, 11(2), 384-393. doi:10.1017/S0890037X00043116
- Forouzesh, A & Zand, Eskandar & Soufizadeh, Saeid & Samadi Foroushani, Sadegh. (2015). Classification of herbicides according to chemical family for weed resistance management strategies-an update. Weed Research. 55. 334-358. 10.1111/wre.12153.
- Sherwani, S. I. , Arif, I. A. , & Khan, H. A. (2015). Modes of Action of Different Classes of Herbicides. In A. Price, J. Kelton, & L. Sarunaite (Eds.), Herbicides, Physiology of Action, and Safety. IntechOpen. https://doi.org/10.5772/61779
- Sherwani, S. I. , Arif, I. A. , & Khan, H. A. (2015). Modes of Action of Different Classes of Herbicides. In A. Price, J. Kelton, & L. Sarunaite (Eds.), Herbicides, Physiology of Action, and Safety. IntechOpen. https://doi.org/10.5772/61779
- Mallory-Smith, C., & Retzinger, E. (2003). Revised Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. Weed Technology, 17(3), 605-619. doi:10.1614/0890-037X(2003)017[0605:RCOHBS]2.0.CO;2
- Vats, S. (2015). Herbicides: History, Classification and Genetic Manipulation of Plants for Herbicide Resistance. In: Lichtfouse, E. (eds) Sustainable Agriculture Reviews. Sustainable Agriculture Reviews, vol 15. Springer, Cham. https://doi.org/10.1007/978-3-319-09132-7_3
- Valavanidis, Athanasios. (2018). Glyphosate, the Most Widely Used Herbicide. Health and safety issues. Why scientists differ in their evaluation of its adverse health effects.

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- European Food Safety Authority https://www.efsa.europa.eu/en/topics/topic/glyphosate
- Herbicide How-To: Understanding Herbicide Mode of Action Published Feb. 2017 | Id: PSS-2778 By Misha Manuchehri https://extension.okstate.edu/fact-sheets/herbicide-how-to-understanding-herbicide-mode-of-action.html
- “Agrotehnică - Transformarea modernă a agriculturii” - Prof. univ. dr. Mihai Berca, Editura Ceres, București, 2011
- “Tratatat de legumicultura”, coordonator Prof. univ. dr. Ruxandra Ciofu, Prof. univ. dr. Nistor Stan, Prof. univ. dr. Victor Popescu, Prof. univ. dr. Pelaghia Chilom, Prof. univ. dr. Silviu Apahidean, Prof. univ. dr. Arsenie Horgoș, Prof. univ. dr. Viorel Berar, Prof. univ. dr. h. c. Karl Fritz Lauer, Prof. univ. dr. Nicolae Atanasiu, Editura Ceres, 2004
- Hoopman, A., North, H., Rajamohan, A., and Bowsher, J. (2018). “Toxicity assessment of glyphosate on honeybee (Apis mellifera) spermatozoa,” in The Society for Integrative & Comparative Biology (SCIB) Annual Meeting 2018 (San Francisco, CA), 2–21.
- Migdał, P., Roman, A., Popiela-Pleban, E., Kowalska-Góralska, M., and Opaliński, S. (2018). The impact of selected pesticides on honey bees. Polish J. Environ. Stud. 27, 787–792. doi: 10.15244/pjoes/74154
- Vázquez, D. E., Ilina, N., Pagano, E. A., Zavala, J. A., and Farina, W. M. (2018). Glyphosate affects the larval development of honey bees depending on the susceptibility of colonies. PLoS One 13:e0205074. doi: 10.1371/journal.pone.0205074.
- Dai, P., Yan, Z., Ma, S., Yang, Y., Wang, Q., Hou, C., et al. (2018). The herbicide glyphosate negatively affects midgut bacterial communities and survival of honey bee during larvae reared in vitro. J. Agric. Food Chem. 66, 7786–7793. doi: 10.1021/acs.jafc.8b02212.
- Mengoni Goñalons, C., and Farina, W. M. (2018). Impaired associative learning after chronic exposure to pesticides in young adult honey bees. J. Exp. Biol. 221:jeb176644. doi: 10.1242/jeb.176644
- Balbuena, M. S., Tison, L., Hahn, M.-L., Greggers, U., Menzel, R., and Farina, W. M. (2015). Effects of sublethal doses of glyphosate on honeybee navigation. J. Exp. Biol. 218, 2799–2805. doi: 10.1242/jeb.117291
- https://hracglobal.com/tools/classification-lookup
- https://hracglobal.com/prevention-management/best-management-practices
- https://hracglobal.com/files/Management-of-Herbicide-Resistance.pdf
- https://www.agro.basf.ro/ro/servicii/ghidul-buruienilor-bolilor-si-daunatorilor/

ANNEX 1. USEFUL REFERENCES

CHAPTER 3 - PLANT PROTECTION PRODUCTS

- https://www.agro.basf.ro/Documents/migrated_files/brosuri_2017_files/catalog_2017_files/bune_practici_de_utilizare_a_produselor_pentru_protectia_plantelor_files/bune_practici_de_utilizare_a_produselor_pentru_protectia_plantelor_1.pdf?1530611045350
- https://pesticidestewardship.org/resistance/insecticide-resistance/take-steps-to-avoid-insecticide-resistance/

Rodenticides and other pesticides

- Galofre-Ruiz, M.D. & Padilla-Castañeda, E. (2014). Intoxicación con rodenticidas: casos reportados al Centro de Información, Gestión e Investigación en Toxicología de la Universidad Nacional de Colombia. Revista de la Facultad de Medicina, 62(1), 27-32. https://doi.org/10.15446/revfacmed.v62n1.43669
- Moreno M., López Ferrer, J. & Jiménez Peydró, R. (2004). El control de los roedores: revisión de los rodenticidas registrados en el ámbito de la sanidad ambiental en España. Revista Española de Salud Pública, 78(1), 05-16. Recuperado en 22 de agosto de 2022, de http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1135-57272004000100002&lng=es&tlng=es
- Rami Abi Khalil, Brigitte Barbier, Antoine Rached, Etienne Benoit, Adrien Pinot, Virginie Lattard. Water vole management - Could anticoagulant rodenticides stereochemistry mitigate the ecotoxicity issues associated to their use? Environmental Toxicology and Pharmacology, Volume 81, 2021, 103536, ISSN 1382-6689, https://doi.org/10.1016/j.etap.2020.103536.
- Sanchez-Bayo F, Goka K. Pesticide residues and bees--a risk assessment. PLoS One. 2014 Apr 9;9(4):e94482. doi: 10.1371/journal.pone.0094482. PMID: 24718419; PMCID: PMC3981812.
- Schaaf, A. A. (2015). Valoración de impacto ambiental por pesticidas agrícolas. Observatorio Medioambiental, 18, 87-96. https://doi.org/10.5209/rev_OBMD.2015.v18.51283
- SEO/BirdLife, 2012. Correcto uso de productos rodenticidas en espacios abiertos. SEO/BirdLife, Madrid
- Rodenticide Resistance Action Committee (RRAC) https://guide.rrac.info/es/alternativas-a-los-anticoagulantes/no-anticoagulantes.html
- https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/nematicide
- https://www.sciencedirect.com/topics/medicine-and-dentistry/molluscacide
- https://www.anasaccontrol.cl/normativa/clasificacion-toxicologica-de-plaguicidas/

ANNEX 1. USEFUL REFERENCES

CHAPTER 4 - FERTILIZERS

- Latini, A., Giagnacovo, G., Campiotti C.A., Bibbiani C. and Mariani S. (2021) "A Narrative Review of the Facts and Perspectives on Agricultural Fertilization in Europe, with a Focus on Italy"
- Megha, S. Managing the Biodiversity Impacts of Fertiliser and Pesticide Use Overview and insights from trends and policies across selected OECD countries – Environment Working Paper N°155 (2020)
- Prost, P.J. (2007) "Apicultura. Conocimiento de la abeja. Manejo de la colmena". Ed. Mundiprensa.
- Rodrigues, C.; Krüger, A.; Barbosa, W. & Guedes, R.N. Journal of Economic Entomology, Volume 109, Issue 3, June 2016, Pages 1001–1008, Leaf Fertilizers Affect Survival and Behavior of the Neotropical Stingless Bee Friesella schrottkyi (Meliponini: Apidae: Hymenoptera) https://doi.org/10.1093/jee/tow044
- Consumo de fertilizantes en la Unión Europea 2019-2029: https://www.grupofertiberia.com/es/blog/2020/enero/consumo-de-fertilizantes-en-la-uni%C3%B3n-europea-2019-2029/
- Methods of application of fertilizers: https://www.tipsytemasagronomicos.com/metodos-de-aplicacion-de-fertilizantes/
- The new fertilizer regulation – consequences for farmers: https://nutriman.net/EU-Fertiliser-Regulation
- https://www.grupofertiberia.com/es/blog/2020/enero/consumo-de-fertilizantes-en-la-uni%C3%B3n-europea-2019-2029/
- https://cropaia.com/es/blog/tipos-de-fertilizantes/
- https://es.scribd.com/document/490165023/PPT-FERTILIZANTES
- https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Fertiliser-Visuals-FB--TW-Visual_01-V4_1200x630.jpeg
- https://scholar.google.es/scholar_url?url=https://www.mdpi.com/2311-7524/7/6/158/pdf&hl=es&sa=X&ei=KkT1YonXOa-Ty9YPrNS_uA4&scisig=AAGBfm1GN8HD_Y50bKEyRikvZ39xpPGACA&oi=scholarr
- https://www.tipsytemasagronomicos.com/metodos-de-aplicacion-de-fertilizantes/
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A1000%3AFIN&qid=1633953687154
- https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)2&docLanguage=
- https://agritech.tnau.ac.in/agriculture/agri_nutrientmgt_methodsoffertilizerappln.html
- https://nutriman.net/EU-Fertiliser-Regulation
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019R1009
- https://www.mapa.gob.es/es/agricultura/temas/medios-de-produccion/productos-fertilizantes/default.aspx

ANNEX 1. USEFUL REFERENCES

CHAPTER 5 - GOOD AGRICULTURAL PRACTICES CONCERNING THE USE OF CHEMICALS

- Chorobiński P. Choroby i szkodniki pszczoły miodnej. ISBN 978-83-940543-1-1
- Kierzek, R., and others. 2015. Code of good plant protection practice. ISBN 978-83-64655-28-9
- Topolska G., Gajda A., Imińska U. 2018. Atlas chorób pszczół najbardziej istotnych dla polskich pszczelarzy. Powszechne Wydawnictwo Rolnicze i Leśne. Warszawa.
- W. Ritter. Zdrowie pszczół. 2016. Zapobieganie chorobom, ich rozpoznawanie i leczenie. Wydawnictwo RM. Warszawa.
- https://www.ior.poznan.pl/plik,2361,kodeks-dobrej-praktyki-ochrony-roslin-pdf.pdf
- https://www.youtube.com/watch?v=JgF-rHQfboo
- https://agronews.com.pl
- https://apimondia.org
- https://piragro.pl/wp-content/uploads/2020/04/Dobra-praktyka-ochrony-ro%C5%9Blin-Ochrona-zapylaczy-podczas-stosowania-%C5%9Brodk%C3%B3w-ochrony-ro%C5%9Blin.pdf
- https://piragro.pl/wp-content/uploads/2020/04/Dobra-praktyka-ochrony-ro%C5%9Blin-Ochrona-zapylaczy-podczas-stosowania-%C5%9Brodk%C3%B3w-ochrony-ro%C5%9Blin.pdf
- http://wril.uwm.edu.pl/sites/default/files/u3/zalacznik_iia_-_autoreferat_w_jezyku_polskim_0.pdf
- https://pasieka24.pl/index.php/pl-pl/pasieka-czasopismo-dla-pszczelarzy/176-pasieka-6-2019/2205-bezpieczenstwo-zapylaczy-i-ochrona-roslin-wspolna-odpowiedzialnosc
- https://www.cdr.gov.pl/images/wydawnictwa/2016/2016-METODY-OCHRONY-W-INTEGROWANEJ-OCHRONIE-ROSLIN.pdf
- https://brzeszcze.pl/pszczoly-kontra-opryski-swiadome-rolnictwo-i-ogrodnictwo,10012
- https://www.nektariada.pl/home,4,dotacje_20212022.html
- https://www.sejm.gov.pl/sejm7.nsf/InterpelacjaTresc.xsp?key=60BC7797
- http://www.zwiazekpszczelarski.pl/wytrucia-srodkami-ochrony-roslin-przyczynek-do-dyskusji2
- https://szkoltex.pl/szkolenia-i-uslugi-rolnicze/szkolenia-chemizacyjne-podstawowe/
- https://odr.pl/szkolenia/szkolenia-inne/szkolenia-chemizacyjne/
- https://www.szkolpol.pl/szkolenia/kursy-zawodowe/kursy-chemizacyjne/
- https://www.dodr.pl/szkolenia/szkolenia-cykliczne/stosowanie-srodkow-ochrony-roslin-przy-uzyciu-opryskiwaczy
- http://forum.farmer.pl/topic/1648-ochrona-pszcz%C3%A3%C2%B3%C3%A5%E2%80%9A/

ANNEX 1. USEFUL REFERENCES

CHAPTER 6 - ORGANIC PRACTICES IN AGRICULTURAL PRODUCTION

- Dima, S., Odero, A. Organic Farming for Sustainable Agricultural Production. A Brief Theoretical Review and Preliminary Empirical Evidence. Environmental and Resource Economics 10, 177–188 (1997). https://doi.org/10.1023/A:1026472410031
- Migliorini, P., Wezel, A. Converging and diverging principles and practices of organic agriculture regulations and agroecology. A review. Agron. Sustain. Dev. 37, 63 (2017). https://doi.org/10.1007/s13593-017-0472-4
- Reganold, J., Wachter, J. Organic agriculture in the twenty-first century. Nature Plants 2, 15221 (2016). https://doi.org/10.1038/nplants.2015.221
- Rigby, D., Cáceres, D. Organic farming and the sustainability of agricultural systems, Agricultural Systems, Volume 68, Issue 1, 2001, ISSN 0308-521X, https://doi.org/10.1016/S0308-521X(00)00060-3https://www.sciencedirect.com/science/article/pii/S0308521X00000603
- Ted Goldammer, 2017. Organic Crop Production, Management Techniques for Organic Farming. Apex Publishers ISBN (13): 978-0-9675212-8-2
- https://ec.europa.eu/info/food-farming-fisheries/farming/organic-farming/organic-production-and-products_en
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32007R0834

CHAPTER 7 - ORGANIC BEEKEEPING

- COMMISSION REGULATION (EC) No 889/2008 of 5 September 2018 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control The Commission of the European Communities.
- Conrad, R. (2013) Natural Beekeeping: Organic Approaches to Modern Apiculture (2nd ed.).Chelsea Green Publishing.
- FIBL&IFOAM- ORGANICS INTERNATIONAL. (2021, September 6). The World of Organic Agriculture Statistics and Emerging Trends 2021. https://www.fibl.org/fileadmin/documents/shop/1150-organic-world-2021.pdf
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008R0889
- Just Bee. (2020, November 3). Why are Bees Important? https://justbeehoney.co.uk/
- https://justbeehoney.co.uk/blogs/just-bee-honey-blog/why-are-bees-important

ANNEX 2. GLOSSARY

A

Agro treatment
Agro-technical treatment - a single operation of tillage (e.g. ploughing, harrowing), fertilization (e.g. manuring, liming), plant protection (e.g. application of herbicide, fungicide, zoicide) and other

Agrochemical
It is a substance used by human beings with the aim of optimizing the performance of an agricultural exploitation.

Anticoagulant
Chemical substances that prevent or reduce coagulation of blood, prolonging the clotting time.

Antimicrobial
An antimicrobial is an agent that kills microorganisms or stops their growth

Apis mellifera
The western honey bee or European honey bee is the most common of the 7–12 species of honey bees worldwide.

Apitherapeutics
Treatments or complex of substances based on products extracted from bees or beehives.

Apitherapist
Professional therapist specialized in the use of bee products for therapeutic reasons.

ATP synthase
A protein that catalyzes the formation of the energy storage molecule adenosine triphosphate (ATP) using adenosine diphosphate (ADP) and inorganic phosphate (Pi)

ANNEX 2. GLOSSARY

B

Bactericide
A substance which kills bacteria.

Bee bread
A mixture of pollen and nectar or honey. This substance is the main source of food for honey bee workers and larvae. The exact composition of the bee bread varies depending on the plants that the bees forage from. This not only changes at different locations but also with the seasons and even at different times of the day.. Bee bread is considered a functional product, having several nutritional virtues and various bioactive molecules with curative or preventive effects.

Bee venom
It is a cytotoxic and hemotoxic bitter colorless liquid containing proteins, which may produce local inflammation.

Biocide
A biocide is defined in the European legislation as a chemical substance or microorganism intended to destroy, deter, render harmless, or exert a controlling effect on any harmful organism.

Biodegradable
“Biodegradable” refers to the ability of things to get disintegrated (decomposed) by the action of micro-organisms such as bacteria or fungi biological (with or without oxygen) while getting assimilated into the natural environment. There’s no ecological harm during the process.

Biodiversity
Biodiversity is a term used to describe the diversity of ecosystems, species and genes on Earth or in a particular habitat. It is essential to human well-being as it provides the sustaining functions of economies and societies.

Bioindication
Method of assessing the state of the environment using living organisms. Bioindicators include animals, plants, fungi and even entire ecosystems.

ANNEX 2. GLOSSARY

C

Carbamate substances
A group of organic chemical compounds - salts and esters of carbamic acid or N-substituted carbamic acids. An example of a salt would be ammonium carbamate formed by the reaction of ammonia and carbon dioxide, which in the presence of water decomposes to ammonium bicarbonate and ammonia.

Cell Culture Assays
A cell culture assay is any method used to assess the cytotoxicity, biological activity and biochemical mechanisms of a material.

Chelated micronutrients
Fertilizers where the micronutrient ion (for example Fe or iron) is surrounded by a larger molecule called a ligand or chelator. Chelated micronutrients are available to plants over a wide pH range, while non-chelated micronutrients will only be available in soils with a pH below 7.0

Chitin
One of the most abundant aminopolysaccharide polymer occurring in nature, and is the building material that gives strength to the exoskeletons of crustaceans, insects, and the cell walls of fungi.

Crop rotation
The practice of planting different crops sequentially on the same plot of land to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure and reduces the probability of developing resistant pests and weeds.

Cuticle
Any of a variety of tough but flexible, non-mineral outer coverings of an organism, or parts of an organism, that provide protection.

ANNEX 2. GLOSSARY

D

Dichlorodiphenyltrichloroethane
An organic chemical compound from the group of chlorinated hydrocarbons. It is used as an insecticide. DDT was first synthesised in 1874 by Austrian chemist Othmar Zeidler. The insecticidal properties of this compound were discovered by Swiss Paul Müller, for which he was awarded the Nobel Prize in 1948.

Drone brood
Drone brood is defined as male bees developing in wax comb cells from unfertilized eggs by a process known as parthenogenesis.

Dymorphism
(Gr. dimorphos: bipedal) - the occurrence within a single animal or plant species of two different forms, different in appearance, structure and physiology.

E

Ecotoxicity
The subject of study of the field of ecotoxicology refers to the potential for biological, chemical or physical stressors to affect ecosystems.

Ectoparasite
Ectoparasites are organisms that live on the skin of a host, from which they derive their sustenance.

Endoparasite
Endoparasites are parasites which live inside a host and generally inhabit areas such as the gut, lungs, heart and blood vessels.

Entomopathogenic fungus
Fungus that can kill or seriously disable insects.

ANNEX 2. GLOSSARY

F

Fertigation
Fertigation is the injection of fertilizers, used for soil amendments, water amendments and other water-soluble products into an irrigation system, so that the nutrients are distributed throughout the land.

Fertilizer
Substances or compounds rich in nutrients of natural or synthetic origin, which are applied to the soil or the plant tissues to supply nutrients, improve soil characteristics, improve crop yields and allow for higher production.

Foliar fertilizer
Liquid fertilizer applied diluted in water on the leaves of the plants by spraying. This fertilizer application form is potentially more dangerous for bees.

Foulbrood
Foulbrood is a fatal bacterial disease of honey bee brood caused by the spore forming bacterium Paenibacillus larvae.

G

GPx
Glutathione peroxidase

Guttation
Guttation is the expelling of excess water or nutrients through tiny openings on leaves and stems.

ANNEX 2. GLOSSARY

H

HbA1c
The hemoglobin A1c

Hemipteran insect
An order of insects, commonly called true bugs, comprising over 80,000 species within groups such as the cicadas, aphids, planthoppers, leafhoppers, assassin bugs, bed bugs, shield bugs.

Herbicide
A chemical that is used to destroy plants, especially weeds

HOMA-IR
Homeostatic Model Assessment for Insulin Resistance

Honeybee
Species of hymenopterous insect of the bee family (Apidae); lives in hierarchical societies, called bee colonies; due to the great diversity of physical and biol. characteristics, 25 subspecies are distinguished. (geogr. races), classified into 4 groups: I - bees of northern and western Europe and northern Africa, II - bees of the Balkans (krainian bee group), III - oriental bees, IV - African bees; the African bee (A.m. adansoni) is considered the most aggressive towards humans and animals.

Honeydew
A sweet liquid found as droplets on the needles and branches of spruce, larch and fir, and on the leaves of some deciduous trees, including oak and lime. It consists of plant sap, flowing from cells damaged by aphids, maggots or honeysuckles (and other sucking insects that feed on plant sap) and the liquid excrement of these insects.
Honeydew is collected by bees and processed into honeys, called honeydew honeys. These honeys are characterised by their dark colour. Sooty fungi proliferate on honeydew-covered plants (leaves, needles), which, by forming a black coating, restrict light from reaching the leaves and impede the gas exchange of the plant, often doing more damage to the plant than the insects that feed on its sap. Many ant species feed on honeydew. Some of them, such as hurtnica pospolita (Lasius niger) live in symbiosis with aphids: the aphids provide the ants with honeydew, the ants defend the aphids from predators.

ANNEX 2. GLOSSARY

I

Imago
Imago (Latin imago - image; adult insect, perfect insect - the final stage in the individual development of insects undergoing transformation. The imago no longer undergoes linień. In most species it is a reproductively capable individual, often taking no or only minimal food.

Inhibitors
A substance added to a fertilizer which extends the time a component, such as nitrogen, is released into the soil.

Insect-pollinated plant
Plants whose flowers are pollinated by pollinating insects. They show a number of adaptations that enable or facilitate this process: The pollen of these plants is heavier and richer in nutrients than pollen from wind-pollinated plants.

IPM
A way of protecting plants against harmful organisms by using all available plant protection methods, in particular non-chemical methods, in such a way as to minimise risks to human and animal health and the environment.

L

LDL
Low-density lipoprotein.

Lepidopteran insect
An order of insects that includes butterflies and moths (both are called lepidopterans).

Lipophilic
Tending to combine with or dissolve in lipids or fats.

ANNEX 2. GLOSSARY

M

Macronutrient
Chemical plant nutrient that can be expressed as: % in the plant or g/100g. The main plant macronutrients are: carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S).

MET
Mitochondrial electron transport

Microbiocide
A microbiocide is any biocidal compound or substance with the purpose of reducing the infectivity of microbes, such as viruses or bacteria.

Micronutrient
Chemical plant nutrient that can be expressed as: part per million = mg/kg = mg /1000 g. The main ones are: copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), boron (B), chlorine (Cl) and nickel (Ni). Occasionally silicon (Si), cobalt (Co), and vanadium (V).

Molluscicides
Chemical substances that act as repellents, eliminating moluscs or preventing their development.

MOR
Substances or mixtures of substances and living organisms, intended to protect crops against harmful organisms, to destroy unwanted plants, to regulate growth, development and other biological processes in crops (excluding fertilizers) and to enhance the properties or effectiveness of these substances (adjuvants).
In international nomenclature, the general name pesticides has been adopted for all plant protection products. The term plant protection products is a narrower concept than the term pesticides, as it applies only to products used in crop production.
In addition to plant protection products, plant protection products also use substances that do not directly kill agrofagibut act on them in such a way that the organisms do not pose a threat to the crop. This new generation of plant protection products includes repellents, atraktanty, antyfidanty, various types of pheromones and the like.

ANNEX 2. GLOSSARY

N

Neonicotinoids
Active substances used in plant protection products to control harmful insects. Neonicotinoid use has been studied in relation to adverse ecological effects, including honey-bee colony collapse disorder (CCD), and declining populations of insect-eating birds. In 2013, the European Union and some neighbouring countries restricted the use of certain neonicotinoids. In 2018 the EU banned the three main neonicotinoids (clothianidin, imidacloprid and thiamethoxam) for all outdoor uses.

Neurotoxin
Neurotoxins are toxins that are destructive to nerve tissue- causing neurotoxicity. Neurotoxicity is a form of toxicity in which a biological, chemical, or physical agent produces an adverse effect on the structure or function of the central and/or peripheral nervous system.

Nutrient
Chemical elements that plants need in their vegetative life process, in addition to water, air and solar energy.

Nutrient balance
Difference between the nutrient inputs entering a farming system (mainly livestock manure and fertilizers) and the nutrient outputs leaving the system (the uptake of nutrients for crop and pasture production).

O

Organic fertilizer
Fertilizer derived from plant residues or livestock manure mainly

Organo-mineral fertilizer
Fertilizer obtained by the mixing of one or more organic fertilizers with one or more inorganic fertilizers (e.g. nitrogen or phosphorus), that is a combination of both origins, a part with inorganic origin but other generated from waste streams.

Organophosphorus substances
Organic chemical compounds containing a carbon-phosphorus bond, for example phosphonates or phosphines. Phosphate esters are also often included under this name, even though they do not contain a P-C bond. The definition of an organophosphorus compound is therefore not straightforward.

ANNEX 2. GLOSSARY

Oxidase
An enzyme that catalyzes oxidation-reduction reactions, especially one involving dioxygen (O2) as the electron acceptor.

P

Pathogen
A foreign body, biological creature or microorganism that causes disease in an organism. There are the following types of pathogens: animate, inanimate, chemical, nutritional deficiency, physical.

Pathogenesis
The process by which an infection leads to disease.

PDSO
Petroleum-derived spray oils

Pesticide
Latin pestis - pestilence, plague; caedo - kill) - synthetic or natural substances used to control harmful or undesirable organisms, used mainly to protect crops, forests, water bodies, but also animals, humans, food products, and to destroy living organisms, considered harmful, in livestock buildings, housing, hospitals and warehouses. The term 'pesticides' is broader than 'plant protection products', as the former also encompasses the control of harmful organisms outside of plant production.

Pheromones
Chemical compounds, or more precisely semiochemical compounds. They are usually composed of several components that occur at different intensities. Interestingly, pheromones do not have zapachu. Even if we are dealing with a high concentration of substances, their scent is very delicate. Pheromones are produced by plants or animals. They are a signal that is intended to convey information or trigger a reaction. It is, for example, about scaring off an opponent, signalling one's dominance or readiness to reproduce.

Phytotoxicity
A delay of seed germination, inhibition of plant growth or any adverse effect on plants caused by specific substances (phytotoxins) or growing conditions

Pollinator
A pollinating animal that transfers pollen from the male anther of a flower to the female stigma of the flower. This helps the male gametes from the pollen grains to fertilize the flower's ovules.

ANNEX 2. GLOSSARY

Polychlorinated substances
Large group of chemical compounds, mainly hydrocarbons with varying degrees of chlorination and structure. Depending on their chemical structure, they show varying degrees of effectiveness in controlling insects and varying degrees of harm to humans and the environment.

Poultices
A paste made of herbs, plants, and other substances with healing properties.

Powdery mildew
Fungal disease that affects a wide range of plants. Powdery mildew diseases are caused by many different species of ascomycete fungi in the order Erysiphales.

Prevention period
The time that must elapse between application of the product and the time when contact between the bees and the treated plants is safe for the bees, i.e. there is no risk of poisoning the bees. During this time, the active substance of the preparation should be broken down into compounds that are inert to the bee organism. The longer the precautionary period, the higher the toxicity of the preparation concerned, and can last from several days to one hour. Before using any plant protection product, it is essential to read the label (instructions for use) carefully so that the chemical treatment can be carried out effectively and safely for the environment.

Propagules
Any material that functions in propagating an organism to the next stage in its life cycle, such as by dispersal.

Propolis
Or bee putty, is a sticky, thick substance used by bees to line the inside of the hive, helping to seal and strengthen its structure. Propolis also protects the hive from pathogens - bacteria, fungi and viruses. Bee putty is made from the secretions and resins of trees and flowers - its source can be poplar, willow, ash, alder, birch or oak, and coniferous trees with damaged bark, such as spruce, fir or pine.

Pyrethroids
Natural and synthetic plant protection products used to control insects. They are included in the third generation of insecticides. They act selectively. They are poisonous to insects and not very harmful to humans and other higher organisms. They have no effect on fungi. They are often used to protect wood. They have a contact and stomach effect on insects and can counteract fistula closure - death of the insect by desiccation.

ANNEX 2. GLOSSARY

R

Re-epithelialization
The resurfacing of a wound with new epithelium.

Resistant varieties
Resistant varieties suppress or retard a pathogen's activity and show little or no symptoms of infection.

Rodenticide
Chemical substances used to control rodents, causing their death by inhibiting blood coagulation or altering their metabolism.

Royal Jelly
Royal jelly is a whitish to yellow substance of viscous jelly consistency with pungent and sour aroma. Royal jelly represents an important substance used as nutrition for the queen and future queens, as well as for the larvae of drones and working bees in the first three days of life.

S

Seed treatment
In agriculture and horticulture, a seed treatment is any additional material added to the seed. By the amount of material added, it can be divided into: A seed dressing, typically containing a "protectant" (pesticide) applied to the seed and possibly some color. A seed coating, a layer of thin film applied to the seed typically less than 10% of the mass of the original seed.

SOD
Superoxide Dismutase

Soil actinomycetes
Actinomycetes are a large group of bacteria that grow as hyphae like fungi. They are responsible for the characteristically "earthy" smell of freshly turned, healthy soil

Soil fumigants
Soil fumigants are pesticides that, when applied to soil, form a gas to control pests that live in the soil and can disrupt plant growth and crop production

Soil improver
Material to be added to the soil to maintain or improve its properties.

ANNEX 2. GLOSSARY

Spray drift
Spray drift is an issue well known to farmers. It occurs when chemicals applied with a sprayer are carried away from the spray zone as a result of air movements. The result of this process can be the inadvertent spraying of neighbouring crops, which can lead to damage.

T

TNF-α
Tumor necrosis factor

Tolerant varieties
Tolerant varieties do not significantly inhibit the pathogen: they may show severe disease symptoms but without significant losses in yield or quality.

V

Varroa mite
Varroa destructor is an external parasitic mite that attacks and feeds on the honey bees Apis cerana and Apis mellifera. It is a major pest of bee colonies contributing to significant losses in beekeeping.

Funded by the
European Union

Financed by the European Enion. The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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BEEPRO: Rational use of plant protection products and fertilizers in terms of the impact on bees in the ecosystem.
PROJECT NO. 2021-1-SK01-KA220-VET-000025257