Science For A Better Life

Honey bee care

Challenges and solutions

Photo: Jürgen Schnorbach

Bayer CropScience

Published by:

Bayer CropScience AG
Alfred-Nobel-Str. 50
40789 Monheim am Rhein
Germany

bees@bayer.com
www.bayercropscience.com

May 2011

CONTENTS

ALL ABOUT BEES

HONEY BEE HEALTH

HONEY BEE PATHOGENS

"COLONY COLLAPSE DISORDER"

HONEY BEES, AGRICULTURE AND INVASIVE ALIEN SPECIES

BEES NEED GOOD NUTRITION

HONEY BEES ARE SENSITIVE TO THE WEATHER

GOOD BEEKEEPING MANAGEMENT PRACTICES

HONEY BEE SAFETY

PESTICIDES: LABORATORY AND FIELD RESEARCH

PRODUCT MONITORING

BENEFITS OF SEED-APPLIED INSECTICIDES

STEWARDSHIP MEASURES

BAYER'S COMMITMENT AND CONTRIBUTION TO HONEY BEE HEALTH AND SAFETY

ALL ABOUT BEES

There is no doubt that honey bees should be protected so that they can continue to provide honey and carry out the pollination services that are so critical to food production.

Imagine a flower garden with bees buzzing around busily collecting the nectar they will turn into delicious honey. Honey bees may appear a small part of this appealing picture, yet they are vital to people and nature.

The focus of beekeepers is often on honey or beehive products, such as wax or royal jelly. Yet the greatest service honey bees provide is pollinating agricultural crops. Pollination increases the yield and quality of many crops and its value to agriculture has been estimated at about €153 billion (US $185 billion) worldwide.

Bees mainly feed on nectar as their energy source and pollen, which provides protein. In their search for food bees also pollinate wild flowers. In this way, they make an immeasurable contribution to biodiversity: many flowers set their fruits only after a bee visit, and these fruits provide essential food for wildlife. Pollinators include honey bees and thousands of wild bees (such as bumblebees and solitary bees), butterflies, wasps, beetles, birds and bats.

The Western (or European) honey bee (*Apis mellifera*) is well established in many parts of the world and relied on to perform most of the commercial pollination. At the heart of the honey bee colony is the queen, which can lay up to 1,500 eggs a day and lives for 2–4 years. Colony duties are carried out by up to 60,000 female worker bees. Several hundred male drones live during the summer months and serve only for reproduction purposes.

The worldwide bee population almost doubled between 1961 and 2007. While managed colonies decreased in some parts of the world (Europe, North America and Japan), increases occurred in Asia, Africa, South America and Australia. A reduction or increase in the number of colonies in some areas may simply be linked to the number of beekeepers, yet there are many factors that can seriously impact honey bees.

10,000 years ago, man learned to domesticate animals and grow plants. Before sugar cane or sugar beets were cultivated, the only source of sugar (apart from fruit, dates or maple syrup) was honey collected from colonies of wild bees. As civilization evolved, bees were offered nesting opportunities to facilitate honey collection, and the beehive was born. Hive images first appeared on Egyptian monuments around 2,400 BC.

Bumblebee

Sculpture of a dome-shaped hive, Denmark (1823)

HONEY BEE HEALTH

The number of bees in a hive naturally varies throughout the year. Their numbers may drop from a peak of up to 60,000 bees in midsummer, when food is available in abundance, to only 8,000 after a long winter.

HONEY BEE PATHOGENS

Since the 1950s, a parasitic mite known as *Varroa destructor* has spread to almost every Western honey bee hive, except Australia. The parasite impacts bee health by feeding on honey bees and spreading viruses among the bee population. In all, about 20 bee viruses are known to exist, including *acute* and *chronic bee paralysis* and *deformed wing virus*.

It is interesting to note that colonies of African or Africanized honey bees in South America and Africa are more resilient to the mite because of their hygienic (grooming) behavior by which they aggressively remove the mites from their bodies. Australia, presently *Varroa*-free, enjoys some of the healthiest Western honey bees on the planet.

Various other bee pathogens exist: *Nosema apis* and *Nosema ceranae*, unicellular parasites, are global in distribution; the small hive beetle (*Aethina tumida*) is found in the US; and the Asian Hornet (*Vespa velutina*), a predator, is spreading in parts of France, Spain and North America. In addition, the American and European foulbroods are bacterial pathogens.

"COLONY COLLAPSE DISORDER"

In the US, worker bees have been reported to be disappearing from colonies, leaving behind the queen and her brood. These specific symptoms have been termed "Colony Collapse Disorder" (CCD) and a combination of factors is thought to be involved. Numerous questions still remain unanswered. Similar "disappearing" behavior has been reported in different kinds of social insects, which leave their "homes" when they are very sick so as to protect their fellow insects.

Parasitic mite, Varroa destructor on bee brood, larva and adult bee

CHALLENGES

The *Varroa* mite currently stands out as the key threat to honey bee health as it proliferates very rapidly and transmits pathogenic viruses. Mite management relies on a limited portfolio of cultural and chemical treatments, to which resistance has already been observed or lack of efficacy experienced. The small size of the market for such products, their relatively difficult access for beekeepers in some countries (because of the need for veterinary prescriptions) and the fact that new challenges are continually being discovered are all contributing to the magnitude of the task.

SOLUTIONS

The most efficient way of managing bee health in the short term is by enhancing hive health through good apiary practices. These include hygienic measures, a sound knowledge of pathogen and bee life cycles, as well as making the best use of currently available mite management solutions.

Harmonization of bee health data within and across country boundaries has been identified as a prerequisite for implementing effective measures and coordinating various research approaches. Breeding bees for increased natural *Varroa* resistance is useful as part of an integrated approach. It is, however, a challenging goal and solutions are neither to be expected for the short term, nor can they be considered a permanent solution.

New mite treatment options are being investigated by various institutions and companies. Bayer offers a variety of products: Bayvarol® (flumethrin), Checkmite+® and Perizin® (coumaphos). They are approved for *Varroa* control in many countries and comply with national veterinary regulations, which vary from country to country. A product acquired in 2010 will complement our existing portfolio and further technological solutions are being explored.

Invasive Alien Species (IAS) are plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health.

A sign raising awareness of IAS, South Africa: Durban Botanic Gardens

HONEY BEES, AGRICULTURE AND INVASIVE ALIEN SPECIES

Alien species that become invasive have been recognized internationally to be a main direct driver of biodiversity loss across the globe. They are also acknowledged to cost the global economy hundreds of billions of dollars each year. In agriculture, the annual environmental losses caused by pests introduced in the US, the UK, Australia, South Africa, India and Brazil have been calculated at over €68 billion (US $100 billion). The *Varroa* mite is just another example with significant financial implications. By one estimate, the economic loss that would occur if the mite should enter Australia would be €11–26 million (US $16–39 million) a year over the next 30 years.

The *Varroa* mite is a prime example of how the Western honey bee is suffering from an IAS introduced from its Asian counterpart *(Apis cerana)*. The latter co-evolved with the mite and has specific characteristics that help minimize the effects of the mite. Other bee species such as Africanized bees also exhibit behavior patterns that reduce build-up of *Varroa*: they swarm more frequently, leaving behind high parasite infestations in the brood. The Western bee does not have such defense mechanisms and is thus more vulnerable to this parasite. Other introduced pests may include the *Tropilaelaps clareae* mite, the small hive beetle and the Asian hornet.

Small hive beetle

CHALLENGES

IAS can be a serious threat for agriculture and apiculture alike. While the threat of species migration has always existed, they are spreading faster than ever before thanks to greater global mobility, increased world trade and changing climate patterns. The sudden and unprecedentedly high impact of an introduced species presents a significant challenge, especially if control measures are unavailable, or fail.

SOLUTIONS

Increasing awareness and understanding of the potential risks and the issues involved in addressing IAS is an overarching issue, critical for food supply and biodiversity conservation. At an international, regional or national level, systems of animal disease notification are in place. They provide management solutions for introduced species, including honey bee pathogens, in an effort to reduce their spread.

Bayer provides various tools to manage IAS, including plant and animal health products as well as technical approaches. One of our bee health products (Checkmite+®) is used in the management of the small hive beetle in the USA and Canada and could potentially be used should the beetle reach Europe.

Bee foraging on goldenrod

However, not all IAS are harmful. Non-native invasive alien plants such as goldenrod or Indian balsam introduced to countries in Europe provide nectar and pollen for bees in summer and autumn when natural forage sources become scarce, thereby helping bees to overcome periods of reduced food availability.

Honey bee health challenges and losses have been described for centuries and are due to a variety and combination of causes. Today, bees face new challenges, which include relatively new pests such as the *Varroa* mite, viral infections and other pathogens, to some extent insufficient forage and increasingly unfavorable weather events.

BEES NEED GOOD NUTRITION

Under temperate climatic conditions naturally occurring plants and agricultural crops provide a variety of flowers in springtime and fewer later in the year. Some agricultural crops – canola/oilseed rape, fruit and vegetables – provide better bee forage in terms of protein content and pollen quality than sunflowers or maize, for instance. Wind-pollinated crops such as cereals (barley, maize, rice and wheat) do not produce insect-attracting nectar and are typically not attractive to honey bees.

Besides quantitative availability all year round, the quality and diversity of forage is important for maintaining the health of wild bees and honey bees alike.

Bee drinking

CHALLENGES

Globally, the increasing world population is "paving" more and more land, which leads to habitat loss and with that, a loss of flower diversity. Likewise, agricultural production requires a greater concentration of crops to provide enough food in response to market demands. This has led to reduced numbers of flowering crops, which in some areas can contribute to reduced forage diversity for bees.

SOLUTIONS

Everyone can contribute to the increased availability of bee forage, for example, by planting nectar- and pollen-rich plants, shrubs or trees. Measures to improve agro-ecosystems – referred to as environmental farm plans, stewardship, land-care or pollinator conservation initiatives – vary, but the positive effects of flower mixtures on farm areas are well known. They can be further promoted if farmers are compensated for potential yield reduction when implementing such measures. It is important, however, to realise that good forage alone will not solve bee losses caused by pathogens.

Bayer promotes sustainable crop management practices, including evaluating measures to enhance on-farm biodiversity and promoting bee health through the creation of foraging and nesting opportunities. This is done in cooperation with farmers, conservation NGOs, authorities and scientific institutions.

HONEY BEES ARE SENSITIVE TO THE WEATHER

Irregular winter weather cycles, such as early and wet springs or a sudden return to winter weather later in the year, can put undue stress on honey bees – either directly (in that they may not be able to maintain the required temperature in the hive) or indirectly (through reduced nectar flow in flowers). Likewise, prolonged rainy or dry weather may negatively influence honey bees just as much as by impacting floral nectar production.

CHALLENGES

In the past decade, losses of honey bee colonies over the winter have in some cases been double (at about 30 %) or even higher than the average previous losses. Although climate change is resulting in more frequent unfavourable weather events in some parts of the world, this is not the primary cause of higher winter losses but rather an additional stressor for bees.

SOLUTIONS

While beekeepers remain dependent on good weather conditions, it has been shown that pests of honey bees and poor nutrition have the greatest impact in reducing the survival of colonies. Addressing these factors would help ensure a hive can over-winter successfully.

GOOD BEEKEEPING MANAGEMENT PRACTICES

Management practices vary greatly throughout the world and have to be adapted locally. Differences also depend on the beekeeping purpose: honey production or provision of pollination services. For example, every year about a million hives are transported over long distances to help pollinate the almond crop in California. Frequent and long-distance colony transport amounts to an additional stress factor for bees.

Bee hive in winter

HONEY BEE SAFETY

There are strong ties between agriculture and beekeeping. As such, agricultural practices can influence bee health in many ways. The effects of pesticides on honey bees were tested as early as the 1920s. Ever since, testing requirements have evolved as scientific knowledge increased.

Laboratory feeding of bees

Honey bee field studies

PESTICIDES: LABORATORY AND FIELD RESEARCH

A reasonable first assumption is that an insecticide might have an effect on an insect such as the honey bee, yet effects vary significantly on a case-by-case basis. It is therefore essential either to demonstrate bee safety or to determine measures to minimize bees' contact with crop protection products.

A step-by-step approach to bee safety evaluation begins with laboratory studies and progresses, as required, to include field and observational studies. Depending upon the outcome of these studies, tailored use recommendations for each product are provided on labels.

CHALLENGES

Laboratory research focuses on the response of bees to different pesticide application rates – including deliberate overexposure. Such research is useful for product evaluation but results do not imply that they are transferable to "real world" field exposure conditions. Thus, care must be taken not to draw the wrong conclusions.

SOLUTIONS

The evaluation of pesticides from a bee safety perspective makes use of study protocols and guidelines developed by experts. What really matters in this cascading process is the interaction between a bee and a pesticide in real field situations. In some cases, avoiding effects may be as simple as not spraying during blooming.

Bayer is highly committed to ensuring that its products can be used in a "bee-responsible" manner. When evaluating pesticides prior to market release, we go beyond legal requirements, recognizing that bee health is critical to sustainable agriculture.

Laboratory feeding of bees

PRODUCT MONITORING

Our commitment to bee safety extends beyond merely selling pesticides and does not stop once a product has been officially approved for use.

As new products are commercialized, the ongoing evaluation process continues and benefits from monitoring, new scientific findings as well as customer experience and feedback gained from the field. Updating regulatory files of products is equally a continuous process and a legal requirement. It is considered "flexible" to allow integration of lessons learned.

Evaluating honey bee combs

CHALLENGES

Varying worldwide use conditions in the field have to be considered for the implementation of stewardship measures and outreach to farmers and other users of our technologies.

SOLUTIONS

Laboratory and field studies, combined with real-world commercial experience, are essential in the development of a technology which will protect the crop and minimize harm to bees. Following pesticide label recommendations is naturally beneficial to bees' safety. In addition, cooperation between farmers and beekeepers about when fewer honey bees are foraging to ensure optimized spraying times can also be supportive.

As a research-based company Bayer moves forward by incorporating the lessons learned from product field monitoring into improved technologies. This is a critical part of our broader approach to promoting responsible and sustainable pesticide use.

Different insecticides have varying effects on bees. In cases where effects may potentially be expected, special care must be given to use them in a "bee-responsible" manner. Strictly following stewardship measures and label recommendations is crucial in this respect.

BENEFITS OF SEED-APPLIED INSECTICIDES

Neonicotinoids are an important family of insecticides introduced two decades ago and adopted by farmers around the world because of their effectiveness in controlling harmful crop pests. Bayer's neonicotinoids Gaucho® (imidacloprid) and Poncho® (clothianidin) are insecticides that are widely used as seed-applied insecticides. They are products taken up by the seeds and thus protect them from within against soil-borne pests as well as early season foliar pests when the seed develops into a young plant.

Applying an insecticide to a seed is very eco-efficient and thus brings many benefits to an agro-ecosystem's overall health: less than 1% of a given area is treated compared to the whole area in a spray application; only insects that feed on the plants are exposed; and potential drift exposure to water bodies and beneficial insects (which help to manage pests) is reduced. What is more, fossil fuels (and with that greenhouse gas emissions) and water use are saved since treated seed saves at least one tractor operation otherwise required for spraying. Farmers value all the added agronomic and economic value associated with healthier plants, increased yield and time freed-up during a very busy period of the year.

Neonicotinoids' use has caught the public's attention and been subject to controversial debates. What contributed to this and what is our perspective?

Bee losses were first attributed to imidacloprid in France during the late 1990s. They were not related to specific product incidents. Later, an accident with clothianidin occurred in Germany and resulted in enhanced mitigation measures to prevent their reoccurrence. As a result of these two cases and their coincidental market introduction at a time when bee health issues increased dramatically, the debate about neonicotinoids nevertheless continues. Today, more is known about the bee safety of the neonicotinoids than of any other compound.

Sowing machine with exhaust air deflector

Treated seeds

Many large-scale multifactorial studies were undertaken in the US, Austria, Belgium, Canada, France and Germany. These have shown that poor bee health is correlated with the presence of *Varroa*, viruses and many other factors, but not with the use of insecticides. Findings of a multi-stakeholder and longer-term German bee monitoring survey running since 2004 and involving over 100 beekeepers and 1,000 bee colonies have confirmed these results, as have monitoring studies in France and North America.

STEWARDSHIP MEASURES

With the aim of continuously improving the proper use of our technologies, various stewardship measures have been developed and implemented in close cooperation with many stakeholders.

They involve:

- higher seed quality standards to ensure the treatment sticks to the seed
- enhanced dust-drift-reducing equipment to deflect exhaust air into the soil
- customized training for commercial seed experts at our regional Seed Treatment Application Centers across the world
- outreach to farmers through so-called "seed bag tags" containing all the necessary information

All these measures have been shared with many countries, some of which have adopted them as legal requirements. Lessons learned from experience, past mistakes, accidents and inappropriate use have proved very valuable in moving forward and understanding how they can be integrated into technology development.

BAYER'S COMMITMENT AND CONTRIBUTION TO HONEY BEE HEALTH AND SAFETY

Bayer has an inherent interest in promoting sustainable agriculture and preserving bee health. In managing our own plant breeding business, we rely on honey bee pollination and fully acknowledge the value of honey bee pollination services to agriculture.

We are committed to finding solutions to enhance honey bee health by:

- providing *Varroa* management products and exploring potential new treatments;
- ensuring the sustainable use of pesticides through research and promotion of "bee-responsible" farming practices;
- sharing knowledge and expertise with relevant stakeholders in the beekeeping and agricultural communities and with scientific and governmental institutions, NGOs, policymakers and regulators.

At the heart of our commitment to honey bee health lies our portfolio of *Varroa* mite management products. In 2010, we acquired a new product derived from natural thymol oil, which we are further developing for use in various countries. Additional innovative solutions for bee health are currently underway and reaffirm our commitment.

To ensure that bees will continue to thrive in the future, we are contributing to finding solutions for improved honey bee health and safety. To that end, we are cooperating in a variety of projects with scientific and governmental institutions.