Relationships of Honey Bees and Pesticides

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Honey bees are an essential component of modern agriculture as their pollination efforts are necessary for production of about one-third of the crops we produce in this country. Exposure to pesticides has produced negative effects on individual bees and their colonies for nearly a century. Historically, dead or dying bees on the hive bottom boards and on the ground in front of the hives, demonstrated to beekeepers the negative effects of such interactions. The losses can be pretty spectacular and piles of dead bees very voluminous. In addition, there also can be negative effects on queens, drones, developing brood, and bee behavior that eventually result in weakened or dead colonies.

Over the decades there has been a succession of insecticides, acaricides, fungicides, and herbicides as new chemistries were developed and older chemicals were retired, often due to resistance in the target pests. More recently-developed insecticides and acaricides are fast-acting, killing most contaminated honey bees before they can accomplish many foraging flights. Some of those foraging bees die in the field. However, before other bees succumb to a toxic dose, or after the pesticide residues have broken down to sublethal levels, contaminated pollen can get carried into the hives. That pollen is transferred to housekeeping bees that pack portions of it into cells. The stored pollen undergoes microbial, partial digestion and becomes preserved with lactic acid for consumption some time during the next half year or so.

Fresh and stored pollens are mainly consumed by so-called “nurse bees” whose head glands extract nutrients from their blood and convert it into brood food. Brood food is a protein-rich, gelatinous secretion fed to the queen, so that she can lay 1,000 to 2,000 eggs a day if required. Brood food is fed to developing worker and drone larvae, and to adult drones and worker bees. When fed to queen larvae, additional proteins and sugar are added to the brood food and we call it “royal jelly.” Nurse bees that consume contaminated pollens will produce contaminated brood food and royal jelly.

In addition to pollen contamination, honey bees can become contaminated by drinking field water which contains chemical residues. While irrigation that leads to tail water puddles or ponds may be declining, the use of chemigation is increasing. Honey bees can drink chemigated water from emitters, leaks in the system, or even from moist soil that contains water from chemigation. Often honey bee colonies show serious decline following imbibition of that water. Additionally, in recent years, insecticides are being formulated as systemic compounds that move throughout the plant tissues. If and when the treated plants bloom, the pesticide is delivered to the bees in the pollen and nectar. In tree crops, those pesticide levels in blossoms can be surprisingly high, even as much as a year following the initial application.

The biochemistry of adult bees is not terribly complex, since they are fully developed and require only maintenance nutrition. Larvae are another story. They are growing at a fantastic rate (1,000 X gain in mass in six days). They undergo six molts during their development that require an intricate balance of hormones in order to reach maturity. That makes the larvae very vulnerable to any chemicals that might interfere with the delicate balance of interacting biochemical pathways being utilized. Pesticides frequently are designed to interfere with one or more biochemical pathways of the target organism. It should come as no surprise that exposure to small amounts of any of a large number of pesticides can disrupt normal larval development. All types of pesticides contain some products that are toxic to developing honey bee brood.

It would be nice to think that we know all about the effects of pesticides on adult and immature honey bees, but that just is not the case. New pesticides, being reviewed for registration by EPA and CDPR, are required to be tested against the relatively chemically inert adult worker honey bee to determine the short-term acute toxicity levels by contact and ingestion. If the product is determined to be toxic to adult honey bees, a warning or prohibition is placed on the label. Any product toxic to adult honey bees also is supposed to be tested against honey bee brood, but definitive protocol for such testing never has been developed at the federal or state level. Some companies conduct such studies on their own volition, but most do not. Also, many products are registered on the basis of toxicity testing of the active ingredient in a pesticide. So-called "inert ingredients" are neither listed on the label nor tested for honey bee toxicity. Thus, some formulations, with active ingredients that are supposedly innocuous to honey bees, kill bees on contact or when taken back to the hive and introduced into the colony food chain. Products that are tank mixed may produce synergistic effects many times more toxic then the individual products, alone, but the tank mixes are not tested for bee toxicity. Label statements can fail to relate the true toxicity of their products to honey bees.

The best way to protect honey bees from damage by pesticides is to keep them from being exposed. Very infrequently do pesticides enter the hive directly. However, on warm to hot evenings very large groups of honey bees can be clustered on the fronts of beehives and are very susceptible to being hit by applications from directly overhead or from pesticide drift. Better attention to local hive conditions by applicators can reduce those problems.

Most honey bees and their food are contaminated by applications through which the pollen foragers fly or by residual products on floral parts (especially pollen) or foliage. Surface contaminated bees will add pesticide to their pollen loads. Contaminated pollen can be returned to the hive. Most pesticides are lipophilic, so they blend chemically with the hydrocarbons in beeswax and the exoskeletons of honey bees. They also become blended with the lipids in the outer layer of pollen grains. Thus, beeswax and pollens exchange contaminants.

To prevent negative effects of pesticides of all types, do not apply them to blooming plants upon which bees are foraging. Evening or night applications of short residual materials, in areas where bees are foraging, will greatly reduce negative effects on bees. What about fungicides that are routinely applied during bloom? Again, proper timing of such applications can be significant. For example, given good flight conditions, pollen foragers will remove nearly all of the day's melon pollen by mid-morning and almond pollen by mid-afternoon. Fungicides applied to almonds from late afternoon until very early the next morning will contaminate pollen or pollen foragers much less than fungicides applied early-morning to mid-afternoon. Concerns about fungicide-induced failure of pupae to emerge as adult bees could be greatly reduced. The least exposure to pesticides is best for the bees.

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