CHAPTER 24

We have to find in the next 25 years, food for as many people again as we have been able to develop in the whole history of man.

Jean Mayer (1975)

BIORATIONALS — 21st Century Pesticides

Pest control practices are evolving rapidly. Some pesticides that will be used in decades to come are currently in use or in early stages of development, while others have yet to appear. Although pesticides have become essential tools, those that are of a conventional heritage have come to sustain societal burdens of doubt, concern and even fear. For decades alternatives have been sought with limited success. IPM managers and organic producers rely on alternatives and the new organic standards created by the USDA in 2002 (www.ofrf.org) may give future impetus to "safer" alternatives. The appeal among consumers for alternatives is growing and the market for "natural" or more environmentally benign pesticides has concomitantly improved over the past few years. These "alternatives" are the *biorationals*, the agents and organisms that are currently being pursued in laboratory and field to become the pesticides of the future.

BIORATIONALS — What are they?

There is no single or legally clear, definition of the word *biorationals*. The EPA identifies biorational pesticides as inherently different from conventional pesticides, having fundamentally different modes of action and consequently, lower risks of adverse effects from their use.

The term *biorationals* is derived from two words, biological and rational. They are substances that are biologically rational or logical, that when used for specific pests have very limited or no affect on nontarget organisms. A related term is *ecorational*. In this instance, the materials are ecologically rational, with no untoward effects on nontarget organisms or the environment. EPA uses a similar term, *biopesticide*, which will be described below.

More recently, *biorational* has come to mean any substance of natural origin (or man-made substances resembling those of natural origin), that has a detrimental or lethal effect on specific target pest(s), e.g., insects, weeds, plant diseases (including nematodes) and vertebrate pests, possess a unique mode of action, are non-toxic to man and his domestic plants and animals and have little or no adverse effects on wildlife and the environment. Biorationals, then, are the ideal pesticides, affecting only the target pest and having few if any side effects.

We classify biorational pesticides into two distinct groups: (1) biochemical (hormones, enzymes, pheromones and natural agents like insect and plant growth regulators) and (2) microbial/inveterbrate (viruses, bacteria, fungi, protozoa and nematodes).

In 1994, the Biopesticides and Pollution Prevention Division (BPPD) was established by the U.S. EPA. This event signaled increased emphasis being placed on what EPA called *biopesticides*. EPA describes "biopesticide" as agents or organisms derived from natural materials (animals, plants, bacteria, canola oil) and even certain minerals (baking soda). EPA discloses that at the end of 2001 there were nearly 200 biopesticide active ingredients registered comprising nearly 800 products. EPA places biopesticides into three categories:

- Microbial pesticides (bacteria, fungi, viruses or protozoa)
- Biochemicals – natural substances that control pests by non-toxic mechanisms. An example is insect pheromones.
- Plant-Incorporated protectants (PIPs) – (primarily transgenic plants, e.g., (*Bt* corn).

Characteristics that distinguish biorational pesticides or biopesticides from conventional ones include: very low orders of toxicity to non-target species, pest targets are specific, generally low use rates, rapid decomposition in the environment, usually work well in IPM programs and reduce reliance on conventional pesticide products. Although EPA requires careful review of biopesticide safety data (chemical composition, toxicity, degradation, etc.) prior to registration, these lower risk products are usually registered much more quickly than conventional pesticides (more information is available at: (http://www.epa.gov/pesticides/biopesticides/).

From the forgoing, one can see that the terms "biorational" and "biopesticide" are quite similar though not identical. The fact that EPA incorporates transgenics (PIPs) under the term biopesticide, but they are not included under biorationals, is one difference. Moreover, biorational agents lack the broad formal agreed criteria needed to conveniently be classified as such, whereas, the EPA, under their authority to regulate, not only have such criteria but apply them through an expert committee that decides, on a case by case basis, whether new biopesticides meet the formal EPA criteria.

INSECT CONTROL

The first-generation insecticides were stomach poisons, such as the arsenicals, heavy metals and fluorine compounds. The second generation included the familiar contact insecticides: organochlorines, organophosphates, carbamates, formamidines and pyrethroids.

Biorationals are the third generation of insecticides. These agents and organisms are generally environmentally sound, comprise natural constituents of insects or plants (or close congeners) or are natural organisms.

Insect Pheromones

Most insects appear to communicate by releasing molecular quantities of highly specific compounds that vaporize readily and are detected by insects of the same species. These delicate molecules are known as *pheromones*. The word *pheromone* comes from the Greek *pherein*, "to carry," and *hormon*, "to excite or stimulate."

Pheromones, comprising one type of a group known as *semiochemicals*, are among the most potent physiologically active molecules known today. These potent agents are excreted outside the insect's body, where they cause specific reactions from other insects of the same species; they are also referred to in older literature as *social hormones*. Other classes of semiochemicals are *allomones* (chemicals excreted by one species which benefit from its effect on another receptor species) and *kairomones* (chemicals excreted by one species that benefit another receptor species).

Of 1,314 species of insects with confirmed attraction responses to identified pheromones, 1,260 of these pheromones are produced by females. Only 54 species use male-produced sex attractants. In a few species both sexes produce the same attractant (Mayer & Laughlin, 1990). A list of known pheromones from lepidopteran and other insects, can be viewed through the following Cornell University website:
http://www.nysaes.cornell.edu/pheronet/.

Pheromones are classified as either, releasers or primers. Releasers are fast-acting and are used by insects for sexual attraction, aggregation (including trail following), dispersion, oviposition and alarm. Primers are slow-acting and cause gradual changes in growth and development, especially in social insects by regulating caste ratios of the colony.

Of the different types of pheromones, the sex pheromones presently offer the greatest potential for insect control. For example, sex pheromones were used in eastern Arizona (1985-90), in the long-staple cotton production area of Graham County. Pheromone traps containing microquantities of the synthetic sex lure of the pink bollworm, gossyplure, captured a sufficient number of early emerging male moths to prevent mating and reproduction from the first generation of the season. The population was suppressed sufficiently to avoid the use of insecticidal control for this pest for most of the remaining growing season.

The sex pheromones of pest moths have received the most detailed chemical study to date. For instance, after 30 years of trial and error, the gypsy-moth sex pheromone was isolated, identified and synthesized in the laboratory in 1960. Since then great quantities of disparlure, the synthetic female gypsy-moth sex pheromone, have been used in male-trapping programs for this forest pest.

There are five principal uses for sex pheromones in current insect control programs: (1) male trapping, to reduce the reproductive potential of an insect population; (2) movement studies, to determine how far and where