INSECT BIOLOGICAL CONTROL

CARLTON S. KOEHLER
University of California Cooperative Extension
Berkeley, California 94720

Biological control has been given a rather restrictive definition by some entomologists, who maintain that it applies only to the use of parasites, predators, and pathogens for the reduction of pest populations to tolerable levels. Others have chosen to expand its definition to include other technologies of a biological nature directed toward pest population reduction. I have followed the latter course.

As plant propagators, biological control has very little to offer you directly. Its greatest utility, based on knowledge to date, comes after the plants you have propagated are planted in the landscape, orchard, vineyard, or other growing site. Yet as plant propagators you properly have an interest in the kinds of pests which attack the crops you produce, the intensity of resultant damage, and the procedures necessary to alleviate pest infestations.

Parasites, Predators, and Pathogens. Our most important parasites are tiny wasps and flies whose adults deposit their eggs in or on pest insects. On hatching, the immature parasite proceeds to devour the pest before emerging as an adult from the dead host to begin the cycle again. A recent success story involved the release of the wasp *Trioxys pallidus* to combat the walnut aphid, *Chromaphis juglandicola*, in California.

A predator normally consumes a number of host insects before completing its development. The more significant predators include the ladybird beetles, green lacewing larvae, ground beetles, and assassin bugs. Also, birds, toads, and a variety of other animals serve an important role in a predatory capacity but these do not lend themselves easily to manipulation by man as do some of the insects which are predators. The first successful instance of the planned biological control of an insect pest involved the introduction in 1888 of a predaceous ladybird beetle, known as the Vedalia, from Australia for control of the cottony cushion scale, *Icerya purchasi*, on citrus trees in California.

Biological control by parasites and predators has the advantage over many other pest control methods in that it is self-perpetuating and therefore rather permanent, inexpensive to initiate, and contributes nothing to the pollution of our environment. It is most effective in dealing with pests which have been accidentally introduced from another country. Such introduced pests usually arrive and become established without their natural enemies. Classical biological control, then, entails the search for and introduction of parasites or predators from the native home of the pest, and the release of these in the pest's new country of residence. Biological control is less effective in dealing with a native pest, for we have no where to go in search of its natural enemies. Unfortunately, a high proportion of the more important shade tree pests in the United States are native insects; therefore the outlook for biological control of these is rather dim. Yet even these native pests have a complex of native natural enemies, although they are not always effective in reducing infestations to acceptable levels. In such cases there are steps which can be taken to improve or augment this naturally-occurring biological control. For example, providing food sources such as nectar-producing plants can result in improved effectiveness of many parasitic wasps. Avoiding the use of broad-spectrum insecticides, especially during critical periods of parasite or predator activity, is another means of achieving the maximum benefit from naturally-occurring agents of biolgocial control.

Pathogens are disease-causing agents which can be manipulated by man to bring about biological control of pest insects. Our greatest experience has been with the bacteria. For many years, *Bacillus popilliae* has been commercially available for use in the soil for control of the larval stage of the Japanese beetle, *Popillia japonica*. *Bacillus thuringiensis* is widely available and effective against a variety of caterpillar pests of ornamental, fruit, vegetable, and field crops. At present much research attention is focusing on insect viruses as pathogens of pests. Like conventional chemical insecticides, pathogens must be thoroughly evaluated for safety to mammalian systems, and for environmental impact, before they can be made commercially available by industry.

Other Means of Biological Control. Beyond parasites, predators, and pathogens, other pest control agents or techniques exist which could properly be considered to fall under the definition of biological control, in that they effect biological systems in a way deleterious to pest insects:

Pest-resistant plants — These are plants with genetically-inherited traits which cause them to be unattractive to insects as a place to deposit their eggs, which are toxic to insects which feed on them, or which are able to support pest infestations without resultant intolerable damage. As examples, the European grape, *Vitis vinifera*, is highly susceptible to the root-infesting form of the grape phylloxera, *Phylloxera vitifoliae*, while the American grape, *Vitis labrusca*, is resistant to it. *Juniperus sabina* 'Tamariscifolia' is heavily attacked and severely damaged by the juniper twig girdler, *Periploca nigra*, but many of the heavier-wooded prostrate junipers are tolerant to this pest.

Entomologists and plant breeders have worked alone and in collaboration with one another for years in an attempt to enlarge the number of pest resistant plant cultivars available to agriculture and forestry. Their record of success is not impressive, however, because of the long-term research commitment necessary and the fact that insecticides have been so readily available to handle almost any plant protection need. Yet with new restrictions and regulations on insecticide use, entomologists are giving increased research attention to the development of pest resistant plants.

Guidelines for the development of insect resistant ornamental plants depart from those recognized in agriculture and forestry. Whereas a breeding effort is needed to develop resistant corn, tomato, or tree fruit cultivars, a program of evaluation and selection of pest resistant ornamental shrub and shade tree species could serve many of our needs very well on a regional basis. In coastal California, for example, *Acacia verticillata*, *A baileyana*, and *A. podalyraefolia* are practically immune to the albizzia psyllid, *Psylla uncatoides*, where the species, *A. retinodes*, *longifolia*, and *melanoxylon* are very severely attacked by this pest. In Contra Costa and Alameda counties, California, the kuno scale, *Lecanium kunoensis*, devastates pyracantha. The use of that plant should be avoided there, and less pest-prone shrubs grown instead. *Cedrus deodora* or *C. atlantica* are much more pest-free than the overplanted and pest-prone Monterey pine, *Pinus radiata*, and *Ginkgo biloba* is almost free of pest problems wherever it is grown. When dealing with ornamental shrubs and trees, we can often make good use of alternate species of plants, so long as they have the appropriate characteristics of color, height, form, and texture for a given situation. Of course in the selection of ornamentals their susceptibility to plant diseases and other disorders must be given consideration as well.

Insect growth regulators — A new family of chemicals is being synthesized which mimic hormones and other substances naturally produced by insects which are essential to the insect's normal growth and development. When applied to insects at a critical stage of their development, these compounds de-rail normal growth processes and the insect dies, is malformed and therefore unable to reproduce, or is rendered sterile. One of these, Altosid®, is available for control of floodwater mosquitoes. When immature mosquitoes are contacted by Altosid, they are unable to transform to the adult stage, and die. Another compound, Dimilin®, disrupts the normal formation of chitin, an essential component of the skeletal covering of insects. The considerable research efforts on insect growth regulators by university and industrial scientists almost certainly will turn up a variety of unique compounds for use in pest control in the years ahead.

Behavior modifying chemicals — The world to an insect is a chemical one, for virtually every aspect of its behavior is controlled by responses to chemicals. This includes orientation to food sources, the selection of a place to deposit eggs, the location of a mate, and its defense against natural enemies. Some of the chemicals so necessary for the wellbeing and survival of insects have now been identified and synthesized and are in an active state of investigation as means of controlling pest insects.

Pheromones are external hormones produced by most insects and which are essential for such activities as finding a mate, aggregation, and maintaining the integrity of social structures of bees and ants. Sex pheromones released by certain female moths have the ability to attract males of the same species from a distance of several miles. By releasing synthesized sex pheromones, we now have the means to detect very low levels of certain insects invading a new area by luring them into sticky traps. Using similar traps, we can more properly time the application of chemical insecticides because of the improved knowledge of when the target insects are active. Attempts are also underway to achieve direct control of insect populations by trap-out strategies, utilizing pheromones, or by disrupting successful mating of males and females through saturation of the insect's environment with a sex pheromone. The potential for manipulating insect populations by behavior-modifying chemicals appears very bright.

Other techniques — The use of crop rotation or other cultural methods, the release of sterilized male insects into the environment, and the use of genetically-altered insects can all be considered biological control procedures but in the interest of brevity their attributes will not be described.

Integrated Pest Management. With this broad array of biological control tools, one might ask why it is every necessary to employ conventional insecticides for pest control. The reasons are that biological control techniques are quite specific as to target insects, some are only regionally applicable, and the number of pests with which we must deal in agriculture and forestry is very large. Also, some of these techniques have only been uncovered in the past few years and it will require some time before their full potential can be discovered and exploited. Finally, the economic pest situation is continually changing — new problems are continually arising but the old ones seldom just go away. In all likelihood the use of conventional chemical insecticides will remain an important component of pest control for many years to come.

Trends in pest control now are in the direction of integrated pest management. Because a single line of attack is often unsuccessful in the long term, methods of integrating two or more compatible techniques show promise for improvement in plant protection over the long term. Integrated pest management programs which have been developed thus far rely heavily on a biological control component, but chemical insecticides are used when necessary, and in a way least likely to disrupt the gains which have been made by biological control.

AERATED STEAM TREATMENT OF NURSERY SOILS

KENNETH F. BAKER

Department of Plant Pathology
University of California, Berkeley 94720

Growers have become increasingly interested in soil treatment and in pathogen-free stock as they have realized that the ultimate sources of disease organisms are the soil (including water and nonliving organic matter) and living plants. Soil treatment may be accomplished by chemical fumigation or by steam. Destruction of microorganisms has been the objective of such treatments since they started in 1880-90, and recommendations have emphasized overkill rather than minimal effective dosage. There is now a marked trend toward minimal treatments and toward fumigants selectively toxic to pathogens so as to avoid creating a biological vacuum dangerously subject to reinvasion by pathogens, and so as to decrease formation of toxins injurious to plants.

Commercial soil steaming to control diseases and insects was begun in 1893. but the methods remained empirical for 60 years, with little scientific study or grower inventiveness. Critical investigations were published in England, Norway, and California in 1954-60. The studies on aerated steam at the first two places were made by engineers in an effort to reduce fuel consumption. Our California studies were aimed at avoiding the creation of a biological vacuum and production of phytotoxins. It has been known for 35 years that moist heat of 140°F for 30 minutes will destroy plant pathogens (except tobacco mosaic virus); treatment at higher temperatures therefore wastes energy and is biologically undesirable. Plant pathogens are more sensitive to heat than are many saprophytic microorganisms. Treatment at a temperature just sufficient to kill pathogens will leave