TOWARD 2000

IDEAS OF THE FUTURE AT WORK TODAY

THE STORY BEHIND BIO-CONTROLS

Today's biotechnology boom means landscapers will enjoy a wealth of bio-control agents in the near future.

by John D. Briggs, Ohio State University

Before today's wide interest in biological controls, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA) encouraged manufacturers to develop "growth regulating chemicals" to attack vital growth activities of insects and mites. In so doing, the EPA wanted to spur development of chemicals that destroy insects yet have no effect on humans, plants or animals.

Growth regulating chemicals work two ways. Either they prevent insects from becoming adults or they interfere with the completion of the insect's skeleton.

Dr. Briggs is professor of entomology at Ohio State University, Columbus. His current research includes participation in a biotechnology team researching new formulations of bacteria in bio-control agents.

Fortunately for landscape professionals, today there is active competition in the pesticide industry for formulations of custom-designed bio-controls. The products will be useful for agriculturists and landscapers. The competition leading to the rapidly advancing technology originated with the products that are still marketed by two imaginative industrial giants who have continued the development of insecticidal toxins produced by *Bacillus thuringiensis* (BT). These are Sandoz Corporation, marketing Thuricide, registered in 1958; and Abbott Laboratories, the producer and market share leader with Dipel. Both corporations are major players among others in developing formulations of genetically engineered bio-controls.

The industry is demanding an increase in the persistence and the stability of bio-controls. In addition, genetic engineering is undergoing a biotechnology boom as researchers seek to incorporate into plants the production of insecticidal toxins by bacteria.

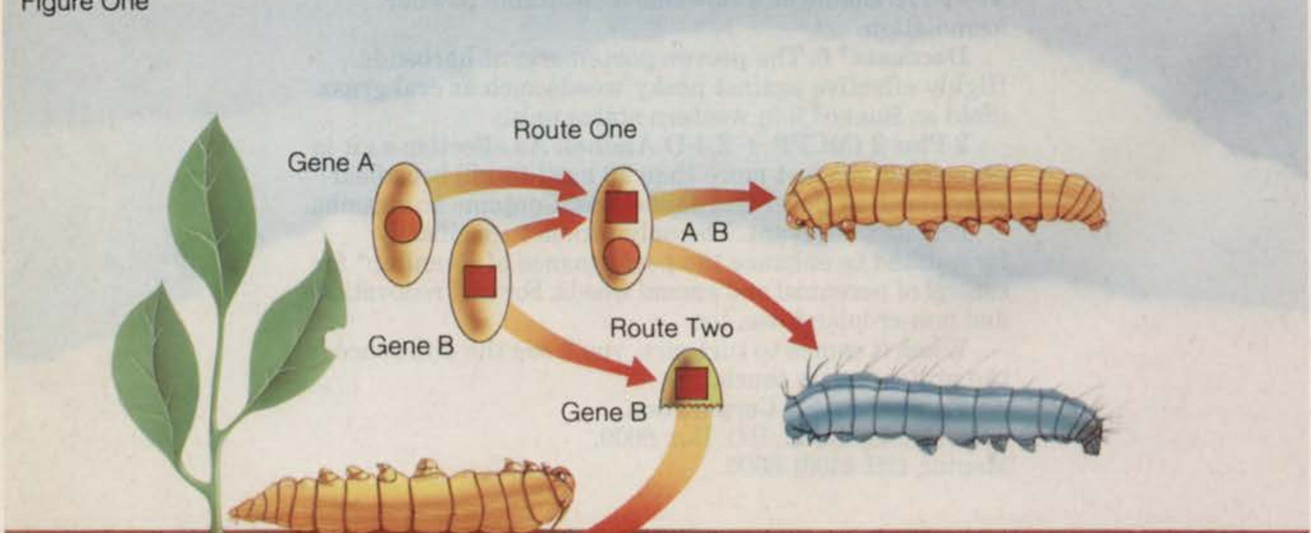
Research goals

By adding insecticidal toxins from bacteria to all the other materials that plants produce, researchers may be able to create new plant varieties with built-in bio-controls.

Another objective is to develop a formulation of bacteria which inhabit plant roots, stems or leaves. The idea is to alter plant bacteria so that they have insecticidal qualities.

This procedure is like one used to change the bacteria on strawberry plants. The new bacteria lowers the freezing point of water, thereby re-

Figure One



The genes A and B each form a separate bacteria that can be moved into a single bacteria, which now produces 2 toxins for 2 different kinds of insects (Route One). Gene B can be moved into plant seeds and the resulting transgenic plants produce the insecticidal toxin (Route Two).

ducing frost damage to the strawberry plant.

The genes factor

Genes are elements in the cells which are the building blocks for bodies of all organisms, including plants, animals, bacteria, fungi and nematodes. Genes carry the inherited blueprint for the characteristic shape, size and behavior of the organism. In humans, for example, genes determine physique and abilities to learn and behave.

Genes are complex chemicals that influence cells to do specific jobs. Many different genes are needed to interact in each cell to produce a whole human, animal or plant.

Manufacturers of bio-controls are moving quickly and successfully to add, remove or change certain genes in animals, plants and bacteria. For example, genes can be chemically and physically extracted from a bacteria. An attempt is then made to put them into another living organism, first in both laboratory and greenhouse experiments then in the field.

Scientists do not shift genes around in humans to change or build a better person—yet. But it is becoming big business to engineer custom-made, safe, useful bio-controls, many of which will be used in certain landscape activities.

Combining genes

Some bacteria can exchange genes with each other through their cell walls when the same kind of bacteria are mixed closely together in soil. This means that different kinds of genes responsible for different kinds of insecticidal toxins can be exchanged or combined.

For example, strains of *Bacillus thuringiensis* (BT) found in different insects around the world can have any one of 20 different types of genes. These genes influence the production of many different insecticidal toxins, some with more or less insecticidal activity than others. By either having scientists move the genes from one strain of BT to another, or allowing the natural exchange of genes between strains of bacteria, different combinations of genes can be developed into a single new strain of bacteria (Fig. 1, route 1).

Chemical alteration

In addition to moving whole genes, the genes themselves can be changed by specific chemical actions. Changing genes provides the opportunity to change toxins regulated by genes. Therefore, regular variations of toxins can help avoid the threat of insects and mites becoming resistant to bio-controls.

Moving genes from one kind of organism to another within the same type of organism (like within bacteria), or moving genes between different organisms (like from bacteria to plants) provides the opportunity for a new patent on the genetically-engineered organism. Examples of this would be a patented beneficial insect resistant to a pesticide for release with an insecticide treatment, or a herbicide-tolerant plant to survive herbicidal treatments in a landscape.

Cotton a forerunner

In 1988 and 1989, cotton plants were field-tested to demonstrate the successful incorporation of a bio-control built into plants. These plants contained genes from bacteria that regulate the production of insecticidal toxins.

These grubs were exposed to milky spore disease, a widely used bio-control in the green industry today. The grub to the left displays early growth, while the one on the right shows advanced disease.

Incorporating bio-control genes from BT into bacteria that normally inhabit plant roots, stems and leaves has also been successful for controlling root-feeding caterpillars. This suggests that we can expect turfgrass varieties to be developed with built-in, custom-made bio-controls for insects that attack roots, as well as those that attack the crown and stems of grass.

Herbicide resistance can also be combined with insect bio-controls in plants.

Hard at work

Industry giants are continuing their genetic engineering programs to increase the tolerance of plants to herbicides. Monsanto Corporation works with the herbicide Roundup. Ecogen Corporation continues its development of Condor, a bio-control using BT for gypsy moth. The caterpillars of gypsy moth are targeted specifically while other collectible Lepidoptera escape injury.

Ecogen, using natural exchange of genes between bacteria, claims to have increased the insecticidal activity of Condor for gypsy moth by 7½ times. This is rearranging and concentrating the activity of a bio-control.

In a second product, Foil, the company claims to have combined the genes for production of two different toxins—one for the Colorado potato beetle and another for the European corn borer—into a single strain of bacteria. This is broadening the bio-control's range of activity.

Transgenic plants

When genes are incorporated into plants so that the plants produce an insecticidal toxin originally produced by the bacteria, the plants are called transgenic plants (Fig. 1, route 2). (Of course, a company that creates such a plant can patent it.) With transgenic plants, the genes from the bacteria are incorporated into the plant's permanent chromosomes.

Most transgenic work has begun on plants which are most easily genetically engineered: petunias, tobacco and tomatoes. Now progress is being made with plants less receptive to new genes: corn, rice and other grasses, cotton and soybeans.

There is another unique way to add the ability of a plant to produce an insecticidal toxin similar to that produced by bacteria. Genes from the bacteria are incorporated into micro-organisms that are always present in the plant's fluid transportation or vascular system. These bacteria are called endophytic bacteria. The plants that result from the gene transfer have a circulating insecticidal activity that can be described as a "systemic pesticide."

What is safe?

If we can make micro-organisms yield genes to other bacteria or plants, can the resulting bacteria or plants be safe for the landscape or for humans? Yes.

The toxins from bacteria, particularly BT, have been used for 30 years. The genes in BT which are responsible for the toxins, have been around a long time. So the use of the BT genes in another bacteria or a plant should not make any difference.

There are federal regulations for the release of genetically-engineered organisms. North Carolina has recently developed a comprehensive set of regulations that could serve as a model for other states wanting to regulate the production and use of genetically-engineered organisms. **LM**