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Soil Microbes and Biotechnology

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There is nothing new about attempts to develop and market microbial products for crop or soil improvement. Several types of microbes have been sold for a variety of agronomic purposes for many years. With the important exception of rhizobial inoculants, these have been generally unsuccessful. Recently however, the scientific revolution in genetics and molecular biology, the need for low cost agronomic inputs, and widespread concern for environmental safety have tremendously stimulated research and commercial activity on microbial products. Claims that cheap, effective microbial inoculants can be developed for pest control, detoxifying pollutants, providing plant nutrients and improving soils have been well publicized.

Genetically Engineered Microbes (GEMS)

Many, but not all, of these potential products involve GEMS. Modification of the genetic composition of bacteria now has become a routine laboratory procedure. Genetic manipulation to produce desired changes in function or growth is generally easier for bacteria than for crop plants. Therefore, the products of GEMS may have a large impact sooner than genetically engineered plant products. Yet, the most immediate applications are likely to be in medicine. For example, valuable drugs can be produced by GEMS carrying mammalian genes.

The question of whether GEMS should be released in nature, which would be required for agronomic applications, is currently the subject of widespread and heated debate. Certain activists have raised the possibility of "genes running amuck" and becoming pests or somehow upsetting the balance of nature. Most knowledgeable individuals believe this scenario is improbable. Some feel that the opposite result is more likely, that lab-created GEMS will survive and function poorly in a competitive environment like soil. Yet field testing of GEMS is being carefully regulated. The first field test, of a GEM designed to reduce frost damage on crops, has been approved and is being conducted in California.

Plant Growth Promoting Rhizobacteria (PGPR)

One example of a potential agronomic application of microbial biotechnology is provided by plant growth promoting rhizobacteria (PGPR). As the name implies, these

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bacteria can grow extensively in the rhizosphere (the root zone), and increase plant growth. It is believed that they do this by producing a chemical called a siderophore, which interferes with the nutrition and growth of harmful microbes. Some testing has provided reasons for optimism; yields of wheat and other crops have been significantly increased by seed treatment with a PGPR. Much work remains to be done before it will be possible to evaluate these organisms as a practical, profitable inoculant.

Other Potential Applications

There is interest in genetically modifying rhizobia to create strains which are more effective N_2- fixers with legumes. One company has applied for permission to conduct a field test of engineered rhizobia in Wisconsin this year.

Mycorrhizal fungi, which occur widely in nature and promote phosphorus uptake by many crop plants, also have potential value as an inoculant. One current limitation in this area is the difficulty of producing large enough amounts of the organism to use as an inoculant on a field scale.

Many investigators are attempting to create microbial insecticides, fungicides and nematicides. One approach is to transfer the gene for a pest toxin from its natural source to common bacterial inhabitants of the root or leaf surface. The advantage of this would be that the microbe does the work of chemical synthesis. Also, the toxin could be confined, that is, formed only at the root surface rather than applied throughout a large volume of soil. Bacillus thuringensis (Bt) is one naturally occurring microbial insecticide which has been found to have some applications.

Improved silage inoculants, or perhaps other microbes which help convert harvested material to more useful forms, are other possible areas for development.

Current Status

Recent advances in molecular biology and in knowledge of how microbes function in nature have suggested that microbes might be used to do some of the agronomic jobs currently done with chemicals. Much more development and testing will be required before this microbial technology is in the hands of producers. At present, conventional rhizobial inoculants and silage inoculants remain the only microbial products with widespread benefits in crop production.