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Biopesticides and the Environment

The United States today produces an abundant amount of food with high cosmetic standards, and uses nearly one billion pounds of pesticides to achieve these standards. Americans eat a great deal of food; in fact, the average American consumes 1,500 pounds of food per person per year. There is a constant battle to protect the food supply from various organisms that attempt to share it, such as insects, weeds, diseases, or rodents.

INCREASED PESTICIDE USE

The United States uses an enormous amount of pesticides, nearly one billion pounds are applied annually for pest control. Despite the use of pesticides and all other controls, 35 percent of all potential world food production is lost to pests, primarily insects, diseases, and weeds. After the 65 percent that is left is harvested, another group of organisms, insects, microbes, rodents, and birds take an additional 20 percent. Despite the use of pesticides and other controls, nearly one half of all the potential food production is lost worldwide.

In the U.S., since 1945, there has been a 33-fold increase in the use of pesticides, yet pre-harvest crop losses to pests have actually increased from nearly 20 percent in 1945 to 37 percent today. Data from the U.S. Department of Agriculture (USDA) indicates that from 1945 to 1988, there has been approximately a tenfold increase in the use of insecticides in agriculture. Despite this tenfold increase, crop losses due to insects has nearly doubled, from seven percent to 13 percent.

The reason for this relates to the changes in biotechnology in agriculture, the way crops are cultured and managed.

In 1945, nearly 100 percent of the corn was grown after soybeans, after wheat, or after oats, and again, according to USDA, the average crop losses in corn in 1945 was 3.5 percent. There has been a 1000-fold increase in the use of insecticides in corn since 1945. In fact, corn is the largest user of insecticides in agriculture today, having finally edged out cotton. Despite that fact, crop losses to insects in corn have increased from 3.5 percent to 12 percent, nearly a fourfold increase in crop losses, with more than a 1000-fold increase in the use of insecticides. The reason is that crop rotations have been replaced with continuous corn crops, thus intensifying insect problems. Continuous corn crops also increase weed problems and disease problems; thus more fungicides and herbicides have to be used.

The biotechnological changes that have been made in agriculture have encouraged pest problems. More insecticides have been used in an effort to stay even, but despite the increased use, farmers have not been able to sustain control.

ENVIRONMENTAL AND PUBLIC HEALTH IMPACT OF PESTICIDES

The estimated environmental and public health costs of using pesticides in the United States are minimally one billion dollars annually. This cost includes human deaths and hospitalization, elimination of natural enemies of pests, and the destruction of crops by pesticide drift. According to USDA and the Environmental Protection Agency (EPA), the U.S. is currently spending $1.2 billion annually just for monitoring pesticides in well water and groundwater. More realistically, the environmental and public health costs of using pesticides in the United States are costing the nation somewhere between $2.2 and probably closer to four billion dollars annually.

Some nations have become very concerned about their environmental and public health problems. Two years ago, Sweden passed legislation to reduce pesticide use by 50 percent during the next five years. Denmark and Holland passed similar legislation and they are making excellent progress. Clearly, there is public and political concern about the environmental problems associated with pesticides.

BIOLOGICAL CONTROLS

Biopesticides are biological materials used for pest control, but they have no relationship to pesticides, other than the fact that they can be cultured and applied. Viruses, bacteria, protozoans, fungi, and nematodes can be used for the biological control of pests. A few of these controls can be released permanently, as in the case of milky disease, which is used to control the Japanese beetle.

Certainly, in the use of natural enemies, biopesticides play a very important role in agriculture and in protecting crops. Part of the problem with using insecticides or other pesticides in crop production is that these controls kill the natural enemies of pests along with the pests themselves. This problem seldom occurs with biopesticides.

The United States and the rest of the world have actually made poor use of biological controls. Of the 60,000 species of pests in the world, only about 0.2 percent are a "classical" type of biological control where a biocontrol agent is introduced and does not require further manipulation. Pesticides normally pay a four dollar return per dollar invested; however, the economics of biological controls are much better, ranging from $30-$ 100 return per dollar invested. These costs include research costs.

VIRUSES AND OTHER BIOLOGICAL CONTROLS

Over 800 viruses that infect insects have already been identified, and there are probably three to five times more that occur in nature worldwide. All of these viruses could be utilized, some may require genetic engineering because they are not as virulent enough for biocontrol.

One virus is very effective against the cabbage looper. A healthy cabbage looper is green in color, while a virus infected looper has a whitish or yellowish appearance. Twenty-four hours after showing the whitish or yellowish color, the cabbage looper is dead.

The virus that attacks the cabbage looper is so pathogenic that genetic engineering is not necessary. If two infected caterpillars are put into 100 gallons of water, stirred, and applied to an acre of land, the virus from just two caterpillars will kill 98 percent of all the cabbage loopers on that acre of cabbage crop. People have been trying unsuccessfully for 20 years to get this virus approved for use on crops, such as cabbage or lettuce, but EPA and the Food and Drug Administration (FDA), have refused to approve the use of this virus on food, despite the fact that everyone has eaten this virus. The EPA and FDA are very concerned about culturing this virus and adding more of it to food. Hopefully, EPA and FDA will approve this virus for use sometime in the near future, because it really is a safe and effective control.

Biopesticides have been approved for use on non-food crops like cotton and trees. For example, biopesticides have been developed and approved for use against the gypsy moth, the Douglas-fir moth, the sawfly, and against the cotton bollworm.

The "new association" technique of selecting biological control agents has been developed and is three times more effective in achieving successful biological control than before. It not only improves the success of introductions for biocontrol, but it has also opened up the opportunity to use biological control for native pests. Since 30 to 60 percent of the U.S.'s major pests are actually native pests, this technology has opened up a whole new area of attack on native pests that were not susceptible to old, classical biocontrol.

A great many organisms can be made use of for biological control. The two successes in bacteria are Bacillus thuringiensis (Bt) and Bacillus poppillat, and both have worked very effectively in biocontrol. There are already at least 500 known species of bacteria that affect insects and many more undiscovered species worldwide. Fungi and protozoans are a little more difficult to handle and manipulate for biological control, but there are still possibilities. There are probably 2,000 to 3,000 species that infect insects and have the potential to control insects. There is a rich variety of microbial species available for use in biotechnology and biological control.

RISKS OF BIOPESTICIDES

Although at least one particular strain of Bt works effectively against caterpillars, not all caterpillars are bad. There are, in fact, caterpillars that belong to various species of butterflies and moths that are on the endangered species list. If Bt were applied near or on these endangered species, it would kill them. Also some strains of Bt have been found to be detrimental to beneficial earthworms.

When biopesticides are applied, the host or the pest population can be significantly reduced. This application may affect some beneficial insect parasites and predators of pests. When biocontrol parasites and predators are eliminated, it takes a while for them to come back, and this begins the cycle of having to reapply biopesticides to maintain control.

Of course, there is always the potential for gene transfer or the moving of genes from one microorganism to another. This is not a great hazard, but it certainly is a potential environmental risk. Mutations could also occur. If Bt mutated, it might switch from attacking caterpillars to attacking beneficial beetles. A great many beetles are beneficial as predators in controlling pests in agriculture.

There are 400,000 species of plants and animals in the United States, and 99 percent of these are beneficial and essential to agricultural production. The honeybee and wild bee, for example, are important in pollinating $30 billion worth of crops in the United States. Insects and microbes are important in degrading livestock wastes. These "small" organisms play a vital role in keeping agriculture productive.

RISKS OF TESTING AND RELEASING BIOPESTICIDES

Generally, genetic engineering of microbes, such as viruses, bacteria, nematodes, fungi, protozoa for insect control and other pest control, have proven safe. There appear to be minimal environmental problems associated with the release of these organisms based on working experience with these organisms in agriculture and forestry. Although an organism has desirable characteristics, once it is released the environmental effects cannot be predicted with 100 percent accuracy. The genetic engineers were incorrect when they made the statement that there have been no environmental problems associated with the introduction of crop plants into the United States. When examining the literature on all the crop plants that have been introduced in the United States, we found that a total of 128 species of crops have become serious weed pests. Some have become major weed pests, like Johnson grass and pigweed.

During testing of genetically engineered organisms, how will scientists control the test organism if the organism is released and it becomes a pest? The literature reveals that rarely have pest species been exterminated once released in the environment. Out of 10,000 species of pests in the United States, only two have been successfully exterminated and with an enormous cost. These pests were the Mediterranean fruitfly and the citrus canker pathogen.

Thus, there is concern about the release of a genetically engineered organism. Once a genetically engineered organism is released in nature, it is different than a pesticide, because pesticides do not reproduce. Based on past experiences, once genetically engineered organisms are released in the environment, the odds of ever controlling them is practically nil. This does not mean that genetic engineering and biotechnology have nothing to offer, they offer many opportunities for reducing pesticide use in sustainable agriculture.

Today genetic engineers are saying, "We know what we are doing, leave us alone. We've released this organism and it had no problems". We should remind society of nuclear engineers in the 1950s, who were giving us the same assurances when environmentalists and others were raising questions about the safety of nuclear energy. There were no problems after the first 12 nuclear plants were built and no problems after the next 70 were built, but then suddenly several problems occurred.

The odds of hazardous events happening in the release of genetically engineered organisms in the environment are small, but problems can happen. It would only take one disastrous event for genetic engineering and biotechnology to lose credibility with the public. It is hoped that we will be cautious and enact suitable regulations to protect the environment and genetic engineering technology.