Biological Seed Protectants

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As organic farmers seek alternatives to chemical seed treatments, there is an increasing interest in biological seed protection materials. Even commercial farmers, seeking alternatives to highly toxic soil fumigants such as methyl bromide, are becoming increasingly interested in biocontrol products.

While a healthy soil, unaltered by agricultural chemicals and salt-based fertilizers, will contain a complex mixture of microbes that is effective in limiting pathogen populations, this is often not the situation under most typical agricultural conditions. When normal microbial populations are disrupted by various means, pathogen populations can increase rampantly, competing vigorously for food resources and attacking weakened plant roots. Stressful environmental conditions, such as cool wet soils during germination, can favor the growth of certain fungi that can rapidly rot a fragile and slowly growing young seedling. Heavy use of fungicides and other agricultural chemicals kill many fungal species, altering the delicate balance of microbial species that hold each other in check. Sterilized soil, such as used in greenhouse production, may indeed provide a golden opportunity with little competition for certain types of pathogenic fungi. Under such conditions, it may be necessary to include biocontrol materials to provide adequate protection to crop plants.

Certain types of fungi and bacteria are proving quite effective in protecting both germinating seeds and plant roots against pathogen attack. There are a number of biocontrol products on the market, some with the ability to control common seed rots such as Pythium and Rhizoctonia and others able to protect mature roots against Fusarium, Armillaria and other pathogens. Many of these products may also provide growth stimulation to plants, possibly due to increased nutrient availability or through the production of various biostimulant materials. As additional bioprotectants are developed and available commercially, studies are showing that some are equal or even better than commonly used chemical treatments, and may provide additional plant growth stimulation benefits.

For a bioprotectant to be considered effective and valuable, it must exhibit high viability and vigor not only under a wide range of typical field conditions, but also in the manufacturing, storage and distribution process. The biological material must be adaptable to a mass production process, and once it is applied to seeds and the seeds are planted, it must begin growing rapidly and effectively protect the seed as it germinates. The cost of producing such a product must also be relatively low, so as to effectively compete against chemical seed protectants. These complex and rigorous requirements greatly limit the types of organisms which could be adapted for biological control products.

Delivering the biocontrol material to where it is needed, and then having it grow more rapidly than pathogens presents different challenges. While pelleting seeds with bioprotectant materials may provide the best means of delivery and for controlling the environment around the germinating seed to favor the beneficial microbe, this may be too expensive or impractical for many types of crops. Dry powders applied to seeds shortly before planting are usually favored by most farmers, but this may not result in uniform inoculation. Soil application of granules can

be effective under certain circumstances, especially in greenhouse situations. Treating seeds with both the biocontrol material and a low toxicity chemical seed treatment may give the beneficial microbe a better chance to become established before significant competition begins. Using the biocontrol product in a liquid drench in greenhouse or small scale operations can be quite effective and would also allow repeating the treatment a number of times while seedlings are at their most vulnerable.

A number of different fungi and bacteria are currently being tested and commercially marketed as biocontrol products. These include the fungal species Trichoderma, Glomus, Gliocladium and Talaromyces. Bacteria species showing biocontrol potential include Bacillus subtilis and Pseudomonas sp. Even the notorious pathogenic bacteria, Fusarium, is showing some promise as a biocontrol agent. Not all Fusarium species are indeed pathogenic, many are harmless soil saprophytes, feeding on dead organic material. Studies have shown that when some these innocuous types of Fusarium are applied to tomatoes growing in a greenhouse, the plants exhibit remarkable resistance to disease causing strains of Fusarium. Tests with other vegetables show similar results.

One common soil fungus, Trichoderma, shows particular promise as a seed treatment. Trichoderma occurs naturally in most soils, inhabiting the root zone of many different species of plants. Though not technically a mycorrhizal fungi because it doesn't directly infect a host plant root cells, Trichoderma does grow in close association with the root surface. Exactly how Trichoderma protects seeds and roots is not fully understood. One approach definitely is to form a physical barrier on the root surface which is difficult for pathogenic soil fungi to grow through. Trichoderma also produces antibiotics and other chemicals that are toxic or inhibitory to certain types of pathogenic fungi. Trichoderma can actually attack and destroy other fungi by coiling its hyphal strands around the pathogen, releasing digestive enzymes that breaks down the cells of the other fungus. Trichoderma also appears to have the ability to promote more vigorous growth in plants, possibly because of certain plant growth stimulant chemicals produced by the fungus. For these reasons, multiple studies have indicated that plants well colonized by Trichoderma have higher yields and good resistance of disease.

Different strains of Trichoderma vary in vigor, in their ability to withstand extremes of soil conditions and agricultural chemicals, and in their ability to colonize the entire root surface of many different types of plants. In fact, the limiting factor in commercially using most naturally occurring strains of Trichoderma is that they are not fully rhizosphere competent, that is, they may colonize different parts of a plant root but not the entire root surface or root colonization may be transient during the growing season. While this can still be beneficial in regions where colonization is complete, it would leave other root sections open to attack.

Many strains of Trichoderma have been tested as potential biocontrol agents. Some have been isolated directly from the soil, while others have been enhanced and selected through a variety of laboratory techniques. One company, BioWorks, Inc., has developed and manufactures a superior strain of Trichoderma harzianum. In this case, two wild strains were isolated, one in upstate New York and one in the southwest US. These parental strains were selected for their ability to colonize plant roots under a wide range of environmental conditions.

When Dr. Gary Harman, Dr. Chris Hayes, and others in their lab at the New York Agricultural Experiment Station in Geneva, NY grew the two strains together under carefully controlled laboratory conditions, the strains mated and a hybrid was formed. This patented hybrid, termed T-22, exceeds either parental strain in rhizosphere competence and vigor under various field and greenhouse conditions. This strain has been developed into a drench and a granular for greenhouse production (RootShield) and a dry seed inoculant for field application (T-22 Planter Box). While this strain is particularly effective against soil borne Pythium, Rhizoctonia and Fusarium root rots, recent studies have shown that foliarly applied RootShield can control botrytis and powdery mildew in greenhouse crops.

Though protection against pathogens may be the primary reason growers choose to use a material like T-22 or RootShield, there is mounting evidence that T-22 actually helps to solubilize rock phosphate and other minerals, releasing nutrients in a form that plants can use. Nitrogen in the soil appears to be taken up more efficiently by a plant root well colonized by T-22, leading to a healthier and more vigorous plant. These effects may account for the yield increase that has been typically noted from the use of T-22 on numerous plant species. Studied extensively in replicated experimental trials at Cornell University and at other locations around the world, T-22 has been shown effective on many field and greenhouse crops. Sweet corn grown under deliberate environmental stress showed increased vigor and yield when the seed was first treated with T-22. Increased root mass in sweet corn treated with T-22 has also been noted. Growers of many horticultural greenhouse crops, particularly poinsettia which is especially susceptible to root rots, have seen significantly improved plant survival and vigor when RootShield is used. Commercial acceptance of T-22 has rapidly increased as growers see that it is a far safer yet still highly effective substitute for pesticide treatments.

T-22, in both the Planter Box and the RootShield formulations, is a federally registered biological fungicide that has been granted an Exemption from Tolerance by the US Environmental Protection Agency. Additionally this materials have a zero Restricted Entry Interval. Recently this material has been listed by the Organic Materials Research Institute (OMRI), clearing the way for its approval by most organic certifiers in the United States. It is available through dealers around the world.

For more information, contact BioWorks, Inc at 800-877-9443 or at <www.bioworksbiocontrol.com>