Biological Control: Past, Present and Future

by Donald Lester

The Australian Hydroponics and Greenhouse Growers Association Conference was held July 19-22 at Sydney Olympic Park. Over 300 growers, industry personnel and government representatives were in attendance, with about 40 vendor booths. Some 20 guest speakers were invited to give presentations about biological control, fertilizer and nutrient management, new and emerging plant diseases of commercial concern and other topics.

Donald Lester is the product manager for JH Biotech, Inc. of Ventura, California, a manufacturer of plant nutrients and biological products. He spoke about the perception of biological control and the development of commercial biological control products in the past and present. He also discussed the social factors and market trends that indicate biological control products will be with us, and be more prominent, in the future. Donald fielded several questions afterwards, mostly in the area of biopesticide regulation differences between the U.S. regulatory system and the Australian government system. The following article is a synopsis of his presentation.

Donald Lester speaking at the AHGA Conference.

The earliest known written record of using one organism to control the population of another was the use of cats for the control of rodents in food stores in ancient Egypt around 3,000 BC. The Egyptians were so impressed with cats that they deemed them gods. Biological Control is a term that was coined by University of California professor Harry Smith in 1919. Currently, in terms of agriculture, the USDA defines biological control as "The involvement of the use of beneficial micro-organisms, such as specialised fungi and bacteria, to attack and control plant pathogens and the diseases they cause." Beneficial micro-organisms that fit this definition are also known as biological control agents (BCAs).

There are over 300 commercially available BCAs on the market today for controlling insects, nematodes, fungi, bacteria, weeds and other pests. The most successful commercial BCA is Bacillus thuringiensis used for insect control. Annual sales of Bacillus thuringiensis worldwide averaged $100 million in the year 2000.

During the past few decades BCAs have been developed for use on soil pathogens. This presentation will discuss four BCAs that have been used in greenhouse and soilless hydroponic systems to control soil pathogens: Bacillus subtilis, Trichoderma sp., Pseudomonas sp. and Mycorrhizal fungi. This presentation will briefly cover how biological control was perceived in the past, how trends in today's world influence how BCAs are viewed and the factors and trends in the marketplace that are driving the increased use of BC's into the future.

Past

In the past few decades biological control has been viewed as the Egyptians viewed it – one organism to keep the population of another organism in check. And like the Egyptians with the cats, BCAs in the last few decades were expected to be self-sustaining with no maintenance required. This natural phenomenon of pest population regulation gave rise to the ecological basis of integrated pest management (IPM) strategies. Biological control was viewed as a self-sustaining component in an IPM program.

There are four mechanisms that biological control agents use to control pests and pathogens: direct competition, antibiosis or antagonism of pest populations, parasitism and inducement of the plant immune system. In the past, competition with detrimental micro-organisms was the main mode of action.

Biological control fell out of favour because of problems with unrealistic expectations. One problem with BCAs was poor formulation. Not too many years ago BCAs often had to be shipped in refrigerated coolers or on dry ice which lent to a very short shelf life. This made usage difficult and the results unpredictable.

Besides high expectations, low efficacy, relatively low cost and widespread availability of conventional chemicals and insufficient knowledge of the biology of BCAs and pathogens all led to a decline in the use of BCAs.

Present

Today much more is known about BCAs. Biological control is considered a mature science. Research has generated a wealth of information on how BCAs impact plant disease. In the past 20 years there have been some 5,000 articles published in refereed journals, and over 50,000 popular articles covering the subject. Advances in computing, molecular biology, analytical chemistry and statistics have led to new research aimed at understanding the pathogens, host plants and biological control organisms on many levels.

Advances in formulation now make it possible for manufacturers to offer BCAs in easy-to-use liquid and granular formulations with shelf lives of up to two years in some cases.

There is also an increased reluctance to use conventional chemicals. In fact, it is said that chemistry sets today do not even come with chemicals anymore due to legal liability. Add to this the fact that modern chemistry equipment can detect chemicals at far lower concentrations than machines just 20 years ago. Now with residues recorded where none had previously existed (values used to be recorded as below detectable limits) consumers see the world as becoming more polluted. They view any amount of chemical residue as too much, especially with the long term negative effects of many chemicals becoming so prominent in the news.

One publication adding to the avoidance of conventional chemicals is the "Shoppers Guide to the Dirty Dozen" list. This list was compiled by the Environmental Watch Group using U.S. government data from 2000-2007 to rank which fruits and vegetables had the highest amounts of pesticide residues.

All of these factors are paving the way for organic foods to

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About 40 leading educators and manufacturers exhibited at the AHGA Conference, making it the largest event of its kind in the Asia-Pacific region for 2009.

enter the marketplace which command a premium price and reduce the use of conventional chemicals.

Moreover, additional benefits of using BCAs have been identified:

- no minimum residue limits (MRLs)
- no withholding periods
- proven efficacy
- IPM friendly and environmentally friendly
- safer to use, reduced liability
- cost-effective
- reduces risk of pathogen resistance build-up
- BCAs more stable than chemical pesticides
- non-phytotoxic
- improvements in overall crop health and yield
- number of organic growers increasing
- no toxic waste disposal problems

However, there are still some factors that limit the effectiveness of BCAs. They are living organisms and suffer from the same environmental pressures that mankind do: weather, temperature, moisture content of soil or media, pH, disease pressure, timing of application, storage and handling and competition from native micro-organisms. But, with proper education growers have been able to successfully employ BCAs in commercial operations with excellent results.

Rather than the old one-on-one model - one BCA for one pathogen - manufacturers and researchers are using combinations of BCA organisms to increase target spectrums or increase the length of time a control may be effective. This new concept fits in well with the goals of IPM and increases the efficacy of BCAs adding to their credibility.

Biological Control in Greenhouses and Hydroponic Systems

Over the years research has shown that BCAs have the capacity to be curative rather than just preventative. Several research studies show good control of several common greenhouse and hydroponic pathogens.

Lettuce has several key pathogens: Pythium, Botrytis and Phytophthora. Studies have shown that Pseudomonas and Bacillus subtilis effectively control these pathogens (Card, et al. 2002, Boshoff 2006).

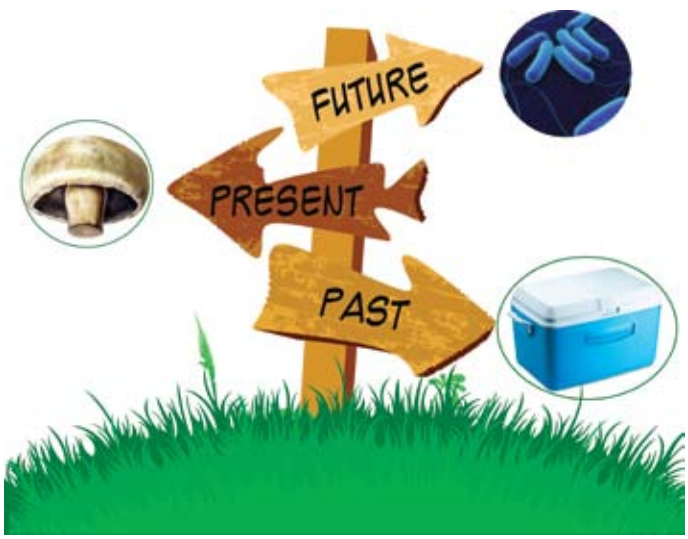
Cucumbers have a slightly larger set of pathogens than lettuce. Pythium has been effectively controlled with Bacillus subtilise (Utkhede, Koch, and Menzies 1999).

Trichoderma and Pseudomonas putida have been shown to control several root, crown and foot rots in tomatoes. And Bacillus subtilis is effective in controlling powdery mildew (Sivan and Chet. 1993, Kamilova, Validov and Lugtenberg 2009, Latunde-Dada 1993).

Cut flowers benefit from BCAs as well. Trichoderma was shown to control Botrytus grey mould. Pseudomonas and Bacillus subtilis are strong candidates for control in hydroponic chrysanthemums. (Elad 1993, Orlikowski 1995, Liu et al. 2007).

Future

Trends show that BCAs are in our future. Surveys of both conventional and organic growers indicate an increasing interest



in using biological control products. In fact, many conventional growers use softer chemistries when they can. One wine grape grower told me that his decision to switch from conventional chemicals to more organic materials was influenced by the complaints he was receiving from his customers about odours in the tasting room. This got him thinking and he was stricken by the realization that his grandchildren play in his vineyard.

Trends also show that chemicals will continue to be banned. Europe banned 22 chemicals in 2008 and six more in 2009. The U.S. Environmental Protection Agency (EPA) is constantly reducing the amount of methyl bromide soil fumigant used every year as well. Furthermore, the cost is always increasing to register conventional chemicals. The growing organics market and increased public awareness of the environment add to the pressures against chemicals. BCAs will not replace conventional chemicals but they will certainly play a role in filling in the vacuum as conventional chemicals disappear.

Besides market trends there are other factors driving the growth in BCAs: organic crop premiums, IPM, worker safety and liability costs, residue management and resistance management. Organic crop premiums induce growers to reduce their chemical inputs. Integrated pest management also stresses reduced chemical usage. The costs associated with worker safety and liability is far greater than using comparatively safe biological products. Would you rather see your workers applying a safe product or would you rather see them in a moon suit? Increased fertilizer and nutrient costs have growers looking at biological agents to break down their crop residues to free up expensive nutrients naturally. And BCAs don't have the resistance build-up phenomenon that conventional chemicals do. So, who is saying this? The greenies? The environmentalists? No, the agricultural chemical industry (Farm Chemicals International, July 2008).

BCAs still have their limitations with environmental factors and sometimes narrow usage conditions, but it is expected that improvements in formulation technology, advancements in biotechnology and increased understanding of micro-organism physiology - over time - will remove the guesswork and specialized education needed to get the full benefit of BCAs. This increase in biological knowledge will no doubt lead to advances in formulation that will take the guess work out of application timing, worries about pH levels, temperatures and other environmental variables.

So, the trend is for chemical usage to decline because of the factors I have outlined above. And as IPM becomes the central strategy in pest control, it makes sense that BCAs will continue to grow in use and popularity as we move forward. MY

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