Some Principles Of Fungicide Resistance VII: Adaptability Of Plant Pathogens

This is seventh in the series

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I have learned never to underestimate plant pathogens. One of the most important principles of fungicide resistance is that microorganisms, such as plant pathogens, are remarkably adaptable.

From a practical standpoint, what this means is that we cannot assume that resistance will never develop to the fungicides we use for disease control. This is especially the case for the many new products with very specific modes of action.

Here is an example. In a previous article in this series, I wrote about how fungicide resistance can be like a coat of armor (Figure 1), protecting the fungus when fungicide is sprayed, but weighing it down in the absence of fungicide. In such a case, we say that there is a "fitness cost" for resistance to that fungicide.

So if there is a heavy cost to resistance to a pesticide, what might microorganisms do? Sometimes they genetically fix that problem, in two steps:

• First, they develop the resistance to the toxin (the heavy armor);

• Then, over several generations, they evolve a progressively lighter and lighter armor, to the point where they still carry the protective armor, but it is no longer a burden.

This process, called "compensatory mutation", has been documented in bacteria, though to my knowledge, not in fungi. But honestly, I know of no reason why it shouldn't happen in fungi. After all, if the armor is heavy, basic evolutionary biology suggests that strains carrying lighter armor will provide a competitive advantage.

Another example: As discussed in the first article in this series, mutation (Figure 2) is a driving force behind the development of fungicide resistance. It turns out that mutation rates vary, depending on the environment. It is especially interesting that environmental stress can actually trigger higher mutation rates in some microorganisms. In other words, under a stressful environment, the genetic machinery of microorganisms may generate more variants than normal. This is highly adaptive, since some of the new variants might be "just right" for the new environmental conditions. In fact, in bacteria, researchers have shown that antibiotics can actually increase the rate of mutation. It is interesting to wonder whether this may happen in response to pesticide application.

Commercial fungicides are recent inventions, so how is it that fungi even have genes for resistance to these materials? The fact is that microorganisms typically use genes that have evolved for other purposes. For example, fungi sometimes resist a fungicide by simply pumping it out of the cell using a molecular "efflux pump" (look at the top of Figure 3). Efflux pumps have existed for millions of years, so they didn't evolve specifically to resist modern fungicides. They evolved to pump out naturally occurring toxins. However, they often work well against our modern pesticides. In fact, they usually work against a variety of unrelated toxins, so they are said to give the microorganism "multi-drug resistance". Thus, fungi may sometimes be "pre-adapted" to resist our modern fungicides, because they possess an efflux pump. We simply select these resistant strains by applying fungicides.

Bottom line

Fungi and other microorganisms are remarkably adaptable. Based on this principle, a conservative assumption is that fungi will find ways to adapt to the fungicides we use for disease control, especially against the many new products with very specific biochemical modes of action. Δ

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Figure 1. Imagine fungicide resistance being like a coat of armor, protecting the spore from the chemical poison. (Image of "ring armor", retrieved 23 June 2013, from http://etc.usf.edu/clipart/)

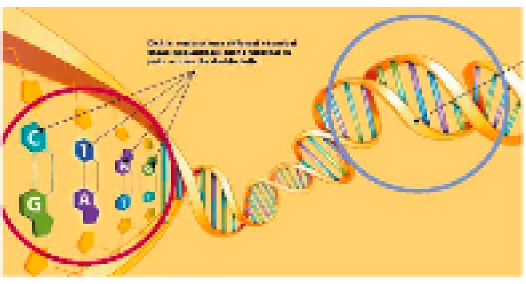

Figure 2. The double helix of DNA, showing a few letters of the genetic code. A change in the sequence of letters is an example of a mutation. Image from http://www.ninds.nih.gov/disorders/brain_basics/genes_at_work.htm.

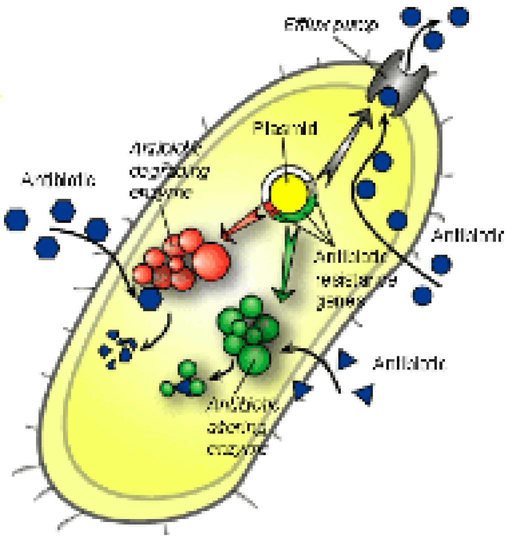

Figure 3. Diverse ways that a microbe may resist a poison. Image from http://www.asu.edu/courses/css335/ar.htm