Some Principles Of Fungicide Resistance V: Ecological Fitness

This article is the fifth in the series.

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Previous articles in this series have presented basic concepts about how fungicide resistance develops in populations of infectious fungi. This article presents a more advanced concept, but one that is key to understanding fungicide resistance.

Ecologists use the term "fitness" to describe the overall ability of an organism to thrive and reproduce in a given environment. Many qualities contribute to ecological fitness. An obvious example is fungicide resistance. In a crop field where a fungicide is being used, if a spore has genetic resistance to that fungicide, it is more "fit" than a spore that doesn't. Think of fungicide resistance like a coat of armor, protecting the fungus from the fungicide (Figure 1).

Let's take the "armor" metaphor a little further. On the battlefield, having a coat of armor is beneficial. However, in daily life, having to wear a coat of armor would get tiresome very fast. Sometimes, this is how it is with fungicide resistance. The genetic resistance to fungicides helps protect the fungus for as long as the fungicide is being used. However, if the producer stops using the fungicide – or switches to a fungicide in another FRAC group – the genetic resistance to fungicides actually may be a burden, like an unnecessary coat of armor.

Here are some real-world examples:

• When resistance develops to strobilurin fungicides (azoxystrobin, trifloxystrobin, pyraclostrobin, and other FRAC Code 11 fungicides), it commonly confers very little to no fitness cost. It is as if the armor were weightless.

• Resistance to the many triazoles and related fungicides (FRAC Code 3) often results in a modest fitness cost, like wearing light-weight armor.

• Resistance to dicarboximides (FRAC Code 2) often comes at a significant fitness cost to the fungus, as if the armor it was carrying was very heavy.

Although you may have never heard of ecological fitness before, it really can work to a producer's advantage, or disadvantage. Imagine that a fungicide-resistant spore occurs on your farm. Here is the range of possibilities:

• If you are lucky, that genetic resistance to fungicides may have a "fitness cost", (=heavy armor). If so, that fungal strain may "limp along" and cause disease on your farm as long as you continue to use fungicides in that FRAC group. However, if you stop using those fungicides, the resistant strain will commonly begin to die out, and it may eventually return to very low levels on your farm. If there is a substantial fitness cost to fungicide resistance, you can commonly go back to using the fungicide, at least for awhile, until resistant strains build up again.

• If you are unlucky, the resistant strain will have absolutely no fitness cost, as if the coat of armor weighed nothing at all. What this usually means is, you are stuck with resistance indefinitely. Even if you stop using fungicides in that particular FRAC group, the resistant strain will persist for a long time.

On a given farm, either of these two extremes may occur, as can outcomes intermediate between these extremes.

So here are some practical questions that follow from this concept of ecological fitness:

•1. When fungicide resistance occurs, how fit are the resistant strains? It is a key question, but it takes quite a bit of research to answer it for any given case of resistance. It is complicated by the fact that each new fungal strain, like people, is a unique individual, and we will only know how well-adapted a strain is by watching how it does in nature. However, one thing is for sure: the occurrence of resistance does not necessarily pose a threat to a farming operation, depending on how fit the resistant strain is.

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/)

2. How can we manipulate the ecological fitness of pesticide-resistant microbes? Great question. But we can't. We have no influence on whether or not the fungal spores in a particular field carry a heavy coat of armor or a weightless one. We can only reduce the risk that the coat of armor will arise on its own (through mutation). You can only hope that, once it arises, the coat of armor is heavy. In ecological terms, we can only reduce the chance that a fit mutant will occur in our fields, but we cannot influence whether there is a fitness cost to that resistance.

3. How can we reduce the chance of a fit mutant occurring in our fields? The only way to reduce the risk of the fit mutant is by reducing disease activity on the farm. See the third article in this series for more on this topic, but basically, it means using resistance varieties and cultural practices to reduce disease pressure. The lower the disease pressure, the lower the chance that a fit mutant will spontaneously occur.

Bottom line:

Fungicide resistance is like a coat of armor, protecting the fungus from the fungicide. In some cases, the coat of armor is heavy, becoming a burden to the fungus in the absence of fungicide. This is referred to as a "fitness cost" to the fungicide resistance. If resistant strains in your field carry a fitness cost, sometimes it is possible to still use that fungicide selectively, because the resistant strain is may die out during periods when that fungicide is not applied. In contrast, if there is no fitness cost to resistance, resistant strains will likely stick around for a long time. Δ

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