Some Principles Of Fungicide Resistance IV: FRAC Codes

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The previous two articles in this series showed how fungicide resistance develops, and why over-reliance on fungicides is risky. This third installment "switches gears" by considering the submicroscopic world of fungicide resistance.

Although they are too small to see with the naked eye, cells of fungi are quite complex (Figure 1). Fungicide manufacturers take advantage of this complexity by creating chemicals that poison the biochemical activity of one or more of these cell structures.

In order to understand how fungicides poison fungi, it is important to understand the normal metabolism of a healthy fungal cell. See Figure 2 for an example. In a healthy cell, enzymes turn a certain molecule (called "substrate") into another molecule (called "product"). Without the simultaneous, furious activity of many thousands of enzymes, the cell would be unhealthy or dead.

A fungicide is merely a chemical that interferes with the normal function illustrated in Figure 2. One way it might interfere is illustrated in Figure 3: by binding the active site of the enzymes. Other fungicides interfere in other ways, but in all cases, they interfere with some molecule normally present in healthy fungal cells.

Thus, each fungicide has a particular biochemical way of poisoning the cell. Why is this important for users of fungicides? This is the key point: if two fungicides poison the cell in precisely the same way, they are the same fungicide, from the point of view of the fungus. It does not matter:

- Whether the active ingredients have different chemical structures
- Whether the active ingredients have different names
- Whether they are sold under different trade names
- Whether they are made by different manufacturers
- Whether they are formulated differently.

From the point of view of the fungus, if they poison the cell in the same way, they are the same fungicide.

Here is a classic example. Benomyl was the first systemic fungicide. It was sold under various trade names, including Agrocit®, Benex®, Benlate®, Tersan 1991®, and others. Another fungicide that continues to be important today is *thiophanate-methyl*, which has been sold under a wide variety of trade names, including Cleary's 3336®, Fungo®, Topsin M®, and many others.

Benomyl and thiophanate-methyl have different chemical structures (Figures 4). However, they both poison the fungal cell in exactly the same way. Therefore they are both considered to be benzimidazole fungicides, a name which communicates this shared mode of action. This means that, even if you alternate between fungicides within a fungicide group, the fungus "sees" them as the same fungicide. It also typically means that if resistance develops to one member of the group, usually resistance is present for all members of that group.

So which group a fungicide belongs to is really important for crop producers wanting to steward fungicides wisely. Our producers have a lot "on their plate", so fortunately, you don't have to learn any biochemistry, or even learn the names of fungicide groups. Several years ago, members of the global Fungicide Resistance Action Committee (FRAC) decided to represent fungicide groups using numbers. So the benzimidazole group (which includes benomyl and thiophanate-methyl) is represented as FRAC Code 1. Any fungicide with FRAC Code 1 poisons fungi in the same way. This also means that any product with any other FRAC Code poisons a different biochemical target, so any fungicides with a different FRAC Code truly are different from the members of FRAC Code 1.

FRAC Codes are presented on the labels of most fungicidal products sold in the USA. See Figure 6 for an example. This makes it easy to alternate products having different biochemical modes of action – just look for products having a different FRAC Code.

Bottom line: Active ingredients within the same "fungicide group" poison fungi in exactly the same way. From the point of view of the fungus, such fungicides are identical, regardless of who markets the product. Fungicides in the same fungicide group share the same FRAC Code. This code makes it easy for growers to use fungicides in ways to reduce the risk of fungicide resistance.

More information on FRAC Codes is available at http://www.frac.info/index.htm. Watch for additional installments in this series of articles on fungicide resistance. Δ

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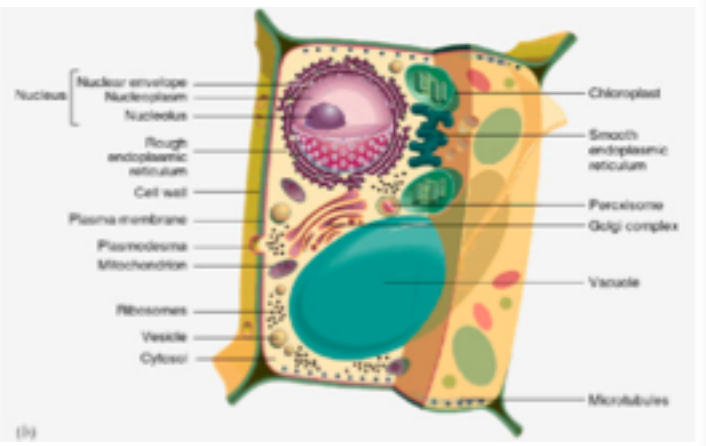

Figure 1. Structure of a typical eukaryotic cell. From: http://www.uic.edu/classes/bios/bios100/lecturesf04am/lect06.htm.

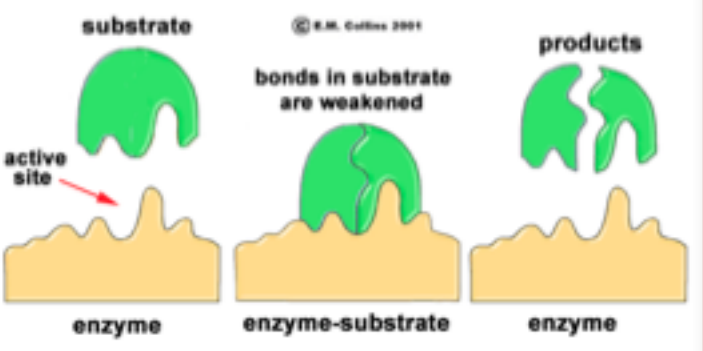

Figure 2. Normal molecular function within a living cell. From: http://waynesword.palomar.edu/molecu1.htm

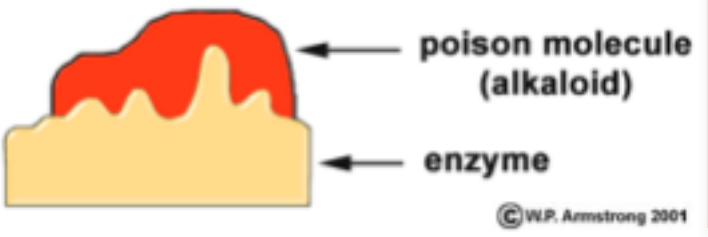

Figure 3. The red chemical is a toxin that interferes with the normal functioning of the enzyme pictured in Figure 2. It binds to the active site of the enzyme, preventing enzymatic activity. From: http://waynesword.palomar.edu/molecu1.htm

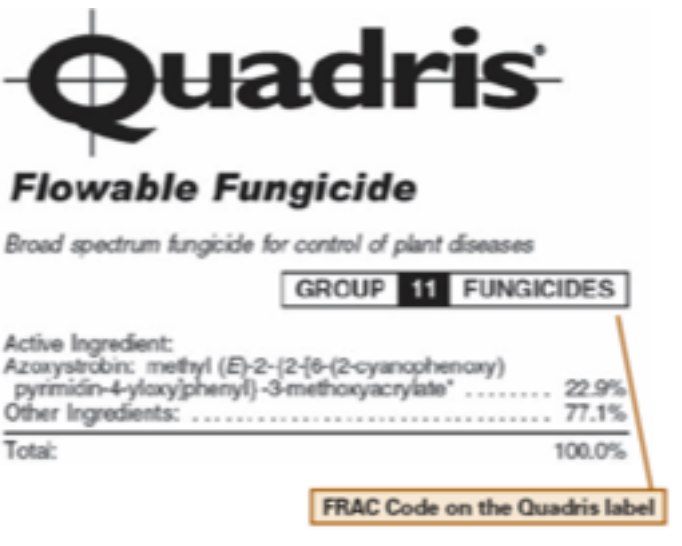

Figure 4. Chemical structure of benomyl fungicide. From: http://webbook.nist.gov/cgi/cbook.cgi?ID=C17804352&Mask=200