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What's New in Plant Pathology: Resistance: Mystery and Misunderstandings

Amy D. Timmerman
University of Nebraska-Lincoln, atimmerman2@unl.edu

Loren J. Giesler
University of Nebraska-Lincoln, lgiesler1@unl.edu

Robert M. Harveson
University of Nebraska-Lincoln, rharveson2@unl.edu

Tamra Jackson-Ziems
University of Nebraska-Lincoln, tjackson3@unl.edu

Stephen N. Wegulo
University of Nebraska-Lincoln, swegulo2@unl.edu

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Amy D. Timmerman, Extension Educator
Loren J. Giesler, Extension Plant Pathologist
Robert M. Harveson, Extension Plant Pathologist
Tamra A. Jackson, Extension Plant Pathologist
Stephen N. Wegulo, Extension Plant Pathologist

One of the most common management recommendations for plant diseases is the use of resistant or tolerant varieties/hybrids in your production system. However, there is common confusion on the definition and differentiation of susceptible, tolerant and resistant varieties/hybrids from a plant pathology viewpoint. A susceptible variety/hybrid allows the pathogen to reproduce and causes significant disease development and in turn compromises the productivity of the plant (i.e. yield). A tolerant variety/hybrid allows the pathogen to reproduce and cause disease at the same or at a slightly reduced rate as a susceptible variety/cultivar; however, there is no noticeable reduction in the plant's overall productivity. Finally, a resistant variety/hybrid limits or prevents pathogen reproduction and disease development; hence, plant productivity is little or not affected while the plant remains very productive. It is important to note that plant resistance is not plant "immunity," where it is expected that a variety/hybrid will have NO disease. Unfortunately, immunity does not exist for the majority of plant diseases and expecting such a reaction (or lack thereof) is unrealistic. Resistance, simply, is a reduction in disease severity due to the plant's defenses. Plants have many mechanisms for defense, but do not possess immune systems comparable to our own that preclude infection and disease development. Figure 1 is a diagram of resistance, tolerance and susceptibility in view of amount of disease development and plant productivity with the y and x-axis crossing point being zero.

When examining plant resistance, there is a gene-for-gene theory that is based on the concept of resistance being related to a single plant gene. In general there is a specific plant gene that defends against a single pathogen gene. Races or biotypes such as soybean cyst nematode HG types are pathogen strains within a species distinguished by different behavior or ability to overcome different types of plant resistance, but not by pathogen appearance. In this subgroup there tends to be more genetic diversity available in the host for resistance. For example, several disease resistance genes may exist, such as in the soybean-Phytophthora root and stem rot pathosystem. . With polygenic resistance there are several gene that are involved working together simultaneously in the resistance mechanism compared to a single locus as would be the case with monogenic resistance. Understanding the type of resistance present in the plant is beneficial regarding the probability of a pathogen being able to overcome the plants genetic resistance. Resistant plants using monogenic resistance have a higher probability of reduced production to develop overtime because the pathogen can mutate or change to overcome that single resistance gene more rapidly. Unlike polygenic resistance, the pathogen must mutate or change to overcome several resistance genes. This concept is comparable to other pests that are more easily able to adapt to pesticides with single site versus multiple "modes" of action.

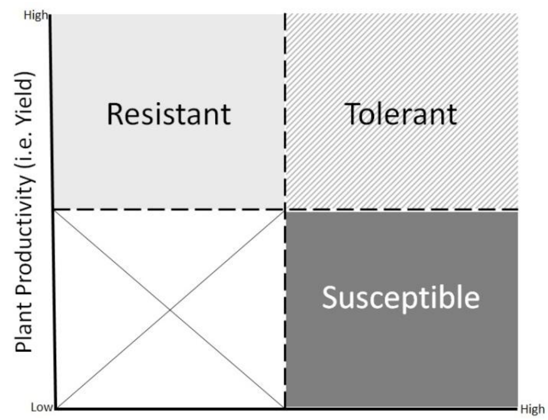

Figure 1: Resistant, tolerant and susceptible varieties/hybrids in relationship with pathogen reproduction rates

Monogenic Resistance

Dry bean rust caused by *Uromyces appendiculatus*, is notorious for being one of the most variable plant pathogens known. Scientists have identified more than 250 races worldwide, with individual fields often containing multiple races simultaneously. With dry bean rust the different races identified are determined by the different reactions (susceptible or resistant) on bean that contain resistance genes to various pathogen races. This host-pathogen relationship is an example of monogenic disease resistance, or the resistance to a pathogen that is controlled by a single gene. Bean breeders have the ability to identify these single genes and now can pyramid these genes to provide varieties that contain multiple resistance genes to provide resistance against several races of rust.

Another example of monogenic resistance occurs in the wheat-stem rust pathosystem. In this pathosystem, single genes provide resistance to many races of the stem rust pathogen, *Puccinia graminis* f. sp. *tritici*. For example, the resistance gene *Sr24* is effective against most races of *P. graminis* f. sp. *tritici*, including the new race of stem rust known as Ug99. *Sr24* is used widely in commercial wheat cultivars throughout the world. There are many such single genes in wheat that provide resistance to numerous races of stem rust, leaf rust, and stripe rust.

Monogenic resistance is also found in viral pathosystems. An example of this is the wheat-wheat streak mosaic virus (WSMV) pathosystem. A single gene, *Wsm-1*, transferred to wheat from intermediate wheatgrass, provides effective resistance to WSMV. This is the gene present in the newly released winter wheat cultivar Mace. Another single gene of unknown origin provides resistance to WSMV in the Colorado wheat line CO960293-2 and the Kansas winter wheat variety Ron-L. However, this resistance is unstable and breaks down at temperatures above 18°C (64°F) whereas the resistance provided by the *Wsm-1* gene does not.

Polygenic Resistance

An example of polygenic resistance is found in the soybean cyst nematode (SCN) pathosystem. Within the soybean host genetics there are several genes that contribute to resistance to SCN. For example, researchers believe there are 9 or more genes related to resistance in the PI88788 resistance source. This is why we see ratings related to resistance to soybean varieties for SCN by some companies. In contrast, if this resistance were monogenic we would typically see a simple yes or no response as we do in those systems and typically we do not see differences in the level of resistance. Looking closer at this mechanism of resistance we see a range in responses and a continuum of susceptibility. Classical resistance studies have indicated that at least 10 different genes are involved in resistance to SCN in soybean. As molecular based studies continue in this area, researchers continue to identify more generic diversity in this resistance.

Trying to manage use of resistance for pathogens that are widely spread on soybean acres and limited inclusion of genetic diversity in the host crop is very difficult and will lead to the development of an overall breakdown in resistance. For example, in a survey published in 1991, there were 34% of the SCN populations surveyed in Illinois that had 10% or more reproduction on PI88788 compared to 65% identified in 2005. It has now become quite common to find SCN populations that reproduce on PI88788, which is the most common source of soybean resistance to SCN.

It is important to note that crop yield does not always directly relate to host susceptibility. In SCN management we typically discuss the idea of SCN population management and trying to keep the field population low. This requires rotation of the various sources of resistance or at least rotating varieties so that the same genetics (even if they are all PI88788) are not expressed to the nematodes in the field each year that soybeans are grown. Given that there is diversity within the PI88788 resistance source with different loci involved and not all loci being incorporated, it is commonly thought that at least rotation of the soybean variety is a good alternative to trying to find varieties with different sources and possibly reduced yields. More information on SCN resistance and results from our SCN field trials can be found at: **http://pdc.unl.edu/agriculturecrops/soybean/soybeancystnematode**.

The soybean industry varies in how companies describe SCN resistance. SCN-resistant soybeans are generally those that allow less than 10 percent reproduction relative to the amount of SCN reproduction that occurs on a susceptible (non-resistant) variety. Soybeans that allow 10 percent or more nematode reproduction, but less than 30 percent, are often designated moderately resistant. In general, these definitions are accepted in the scientific community and the soybean seed industry, but some seed companies use other designations. One utilizes a unique numerical scale for SCN resistance based on the amount of SCN reproduction that occurs on their varieties, while another company only verifies that the main SCN resistance genes are present in varieties they describe as "SCN resistant" and do assess SCN reproduction on their varieties. Unique, company-specific designations of SCN resistance are confusing and make SCN management efforts difficult when the ability of the varieties to support SCN reproduction is not clearly defined. This is the main reason that growers should utilize standardized testing programs to determine how different varieties perform.

SCN resistant varieties that suppress nematode reproduction not only produce greater yields than susceptible varieties in SCN-infested fields, but they also do not support large increases in SCN populations. Minimizing SCN reproduction allows for profitable and sustainable production of soybeans in SCN-infested fields.

During recent years, the disease Goss's bacterial wilt and blight of corn (for more details about the disease, see the Corn Disease Update) has reemerged as a serious threat to corn production across Nebraska and much of the rest of the Midwest Corn Belt. Since the disease is caused by a bacterial pathogen, it cannot be directly managed with the popular systemic foliar fungicides that are in use today. Instead, the most effective disease management strategy for Goss's bacterial wilt and blight is one that utilizes a combination of management tools that includes planting corn hybrids that are resistant to the disease.

As recent as 2006, only about 25% of the seed companies marketing in Nebraska publicized their hybrid ratings to the disease. Since then, with the rapid increase in disease incidence and severity across the region, more than 65% of companies evaluate their hybrids for their reaction to Goss's wilt and publicize the results.

Resistance to Goss's wilt is another example of polygenic resistance that is conferred by multiple plant resistance genes. Polygenic resistance is known to be difficult to select and breed for, compared to monogenic resistance. In addition, as is the case for both Goss's wilt and SCN resistance, the genes can have an additive effect on resistance. Additive effects imply that increasing the number of resistance genes present also increases the magnitude of resistance to the disease, creating a range of reactions that are possible when comparing varieties/hybrids.