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Soybean researchers pin hopes on disease resistance genes

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Like people, plants sometimes get sick. However, if those plants are in fields of corn or soybean, the costs to both producers and consumers can be enormous.

To control plant diseases, breeders take advantage of disease resistance genes – frequently the most cost-effective and environmentally friendly method of managing crop diseases. In recent years the genetic structure – and even DNA sequence – of many plant disease resistance genes have been described.

With support from USDA's National Research Initiative (NRI), scientists at the University of Minnesota are using genomic strategies to understand disease resistance genes in soybeans.

One important disease pest of soybeans is *Heterodera glycines*, also known as the soybean cyst nematode (SCN). This tiny worm attacks the roots of soybeans, setting up a home within roots that consists of a feeding site and a protective "cyst" for hundreds of nematode eggs.

The roots of a single soybean plant can be attacked by many hundreds of nematodes all at once. SCN significantly reduces soybean yield and makes the plant even more susceptible to other environmental or disease problems.

David Hansen, Minnesota Agricultural Experiment Station

The cyst nematode (*Heterodera glycines*) grows on the roots of soybean plants.

Gene Mapping

The researchers began by mapping the chromosomal location of *rhg1*, the most important SCN resistance gene. While earlier work had indicated that SCN resistance was genetically complex, DNA marker technology revealed that just a few genes were essential, especially *rhg1*.

The first DNA markers to pinpoint *rhg1*

A new generation of DNA markers will speed the process of marker-assisted breeding for disease resistance.

were known as "Restriction Fragment Length Polymorphisms" or RFLPs for short. Unfortunately, RFLPs are rather cumbersome to use and require radioactive nucleotides.

The challenge was to find simpler and more efficient markers to tag *rhg1*. In collaboration with Dr. Perry Cregan of the USDA-ARS facility in Beltsville, MD, better markers were soon discovered in the form of "Simple Sequence Repeats" (SSRs). Now soybean researchers can track the inheritance of *rhg1* with a quick and highly accurate DNA sequence tag.

New Tools

As work on SCN resistance moved forward, rapid advances in genomics were providing new strategies for studying plant disease resistance genes. The researchers integrated many of the most exciting genomic approaches into their research program.

For example, high-throughput DNA sequencing made it possible to discover dozens of candidate resistance genes in soybeans, genes that presumably control many of the diseases that strike this crop. Unfortunately, none of these original candidate genes turned out to be *rhg1*. However, through the use of other genomic tools, collaborators throughout the country have uncovered additional candidate resistance genes for SCN that are now being tested.

In the course of this work, the researchers found that soybean resistance genes are almost always found in large clusters along the chromosome. This discovery confirmed similar observations in other plants, indicating that plant disease resistance genes are generally organized as tandem clusters of related sequences. This form of genome organization is critically important in the evolution of new forms of pathogen recognition and disease resistance.

Studying the chromosomal region surrounding *rhg1* also revealed intriguing similarities in genome organization between soybeans and other plants. The first plant genome to be fully sequenced is known as *Arabidopsis thaliana*. It has no direct value in agriculture, but its potential to speed understanding of plant biology is vast.

Impact

A new generation of DNA markers will speed the process of marker-assisted breeding for disease resistance. New genomic tools, especially DNA microarrays and DNA chips, will enable scientists to examine the precise timing when defense response genes are activated.

Complete genome sequencing in soybeans and other crops will reveal all of the genes responsible for the resistance response. It is clear that the application of basic discoveries in molecular genomics is rapidly revolutionizing agricultural research.

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