IOWA STATE UNIVERSITY

Plant Sciences Institute UPDATE

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Soybean rust research

The Plant Sciences Institute launched a set of research initiatives in 2004 to address challenges to Iowa agriculture and several have begun to pay off. One success story addresses a threat to our soybean crop, caused by the Asian soybean rust fungus.

The Asian soybean rust project was initiated before the pathogen had even been reported in the United States. The Institute's Center for Plant Responses to Environmental Stresses (CPRES) deemed it a research priority and the focus of its Crop Protection Research Initiative because the disease can devastate soybean crops. In severe infestation outbreaks, it can wipe out 80 percent of soybean yields and spread rapidly depending on environmental conditions.

The initiative funded the work of Thomas Baum and Steve Whitham, faculty members in the plant pathology department and affiliates of CPRES, and plant pathology postdoctoral researcher, Martijn van de Mortel.

The results of their work were published as a "Spotlight" story in the August issue of *Molecular Plant-Microbe Interactions*. "Distinct BiPhasic mRNA Changes in Response to Asian Soybean Rust Infection" describes the results and conclusions of experiments that measured the levels of gene expression in two groups of plants

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Hayden—the prairie conservationist

Throughout her career, Ada Hayden could often be seen throwing a johnboat on top of her car. She would strap it on and drive to the lakes of northern Iowa to do her field work. Iowa State botanist Lois Tiffany, who was an undergraduate in the late 1940s, remembers this.

"She was so intensely interested in her work," said Tiffany. "I think she probably had to fight for everything she got."

Hayden was the first woman to get a doctorate at Iowa State in 1918. She was on the faculty in the botany department from 1920 to 1950. She did floristics—the study of plants in a certain area. Her work in northern Iowa may be the most authoritative for any part of the state. In 1934 she became curator of the Iowa State herbarium, adding 30,000 specimens to the collection throughout her career.

But her work as a conservationist to save the prairies of Iowa often goes unnoticed.

"As important as the herbarium is, the preservation of the prairies is even greater," said Lynn Clark, professor in the Department of Ecology, Evolution and Organismal Biology and director of the Ada Hayden Herbarium. "We wouldn't have even the little bit of prairie land that we have today if it weren't for her. No one else was pushing that."

Hayden grew up on a farm near Ames surrounded by prairies. The story goes that Louis H. Pammel was giving a talk to Hayden's high school class when he noticed a bouquet containing pasque-flowers on the teacher's desk. He inquired about them and the teacher presented Ada, who had picked them. They talked, he recognized her talent and became a huge influence on her life. For

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Food and fuel

Feeling a pinch at the pump and in the grocery cart? The demand for corn to produce biofuels is a boon for Iowa's economy, but it is hitting our pocketbooks. *The Washington Post* says "Corn price increases flow like gravy down the food chain, to grocery stores and menus. Beef prices are up. So are the costs of milk, cereal, eggs, chicken and pork."

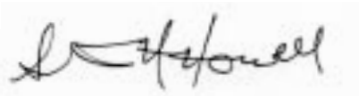
"What we've done with the usage of biofuels—based on corn—is link our food prices to energy prices," said Michael Swanson, an agricultural economist for Wells Fargo. "And now you can either sell corn for feeding animals or for fueling vehicles." (*Chicago Sun-Times*).

The problems caused by the linkage of food and fuel prices are not going to go away soon. According to a recent government report, almost a third of the U.S. corn crop will be used to produce fuel ethanol in five years, possibly raising animal feed costs for farmers and meat prices for consumers (Reuters).

Economists argue that market forces will stimulate production with increasing demand. Indeed, U.S. corn producers planted 90.5 million acres of corn this spring—the highest acreage planted in 63 years (*Farm Industry News*).

The bright side of all this is that the bioenergy industry is fueling growth in Iowa's economy, contributing more than $8 billion to the gross state product last year, according to the Iowa Renewable Fuels Association. The less bright side is that food and fuel costs will increase the burden on everyone, particularly for marginalized populations in this nation and developing countries.

In this period of prosperity in bioenergy, we should try to make everyone a winner.



Stephen Howell
Director

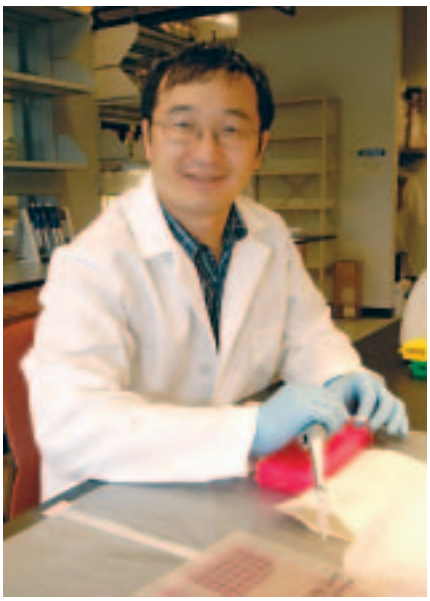
A unique bacterial mechanism gives insight into plant disease

Bacterial pathogens have developed malevolent mechanisms to produce disease in plants. Bing Yang, a new assistant professor of genetics, development and cell biology, is studying bacterial blight in rice as a means of understanding emerging diseases in crop plants.

"What's kind of amazing is that bacteria have developed a mechanism somewhat like a hypodermic needle to inject pathogenic proteins into host cells," said Yang, an affiliate of the Center for Plant Responses to Environmental Stresses.

This protein injection mechanism mediates the interactions between the bacterium and its host and is similar to secretion systems used by some bacterial pathogens that produce disease in animals and humans.

Yang, who arrived at Iowa State in January, explained that the pathogen uses its injected proteins to take advantage of the plant cell, monopolizing the plant's energy for the advantage of the bacteria growth. On the other hand, the plant recognizes the intruder and mounts a defense response. In this way, there is an ongoing battle between the host plant and the bacteria at the molecular level.



Assistant professor of genetics, development and cell biology Bing Yang is studying a unique bacterial mechanism.

Yang's goals are to identify the bacterial proteins and the group of host genes involved in the defense response of the rice plant. Yang hopes that a better understanding of the disease will lead to better breeding strategies for disease control in crop plants.

Hayden—the prairie conservationist/CONTINUED

the first half of her career she contributed greatly to his publications.

She wrote the first call to save the prairies in a paper in 1919. Deborah Lewis, curator of the Ada Hayden Herbarium and informal biographer of Hayden, said it is suspected that she put down this conservation effort for reasons related to Pammel who worked closely with farmers.

In 1940, Hayden received a $100 grant from the Iowa Academy of Sciences to survey the remaining prairie areas. She traveled throughout the state and selected 22 as the best examples of various kinds of prairies in Iowa. But that was not the end, said Lewis.

"She pushed it. She was interviewed on the radio, gave public lectures, she even hand colored a set of the old lantern slides so they were pretty, to impress people as she gave her talks," Lewis said.

Throughout her career she was never promoted past assistant professor—a sign not of her vigorous work, but of the time. Three prairies had been purchased for conservation by the time she died in 1950, one of them a 240-acre swath of prairie land in Howard County, named for her. Hayden herself described this prairie in 1946 as, "… An impressive sweep of rolling country may be seen. A colorful panorama of flowering plants occurs throughout the growing season."

Soybean rust/CONTINUED

exposed to the rust fungus: a susceptible variety and a resistent variety in which the disease progresses slowly.

Results of the study showed that within the first 12 hours in both susceptible and less susceptible plants, pathogen inoculation induced substantial gene expression changes.

"What was surprising though was that 24 hours into the infection, gene expression returned to the baseline—the plant's response to the rust pathogen essentially turns off," said Whitham.

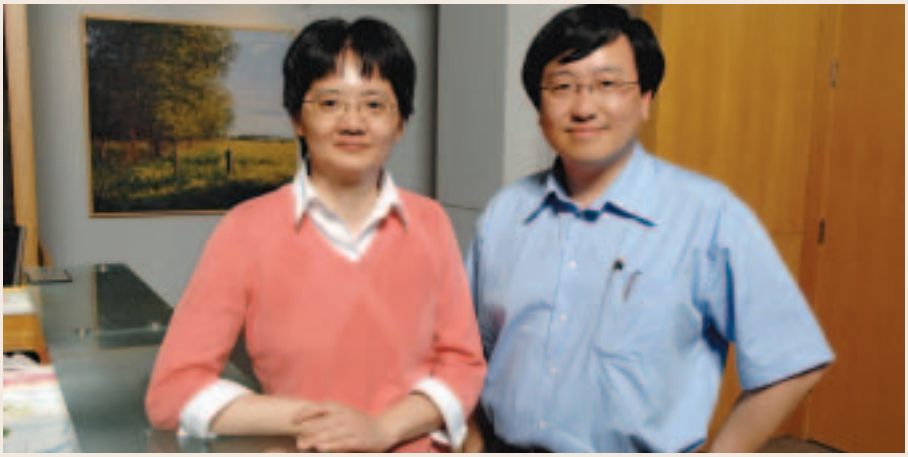
Later, gene expression changes in response to rust infection turned on again, Whitham said, likely because the fungus produced something the plant recognized as foreign. But it happens a day or two earlier in the resistant plants, indicating that these genes may be involved in regulating or affecting soybean defense mechanisms. Overall, the experiment has helped narrow down the search for genes involved in defending the soybean plant from 37,500 to a few hundred.

"The real use of our work is that we generated a huge genomic resource that we and everybody else in the world can now use for further study," said Baum. "The Crop Protection Research Initiative served its function to address an imminent need that poses a threat to crops in Iowa, and we used these seed funds to create a new research project."

Baum, Whitham and van de Mortel will continue the Asian soybean rust research with funding from the Iowa Soybean Association.

The Plant Sciences Institute took part in Iowa State's sesquicentennial kick-off at VEISHEA. Thousands of people made their way through central campus, where the institute's tent was located.

Nanotechnology, a powerful tool for plant science



Iowa State scientists Kan Wang and Victor Lin

Iowa State scientists are the first to use nanotechnology to penetrate plant cell walls and simultaneously deliver a gene and a chemical that triggers its expression with controlled precision. The research, supported by the Plant Sciences Institute, presents a powerful new tool for targeted delivery into plant cells.

The work is a collaborative effort between the labs of Kan Wang, director of the Center for Plant Transformation and professor of agronomy and genetics, development and cell biology, and Victor Lin, professor of chemistry and senior scientist at the U.S. DOE Ames Laboratory. Wang and Lin with postdoctoral research associates Francois Torney and Brian Trewyn present their methods and results in "Mesoporous Silica Nanoparticles Deliver DNA and Chemicals into Plants," a highlighted article in the May issue of *Nature Nanotechnology*.

Thus far, there are no other examples of nanotechnology being used in agriculture or plant biology said Lin.

"Other universities may have good materials and research programs, but they may not have the agricultural application or the plant scientists on their campuses as we do here at Iowa State," he said.

The project started with an Iowa State proprietary technology developed by Lin's group. It is a porous, silica nanoparticle system with a honeycomb-like structure that can be filled with chemicals or molecules. The system has a unique "capping" strategy that seals chemicals inside. It can be chemically activated to release its cargo, providing total control for timing the delivery.

Even though the Lin group has demonstrated that this system could be engulfed easily by animal cells, animal cells don't have rigid cell walls like plants. To make the system work on plants, they modified the nanoparticle surface with a chemical coating, allowing naked plant cells to absorb the nanoparticles.

In order to deliver into walled plant cells, a common practice in genetic transformation, biologists often use a gene gun. To adapt the system for standard gene gun use, the chemists made another modification to the nanoparticle surface. They synthesized even smaller gold particles to cap the nanoparticles. These "golden gates" prevented leakage of the encapsulated chemical and added weight to the nanoparticles, enabling their delivery into the plant cell.

"With the mesoporous nanoparticles, we can deliver two biogenic species at the same time. We can bring in a gene and induce it in a controlled manner at the same time and at the same location," said Wang. "This is truly a breakthrough."

The biologists successfully used the technology to introduce DNA and chemicals to Arabidopsis, tobacco and corn plants. In the future, scientists could use the new technology to deliver imaging agents or other genetic materials, such as RNA and proteins, inside cell walls. This would provide plant biologists with a window into intracellular events and more opportunities to study the gene functions and mechanisms.

Recent research grants

The following 18 new grants totaling $5.2 million were awarded recently to plant science researchers at Iowa State.

Oligomeric Structure of Membrane Peptides from Solid-State NMR
National Science Foundation—$164,781
(M. Hong, chemistry)

Novel Signaling Components for Plant Steroid Regulated Gene Expression in Arabidopsis
National Science Foundation—$125,000
(Y. Yin, genetics, development and cell biology)

Seed Systems Development Project
International Crops Research Institute for the Semi-Arid Tropics—$101,601
(J. Cortes, Seed Science Center)

Design of Nanostructured Organic-Inorganic Hybrid Catalysts for Biorenewable Conversion
National Science Foundation—$101,234
(B. Shanks, chemical and biological engineering)

Solid-State NMR Studies of Antimicrobial Peptides
National Institutes of Health—$212,190
(M. Hong, chemistry)

Synthesis of A-Type Procyanidins
Phytomedical Technologies Corporation—$204,686
(G. Kraus, chemistry)

Collaborative Research: Comprehensive Molecular, Genetic and Cytogenetic Analysis of Transposon-Induced Chromosomal Rearrangements in Maize
National Science Foundation—$178,970
(T. Peterson, genetics, development and cell biology)

Sequencing the Maize Genome
Washington University—$46,450
(P. Schnable, agronomy)

Biofuels Research Program
ConocoPhillips Company—$1,303,700
(R. Brown, mechanical engineering)

Mesoporous Silica-Supported Metal Oxide-Promoted RH Nanocatalysts for Selective Production of Ethanol from Syngas
Department of Energy—$453,637
(G. Kraus, chemistry)

CAREER: Meshing Synthesis and Biosynthesis in Research and Teaching
National Science Foundation—$102,000
(N. Pohl, chemistry)

North Central Plant Diagnostic Network Asian Soybean Rust Supplement
Michigan State University—$60,000
(T. Baum, plant pathology)

Bone Response to Soy Isoflavones in Women
National Institutes of Health—$678,966
(L. Alekel, food science and human nutrition)

Functional Genomics of Plant Disease Defense Pathways
National Science Foundation—$513,148
(R. Wise, plant pathology)

A Highly Efficient Homologous Recombination System for Plants
National Science Foundation—$489,244
(D. Voytas, genetics, development and cell biology)

Functional Genomics of Soybean Response to Cyst Nematode Parasitism Proteins
USDA—$300,000
(T. Baum, plant pathology)

Oil Production of Soybean Varieties with Mid-Oleic and 1% Linolenic Acids for Industry Testing
United Soybean Board—$100,000
(W. Fehr, agronomy)

Scale-Up of Soy Hydrolysate Ingredient for Wood Adhesive Formulations
United Soybean Board—$79,687
(D. Myers, food science and human nutrition)

Plant Sciences Institute UPDATE

The Plant Sciences Institute Update is published four times each year by the Plant Sciences Institute at Iowa State University, 1060 Roy J. Carver Co-Laboratory, Ames, Iowa 50011-3650; phone 515 294-5255.

The Plant Sciences Institute at Iowa State University is dedicated to becoming one of the world's leading plant science research institutes. More than 200 faculty from the College of Agriculture and Life Sciences, the College of Liberal Arts and Sciences, the College of Human Sciences, and the College of Engineering conduct research in nine centers of the institute. They seek fundamental knowledge about plant systems to help feed the growing world population, strengthen human health and nutrition, improve crop quality and yield, foster environmental sustainability and expand the uses of plants for biobased products and bioenergy. The Plant Sciences Institute supports the training of students for exciting career opportunities and promotes new technologies to aid in the economic development of agriculture and industry throughout the state. The institute is supported through public and private funding.

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