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Chairman Roberts, Ranking Member Stabenow, and distinguished members of the Committee, thank you for the opportunity to speak with you today.

I am Ray Hammerschmidt, a professor of plant pathology at Michigan State University (MSU) for the past 37 years. I am also the founding and current director of the North Central Plant Diagnostic Network, (NCPDN, one of the regions of the USDA National Institute for Food and Agriculture-supported National Plant Diagnostic Network, or NPDN[1],[2]) faculty coordinator of MSU Diagnostic Services, and have served twice as executive director of the NPDN. Through these activities, I have become very interested in looking at the current and potential threat situations, and how we need to be proactive in safeguarding plant agriculture and natural resources from pathogens and pests.

I'll start by saying that we are ill-prepared to combat pathogens and pests that threaten our food supply and many other important economic drivers. There is a defined set of plant pathogen select agents for which we must be on guard, but there are many other pests and pathogens that can threaten our plant production. There appears to be a lack of urgency across many different levels to address this critical issue, even as it impacts our global food system. Pathogens and pests do not recognize state or intercontinental borders and regulations, and this should give us pause. In some plant systems we are seeing increasing potential for plant pathogens and pests to

[1] Stack, JS, Bostock RM, Hammerschmidt R, Jones JB, Luke E. 2014. The National Plant Diagnostic Network: Partnering to protect plant systems. Plant Disease 98: 708-715.

[2] The National Plant Diagnostics Network, https://www.npdn.org/home. This site has several fact sheets on the impact of the NPDN and links to all labs associated with the NPDN.

jump from one host species to another, as well as the effects of a changing climate. We need to pay more attention and raise public awareness of these important plant disease and pest issues.

Pathogens and pests pose harm not only to plant and animal agriculture, but they also threaten non-edible industries such as the greenhouse and nursery industries. In Michigan alone, there are over 700 greenhouses producing $472 million worth of ornamental and vegetable crops that are susceptible to various threats.

There are also implications on the natural resources side, such as impacts on forestry – including the logging industry – and our planet in general. Movement of a pathogen from one woody host species to another has recently been identified in Michigan. In fact, some pathogens may have a host range that is broader than one or two plant species, resulting in possible introductions to other plants.

Furthermore, pathogens and pests also pose secondary threats to the livestock industry since many crops serve as forage for cattle and other animal agriculture industries and some pathogens produce mycotoxins that contaminate grain and thus harm both livestock and human health.

We know that it is not *whether* a major event will occur, but *when*. It's coming and we need to do more to be better prepared to defend our food supply, our economic vitality and our planet. Before discussing this issue, a little background might be useful.

Development of plant diseases and pests

The most important factors to determine whether an endemic pathogen or one deliberately introduced will cause significant damage are:

- Presence of a pathogen
- Susceptibility of the plant
- Environment conducive to disease

A classic example of how these three factors work together is late blight disease of potato – the cause of major potato losses in Ireland and Northern Europe in the 1840s and one we still battle to this day. This pathogen likely originated in what is now central Mexico and was transported via plants to Europe. The pathogen was severe and spread very quickly because of a favorable environment and lack of resistance in the potato plant.

Resistance was eventually bred into the potato, but this was quickly overcome through mutation and selection of the pathogen. Simultaneously, specific fungicides have lost efficacy as the pathogen, through mutation, has developed resistance to these chemicals.

This scenario has been replicated with many plant diseases, representing risks even with pathogens we have dealt with for years.

Pathogens can also evolve greater virulence or aggressiveness. As early as the 1970s, the U.S. saw a major loss in corn production due to the presence of a newly-evolved strain of the southern corn leaf blight epidemic. In another example, the breeding for rust resistance in oats led to varieties that are very susceptible to what has been a very minor pathogen. Thus, changes in pathogen genotypes can lead to the development of new strains that are even more destructive that the original strain.

Diagnostics laboratories

Early and rapid detection and diagnostics are vital, and preparedness is paramount.

The MSU Plant Diagnostics Laboratory is a major contributor to early detection and accurate diagnoses. The lab conducts tests on about 8,000 samples annually, representing over 100 plant species. The lab has introduced new diagnostic tools for many important diseases. While samples come mostly from agriculture organizations, industry groups and growers, the general public is also served by the lab. On an annual basis, samples from almost every county in Michigan are analyzed, as are samples from several other states.

A one-stop diagnostic destination, MSU Diagnostic Services formed in 1999 when Project GREEEN (Generating Research and Extension to meet Economic and Environmental Needs) united the Arthropod/Insect Diagnostic Lab, the Nematode Diagnostic Service Lab and the Plant Disease Clinic under one roof. This is truly a unique multi-disciplinary lab.

Diagnosticians address insect, nematode, plant pathogen, herbicide/weed problems and combinations of those issues. This is critically important as most plants are susceptible to more than one of these issues. This integrated approach has resulted in greater efficiency and the ability to investigate several thousand more samples per year than similar programs around the country.

With four diagnosticians, each of whom specialize in one of the four major plant pest groups, and two technical support staff members, the lab is one of the largest among the Land Grant University laboratories that collectively form the National Plant Diagnostic Network (NPDN). NPDN laboratories immediately report their findings to appropriate clients, responders and decision makers, resulting in rapid detection, diagnostics, and information needed for mitigation. The NPDN also provide training through education and outreach, and enhanced communication among public agencies and stakeholders responsible for responding to and mitigating new outbreaks.

The NPDN has five hub labs (MSU, Kansas State University, University of Florida, Cornell University and the University of California-Davis) and is financially supported by NIFA through the Food and Agriculture Defense Initiative or FADI. The sister networks supported by FADI are NAHLN (National Animal Health Laboratory Network) and Extension Disaster Education

Network. The NPDN labs work closely with USDA APHIS PPQ to complement their regulatory roles in activities by serving as triage for pathogens of regulatory concern, such as those that cause plum pox and ramorum blight, and assisting in surge diagnostics. Along those lines, all of the labs in the NPDN can be thought of as sentinels, and thus a first line of defense for new and emerging diseases and pests

Accreditation for specific high-consequence pathogens comes through the National Plant Pathogen Laboratory Accreditation Program and is administered through USDA's Animal and Plant Health Inspection Service (APHIS) – which only a few labs, including MSU, have.

Because it is unlikely that we could ever prevent all pathogens or pests from entering the U.S., and similarly unlikely that we can prevent all new outbreaks of endemic pathogens, we must be prepared at many levels to stop these threats before they become an epidemic. First, we must be able to detect new and potentially destructive pathogens and pests. Because of the distributed nature of agricultural and forestry systems, detecting new pathogen development can be difficult. However, this can be assisted through a cadre of "first detectors" who are trained to identify when something new or unusual has occurred.

The MSU diagnostic lab and many others have tools to quickly determine the type of pathogen and then use this information to identify the specific organism by one of several means. Because of the NPDN, we can rapidly and securely communicate about new, emerging and re-emerging pathogens with other laboratories at both the state and federal levels. We need to be prepared to detect all new pests and pathogens rapidly and accurately so that small problems do not escalate into large, devastating problems.

MSU continues to adopt new diagnostic tools and capabilities to ensure that samples can be quickly and accurately diagnosed. A few of the new molecular diagnostic tools to diagnose some of the more devastating diseases such as soybean sudden death, oak wilt, and a new disease – potato soft rot caused by the bacterium Dickeya – have been implemented in the lab. In addition, the capacity to screen for unknowns has also increased so that potential pathogens - even those that are new - can be identified more rapidly.

The NPDN has benefitted from diagnostic trainings on pathogens of regulatory concern that are provided by USDA APHIS Plant Protection and Quarantine (PPQ). In addition, MSU – as the hub lab for the North Central region – and other NPDN hubs have coordinated and hosted diagnostics trainings and provided support for implementing new approaches. The NPDN has also provided a mechanism to support communication among diagnosticians at land-grant universities, State Departments of Agriculture and USDA. The MSU lab also coordinates closely with the Michigan Department of Agriculture and Rural Development lab in diagnostics and exchange of information. Together, they stepped in to rapidly examine around 70,000 samples when Plum Pox was first detected in Michigan.

Needs in Michigan and beyond

Even with ongoing local and national efforts, there is still a need for better detection tools. More sophisticated surveillance equipment, such as drones and detecting other early warning signs of disease and pests such as volatile organic compounds, are needed to survey large acreage crops and natural resource.

We also need to continue to educate and prepare first detectors – individuals who are trained to detect an unusual event and know how to sample and ship samples for diagnosis. Providing this information to outreach programs, Extension educators and crop consultants needs to expand. We also need to arm more members of the general public with educational materials from the NDPN.

Better diagnostic tools and improved diagnostic infrastructure are high on our want list. We will also continue to partner with researchers at the land-grant universities as well as those at USDA APHIS PPQ and USDA ARS to help develop new tools.

Equally important is the need to raise the public awareness about the importance of this issue. This becomes even more complex as we face the challenge of having to double our food supply by 2050, with fewer natural resources and the same amount of land. We need to be more proactive when it comes to both endemic and introduced pathogens and pests. Early detection and diagnosis is critical to reducing the risk. Working with Extension to deliver training and education to first detectors and the general public is one of several strategies that can be used.

Resistance is a constant challenge

Resistance to pest management chemicals is a battle we continue to wage. Research efforts must also focus on developing new varieties that have durable host resistance.

On the herbicide, fungicide and insecticide front, we are working to address decreased efficiency due to resistance. This is only complicated by the fact that the pipeline of new chemistries is drying up. Programs like IR-4 (Interregional Research Project No. 4 – which ensures that pesticides are registered for use on crops) are becoming much more important as we address risks of endemic and re-emerging pathogens and pest.

There is a continual need to develop new and more rapid diagnostic tools for pesticide resistance. With advances in molecular biology and more information available on the genomes of pathogens and other pests, this type of development is occurring. Early detection of pesticide resistance is critical when deploying disease management approaches.

There is also a need to work toward the development of plant varieties that have durable resistance to diseases and pests and find new ways of preventing the onset of pathogen and pest resistance to fungicides, antibiotics, insecticide and herbicides. Changes in host genotypes in relation to pathogen virulence and potential for development of resistance to chemical controls must be taken into account as broader plant protection plans are developed for the future.

The added pressure of climate change

The situation of potentially devastating pathogen and/or pest infestations has become even more complicated by climate change. Temperature and weather play a key role in determining the susceptibility for certain diseases to spread and survive throughout winters, even those in Michigan.

The change in climate may also impact the expression of disease in a positive or negative way. Drier or even wetter conditions may increase the threat of some disease, but these stresses may render them more susceptible. Changing climate may also change cropping systems and with it, growing plants that have different disease susceptibilities. Some pathogens that are less cold tolerant may have expanded northern ranges as overwintering temperatures warm.

In Michigan, potato growers are provided with early season risk assessments for late blight by informing them of the likelihood of tubers left in the field surviving the winter. The blight pathogen can only survive in living tubers, and over the last few years the risk of tuber survival in the field has increased and thus the risk of late blight as well.

At MSU, plant breeders and plant pathologists have teamed up to examine how potatoes will respond to the climate of the future. Using historical weather data dating back to 1980 and climate change projections from the North American Regional Climate Change Assessment Program, they’ve developed three potential climate models – each for Michigan between the years 2040 and 2070. This range was selected because the models would retain a high degree of accuracy and would give enough time to develop entirely new potato cultivars.

It takes between 10 and 15 years to create a new potato variety from start to finish, so we need to be proactive about identifying the challenges the future could bring. Farmers can’t simply change their varieties year-to-year to react to last season’s issues. They must look ahead as best they can.

The impact of climate change also varies depending on the potato cultivar. Most potatoes harvested in Michigan are ultimately moved into long-term storage, where they can be preserved for months and provide processors and retailers with product nearly year-round. Examining the impact of climate change on the potatoes’ ability to retain their quality in storage is of importance as well.

The climate models and experiments are telling us that we’re going to see new stresses on potatoes, and that means we need to develop new varieties that can withstand that type of environment. And this goes beyond Michigan – it's going to affect all potato-growing states across the northern U.S., which together feed a lot of our country.

Few crops are as important to Michigan as the potato, the top vegetable crop. Michigan farmers have 50,000 acres of potato production, which, along with processing and marketing, generates over $1.24 billion annually and contributes more than 3,200 jobs to the state's workforce.

Climate change is also impacting the apple industry, as apple trees break dormancy earlier every year, running the risk of damage from frost. Higher temperatures and wetter conditions exacerbate major diseases like fire blight and apple scab. For example, a fire blight epidemic in 2000 wiped out nearly 400,000 apple trees in southwestern Michigan and caused over $42 million in losses. To combat rising instances of both diseases, new cultural practices and monitoring for fungicide and antibiotic resistance in the pathogens are being provided to growers for removing fire blight cankers and hastening the decomposition of dead leaves (in which the apple scab fungus overwinters) with fertilizers.

Some Additional Michigan threats

Disease and pests can cause significant economic losses. In Michigan, there are many examples of the spread of new and even re-emerging pathogens. Examples include downy mildew of cucumber, *Phytophthora* fruit and vine rot of cucurbits, sudden death of soybean, fire blight of apple, spotted wing drosophila, stripe rust of wheat and oak wilt. In many of these cases, disease resistance may not be available and this is confounded by the development of resistance to effective pesticides by the pathogens. There is also a risk for pathogens and pests to make their way to Michigan via the busy port of Detroit and Metro Detroit Airport.

To address these issues, forward thinking applied and fundamental research on these and other problems is ongoing at MSU to find sustainable solutions.

Downy mildew: Michigan is the No. 1 producer of pickling cucumbers in the nation. *Pseudoperonospora cubensis* is a fungal-like organism that causes downy mildew disease and can infect a variety of cucurbit crops including cantaloupe, cucumber, gourd, honeydew, muskmelon, pumpkin, squash, watermelon and zucchini. Downy mildew reemerged as a problem on cucumbers in Michigan in August 2005 when the disease spread across the eastern region of the United States and has recurred every year since then.

Spotted Wing Drosophila: This tiny invasive fly has caused fruit growers, including cherries, raspberries and blueberries, great concern. While researchers are feverishly studying this insect, they have yet to find any good controls other than spraying, but we lack the chemicals to treat the pest. Females can deposit up to 100 eggs per day by puncturing the soft skin of the fruit. It arrived from Asia in 2008.

Leaf spot: In 2017, sugar beet growers were on heightened alert for the increased risk for leaf spot. Fungicide resistance has developed in some fungicides and is increasing in the other chemistries. Until new leaf spot-tolerant varieties enter the market, the majority of the highest yield potential varieties are fairly susceptible to leaf spot disease. With sugar prices relatively low and nitrogen cost fairly high, economics will change the most cost-effective rates.

Brown marmorated stink bug: First detected in the United States in 1998, this invasive pest has now spread to 43 states and four Canadian provinces. It is known to prey on over 300 different host plants, including over 100 agricultural crops and ornamental plants. In 2010 alone, the brown marmorated stink bug is estimated to have caused over $37 million in damage to the apple industry across the mid- Atlantic, with some growers losing up to 60 percent of their crop. Current efforts to control the pest include developing an online reporting system to track the population and introducing natural predator wasps from its native range.

Removing pathogens from greenhouse water: a new approach to disease management

Addressing these issues takes a multidisciplinary approach and that research is underway at MSU. Consider this example: a soil physicist has teamed up with a plant pathologist to better understand and prevent the transportation of plant pathogens in greenhouse systems. They are focused on removing *Phytophthora* and *Pythium*, water molds that wreak havoc on a wide range of crops, from nursery and greenhouse waste water so it can be reused. Spores from these molds called zoospores can travel through water and infect neighboring plants, a chain reaction that can quickly devastate a grower's operation.

They focused on methods to retain *Phytophthora* zoospores in the filtration process, analyzing the retention ability of porous media such as iron-oxide-coated sand and uncoated sand in a range of solutions at different pH levels. The filters function similarly to household units attached to faucets, but the media in those filters is typically activated carbon. The group found that the iron-oxide-coated sand retained zoospores at a greater rate in higher-pH solutions. Both the coated and uncoated sand performed well in low-pH solutions.

These findings indicate that filtering the pathogen can be effective and is optimized when the environment is better controlled — an encouraging sign for greenhouse systems. The team has most recently constructed a water-recycling unit using the same filters. In trials with squash and poinsettias, iron-oxide-coated sand filtration again proved effective, outperforming both activated carbon and a fungicide treatment with no filter. The results bode well for implementing recycled-water systems, which require less water, fungicides and pesticides.

In summary

Pathogens and pests will continue to evolve in ways that overcome host resistance and chemical control tools thus making endemic and re-emerging pests more dangerous. Some may even find new hosts. Environmental stresses on plant growth can also lead to more extensive damage caused by pests and pathogens. Because of global trade, we are at risk of introducing new pests and pathogens as well as variants of endemic species. Thus, the threat to plant systems can come from many different directions, and the need for proactive detection and diagnostic technologies, and enhanced preparedness at all levels is more important than ever before.

Thank you again for the opportunity to speak with you today and I look forward to addressing your questions.