ABOUT NPMTI

The National Predictive Modeling Tool Initiative (NPMTI) is designed as a multi-year program to develop research-based "tools" that will help forecast incidences of diseases and mycotoxins affecting U.S. crops. Armed with this information, growers and their consultants will be able to make better informed management decisions.

NPMTI Goals

The overall goals of AgPMT are to:

- Ensure crop sustainability and crop quality.
- Provide climate change resilience.
- Improve soil health.
- Monitor pathogens and microbial diversity in the environment, including, but not limited to, crop residues, soils, and air.
- Improve crop disease management, thereby reducing yield losses.
- Increase precision of in-season crop disease management tactics.
- Increase precision of pesticide use.

NPMTI Hypothesis

In-season risk for plant disease development can be improved to near real-time by developing a comprehensive and coherent modeling tool that integrates:

- Quantifying pre-season pathogen inoculum density in the field.
- Superior crop/host genetics.
- The effects of soil type and other agronomic factors on pathogen inoculum density.
- An air monitoring system for wind-borne pathogens.
- Meteorological (and other agronomic data), in a coherent information and decision support system.
- The use of other artificial intelligence platforms (e.g., unmanned aerial vehicles).
- Information from historic outbreaks for specific plant diseases.

AgPMT will incorporate monitoring techniques to address all sides of the "plant disease triangle" concept to provide a more precise predictive tool for in-season disease risk. In turn, this will help to achieve the goals listed above.

Rationale

From year to year and state to state, disease severity and the resulting losses can differ greatly. Disease development is dependent on three factors, which are often called the plant disease triangle: the presence of the pathogen, the susceptibility of the hybrid to that pathogen, and the environment (prevailing weather conditions, agronomic practices, cropping history, etc.). Disease management relies on manipulating these factors in ways that discourage infection or slow the progression of disease. For example, growing a resistant hybrid, managing previous crop residue (often a source of inoculum), crop rotation, or applying a fungicide.

In recent years, many growers across the nation have adopted soil conservation practices including reduced tillage and cover crops to address the resulting threats of soil erosion, rainfall runoff, and soil crusting. Reduced tillage also provides climate change resilience. The practices have helped to improve the sustainability of U.S. agriculture. However, these soil conservation practices have precluded the use of two standard disease controlling tools: 1) crop residue incorporation (i.e., sanitation) and 2) exclusion of alternate hosts.

Historically, post-harvest crop residues were buried to decompose. With conservation tillage, these residues remain on the surface providing climate change resilience and soil health benefits. However, this also can increase pathogens for future infestations. Farmers need tools to predict when pathogens will threaten. Wind- or insect-dispersed pathogens require community efforts to control costs and minimize yield/quality loss. NPMTI is adapting recent advancements in human pathogen detection and modeling to agricultural systems.

Modeling

Currently growers rely on scouting to determine the level and severity of disease in a particular field. As farm sizes increase, it becomes increasingly difficult to scout every field. For some crops, models have been developed to predict risk of disease and recommend a management practice. Good examples include the

Fusarium head blight risk assessment tool that integrates specific weather variables 15 days prior to flowering to estimate the risk of Fusarium head blight being greater than 10%. Farmers, extension specialists, or crop advisors use the information to schedule targeted fungicide applications to manage disease and thereby reduce losses and ensure grain quality. More recently, a model to predict white mold of soybeans was developed using 30-day weather averages, crop growth stage, and cultural practice data that has been validated and integrated into a smartphone app that producers and consultants use to determine if a fungicide application is warranted.

The Case for Advanced Modeling

While epidemiological models predict the likelihood of disease based on environmental conditions conducive to the pathogen of interest, pathogen monitoring methods that include post-harvest soil and crop residue sampling and in-season spore trapping could also be used to detect early onset of plant disease. A strong correlation between spore collections and model predictions of the spread of soybean rust in the U.S. has been reported. Cucurbit downy mildew outbreaks in the eastern U.S. were predicted using a forecasting system that combined data on known inoculum sources, long-distance atmospheric spore transport and spore deposition modules. In recent years, spore trapping technologies have advanced in tandem with the advances in molecular tools available for pathogen identification, yet their inclusion into predictive models for disease detection are vastly underutilized. Since many field crop diseases are spread by spores, a network of spore samplers across a region could be used as part of a disease-forecasting system that will build off of post-harvest soil and crop residue sample results.

Methods to forecast inoculum exposure would allow growers to take timely preventative actions such as: delayed planting, resistant varieties, selective fungicides, crop growth regulators, irrigation management, targeted rotations, and – only where necessary – limited tillage, among other agronomic practices.

The last two decades have demonstrated that the U.S. is vulnerable to invasive and resurgent pathogens spreading from distant states or countries, often triggered by unusual weather. The next two decades could be even more challenging as pathogens from the South spread farther north. A forecast system would provide growers actionable detection of pathogens before widespread damage occurs and provide public scientists data on changes in pathogen diversity necessary to breed and deploy protective host plant resistance traits.

NPMTI Leading the Way

Ultimately, NPMTI will be a national, multi-crop disease forecasting tool that will expand to include a diversity of crops and scientific disciplines across the United States. The current endeavor brings together a network of scientists from Land Grant universities, USDA-ARS, and cooperating national laboratories. NPMTI is foundational for leveraging human infectious decision support tools for agriculture. Adaptation of these tools for key diseases of a variety of crops will facilitate disease management and preventive/mitigative actions, and planning for disease prevention. These tools offer decision support at varying temporal and spatial scales and can be used along the spectrum of engagement, from early detection to outbreak management to post-harvest investigation to host plant resistance breeding.

Over time, baseline background levels of various pathogens can be established, which will help with anomaly detection and serve as an early warning system for our nation’s food security.