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Research Proposal

PROJECT TITLE: Extension of State-Wide Disease Forecasting Models for Anthracnose Ripe Fruit Rot and Botrytis Fruit Rot

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ABSTRACT: The objective of this work was to develop a decision support system to help strawberry growers reduce the number of fungicide sprays for anthracnose fruit rot and Botrytis gray mold management without compromising levels of disease control. A State-wide weather monitoring system was developed in cooperation with the NC State Climate Office and critical parameters to drive plant disease, insect and crop phenology models was refined in cooperation with G. Buol and G. Wilkerson in Crop Science to develop an integrated framework. The initial implementation of the framework has been used to develop decision aids for predicting strawberry disease risk during flowering and fruiting. Links were incorporated into the NC strawberry extension portal for real-time and rapid access for grower use. The forecasting outputs were further linked to disease factsheets and fungicide recommendations for both Botrytis and anthracnose, updated annually. The complexity of the updates has changed dramatically with the emergence of fungicide resistance in both the Botrytis and anthracnose populations. The Strawberry Fruit Infection Risk Tool and updated control recommendations were presented at multiple local, regional and national meetings. Linking forecast models to updated control recommendations provides growers a suite of tools to improve strawberry fruit rot management.

JUSTIFICATION: Strawberry yields are limited by anthracnose ripe fruit rot and Botrytis gray mold. These diseases are recurrent and cause serious economic problems. Growers rely heavily on scheduled fungicide sprays to limit losses. However, growers face numerous challenges with regard to the use of fungicides as the primary means to control disease. Fungicide resistance has emerged in both the Botrytis and anthracnose pathogen populations. The overall goal of our program is to provide up to date information and decision aids to help strawberry producers reduce the number of fungicide sprays and economic losses associated with plant diseases and increase efficacy of control.

We now have the IPM portal, so information can be found in a single location.

METHODOLOGIES AND RESULTS:
IPM outcomes are best served by availability of near real-time data generated through monitoring and/or validated models to local pest management decision makers. Growers and other pest management decision makers consistently identify rapid access to data as a high priority to optimize management strategies. Historically, management recommendations were linked to multiple, typically inter-disciplinary, publications and static webpages that addressed stakeholder needs and information priorities. Over the last few years we have conducted field tests and developed an infrastructure to capture weather data and then use this data to drive models to guide grower fungicide

decisions. We were able to catalyze this Small Fruit Center Grant with Extension IPM funding and money from the NC Strawberry Growers to advance the Strawberry Fruit Infection Risk Tool. (https://ipm.ces.ncsu.edu/strawberry-fruit-infection-risk-tool).

Our State Climate Office Pest Modeling team completely re-wrote and greatly enhanced the web-services pathway to our entire weather database. This new Application Programming Interface (API) allows for a more seamless data search and retrieval of station data from a range of public providers (e.g. Ag Research Stations, National Weather Service, and Forest Service) and is the mechanism for feeding weather observations into disease and insect risk tools and crop phenology tools. The API has been engineered to serve a range of current and future needs, and will allow for broader implementation and delivery of pest decision support tools. We worked with the Climate office to deploy 34 leaf wetness sensors across the state at existing weather stations (see figure). Leaf wetness is a critical component of the Botrytis and anthracnose fruit rot rick models (unfortunately, otherwise our system could capture data from 100s more weather stations for higher measurement).

We also worked with Greg Buol and Dr. Gail Wilkerson in Crop and Soil Science to further optimize an integrated framework to utilize the weather data and translate it into useable information for growers. The framework utilizes a multitier architecture composed of data, business, RESTful web services, and client application layers. The framework manages weather data from multiple external data sources and networks including National Weather Service (NWS) 7-day hourly forecast data to drive the prediction models. To achieve acceptable levels of performance, the framework relies on short term data caching and parallel processing to handle weather data and execute models. The initial implementation of the framework has been used to develop decision aids for predicting strawberry disease risk during flowering and fruiting. This captured data is pulled in real time, analyzed and then portrayed on a map accessible through our Strawberry Portal (strawberries.ces.ncsu.edu). Growers then chose the location nearest them to observe the level risk due to Botrytis fruit rot (gray mold) or anthracnose fruit rot. The Strawberry Fruit Infection Risk Tool provides a graphical display of risk for the past 10 days and coming seven days (see figure). This provides growers additional

information as they weigh the multiple factors that determine a decision to apply a fungicide.
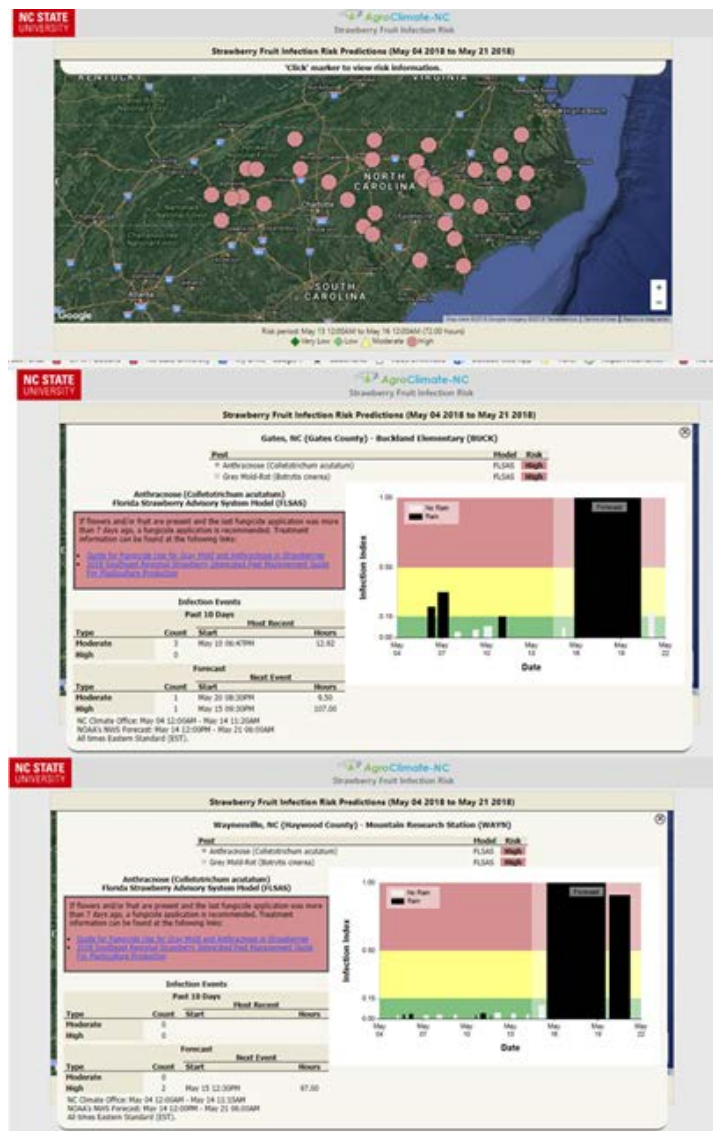
We initially included the Florida Strawberry Advisory System (FLAS) and a Generic Infection Model. However, after this proposal was submitted and funded, we elected to only include the FLAS in our extension products. We also provided detailed information about the models: https://ipm.ces.ncsu.edu/development-of-anthacnose-and-botrytis-strawberry-fruit-infection-risk-models. In our proposal, we also sought to push alerts to grower smart devices. However, in collaboration with our extension IT team we elected not to pursue this mechanism of notification. Growers can access the model from any device at their convenience. We conducted two grower surveys and found approximately 25% to 50% of growers use the models to guide decisions. Many growers were not aware of the models suggesting more extension education is warranted.

A critical part of our recent extension efforts has been to link the model to other IPM-based information. The description of the model (https://ipm.ces.ncsu.edu/strawberry-fruit-infection-risk-tool) has links to updated factsheets on the fruit rot diseases. This enables growers to learn more about the biology of the pathogens and diagnosis and management of the diseases. We also include a link within the graphical display (see figure) to our Guide for Fungicide Use for Gray Mold and Anthracnose in Strawberries, designed to further help growers make fungicide decisions. We also incorporated a link to the annul updates of our Southeast Regional Strawberry Integrated Pest Management Guide for Plasticulture Production hosted at the Small Fruit Center. In the past two years, we have substantially edited this product to include very specific, and we hope more helpful, guidelines to manage fungicide resistance and to target resistant pathogen populations. The guide in turn also provides a link to the Strawberry Fruit Infection Risk Tool.

Finally, we presented data, the strawberry disease-risk tool, our most up to data IPM recommendations and current challenges and new IPM practices at local and regional meetings to communicate to strawberry growers the outcomes of this funded work. We hope that these tools will reduce risk of disease in strawberry production systems and enhance grower profits.