A. Grant Data

Title: **Validation and Implementation of a Weather-based Spray Advisory Model for White Rust of Spinach**

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B. **Nontechnical Summary**:

Spinach is grown on more than 35,000 acres in the U.S. It is an important crop for the fresh and processing markets in Maryland and Delaware where acreage has increased over the last ten years. White rust is the most important foliar disease of spinach in the mid-Atlantic region. Despite widespread crop rotation and some use of host resistance, white rust is managed primarily through fungicide use. A fungicide-application model for spinach white rust based on local weather was developed in Oklahoma. Preliminary trials in the mid-Atlantic indicated that the model may improve timing of fungicide applications. The overall objective of this project is to assist growers in adopting a weather-based fungicide application model for spinach through an improved understanding of *i*) presence and extent of over-wintering oospore inoculum, *ii*) identification of the optimum time to initiate fungicide applications, and *iii*) identification of fungicides that can be successfully used with a weather-based fungicide application model.

C. **Introduction**

Spinach (*Spinacia oleracea* L.) is an important crop grown for the fresh and processing markets in Maryland and Delaware where acreage has increased in the past ten years. Together Delaware and Maryland constitute the fourth leading spinach producing area in the U.S., with 2700 acres produced in Maryland alone. White rust (*Albugo occidentalis* G. W. Wils.) is consistently identified as a priority concern of spinach growers and

processors in the mid-Atlantic region. White rust is frequently cited as the most prevalent and difficult to control disease of spinach.

Crop rotation is used on most of the spinach acreage in the U.S.; however, rotation alone is not adequate to control white rust. Recently cultivars that have moderate levels of resistance to white rust, and with fair agronomic characteristics, have been developed. However, fungicide applications are necessary on moderately resistant cultivars to limit the incidence of white rust lesions that reduce leaf quality. Despite widespread crop rotation and limited use of host resistance, fungicide usage is very high on spinach in order to control white rust.

Fungicide applications may be reduced without incurring yield or quality loss in some environments and on some cultivars. The ability to schedule fungicide applications to coincide with periods of environmental conditions that are conducive to disease would reduce application frequency and/or increase the efficacy of each application. A fungicide-application model based on the relationship between the environment and white rust on spinach was developed in Oklahoma. Temperature during periods of leaf wetness was used to time fungicide applications. There is great interest in adaptation of this weather-based fungicide application model and it was modified and preliminary tests were conducted in the mid-Atlantic. Experiments in Maryland in 2002 indicated that the model may improve timing of fungicides and economic return for growers.

However, despite preliminary success with the model, the time within the growing season to initiate the model has not been adequately tested. In addition, growers are looking for reduced-risk fungicide and biofungicide alternatives to their currently used controls.

D. **Objectives**

The overall objective of this project is to assist growers in adopting a weather-based fungicide application model for spinach through an improved understanding of *i*) presence and extent of over-wintering oospore inoculum, *ii*) identification of the optimum time to initiate fungicide applications, and *iii*) identification of fungicides that can be successfully used with a weather-based fungicide application model.

Progress on completion of all three objectives was made during this report period.
Trials were conducted in the fall of 2005 at UM-Wye REC and UM-LESREC; however no white rust developed at either location. In the spring of 2006 plots were established at the UM-Wye REC. White rust developed and we found significant differences among treatments.

E. **Approach**

A survey of growers' fields was conducted in winter 2005-2006. In addition, fungicide timing and fungicide efficacy was studied in replicated field trials at two locations in Maryland.

F. **Progress**

Spinach fields in Kent and Sussex counties in Delaware; and Caroline, Carroll, and Queen Anne's counties in Maryland were scouted for presence of white rust. Leaves infected with white rust were collected and observed microscopically. No oospores were found.

Trials were conducted in the fall of 2005 at University of Maryland's Wye Research and Education Center (UM-Wye REC) and Lower Eastern Shore Research and Education Center (UM-LESREC); however no white rust developed at either location. Because the model-based foliar fungicide timings are based on weather, we did apply sprays in the fall of 2005 when no disease occurred. This indicates that the model over predicts applications under some weather conditions.

In the spring of 2006 plots were established at the UM-Wye REC. Fungicide applications were scheduled to begin according to four fungicide timings (foliar fungicide application initiated at first sign of disease and subsequent applications weekly; foliar fungicide application initiated at first sign of disease and additional applications according to the model; foliar fungicide application initiated three weeks after emergence and additional applications weekly; model initiated two weeks after emergence and applications scheduled according to the model). However, due to weather conditions the model applications were applied on a weekly schedule (the threshold always was reached within a week). Therefore there were effectively only two times of initiation of sprays, applications began either at the first sign of disease or applications began three weeks after emergence. Preliminary results indicate that delaying the first application until white rust is observed in the field resulted in an unacceptably high level of disease (19% of leaves were infected when applications began with scouting, and 2% of leaves were infected where the applications began 3 weeks after emergence). There was a trend that increasing the Ridomil Gold rate from no Ridomil Gold applied at planting to 2 pt/A reduced the percentage of white rust infected leaves.

An experiment to evaluate reduced-risk fungicides and biofungicides also was conducted in the spring of 2006 at the University of Maryland's Wye Research and Education Center in Queenstown. The plots were established at N38.91928 and W076.13763 and cultivar Seven R was seeded on 12 Apr. Weeds were managed by mechanical cultivation and application of Spinaid at 3 pt/A on 12 May. Damping off was managed with a post-plant soil application of Ridomil Gold 4E at 1 pt/A. Ridomil Gold has activity on white rust and the length of residual activity of soil application is estimated at 3 to 4 weeks. Foliar fungicides were applied with a tractor mounted boom sprayer and began on 15 May (three weeks after emergence). Plots were inoculated on 29 Apr by placing an infected spinach leaf at the center of the bed every 10 feet. Additional infected leaves were placed in the border rows on either side of the experiment on 23 May.

Plots were harvested on 5 June and leaves that had no white rust lesions or that had lesions that were less than 1 cm ("non-infected") were separated from leaves that had one or more white rust lesion that were 1 cm in diameter or larger ("infected"). Infected and non-infected leaves were weighed.

White rust was first observed on 26 May in numerous foci that were distributed throughout the field. All fungicide treatments reduced the white rust infected tissue compared to non-treated plots. In addition there were no differences among fungicide treatments.

Fungicide and rate /A	% leaves with lesion*	
Quadris 208F 8 fl oz (1, 2)		
Kocide 2000 53.8DF 1 lb (3) …….....	0.9	b**
Actigard 50WG 0.8 oz ……...	2.2	b
Pristine 38WG 15oz ……	0.0	b
Cabrio 20EG 12 oz …….....	0.4	b
Tanos 50WG 8 oz ……	0.3	b
Reason 8.5 fl oz ……..	0.0	b
Zoxium 80W 3.3 oz plus		
Kocide 2000 53.8DF l lb …….....	0.5	b
Serenade ASO QRD143 3 qts plus		
Kocide 2000 53.8DF 1 lb …….	1.7	b
Nontreated ……...	15.1	a

* Percentage of leaves with lesions 1cm in diameter or more.

** Means within a column followed by the same letter are not significantly different (*P*=0.05).

Figure 1. White rust symptoms appear first as chlorotic spots on the adaxial (upper) leaf surface.

Figure 2. Profuse sporangial development on the abaxial (lower) surface of the leaf.

Figure 3. White rust is spread through the spinach crop as sporangia fall to lower leaves in the plant canopy and are blown to nearby plants.