Final Project Report to the NYS IPM Program, Agricultural IPM 2000 – 2001

Title: Developing Damage and Economic Thresholds for Foliar Disease Management in Perennial Plantings of Strawberry

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Type of grant: Monitoring, forecasting, and economic thresholds

Project location(s): Findings can be applied across the Northeast

Abstract: Leaf spot, leaf blight, and leaf scorch are foliar diseases of strawberry commonly found in perennial plantings throughout North America. These diseases are suspected to adversely affect yield, winter hardiness, and the overall production life of a planting. A three year study was implemented to determine to what extent these diseases impact yield and the production life of a planting, and to define when it is economically feasible to manage them. The first year of the study focused on: 1) Gathering baseline yield data in established plots in Ithaca, NY; 2) Creating a disease gradient across these plots so that we may effectively study how disease impacts yield over the production life of the planting; 3) Establishing a ½ acre strawberry planting in Geneva, NY with varieties that are differentially susceptible to the diseases under study; and 4) Developing and refining experimental procedures to look at the effects of disease under experimental conditions. From the above, we were able to establish that yield across all experimental plots located in Ithaca was statistically identical this year (as we expected). Therefore, our hypothesis is that any future reduction in yield would be directly correlated with the disease gradient, i.e., the lowest yielding plots would have the highest level of disease. For greenhouse/laboratory-based experiments, we had to work through several glitches in the experimental procedures before we were able to make any headway. We started work with leaf scorch (we will look closely at the other diseases this winter). Preliminary results showed that photosynthesis declined rapidly and approached zero as leaf scorch severity increased. This implies that moderate to heavily infected leaves are contributing very little to the development of the plant and would presumably have a negative impact on yield. Identifying these types of relationships for the other diseases under study will allow us to make formal recommendations as to when management is economically feasible. The second year of the study will bring to light much about these diseases and their affect on production.

Background and justification:

Leaf spot, leaf blight, and leaf scorch are foliar diseases of strawberry encountered commonly in perennial plantings throughout North America (Ellis, 1995; Ellis, 1998; Xue et al, 1996). The three diseases are relatively easy to distinguish through their symptoms, even when found on the same leaflet. All three diseases are caused by fungi. Leaf scorch is caused by the fungus *Diplocarpon earlianum* (Ell. & Ev.) Wolf. Strawberry leaf spot is caused by the fungus *Mycosphaerella fragariae* (anamorph *Ramularia brunnea*) and is one of the most common and destructive diseases of cultivated strawberry worldwide (Maas, 1984; Nemec, 1972). A serious disease of strawberry occurs when *M. fragariae* infects the fruit known as black seed, (Maas, 1984). The causal agent of leaf blight is the fungus *Phomopsis obscurans* (Ell. & Ev.) Sutton. In years of high disease pressure, infections may develop on the stolons, petioles, and fruit (Howard and Albregts, 1973).

All three pathogens overwinter in diseased tissue and leftover crop debris. In spring, they become active and produce inoculum to initiate epidemics. Secondary cycles of infection result from primary infections and can continue throughout the season under favorable conditions. *M. fragariae* and *D. earliana* infect young, expanding leaves and petioles. *P. obscuans* primarily attacks older leaves and typical disease

development begins in late spring or early summer in New York. In years of high disease pressure, infections may also develop on the fruit causing significant economic losses (Howard and Albregts, 1973). All three pathogens require free moisture for infection. The optimum temperature for infection and disease development is in the range of 15 and 25 C for leaf spot and leaf scorch and a little warmer for leaf blight.

In a typical year, disease severity reaches its peak at or after harvest on June-bearing varieties. The extent of direct losses attributable to these diseases is not known, but high levels of disease weaken the plant which may affect winter hardiness and, quite possibly, yield in the *following* season. Furthermore, it is unclear what affect recurring annual epidemics have on the production life of a perennial planting. The average production life of a perennial matted row strawberry planting is approximately 4 years, but it is unknown whether this can extend beyond 4 years if these diseases were managed.

Many growers are reluctant to apply fungicides to control foliar diseases after harvest because the economic benefits of doing so are unclear. Simply, the cost of applying a fungicide with good broad-spectrum activity against foliar diseases, such as Nova 40W, must be compensated by an equal increase in revenue. This could be manifested in either an increase in yield the following season, an extended life of the strawberry planting, or a combination of the two. The financial reward of extending the life span of the planting is measured not only in net return of yield, but also in terms of the cost savings associated with delaying removal and re-planting of a field.

Several questions must be addressed in order to assess the value of summer management of foliar diseases. First, what is the relationship between foliar disease severity and yield? Answering this question will help to establish damage and, eventually, economic thresholds. Second, do each of the three foliar diseases affect plant health similarly? This can be assessed by measuring photosynthesis rates in relation to disease intensity. And thirdly, is it economical to manage these diseases after harvest? The goal of this study is to determine the yield loss attributed to foliar diseases and determine an economic action threshold for managing these diseases. This proposal is slightly modified from the original.

Objectives:

1. Conduct a greenhouse study to determine the effect of leaf spot, leaf blight, and leaf scorch on the rate of photosynthesis in strawberry leaves.
2. Determine the effect of leaf spot, leaf blight, and leaf scorch on strawberry yield and photosynthesis in perennial matted row plantings of strawberry.
3. Determine an economic threshold for foliar disease management based on the relationship among disease severity, photosynthetic rate, and strawberry yield.

Procedures:

Objective 1: Plants of the varieties Jewel, Honeoye, and Kent will be potted in 6 inch pots and grown under greenhouse conditions. Because leaf age has an effect on the susceptibility of leaves to infection, leaves will be tagged as they emerge to track leaf age (Zheng and Sutton, 1994). The pathogens will be isolated from diseased leaf tissue and cultured on a suitable medium. *Phomopsis obscurans* and *Diplocarpon earliana* will be cultured on potato dextrose agar (Eshenaur and Milholland, 1989) and *Mycosphaerella fragariae* will be cultured on strawberry agar nutrient medium (Carrise and Peyrachion, 1999; Delhomez et al., 1995). To assure that all isolates maintain their pathogenicity, they must reisolated from diseased tissue after no more than three successive transfers on artificial media. This was unknown to us before we initiated the experiment last year.

Two sets of inoculations will be performed. In the first, individual suspensions of *P. obscurans*, *M. fragariae*, and *D. earliana* conidia will be prepared by washing conidia from single-isolate cultures of the selected fungus into a 0.1% vol/vol Tween 20 solution and adjusting the concentration of each to 10^5

conidia/ml via a hemacytometer. For the second set, individual inoculum suspensions will be prepared as described above and then mixed in equal volumes to produce a 10^5 conidia/ml suspension of mixture of the three pathogens.

Single plants will be inoculated with either one of the three single-pathogen suspensions or with the pathogen mixture, placed in a 20 C mist chamber and, after a prescribed period of wetness, removed from the mist chamber to the greenhouse to allow disease to develop. By exposing plants to different leaf wetness periods, a range of disease severities will be produced allowing us to evaluate the effect of disease on photosynthesis. We will use the results of Carisse et al. (2000) and Zheng and Sutton (1994) as guidelines for determining suitable wetness periods.

Rates of photosynthesis will be measured for each leaf on every plant using a photosynthesis meter. Measurements will be taken on the same day for all leaves under optimal conditions (i.e., under bright sunlight with relatively cool temperatures). After photosynthesis measurements have been taken, leaves will be detached from the plant, photographed, and their images digitized. The digital images will be used to calculate leaf area and the proportion of the leaf area diseased. Photosynthesis rates will be averaged over leaves with identical ages on the same plant. Data will be analyzed in a generalized linear model (GLM) with rate of photosynthesis as the response variable, disease severity and leaf age functioning as continuous predictor variables, and individual plants serving as the replication.

Objective 2: Research plots will be established in commercial-scale perennial plantings of strawberries on Cornell University research farms in Ithaca and Geneva. Strawberries of the varieties Jewel, Honeoye, and Kent will be grown in a matted-row system on 4-ft centers. Individual plots will consist of three 15ft row sections. To control the level of foliar disease within plots, different application rates and timings of the fungicides Nova and Captan (either in tank-mix or in alternation) will be used as described below. Nova and Captan should show efficacy against all three pathogens (Ellis et al., 1997). In each planting, a randomized complete block design with 6 treatments and 6 blocks (reps) will be established. The treatments applied to control foliar disease levels will be as follows: 1) no fungicide; 2) quarter-rate applied every other recommended application; 3) half-rate applied at every recommended application; 4) quarter-rate applied every recommended application; 5) half-rate applied every recommended application; 6) full label rate on calendar spray. Except for fungicide applications, plots will be managed using standard commercial practices.

Plots will be sampled every two to three weeks to monitor disease development from mid-May through October. Individual sampling units will consist of five leaves of three leaflets each, where each 15ft plot contains five evenly-spaced sampling units. In each sampling unit, leaflets will be rated for the presence or absence of leaf blight, leaf spot, and leaf scorch symptoms. This sampling procedure has been used extensively in sampling for foliar diseases of strawberry in Ohio (Turechek and Madden 1999a,b and 2000). Photosynthesis will be measured on a subset of leaves in each plot with a photosynthesis meter. Strawberries will be harvested in accordance to the season and the berries weighed for each plot to provide a measurement of crop yield. Regression analysis will be used to characterize the relationship between foliar disease incidence (final and average), rate of photosynthesis, and yield in the following year.

Objective 3: Using the results obtained in objectives 1 and 2, an analysis will be performed to determine economic thresholds for the management of foliar diseases. The analysis will be conducted using an Excel spreadsheet designed by Alison DeMarree, Regina Rieckenberg, and Marvin Pritts to evaluate the cost of strawberry production. The analysis will consider the effect of factors such as the reduction in yield relative to disease severity, the market price for strawberries, and the cost of fungicide applications.

Results and Discussion:

Objective 1. After working through several glitches in the experimental procedures, and once we learned how to effectively manage powdery mildew in the greenhouse in manner that would not interfere with the pathogens that we want to work with, we began to make progress on objective 1. We started by looking closely at the effect of leaf scorch on photosynthesis under greenhouse conditions, i.e., in a greenhouse maintained at approximately 65-70 F. (The effect of the other two diseases are being investigated this winter.) We inoculated plants of the cultivar Honeoye with the leaf scorch pathogen *Diplocarpon earliana*, placed them on a greenhouse mist bench to maintain leaf wetness, and after a prescribed period of misting, plants were removed from the mist bench and placed on a dry bench to allow disease development. By exposing plants to different leaf wetness periods, we were able to produce a range of disease severities that allowed us to better evaluate the effect of disease severity on photosynthesis. Disease developed approximately 1 week later. We then measured photosynthetic rate on individual leaves using a photosynthesis meter and measured the proportion of area of leaf infected with digital imaging equipment.

Preliminary results from the first trial of this experiment are shown in figure 1. It was clear from these results that photosynthesis declined rapidly and approached zero as leaf scorch severity increased. These results, however, are preliminary and this trend may be different in the field, where environmental conditions are more variable, or on different varieties. But if we assume that this trend is representative of the effect of leaf scorch (at least under some conditions), this implies that moderate to heavily infected leaves are contributing very little to the development of the plant and would presumably have a negative impact on yield.

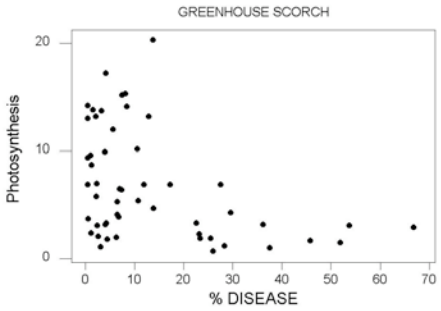

Figure 1. The effect of leaf scorch on photosynthesis of strawberry leaves under controlled conditions.

Objective 2. Research plots were established in a commercial-scale perennial planting of Jewel located at Cornell Orchards in Ithaca, NY. Individual plots were created by subdividing the row into six 12 ft sections, with 3 ft buffer between each section. To get differential levels of disease across the plots, the fungicides Nova or Captan were applied at various reduced rates. We harvested berries to get a baseline estimate of yield per plot and, at the end of the season, we rated disease intensity in each plot (see Table below). The predominant disease in this planting was leaf blight. The control plot had the highest level of disease and plots treated with the 2 higher rates of Nova had the lowest level of disease. In the table, values with a common letter are statistically equivalent.

Treatment	Total weight (kg)	% Leaf blight	% Leaf spot
Nova 1.0 oz/A	53.68 a	32.2 d	0.2
Nova 2.5 oz/A	49.89 a	35.3 cd	0.9
Captan 0.165 lb/A	47.99 a	42.7 bc	0.0
Nova 0.25 oz/A	56.34 a	44.9 abc	0.2
Captan 1.0 lb/A	52.23 a	47.6 ab	0.0
Captan 1.5 lb/A	49.82 a	46.0 ab	0.0
Control	55.97 a	54.9 a	0.0

As discussed above, disease readings taken this year will be compared to next years yield because the development of disease predominantly occurs after harvest. In addition to field plots in Ithaca, we planted a ½-acre field of Honeoye, Jewel, and Kent at the NY State Agricultural Experimental Station in Geneva, NY. This planting will be used to broaden the scope of the experiment beginning next season. The planting in Geneva is better suited to look at multiple diseases because the varieties chosen are differentially susceptible to the diseases under study. For example, Kent is very susceptible to leaf spot, whereas Honeoye is not.

Objective 3. Using the results obtained in objectives 1 and 2, an analysis will be performed to determine economic thresholds for the management of foliar diseases. This objective will be addressed in the future once sufficient data has been collected.

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