MYCOS, A COMPUTER SIMULATOR OF ASCOCHYTA BLIGHT OF CHRYSANTHEMUM

RANDOLPH E. McCoy
2305 SW 70 Ave.,
IFAS, Agricultural Research Center,
University of Florida,
Fort Lauderdale, FL 33314

Additional index words. ecosystem simulation.

Abstract. A computer simulator of the epidemic development of Ascochyta blight of chrysanthemum, caused by the fungus Mycosphaerella ligulicola, has been developed. The simulator is a computer program based on biological data that calculates the response of the pathogen and the host to the environment. The Ascochyta blight simulator, entitled MYCOS, is designed to evaluate the daily weather data of an entire growth season and make daily calculations of the amount of expected disease resulting from the actual weather encountered. Tests of MYCOS using weather data from 12 two-month long growth seasons over a 4-year period for which actual Ascochyta blight incidence values were known showed the simulator to qualitatively determine disease seasons of high or low incidence. As determined by simulation, seasons of high disease incidence were associated with development of the sexual spore stage of the causal fungus.

The science of ecosystem simulation has provided plant pathologists with a new tool for gaining a better understanding of the processes involved in the development and spread of plant disease. The plant disease simulator is a computer program designed to analyze numerically the plant-pathogen-environment interaction over a period of time. This concept originated with Waggoner (12) who used data from the literature to construct a computer simulator of Phytophthora late blight of potato. The simulator was designed to evaluate daily weather data and make calculations of disease progress as a result of actual weather conditions.

At the heart of the plant disease simulator is the biological data used to calculate the interaction occurring between the individual infection on the individual plant and its physical environment. Epidemic development is simulated by summation of the number of infections in the crop as a whole. Biological data on Mycosphaerella ligulicola Baker, Dimock and Davis, cause of the Ascochyta blight of Chrysanthemum morifolium (Ramat.) HemsL, together with data on growth of the host plant, was written into a computer simulator of this disease (4). This paper summarizes the construction details of this simulator, which is entitled MYCOS2, and presents results of tests of the program against actual field incidence data.

Materials and Methods

Construction of MYCOS. MYCOS is a computer program which estimates disease development each day of the growing season as influenced by weather, stage of host development, and past disease history. Each day is divided into four periods of 6 hours duration each, for which means of temperature, relative humidity, wind, and sky cover are evaluated for their effect on pathogen and disease development. Also evaluated are the factors of rainfall or irrigation, and dew; a total of 32 pieces of weather data being analyzed daily. A period-by-period account of the various biotic factors influencing disease development is then calculated for each day for which weather data is available. Finally a graph of disease progress is plotted for the season as a whole.

The systematic analysis of Ascochyta blight is based on the life cycle of M. ligulicola (Fig. 1). Each phase of this cycle, infection and dispersal, is equally important to the development and spread of the pathogen. The infection portion involves spore germination and ingress, lesion growth, and reproduction of the causal fungus, all of which occur on the host plant. Dispersal includes the liberation, transport, and deposition of spores from their sources to new infection sites.

Every step of the disease cycle was examined individually and numerical parameters placed on the biological processes of each. For example, growth of M. ligulicola lesions on chrysanthemum is dependent on temperature and relative humidity (6). The temperature vs. growth data is incorporated into MYCOS in the form of an equation that calculates lesion growth when temperature is known. The result is then modified by relative humidity. Multiplying this lesion value by the number of infections present in the crop

1Florida Agricultural Experiment Station Journal Series No. 288. Supported in part by special funds provided by the Center for Environmental Programs, IFAS, University of Florida.

2Copies of the computer simulator MYCOS written in FORTRAN IV may be obtained from the author.

**Fig. 1. Life cycle of Mycosphaerella ligulicola on chrysanthemum.**

gives the increment in lesion growth for the crop as a whole for the particular day and period under consideration. This information is stored in a table (array) for use in calculating subsequent fungal reproductive development and disease progress.

Reproductive development occurs on the lesioned tissues, and, depending on environment, may be either sexual (perithecia) or asexual (pycnidia). Pycnidia and perithecia have different temperature optima and different rates of development (2, 9). Pycnidia are produced over a broader temperature range, have a higher optimum temperature, and mature more rapidly than perithecia. In MYCOS, increments of pycnidial and perithecial development are calculated for each lesion increment for each day of the growing season.

Pycnidia and perithecia produce two types of spores, conidia and ascospores, respectively. Conidia are dispersed by splashing water, and ascospores are carried by air currents (5, 7). Very little quantitative data are available in the literature regarding spore dispersal. In MYCOS, spore dispersal is based on a physical model of splash distance of raindrops for conidia (3), and on atmospheric turbulent diffusion for ascospores in the field (10). In a greenhouse airborne spread of ascospores is based on a closed system model in which spores do not escape from the crop.

Spores dispersed to new infection sites are subject to washing off by rainfall or irrigation (13) and this is accounted for in MYCOS before any determinations of new infections are made. Spore germination is influenced by temperature and leaf wetness (1). If the foliage dries off before germination and ingress into the host are completed, no infection will result.

Disease development is greatly influenced by the condition of the host crop. MYCOS calculates new host parameters each day of the season to account for changes in crop height, leaf area, and floral development. These calculations are based on the measured development of chrysanthemum cultivar 'Fred Shoesmith.' Information for simulating growth of other varieties could easily be programmed into MYCOS.

The plant disease simulator attempts to mimic all aspects of the plant disease cycle, integrating these into a numerical whole for use in assessing the disease potential brought about by differing environmental conditions. The flowchart of MYCOS depicts how this information is assembled by the computer in actual use (Fig. 2). Output from MYCOS consists of a set of graphs of percent disease incidence, X, in the crop and the logarithmic transformation In (X/(1-X)) for calculation of apparent infection rate values (11). In addition, a weekly summary of the major host and pathogen parameters such as host area, lesion area, numbers of infections, and numbers of fungal reproductive structures is presented. If additional detail is requested, a period-by-period, day-by-day summary of these estimates can be printed.

**Testing of MYCOS.** The true test of any model is its validity, that is, does it accurately mimic the real world? To test MYCOS, Ascochyta blight incidence data over a 4-year period was obtained from a major chrysanthemum propagation company in Florida. Corresponding weather data was obtained from the Florida Climatological and Hourly Precipitation Data records published by the National Oceanic and Atmospheric Administration. For example, actual weekly disease incidence values and mean temperature are plotted in Fig. 3. The weather data of 12 eight-week growth seasons having high or low actual disease incidence were selected for evaluation by MYCOS. The calculated incidence of Ascochyta blight was then compared to the actual incidence values measured in the field.

**Results and Discussion**

On a qualitative basis, the simulator produced seasons of high disease incidence when actual incidence was high, and predicted low incidence when actual incidence was low.
in 11 of 12 cases tested (Table 1). In the single exception, weeks 1-8, 1965, moderate disease development was predicted while actual incidence was low. Quantitative determinations based on absolute numbers of infections were not attempted in these tests due to the fact that the fields concerned were under an intensive spray control program and the simulator was calculating epidemic development as though no controls were being applied. Although control measures may be simulated (8), the dates and times of spray application in the actual crop were not known and could not be incorporated into the data being evaluated. Even so, sufficient disease did develop in the field to define periods of high or low disease pressure.

Table 1. Comparison of calculated percent disease incidence compared to actual numbers of detected Ascochyta blight infections during 12, 8-week long periods during 1964-1967. Also calculated are determinations of whether the environmental conditions of these periods could have induced the production of perithecia.

<table>
<thead>
<tr>
<th>Weeks - Year</th>
<th>Actual disease incidence</th>
<th>Calc. % disease incidence</th>
<th>Presence of perithecia (calc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-15 1964</td>
<td>3000</td>
<td>09</td>
<td>+</td>
</tr>
<tr>
<td>30-37 1964</td>
<td>0</td>
<td>01</td>
<td>-</td>
</tr>
<tr>
<td>38-46 1964</td>
<td>75</td>
<td>05</td>
<td>+</td>
</tr>
<tr>
<td>1-8 1965</td>
<td>10</td>
<td>18</td>
<td>+</td>
</tr>
<tr>
<td>20-28 1965</td>
<td>10</td>
<td>01</td>
<td>-</td>
</tr>
<tr>
<td>30-38 1965</td>
<td>10</td>
<td>01</td>
<td>-</td>
</tr>
<tr>
<td>1-8 1966</td>
<td>1000</td>
<td>28</td>
<td>+</td>
</tr>
<tr>
<td>20-28 1966</td>
<td>10</td>
<td>01</td>
<td>-</td>
</tr>
<tr>
<td>44-52 1966</td>
<td>20000</td>
<td>23</td>
<td>+</td>
</tr>
<tr>
<td>1-8 1967</td>
<td>1000</td>
<td>28</td>
<td>+</td>
</tr>
<tr>
<td>30-38 1967</td>
<td>50</td>
<td>01</td>
<td>-</td>
</tr>
<tr>
<td>44-52 1967</td>
<td>1000</td>
<td>33</td>
<td>+</td>
</tr>
</tbody>
</table>

Several interesting phenomena were observed when the underlying factors involved in the development of seasons of high or low incidence were examined through simulation. The seasonality of Ascochyta blight was regulated in the simulated epidemics by the development of perithecia. The warm wet Florida summer is of optimal temperature for production of pycnidia, for lesion growth, and for rapid spore germination. Since summer is the rainy season one would expect maximal dispersal of conidia and ample moist periods for spore germination. However, summer is the season of lowest disease incidence and this fact was verified in the simulation studies.

Summer temperatures were, in general, too hot for development of the sexual stage with its airborne ascospores. Aerial dispersed ascospores have a much greater range than splash dispersed conidia and therefore have a greater exposure to the crop. Although winter temperatures were less than optimal for some steps of the disease cycle, the greater epidemic potential of the airborne ascospore apparently more than offsets this disadvantage.

The simulator also mimicked the observed spread of disease as seen in the field. New infections during most of the growing season were principally from conidia, resulting in isolated foci of limited diameter. Later in the season when perithecia were calculated to have matured, the crop was also approaching the flowering stage. When flowers were beginning to open, ascospores were being dispersed throughout the crop from the few isolated foci developed earlier in the season through splash dispersal of conidia. The result was the destructive petal-blight phase of the disease which has destroyed apparently healthy crops on numerous occasions just prior to harvest.

Another interesting factor observed in the simulation of Ascochyta blight is timing of perithecial development. Little data are available on the seasonality of perithecial development in Florida; however, it is possible that analysis of actual weather data by MYCOS could be a means of determining the best time of year to search for the presence of these structures. This could ultimately be of help in predicting periods of high disease pressure.

The greatest potential value of a simulator such as MYCOS is its propensity to monitor disease potential under given environmental conditions. The possibilities for using the simulator to predict disease outbreaks or subsequent disease development are excellent. Various control measures may be simulated using different sets of environmental data.
...and the degree of control determined. Eventually it may even be possible to compare the costs of applying various control measures to the economic benefits derived, entirely through simulation. Through simulation it will ultimately be possible to develop optimized control programs for Ascochyta blight which are based on the calculated disease pressure. It may be possible to develop optimized control programs for Ascochyta blight which are based on the calculated disease pressure brought about by actual weather conditions.

Literature Cited

Cultural Practices Affect Damage to Chrysanthemum by Liriomyza sativae Blanchard

S. L. Poe
IFAS, University of Florida, Gainesville, FL 32611
J. L. Green
Horticulture Dept., Oregon State University, Corvallis
C. I. Shih
IFAS, University of Florida, Gainesville, FL 32611

Additional index words. Leaf miners.

Abstract. The effects of various irrigation, fertilization and cultural practices on growth and yield of chrysanthemums and on damage caused by the vegetable leafminer, Liriomyza sativae Blanchard, were investigated in the Fall of 1974. The level of leafminer infestation was less when plants were grown as a pinched rather than as a non-pinched crop. Irrigation or fertilizer variables did not appear to influence the total number of mines in the foliage at harvest. However, the percentage of miners that completed development was increased by the higher fertilizer level. Plant weight was less at the low moisture level.

The current philosophy in modern applied entomology is an integrated approach to pest control employing combinations of available tactics to negatively influence the pest population. As the effect of each tactic is integrated there is a potential incremental decrease in population numbers or their damage. However, the effects of modern agricultural production techniques and growing practices, developed under an umbrella of chemical pesticides, are largely unknown factors in the bionomics of many pest species (4). This is especially true in new agricultural production areas, with new commodities or new insect pests. A good example is Liriomyza sativae Blanchard (5), a dipterous leafminer which attacks chrysanthemum, leaving a winding white trail on the foliage. As with most insects, low populations are routinely treated with insecticides which may lead to population buildups apparently due to insecticide resistance (2).

Various cultural practices researched on other crops are known to influence populations of the leafminer. Both leafminers and their parasites on tomato were influenced by cultural practices of staking and mulching (5). Sources of nitrogen fertilizer are known to influence insect populations (1) and Wolz and Kelsheimer (6) showed that damage by leafminer populations increased with increasing nitrogen but not potassium. Greater damage was incurred at lower potash levels. These reports suggest habitat control by manipulation of cultural variables might be a means to reduce numbers and manage pest population levels in an integrated system.

The influence of production system variables on several insect and mite pests was studied in a series of experiments 1973-75 at AREC Bradenton. Production practices such as irrigation, use of mulch, fertilizer type and placement, and cultural techniques were treated as variables to ascertain their influence on pest population levels on several cultivars of chrysanthemum (4).

This report describes an experiment which shows the influence of cultural variables and discusses the results for their implications and use in management of the vegetable leafminer on chrysanthemum.

Materials and Methods

The experimental planting was established on ground beds of Leon fine sand under saran cloth (30% light reduction). Rooted cuttings of 'Manatee White Iceberg' were planted on September 6, 1974, in a random split plot design with variables of low (1X) and high (3X) soil moisture levels. Within each moisture level there were two nitrogen fertilization treatments: 1) low inorganic nitrogen (10 weekly applications of liquid fertilizer containing 15 lbs N/