Adapting predictive models to reduce fungicide sprays on tomatoes in Iowa

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Adapting predictive models to reduce fungicide sprays on tomatoes in Iowa

Abstract
Iowa tomato growers face critical challenges in pest control. The public is concerned about the health risks of pesticide residues on fruits and vegetables as well as environmental contamination; the result has been fewer, more restricted, more expensive pesticide products for "minor" crops such as tomatoes. At the same time, the market continues to demand high-quality, abundant, blemish-free produce.

Keywords
Plant Pathology and Microbiology, Horticulture, Biocontrol and Integrated Pest Management, Fruit and vegetables

Disciplines
Agricultural Science | Agriculture | Horticulture | Plant Pathology
Adapting predictive models to reduce fungicide sprays on tomatoes in Iowa

Background
Iowa tomato growers face critical challenges in pest control. The public is concerned about the health risks of pesticide residues on fruits and vegetables as well as environmental contamination; the result has been fewer, more restricted, more expensive pesticide products for "minor" crops such as tomatoes. At the same time, the market continues to demand high-quality, abundant, blemish-free produce.

Even before recent pesticide controversies, some producers sought alternative pest control methods. At present, Integrated Crop Management (ICM)—which uses cultural and genetic resistance as well as biological and chemical control to minimize pesticide use while controlling pests and maintaining yields—offers the most practical way to help growers reduce pesticide use. Iowa tomato growers spray fungicides to control three fungal diseases: early blight, Septoria leaf spot, and anthracnose fruit rot. Non-pesticide ICM tactics for controlling this set of diseases are limited; crop rotation affords some protection, but effective genetic resistance and biological control measures have not yet been developed.

Disease-warning systems are the most effective ICM option for tomato disease control. These systems use research-based information about weather conditions that increase the risk of fungal disease outbreaks. Disease-warning systems allow growers to spray fungicides only when the risk of an outbreak (and accompanying potential economic loss) is sufficiently high. In tomato-growing regions in both Ontario, Canada, and Pennsylvania, weather information is collected by automated dataloggers and sensors at several sites. The data are input to a disease-warning model at a university; growers can then telephone a toll-free number to access the resulting spray advisory output. In Ontario, growers use a simplified model called TOM-CAST, which provides a message listing disease-risk ratings, called Daily Severity Values (DSVs), and explains how to add the DSVs and apply a fungicide spray only when the sum reaches a predetermined threshold. Ontario growers have achieved excellent disease control on processing tomatoes while reducing the frequency of sprays by up to 50% over traditional "spray by the calendar" approaches.

In Iowa in 1989, investigators tested a model called FAST, which is the predecessor of TOM-CAST. While it showed an average fungicide-spray reduction of 42% for processing tomatoes compared to a weekly spray program, with no loss of yield or fruit quality, results were limited by an absence of disease pressure and a lack of comparison to other such systems. Thus, this study was needed to ensure that one of these models was sufficiently reliable for use by Iowa growers.

The objectives of this work were to
(1) validate the TOM-CAST disease-warning system in the Iowa tomato-growing environment,
(2) facilitate its use by Iowa tomato growers, and
(3) inform the public that growers are helping in this project to reduce pesticide sprays.

Approach and methods
To determine an optimal action threshold for the TOM-CAST model on processing and fresh-market tomatoes, to determine how distance from a weather-data source to a tomato field influences the reliability of TOM-CAST, and to compare the validity of placement of sensors in a tomato field and on adjacent

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$30,000 for year two
$30,612 for year three
turf grass, field experiments were conducted at the Iowa State University Horticulture Research Farm near Gilbert in 1990-1992.

Processing tomatoes were used in 1990 and 1991; in 1992 the project was re-oriented to fresh-market variety tomatoes. In 1990, four replications per treatment consisted of three rows of plants. The two outer rows were unsprayed; the center one was the treatment row. Treatments included the distance from a weather station to the field plot, the action threshold for fungicide application, and the portion of the season in which TOM-CAST was used. In 1991, five replications per treatment were used. The initial planting was replaced in June because of a bacterial outbreak. In 1992 there were five replications per treatment.

Plots were fertilized each year prior to transplanting and sidedressed later. Irrigation was used as needed. The herbicide Treflan 4E (trifluralin) was applied two weeks before transplanting; insecticides were applied weekly. The guard rows of each plot were inoculated with pathogens of all three target diseases—early blight, Septoria leaf spot, and anthracnose fruit rot—to ensure their development. Fungicides were applied as dictated by the experimental treatments.

In 1990, investigators established weather stations immediately adjacent to the field plot and 1.5, and 12 miles west-southwest of the project site. Additional sites 15 and 25 miles from the Horticulture Farm were added in 1991 and 1992, respectively. At each site, temperature, relative humidity, rainfall amount, and duration of wetness periods were recorded by electronic sensors at 5-minute intervals and summarized hourly by an automated datalogger. Data were downloaded to a personal computer (PC) at ISU via modems and telephone so that DSVs for TOM-CAST could be calculated for the period from noon to 11 a.m. each day. When TOM-CAST’s action threshold (the sum of the DSVs for a particular station) was reached, fungicide was sprayed on the appropriate treatment within eight hours.

In 1990 and 1991, investigators estimated percent defoliation in each plot at regular intervals in late summer. Treatments were harvested when about 90% of the fruit showed red color. The center 20 plants in each plot were harvested manually. Processing-tomato fruit was separated into marketable red (any red color), green, and anthracnose symptoms, early blight symptoms, blossom-end rot symptoms, soil rot symptoms, and physical injury symptoms. In 1992, fresh-market tomatoes were harvested weekly when ripe and sorted into marketable or cull (reject) categories. Incidence of anthracnose and early blight symptoms on fruit were recorded.

In 1991, in a cooperative trial held at a farm near Muscatine, fungicide was sprayed on 15 acres of processing tomatoes according to a conservative version of TOM-CAST and an adjacent 15 acres of the same cultivar by the standard schedule. A datalogger conveyed information to a PC at ISU, where DSVs were calculated. The cooperators were notified when the model advised applying a fungicide spray to the TOM-CAST plot. At another farm near Kalona in 1991, wetness and temperature data were recorded with one type of datalogger and compared with data from adjacent sensors in the same row that were attached to a different datalogger. In 1992 trials conducted with two fresh-market growers, a portion of the planting was sprayed with fungicide by the TOM-CAST schedule and the remainder by the growers’ standard spray regimen. As in 1991, dataloggers and sensors placed in the cooperators’ plantings were accessed from ISU by telephone and TOM-CAST spray advice was relayed back via telephone.

Findings

For the various versions of TOM-CAST at the Horticulture Farm, reduction in fungicide sprays compared to standard grower practices ranged from 46-76%. Even conservative versions of TOM-CAST offered substantial reductions in fungicide use. This savings in sprays includes cost reduction not only in pesticides but in labor, fuel, and machinery depreciation.
In 1990 and 1992, bacterial spot, a non-target disease, progressed rapidly due to rainy weather; this disease is not controllable by fungicides. Thus, although symptoms of early blight and Septoria leaf spot appeared in July in both years, it was impossible to separate their effect on defoliation from that of the bacterial disease. Rapid defoliation by the bacterial spot led to premature ripening of fruit, which suppressed development of anthracnose rot on harvested fruit. These experiments thus could not provide conclusive results.

The 1991 TOM-CAST experimental trial results showed that a DSV threshold of 25 caused significantly greater defoliation than more conservative thresholds (20 or 15). For the latter, foliar disease was not significantly different than for a weekly spray schedule. Moreover, when the threshold was 15, foliar disease was not significantly different from the weekly-spray control regardless of whether sensors were located in the tomato field, immediately adjacent to it, or 7, 5, or 15 miles away. Percent incidence of anthracnose was not significantly higher for thresholds of 20 or 25; with a DSV threshold of 15, anthracnose incidence was affected neither by sensor location nor by distance from the field to a weather station. Marketable yield for DSV thresholds of 15 or 20, but not 25, was not significantly lower than for the weekly-spray treatment. With a DSV threshold of 15, yields were not significantly affected by sensor placement or by distance from the sensor to the field. The 1991 results suggest that a DSV threshold of 15, or possibly 20, could be used to implement TOM-CAST in Iowa, and that with a conservative version of TOM-CAST (DSV threshold = 15), weather instruments can be placed adjacent to the field or up to at least 15 miles away without additional disease development or yield loss. This result should be validated with additional field experiments on fresh-market tomatoes before being adopted on a large scale by Iowa fresh-market tomato growers.

At Muscatine in 1991, cooperators applied two fewer fungicide sprays with the conservative version of TOM-CAST than their standard practice—a 29% savings. Yields in the TOM-CAST and standard-practice field were equivalent, and 96% of the fruit in each field was marketable-grade. Using a cost estimate of $18/spray for processing tomatoes, TOM-CAST saved cooperators $540 on their 15-acre test plot. In 1992, the two cooperators in the fresh-market trials each saved one fungicide spray using TOM-CAST in comparison with their normal practices (see Fig. 1). This represented savings of 50% and 33%, respectively. Symptoms of the target diseases were not evident, and yields were reported to be equivalent on trial and standard-practice plots.

The 1991 data from the farm where wetness-duration measurements were taken by adjacent wetness sensors attached to two different dataloggers showed considerable difference, which resulted in the accumulation of 15 more DSVs by one of the dataloggers—the equivalent of an additional fungicide spray. This has prompted tests to determine the accuracy of the sensors.

Outbreaks of bacterial spot obscured results of field experiments in two of three years. This result emphasizes that Iowa tomato growers need to rotate away from hosts of bacterial spot (tomatoes and peppers) for at least five years in order to minimize risk of losses from this disease, which cannot be controlled adequately with chemical bactericides.

Findings from this project provide a framework for addressing the following questions:

1) How accurate is the wetness-duration data on which TOM-CAST relies?
2) Can wetness duration be estimated reliably from relative humidity and wind speed?

Fig. 1. Number of fungicide sprays applied in 1992 by two growers of fresh-market tomatoes during a cooperative trial comparing TOM-CAST to their regular spray schedule.
(3) Does weather affect the spread of Septoria leaf spot similarly to the way it affects early blight? If not, does TOM-CAST need to be revised to reflect the difference?

(4) Would development of user-friendly software facilitate wider use of TOM-CAST?

Implications

This project has shown that TOM-CAST can control the major fungal diseases of Iowa tomatoes with substantially fewer fungicide sprays than the preventive schedules most growers follow. This translates into substantially reduced farm input costs and improved profits. Fewer sprays also mean reduced health risks from pesticide exposure and lessened risk of environmental contamination from off-target movement of pesticide.

Indications are that TOM-CAST can be run successfully in Iowa from weather stations located regionally rather than on each individual farm. The most significant factor limiting the wider implementation of TOM-CAST and other such models is the need for reliable weather data. Wetness sensors must be calibrated against visual observations for accurate determination of dew-period duration. Data logger and sensor cost and complexity are also drawbacks. Thus, growers must share weather information in a network in order to share the cost and ensure quality control of the data. Because TOM-CAST weather data can be taken 15 miles from a tomato field, subregions at least 30 miles in diameter can utilize a single weather station. Automating a network of such stations would allow for TOM-CAST output to be accessed via a toll-free telephone line. Such a low-cost statewide network is feasible with current technology.

Until such a network is developed, however, wetness data can be derived from existing Iowa weather-station networks. While most do not record wetness duration, they are a "no cost" data source that could be used to implement TOM-CAST by combining dew-period estimates with routine rainfall measurements.

Future research and demonstration are needed to give growers additional on-farm experience and to make weather monitoring strategies that are more timely and more affordable. Closing these knowledge gaps will hasten the adoption of nonchemical control strategies.

Education, outreach, and cooperative efforts: This research has generated several scientific journal articles as well as reports and abstracts for conferences and workshops. In addition, this project produced an Extension bulletin and videotape, summary handouts, a field day, on-farm cooperative trials, and presentations at grower meetings. The bulletin was part of a larger integrated pest management manual for various fruit and vegetable crops that has been sold to growers throughout the state.

Funding from Heinz, U.S.A. contributed significantly to project progress during 1990 and 1991. Heinz also assisted in the on-farm trials by helping to identify cooperators, monitor the weather stations, and plan for the field day. The Iowa Fruit and Vegetable Growers Association helped to identify cooperators for the 1992 on-farm, fresh-market tomato trials. In addition, the Fremont Pickle and Tomato Growers helped to fund two "spin-off projects: a 1992 grant for a field study of wetness-sensor performance, and a 1993 grant to write user-friendly software to implement TOM-CAST.