Control of Late Blight on Tomato in Western Washington Using High Tunnels

Debra Ann Inglis, Babette Gundersen, and Carol Miles

Late blight can be serious on tomato in western Washington, whether plants are grown in greenhouses, gardens, nurseries, or commercial fields. The effect of high tunnels (HTs) on late blight of tomato has not been studied, however. HTs are temporary field structures, covered with one or more layers of clear plastic via a hoop-shaped frame, and are solar heated. HTs provide protection from seasonal rainfall and elevate daytime temperatures, especially under sunny conditions (Fig. 1).

Northwestern Washington’s mild, marine climate is highly favorable to late blight which is caused by Phytophthora infestans, a water mold. Under optimum temperature and relative humidity, the pathogen needs periods of leaf wetness in order to infect plants. For example, when temperatures are between 60 and 80°F with >90% relative humidity, only 13 to 15 hours of continuous leaf wetness can result in disease outbreaks; 16 to 18 hours of continuous leaf wetness can lead to moderate disease spread; and, 19 to 21 hours of continuous leaf wetness can favor severe epidemics (Fig 2.).

Successful management of late blight often requires spraying with fungicides that are usually only effective when applied protectively (i.e., before the spores of the pathogen come into contact with the plant and germinate), and if repeated several times. Cultural management includes: planting disease-free tomato transplants; eliminating sources of infested plant debris; removing volunteer plants; improving air movement in the plant canopy by spacing and pruning; orienting plants to reduce shading; irrigating so as to prevent wet foliage and fruits, etc. Because cultural practices alone cannot stop late blight, especially during rainy, foggy and cloudy weather, and since only a limited number of fungicides are registered for garden settings (http://pep.wsu.edu/hortsense/), we investigated whether HTs (Fig. 3) can be used for managing late blight in small-scale, commercial tomato production in western Washington.
Late Blight Control Continued

Methods. HTs measuring 120 ft long x 27.5 ft wide x 10 ft high were erected in a field managed organically. In 2010, seedlings of 6 tomato cultivars were transplanted into 4 replicates of HT and open field (OF) plots on 27 May and 3 Jun, respectively. Organic fertilizer Par 4 9-3-7 was broadcast-applied at 80 lb N/acre to bed centers; beds were shaped with a raised bed mulch layer; and, drip tape and black plastic mulch were installed on top of each bed. Plants were drip-fertigated and -irrigated weekly, from transplanting to season end, and pruned and staked using a Florida Weave training system. Environmental data on leaf wetness and precipitation were recorded each growing season. Plots were rated visually each week for percent late blight. Disease ratings were converted to AUDPC values (the higher the value, the more severe the disease). The weights of total and blighted fruit were recorded over multiple harvests. In 2010, the last harvest date in open field plots was 6 October while tomato harvest in HTs continued until 19 October.

Table 1. Data on late blight in high tunnels vs. open fields at WSU Mount Vernon NWREC in 2010. AUDPC = area under disease progress curve; the higher the AUDPC number, the more severe late blight.

<table>
<thead>
<tr>
<th>Tomato cultivar</th>
<th>AUDPC</th>
<th>Total weight of fruit harvested (lb/plot)</th>
<th>% Blighted fruit</th>
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<tr>
<td></td>
<td>High tunnel</td>
<td>Open field</td>
<td>High tunnel</td>
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<tr>
<td>Celebrity</td>
<td>0.03</td>
<td>317</td>
<td>24.6</td>
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<tr>
<td>Cher. Purple</td>
<td>0.01</td>
<td>257</td>
<td>34.2</td>
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<tr>
<td>Early Girl</td>
<td>0.05</td>
<td>320</td>
<td>25.9</td>
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<tr>
<td>Or. Spring</td>
<td>0.00</td>
<td>423</td>
<td>37.9</td>
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<tr>
<td>R.Brandywine</td>
<td>0.00</td>
<td>229</td>
<td>33.7</td>
</tr>
<tr>
<td>Stupice</td>
<td>0.00</td>
<td>289</td>
<td>36.5</td>
</tr>
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</table>

Results. Late blight was lower on tomatoes grown in HT compared to OF plots, and tomato yield was higher in HT compared to OF. The few late blight lesions noted in the HTs occurred mostly on plant tissues either near side walls where there was water condensation, or at end openings when there was rainfall. The foliage of all tomato cultivars proved susceptible. Although Celebrity, Cherokee Purple, Early Blight, and Red Brandywine had 16% to ~38% blighted fruit in the open field, they had only 2.2% to 7.7% in HTs. Oregon Spring and Stupice had the least blighted fruit and were the highest yielding, whether they were grown in HTs or the open field.

Conclusions. HT environments, where there is no rainfall or overhead irrigation, were not as favorable for the development of late blight as the open field environment. We have obtained the same result in 2008 and 2011 experiments. Since most tomato cultivars are very susceptible to late blight, disease scouting is still necessary when using HTs. However, HTs offer an alternative for growing near late blight-free tomatoes under northwestern Washington conditions. HTs also can extend the tomato growing season, and increase fruit yield in a climate otherwise not conducive for tomato culture.

For Further Information and Other Resources

WSU Mount Vernon NWREC Vegetable Pathology Program
http://mountvernon.wsu.edu/plant_pathology/plant_path.htm

WSU Mount Vernon NWREC Crop Tunnels and Mulch
http://mtvernon.wsu.edu/hightunnels/

eOrganic Webinar on High Tunnel Production
Late Blight Control Continued

Acknowledgements: Funding for this project was by USDA-AFRI Specialty Crops Research Initiative (SREP Award 2009-02484).

Fig. 2. Symptoms of late blight on tomato foliage (left two photos) and fruits (right two photos).

Fig. 3. Differences in late blight on tomatoes in August in a high tunnel (bottom left) versus the open field (bottom right) at WSU Mount Vernon NWREC.

Managing Nitrogen in Silage Corn Production

Chris Benedict, WSU Whatcom County Extension

To achieve optimum yield in silage corn production effective nutrient management is essential. Nitrogen is the most yield-limiting nutrient for corn. Manure commonly supplies enough nitrogen for the season, but to achieve optimum yield application timing is essential. This article will briefly cover nitrogen use by corn, methods to determine nitrogen needs, optimum timing of additional nitrogen sources, and the effective rates to maintain yields and reduce losses to the environment.

If manure applications have occurred in a field within the past three years or the field has received adequate manure applications, starter fertilizer is usually not needed. Outside of these situations, application of 40 lb/a of nitrogen will be needed at planting. Throughout the growing season, corn nitrogen uptake increases. Until the 10-leaf stage 20-40 lb/a of nitrogen is assimilated by the plant; while this amount increases to 90 lb/a between the 10-leaf stage and silk emergence. At this point almost 66% of the total seasonal nitrogen needs has been taken up by the plant. Research has determined that aboveground biomass (dry matter) accumulation is slower than nitrogen uptake.
Using this understanding of nitrogen demand can assist with management decisions especially if you utilize Pre-Sidedress Nitrogen Tests (PSNT) or chlorophyll meters (See This Article for more information\(^2\)) to drive additional sidedress nitrogen applications. Waiting until the 5-6 leaf stage to apply additional nitrogen reduces losses to the atmosphere and supplies it to the plant when most needed. If sub-adequate nitrogen levels exist during the 10-leaf to silk stage yields will be compromised.

PSNT can be done by taking 12”-deep soil samples at the 5-6 leaf stage to indicate additional nitrogen needs. If results indicate less than 25ppm, additional nitrogen is needed.

- Soil samples should be taken once corn plants have at least 5 leaves (usually around 12” at whorl center).
- Samples should be representative of the field, avoiding in-row regions or irregular areas.
- Sample to 12”
- Mix in a container (a 5-gallon bucket works well)
- Send sample to soil testing lab to be analyzed for nitrate-N (NO\(_3\)-N). Samples should be dropped off immediately or refrigerated in the meantime.
- Request results in ppm pr mg/kg, not lb/a

Table 1 outlines nitrogen rates needed based on lab results and has been adapted from the Oregon State Extension Bulletin EM 8978-E\(^1\).

Table 1. Nitrogen rate recommendations for western Oregon using the PSNT*

<table>
<thead>
<tr>
<th>PSNT Value NO(_3)-N (ppm)</th>
<th>Apply this amount of N (lb/a)</th>
<th>If manure supplies 4 lb N/1,000 gal</th>
<th>If manure supplies 6 lb N/1,000 gal</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>(gal/a)</td>
<td>(acre-inches)</td>
</tr>
<tr>
<td>0-10</td>
<td>100-175</td>
<td>25,000-44,000</td>
<td>1.0-1.5</td>
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<td>11-20</td>
<td>50-100</td>
<td>12,500-25,000</td>
<td>0.5-1.0</td>
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<tr>
<td>21-25</td>
<td>0-50</td>
<td>0-12,500</td>
<td>0-0.5</td>
</tr>
<tr>
<td>Above 25</td>
<td>0</td>
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<td>0</td>
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</tbody>
</table>

*The authors suggest that is only to be used as a guide. That to refine nitrogen rates for your cropping system, monitor yield, silage crude protein, and stalk nitrate-N, or use a post-harvest soil nitrate test


Nitrogen Management in Small Grains
Karen Hills, WSU Mt. Vernon

In the maritime climate of Northwestern Washington, proper management of nitrogen (N) is important for both crop yield and quality and to prevent this highly mobile nutrient from leaching into ground and surface water. Too much nitrogen in small grains and you can get lodging (falling over) of the grains, too little and your yield will suffer and the quality of the grain may be reduced. So how is a person to know how much nitrogen to apply, in what form and when? Let’s first consider the general N needs of small grains. Grains require the most N when they are actively growing and tillering, or sending up new stems. By the time of heading, most of the N uptake has already occurred. N applied at an early stage of development will help determine total yield. Once small grains are in the “boot” stage where the head of grain has almost emerged, any additional N taken up by the plant will increase grain protein.

There are fertilizer planning guides available for small grains west of the Cascades available on the Plant Breeding website for the WSU Northwestern Research and Extension Center. These resources will allow you to make your own N recommendations based on your soil test results. Total N applied will depend on expected crop yield based on the yield potential of your soils. Make sure to give credit for N release from soil organic matter (10 – 40 lbs N released per acre for each percent organic matter) and any manure that has been applied.

For winter grains (usually planted in late fall), no N is generally applied pre-plant (except in extremely depleted soil where no more than 20 lbs. N per acre is used at planting) because winter rain will cause it to leach out of the root zone. Instead, make the first application of N when the plant starts actively growing in the spring. For winter wheat in Mount Vernon this is usually mid-March, but will vary according to local conditions. Apply 30-50 lbs N/acre at this time, or more if you are using a slow-release fertilizer, such as sulfur-coated urea. For soft wheat (or grains for which protein is not a concern), make one more application of N to bring you up to your total recommended level (see resources below for calculating N recommendations). For hard wheats, or when a higher protein level is desirable, make two additional applications spaced about a month apart, with the last one occurring at boot stage.

For spring grains, total N needs are 40 lbs N/acre based on 2000 lb/acre yield and add about 40 lbs N/acre for each additional 1000 lbs of yield potential\(^1\). The timing of application depends on whether you are using a slow release product or not. If not, you should split applications so that the crop has extended access to N throughout its growth phase.

Judicious use of nitrogen fertilizer is good for your crops, your pocketbook, and protects surface and ground water resources.


For Further Information and Other Resources
WSU Mount Vernon NWREC Plant Breeding Page
http://plantbreeding.wsu.edu/grainInfo.html#fertilize
Glyphosate Carryover in Seed Potatoes

Pamela Hutchinson, University of Idaho, Aberdeen
Phil Nolte, University of Idaho, Idaho Falls

*This article is a re-print from the May 2012 Issue of Potato Progress (http://www.potatoes.com/potatoprogress.cfm)

We want to remind seed potato growers that glyphosate can carryover in tubers and will affect sprouting and plant health the following season. The daughter tubers may or may not have visible damage such as folding in the bud end. Multiple sprouting below ground, sometimes called “candelabra sprouting,” can occur, as well as poor emergence, stunted plants, and yellowing similar to symptoms caused by a direct glyphosate spray or drift.

There are a few likely ways glyphosate can contact foliage of the seed crop: 1.) drift from applications to adjacent fields, 2.) direct spray onto the potato plants from spot spraying within the crop, or 3.) residue left in a sprayer tank which also is used for vine killing the mother crop. Growers and custom applicators applying glyphosate in seed potato production areas should take special care to avoid drifting onto the seed crop or simply decide not to apply glyphosate in fields adjacent to potato seed. Such applications may be occurring on non-cropland or fallow ground for perennial weed control. Glyphosate also is labeled for use in wheat and barley at the end of the growing season for weed control after the grain has reached a certain moisture level (refer to a label for specific information).

Spot spraying glyphosate within or on the borders of a seed potato field should be avoided altogether and if a sprayer was used for glyphosate applications earlier in the season, the tank, boom, and injection/mixing system should be thoroughly cleaned with the appropriate spray tank products and well-rinsed before using the sprayer for vine-kill applications. Ideally, keep a sprayer dedicated to glyphosate applications, not to be used for any other herbicides.

University of Idaho research: We recently studied glyphosate drift in Ranger Russet to determine effect on the mother crop during the application year, and symptoms in plants grown from tubers produced by affected plants. Glyphosate at 1/100, 1/16, 1/8, ¼, or ½ typical use rates was applied to potato foliage when plants were 3 to 6 inches tall, at stolon hooking, tuber initiation, or mid-bulking. During the application year, foliar damage and tuber yield, grade, and symptoms were recorded. Tubers were kept in storage and planted the following year.

During the application year, the most foliar damage of stunting and leaf yellowing resulted from the earlier applications. In contrast, the mid-bulking application caused little or no visible injury. Tuber yield and grade from treated plots were reduced compared to the non-treated controls, and some of the tubers coming from treated plants had a rough, elephant-hiding appearance and bud-end folding. As an example of yield impacts, when plants encountered glyphosate during hooking or tuber initiation even at 1/100 the use rate, U.S. No. 1 yields were reduced as much as 37% compared to when the plants were sprayed at 3 to 6 inch height.

Daughter tubers with and without symptoms were planted the following spring. Surprisingly, since the most damage to the mother crop was from early applications, the poorest emergence was in plots with tubers from the last application made during mid-bulking. In fact, regardless of glyphosate rate applied the previous year, emergence of the daughter tubers from the mid-bulking timing was reduced 80% compared to emergence of tubers coming from nontreated plants. Tubers with and without symptoms were equally affected. No multiple sprouting below ground was observed and emergence of symptomatic or non-symptomatic tubers was similarly poor.

This past year, we conducted two trials partially funded by the Idaho Potato Commission. The first trial used Russet Burbank tubers from plants sprayed with a low glyphosate rate at vine-kill in 2010. Doug Boze (Idaho Crop Improvement Association) helped by planting some of the daughter tubers from those plants in the California winter grow-out trials. He noted poor emergence in tubers coming from treated, compared with non-treated, plants. Some multiple sprouting also was observed. When more of those daughter tubers were planted spring 2011, 86% of the tubers from non-treated plants compared with only 8% from treated plants emerged even if they had no tuber symptoms such as folding on the bud end.

In the second trial, Russet Burbank was planted spring 2011 and glyphosate at 1/100, 1/16, 1/8, and ¼ the typical use rates was applied to potatoes at the same times used in the Ranger Russet trial with the addition of a vine kill timing. Preliminary analyses of the 2011 yields has shown that unlike the Ranger Russet trial where U.S. No 1 percent of total yield was reduced the most when glyphosate was applied at hooking or tuber initiation, Burbank U.S. No 1 percent of total yield during the application year was reduced the most from the 3 to 6 inch tall plant timing. Tubers from all the Russet Burbank treatments including the non-treated control were sent to the California winter grow-out trials and watched for underground multiple sprouting, emergence, and emerged plant symptoms. Preliminary analysis of those data shows little or no effect on emergence from the 1/100 rate even at the late application timings, however,
**Glyphosate Carryover in Seed Potatoes continued**

the higher rates affected emergence of daughter tubers from all timings except the earliest. Unlike Ranger daughter tubers, the Burbank tubers had some underground multiple sprouting. The Burbank daughter tubers will be planted spring 2012 to determine differences of tuber, emergence, and plant symptoms between rates and application timings.

In the future, we hope to conduct similar trials with Shepody and specialty varieties since each may have unique reactions to glyphosate.

**Summary:** The take-home message from this study is that if glyphosate contacts seed potato crops late in the season, foliar damage might not be noticed since the vines may be starting to naturally senesce. However, this timing of glyphosate contact on the seed crop has the most effect on the tubers planted the next year! In the case of a spray tank used for vine kill contaminated with glyphosate, the foliage is dying from the desiccant and any effect from glyphosate will most likely not be visible. Tuber yield and quality during the “application” year and daughter tuber underground sprouting and emergence may vary depending upon potato variety.

So, be cautious and careful when making glyphosate applications near seed potato crops, or avoid spraying glyphosate near the crops altogether. Do not spot spray glyphosate within or on the borders of the seed crop itself and thoroughly clean any sprayer after glyphosate use.

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**SWD Scouting Update**

Colleen Burrows, WSU Whatcom County Extension

Whatcom County WSU SWD traps near native borders have begun to catch male and female SWD. These are suspected to be the overwintering generation; we are still uncertain of their fecundity. The graph below shows degree days and average trapped SWD per week for 2010, 2011, and 2012. Degree days are accumulating more quickly in 2012 which could make this a year for earlier increases in SWD populations. Find weekly trap count results at: [whatcom.wsu.edu/ipm/swd/](http://whatcom.wsu.edu/ipm/swd/) and current treatment recommendations at: [www.mountvernon.wsu.edu/ENTOMOLOGY/pests/SWD.html](http://www.mountvernon.wsu.edu/ENTOMOLOGY/pests/SWD.html)
Weather Recount

All information here is derived from the four weather WSU AgWeatherNet stations ([http://weather.wsu.edu/awn.php](http://weather.wsu.edu/awn.php)) in Whatcom County. Current weather conditions can be found at: [http://whatcom.wsu.edu/ag/currentdata.html](http://whatcom.wsu.edu/ag/currentdata.html). Station information can be found [here](http://whatcom.wsu.edu/ag/currentdata.html).

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Growing Degree Days, Whatcom County

WSU Whatcom County Extension
Chris Benedict & Colleen Burrows
[www.whatcom.wsu.edu/ag](http://www.whatcom.wsu.edu/ag)