Blossom thinning has the greatest potential to increase fruit size and can promote return bloom next season. Growers have an opportunity to assess the efficacy of blossom thinners before applying post-bloom thinner.

**Blossom Thinning Apples with Lime Sulfur: Old Dog, New Trick**

As of 2019, specific formulations of liquid lime sulfur can be used for apple crop thinning in several eastern and Midwestern states. Additionally, a series of variety-specific pollen tube growth models are available to eastern apple growers beginning in 2019. These models are used to inform the application timing of lime sulfur thinning programs. These technologies are relatively new to eastern thinning programs – this is a reference to get you started.

**Introduction**

Liquid lime sulfur (LS) has been registered as a blossom thinner for apple in the Pacific Northwest since 2003. Of all blossom thinners evaluated since the loss of Elgetol in 1990, the most consistent blossom thinning programs include LS (Schmidt et al., 2011). A survey by the Washington Tree Fruit Research Commission (WTFRC) found that ~60% of all apple acres in WA are being thinned with LS (Tory Schmidt, WTFRC). Growers in WA have used pollen tube growth models (PTGM) for timing LS thinning sprays since 2014. In 2018, over 1600 blocks of apples were registered to use the PTGM.

Specific formulations of LS were recently labeled for blossom thinning in several eastern states as well [NovaSource™ Lime-Sulfur Solution (Tessenderlo-Kerley, Inc.); Rex Lime Sulfur Solution (Or-Cal, Inc.)]. Registration of these products extends the range of effective chemical thinning options to include bloom. Additionally, seven variety-specific pollen tube growth models are available to commercial apple growers in 2019 through the Network for Environment and Weather Applications (NEWA). These models are used to help with application timing of lime sulfur thinning programs.

**How it works**

Lime sulfur thins flowers by inhibiting pollen germination and pollen tube growth in the pistil, preventing fertilization of the flower (Figure 1). Unlike other pollinicides, LS has about 24 hours of kick-back after the pollen grain germinates (Yoder et al., 2009). This post-germination activity extends the time for making an effective thinning spray. LS is also a photosynthetic inhibitor (McArtney et al., 2006). A temporary reduction of apple leaf photosynthesis can also contribute to thinning by causing a brief period of carbon stress. Spray oil can be added to LS to enhance its penetration and boost its efficacy. When tank mixed with spray oil, LS is used at a lower concentration.
Spray Application and Rates

Application of LS as a blossom thinner has a very small target: the pistil of unfertilized flowers. Thorough coverage is essential. For well-pruned dwarf and semi-dwarf trees, a spray volume 80-100 gallons per acre via air-blast is typically used. For small trees with narrow open canopies, 50 gallons per acre may be enough, while older larger trees may require 200 gallons per acre to obtain thorough coverage. Avoid excessive spray volume to minimize leaf damage and fruit russetting. The action of LS is based on its concentration, not on the rate per acre. Do not concentrate the chemicals when spraying at a lower volume.

LS is applied at 4-10% (v/v) when used alone. When mixed with oil, use LS at 1.5 to 2% (v/v). Oil options include fish oil at 2% (v/v), dormant petroleum oil at 1%, or summer oil at 1 to 1.5% v/v. Our trials in the mid-Atlantic indicate that an oil + LS combination is more effective than LS alone.

Two LS applications during bloom are suggested if possible. If weather conditions are not conducive to a 2nd application or if less aggressive blossom thinning is desired, a solitary application would still be of benefit in multi-step thinning programs (nibble approach). In years of a protracted bloom period, a 3rd application is possible. Until more data regarding the appropriate number of LS applications in the east is available, we suggest using no more than two LS applications during the bloom period.

Timing LS thinning sprays

Before the PTGMs were developed, the timing of LS thinner was by visual estimates of the percentage of open blossoms. Typically, two sprays, one at 20-30% bloom followed by a second spray at 80-100% bloom. If you don’t have access to the models or choose not to use them, this method of timing can still be done with satisfactory results. The model just makes the timing more precise.

Inconsistent blossom thinning responses may be attributed to application timing since pollen tubes can reach the base of the style within 48 hours (Yoder et al., 2009). Blossom thinner applications that occur at full bloom or later can increase fruit russet (Byers, 2003). To improve application timing of LS + oil, researchers at Virginia Tech and the WTFRC developed predictive models to estimate pollen tube growth rates. After over a decade of research, pollen tube growth models have been released for seven varieties (Cripps Pink, Fuji, Gala, Golden Delicious, Granny Smith, Honeycrisp, and Red Delicious). Several LS thinning trials have been conducted in the mid-Atlantic and southeast with the PTGM with positive results.

Pollen tube growth rates for each variety are estimated based on hourly temperatures. To use the PTGM, average style length must be measured in each block. Additionally, the number of open blossoms must be actively monitored. Once the number of open blossoms is equivalent to the desired crop load, the model is initiated.

- Detailed instructions with the NEWA interface are provided in the Using the Pollen Tube Growth Models on NEWA section below.

Precautions

When applied properly under favorable weather conditions, LS is safe to use as a blossom thinner. LS can cause apple leaf burn and fruit russet. Avoid use of LS when a high temperature is forecast to exceed 85°F within 24 hours. The potential for injury is greater under slow drying conditions (low light, high humidity). Avoid spraying under these conditions and use the lowest effective rate and spray volume if you must thin when high temperatures and poor drying conditions are imminent. Tender foliage that grew under cool, cloudy, damp conditions is tender and more likely to show symptoms.

Do not tank mix other spray materials when thinning with LS or LS plus oil. Additional applications of either oil or LS immediately after LS thinning sprays is very likely to increase thinning response. Oil and Captan fungicide should never meet on your trees. To allow oil residues to weather, leave a 2 to 3-week interval between the last spray containing oil and the first captan spray. If there is a
high risk of severe frost or freeze damage during the bloom period, consider delaying or avoiding application of LS as a bloom thinner.

What to expect after thinning with LS

Petal browning is common and can be observed within a day of application (Figure 2). While visually unappealing, petal browning is perfectly normal and does not indicate a problem. If applied under favorable weather conditions, minor leaf phytotoxicity (leaf curling, yellowing, marginal necrosis) may occur. If LS is applied under suboptimal weather conditions, significant damage to spur leaf tissue can occur. Excessive damage to spur leaves is undesirable. Spur leaves are important in promoting fruit growth, and injury to these tissues has been shown to have negative impacts on fruit size, fruit set, and fruit mineral content (Ferree and Palmer, 1982). Again, only apply LS under favorable weather conditions to minimize damage to spur leaf tissue.

Figure 2. Petal browning (left) and leaf damage (right) can occur after LS applications. Photo: Tom Kon, NC State University

Since LS inhibits flower fertilization, the effects of this thinner on fruit drop can be seen shortly after petal fall. An advantage of this strategy is that a clear size difference between setting and shedding fruit can be observed in advance of making a subsequent thinning application at 8 to 12 mm fruit diameter (Figure 3). Growers can adjust rates of post-bloom thinners based on the efficacy of the blossom thinning application(s). To take advantage of this interval, the grower may not wish to apply a petal fall thinner and wait to observe the effect of blossom thinning on fruit set.

Figure 3. After thinning with LS, a clear size difference between setting and shedding fruit is observed. Photo: Tom Kon, NC State University

Regulatory and Safety

Use an LS product that is labeled for thinning in your state. For 2019, in NC and PA, that product is NovaSource™ Lime-Sulfur Solution. Read the label of the spray oil you intend to use and make sure that it is labeled for use on apple at bloom. Do not make more than three applications of LS for blossom thinning per season. NovaSource™ LS has an REI of 48 hours. Refer to the label for a list of PPE for pesticide handlers, applicators and early re-entry. Note that LS is hazardous to eyes, so spray applicators, and other handlers must wear goggles or a face shield.
Conclusion

Many eastern growers now have access to a consistent and effective blossom thinner and predictive model to aid in application timing. When compared to later application timings, blossom thinning has the greatest potential to increase fruit size and can promote return bloom in the following season. Unlike petal fall thinner applications, growers have an opportunity to assess the efficacy of LS application(s) before applying post-bloom thinner. However, these benefits are not without risk. To minimize the risk of damage to fruit and spur leaves, only apply LS under favorable weather conditions. Use common sense regarding frost risk and pollinator activity during the bloom period. We suggest small-scale evaluations of LS and the PTGM until experience is obtained in your orchard. Strongly biennial (Fuji, Honeycrisp, Delicious, etc.) and small-fruited varieties (Gala and Pink Lady) might be a good place to start. Additionally, inhibiting/reducing fruit set on young or newly planted orchards would be another natural area that LS could fit into crop load management programs.

Literature cited


Using the Pollen Tube Growth Models on NEWA

Editor's Note:

To our readers: In 2022, Cornell updated NEWA, performing a complete refresh of the website (currently versioned as '3.0'). Consequently the screen captures that are embedded in this article no longer correspond to the look, appearance, and procedures necessary for performing the model. This article will remain online for now since the process and technique - if not the actual steps to take on the website - is still valid and informative. Additionally, the content of this article discusses the why of the pollen tube growth model, whereas the tutorial on how to perform the modeling on NEWA's site lacks some of this information. A revision to this article that contains current screen captures and a revised protocol will be published in the future. [Daniel Weber, Ph.D. - Thu Mar 23 11:03:28 EDT 2023.]

Get Started

Go to the Network for Environment and Weather Applications (NEWA) home page and select "Apple Pollen Tube Growth" under "Crop Management."
Step 1
Select "+ Block" to create a site-specific model.

Step 2
- A. Add a descriptive name for the block that you plan to monitor.
- B. Using the "Variety" drop-down menu, select the appropriate cultivar.
- C. Select the appropriate state.
- D. Select a NEWA weather station that is in close proximity to the block you plan to monitor.
- Once all fields have been filled, select "Add Block."

Step 3
When appropriate, add the start date (i.e., timing of model initiation) and average style length by selecting each of the icons to input this information.

When should you initiate the model?
- The model should be initiated once the number of open blossoms is equivalent to your target crop load.
- Can be determined using visual estimates or by counting the number of open blossom on whole trees or limbs.
- In a warm spring, frequent monitoring will be required, due to rapid bud development.
- Once the number of open blossoms meets the target, the model is initiated.

Selecting Model Start Date: PTGM on NEWA
- Select "Start Date."
- Click the model start date on the calendar.
- Click "Select Time" and add the model start time to the nearest hour.
Estimating average style length

- Watch the video ABCs of Determining King Bloom Average Style Length
- 25 to 50 king blossoms at late balloon stage are sampled per block
- Styles are detached with a razor blade. For each sampled flower, measure the length of the longest style with a set of digital calipers.
- Record all values.

Entering Style Length: PTGM on NEWA

- Average style length can be entered by selecting "Insert average style length."
- The second option is to insert the style length measurements, and software will calculate the average. In this case, select "Calculate average style length."

Step 4

- Once the model start date/time and style length are added, you can observe estimated pollen tube growth rates.
- Also, you can see the estimated date of your 1st application, when pollen tube growth is ~100% of the average style length.
Step 5: Set the timing of your 1st spray

- Ideally, this should occur when pollen tubes are estimated to be equivalent to the average style length of 100%.
- In this example, LS + oil should be applied ~ 6 am on 4/14.
- The model does not account for environmental conditions at the time of application.
- From a practical perspective, try to make the 1st spray between 100 – 110%.

Step 6: Set the timing of your 2nd spray

- Once the 1st application is made, add the date and time of the application to the block, to the nearest hour.
- Apply your 2nd application at 50 to 60% estimated pollen tube growth rates relative to style length.
- If you wait to apply at 100% on the 2nd application, then you are at risk of thinning too late. Applying at 100% would allow pollen tubes to have the opportunity to grow the length of the style and will likely reduce thinner efficacy.

Model Limitations and Practical Considerations

The model does not account for:

- weather conditions at the timing of application
- pollinator activity
- frost/freeze damage

For first use

- Work with the model and get comfortable with it before thinning season.
- Try the model on a small block.
- Be sure to leave check trees.

The pollen tube growth model (PTGM) was developed at Virginia Tech. It is based on apple pollen tubes growth rates that were empirically derived under controlled temperature conditions. Model validation has been conducted in Washington, Virginia, and New York orchards.

The PTGM begins when the desired number of king bloom flowers are in full bloom (that is when the petals no longer cover the reproductive organs thus allowing for cross-pollination). The desired number of open king bloom flowers is equal to the desired crop load and is determined by counting the number of open king bloom flowers per tree or by visual assessment of full bloom density in the orchard. Average style length is measured at this time and is used as a variable in the model.

Hourly temperatures recorded in or near the orchard are used with the pollen tube growth rate equations to calculate cumulative pollen tube growth. Chemical bloom thinning applications are made when the pollen tube lengths are equivalent to average style length. The supposition is that fertilization has occurred at this point.

Assuming that pollen tubes must grow the entire average style length on flowers that reached full bloom after an application of a bloom thinner, the model is reset after the bloom thinning application is made. Additional bloom thinning applications occur before pollen tubes grow to the end of the style to prevent additional fertilization. Applications cease at the end of bloom. Typically, two chemical thinning applications are necessary each year. Occasionally, a third application is necessary.

References
