WSU Tree Fruit Extension

Fire Blight

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Overview

Fire blight is an important disease effecting pear and apple. Infections most commonly occur on late blooms in May or June during the three weeks following petal fall. Increased acreage of highly susceptible apple varieties on highly susceptible rootstocks has increased the danger that infected blocks will suffer significant damage. In Washington there have been minor outbreaks annually since 1991 and serious damage in about 5-10 percent of orchards in 1993, 1997, 1998, 2005, 2009 and 2012.

Causal Organism

Fire blight is caused by *Erwinia amylovora*, a gram-negative, rod-shaped bacterium. It has a flagella, which allows it to move in water. The bacteria grow by dividing. The rate of colony growth in host flowers is regulated by temperature. *E. amylovora* growth is very slow until air temperature rises above 21° C (70° F), with almost no growth below 10° C (50° F). Then the rate of division increases rapidly. Optimal growth temperature for *E. amylovora* is 27° C (80° F). Depending on the strain, growth stops and colony numbers decline above 35 to 39° C (95 to 105° F) (Pusey and Curry 2004). Colonies on the host experience a wide range of temperatures each day, so actual rate of colony growth varies from one moment to the next.

Overwintering canker. ***Photo credit:*** *Mark Longstroth, Michigan State University.*

Signs and Symptoms

Overwintering cankers

Affected areas appear black and dry. In older tissue the bark may be sunken. If the bark is cut away from the edge of an active canker, reddish flecking can be seen in the wood adjacent to the canker margin. This flecking represents new infections the bacteria cause as they invade healthy wood. As the canker expands, the infected wood dies, turns brown, and dries out. Areas of dead tissue become sunken, and cracks often develop in the bark at the edges of the canker (Teviotdale 2011).

Orchard with burnt appearance due to severe fire blight infection. ***Photo credit: Tim Smith, WSU Extension.***

Blossom clusters and young shoots

Blossom symptoms are first observed one to two weeks after petal fall. The floral receptacle, ovary, and peduncles become water soaked and dull, grayish green in appearance. Later these tissues shrivel and turn brown to black. Similar symptoms often develop in the base of the blossom cluster and young fruitlets as the infection spreads internally. During periods of high humidity, small droplets of bacterial ooze form on watersoaked and discolored tissues. Ooze droplets are initially creamy white, becoming amber tinted as they age (Johnson 2000).

Shoot symptoms

Tips of shoots may wilt rapidly to form a "shepherd's crook." Leaves on diseased shoots often show blackening along the midrib and veins before becoming fully necrotic, and cling firmly to the host after death (a key diagnostic feature.) Numerous diseased shoots give a tree a burnt, blighted appearance, hence the disease name.

Shepherd's crook death of shoot tips. ***Photo credit: Tianna DuPont, WSU Extension.***

Apple rootstocks

Rootstock infections usually develop near the graft union as a result of internal movement of the pathogen through the tree or from infections through water sprouts or burr knots. The bark of infected rootstocks may show water-soaking, a purplish to black discoloration, cracking, and signs of bacterial ooze. Red-brown to black streaking may be apparent in wood just under the bark. Symptoms of rootstock blight can be confused with Phytophthora collar rot. Malling 26 and 9 rootstocks are highly susceptible to fire blight (Johnson 2000).

Graft union necrosis 'rootstock blight' caused by fireblight. ***Photo credit: Tim Smith, WSU Extension.***

The Infection Process

Erwinia amylovora, the bacterial pathogen that causes fire blight, overwinters within diseased bark tissue (i.e., the blight canker) that was infected the previous season. Frequently, over the winter, the pathogen dies out in many of these cankers, but in 20 to 50% of cankers, active cells of the pathogen survive until the next bloom period (van der Zwet and Beer 1991). When humidity is high in spring, the pathogen oozes out of these old cankers. This ooze is attractive to insects (e.g., flies) as a food (Ogawa and English 1991).

Bacterial ooze is attractive to insects which help transport the pathogen. ***Photo credit: Tim Smith, WSU Extension.***

Subsequently, when these insects also feed on nectar in nearby flowers, they transfer the blight pathogen to the floral stigmas, the nutrient-rich surfaces located at the top of the floral styles. Cells of the pathogen can also be moved from old cankers to flowers by splashed and wind-blown rain. The pathogen multiplies on the stigmas during the 4 to 8 days the flower is open. Once a few blossoms are infested, honeybees, other insects and rain can move the pathogen to additional flowers (Pattemore et al. 2014; Johnson et al. 1993). If the weather is warm, the pathogen grows rapidly forming a colony on the stigma. These colonies can then be washed down the style into the floral nectary by water (usually from rain or heavy dew). If the pathogen is successful in infecting the developing fruitlet, the disease spreads into the cambium (just between the bark and the wood) of the tree, killing young host tissues as it progresses (Momol et al. 1998).

Characteristic “strike” symptoms may take 21 days after infection to be noticible. During this period of symptom development, the bacteria migrate inside the tree, well ahead of the visible symptoms. The pathogen can move within the tree to other highly susceptible tissues, such as nearby shoot tips or even the rootstock. As the tree goes dormant in the fall, the bacteria form a dormant mass along the living edge of the current season’s strike, and overwinter there until the following spring. Cankers that develop later in the growing season, and those on younger wood are the most likely to harbor surviving pathogens cells and create ooze the following spring.

Critical Timing & Temperatures

Side blooms above are a key site of infection

It is critical that growers are aware of fire blight risk from when primary bloom begins until the end of secondary (rat tail) flowering. Secondary bloom, typically 1 to 3 weeks after full bloom is generally a prime period for infection. Compared to non-dwarfing rootstocks, dwarfing rootstocks tend to promote secondary flowering. Many modern cultivars (e.g., Bartlett pear and Cripps Pink apple) also tend to produce secondary flowers.

At temperatures of 60-70° F, the fire blight pathogen grows slowly. When temperatures reach 70-75° F, it is important that growers watch the weather forecast and blight risk warning models, and prepare to apply preventative spray treatments. 75-90 °F is fire blight weather. The bacteria will replicate quickly at these temperatures (Pusey and Curry 2004).

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Blight Hazard Factors

Tree age

The younger the tree, the more damage is likely to occur if it is infected. Fire blight rapidly progresses on young, rapidly growing portions of a tree. Strikes usually slow their expansion once they reach two or three-year-old apple wood, even on more susceptible varieties. On very young trees, low numbers of pathogen cells can move in 21 days from infections in upper limbs through the trunk to the graft union with the rootstock (Aldwinckle 1998).

The older an apple trees is, the less likely that infection will kill the tree by progressing all the way to the rootstock. Infection during the first three years is most dangerous. There can be serious problems with rootstock blight up through the fifth leaf, and sometimes as late as the seventh season. After that, rootstock blight is much less common.

Rootstock

If the rootstock is highly susceptible to blight, (M.9, M.26, MM106) "rootstock blight" may kill the tree. If the rootstock is no more susceptible than the scion variety, (M.7, Bud9, seedling), then rootstock blight generally does not occur. Fire blight does not cross the graft union in Bud 9 but it is susceptible with direct inoculation which is a concern due to its prolific rootsuckering. Rootstock blight does not occur in pear.

Newer "Geneva" series rootstocks with dwarfing characters similar to M.9 are resistant to fire blight. All Geneva rootstocks in commercial propagation have fire blight resistance. G.11 is susceptible to some races of fire blight. G. 935 is more resistance than G. 11. G. 41 apears to be immune. G.210, G.214, G.969 and G.890 have yet to be tested with the fire blight inoculum spray at full bloom onto the scion. Infected scion cultivars on Geneva rootstocks may still be badly damaged by fire blight, but are much more likely to survive and regrow, rather than die from rootstock blight.

Cultivar susceptibility to infection

Cultivar susceptibility to fire blight has a genetic component but can also be strongly linked to the flowering habit of the cultivar. Lists of reported tolerance of various apple and pear cultivars to fire blight infection are available. However, no commercial cultivars are known to be immune to infection. Cultivars that bloom over a relatively short period, then quit for the season frequently escape infection. Cultivars that straggle out the primary bloom, then scatter late bloom during late spring and summer are more frequently infected.

Late 'Rat tail' blooms after primary blooms have formed fruitlets.

Tree Vigor

Tree vigor is influenced by age, nutritional status, and crop load. For example, a young tree pruned heavily and supplied with lots of nitrogen to encourage vegetative growth, is more likely to suffer extensive damage when diseased with fire blight than an older tree that is being managed to produce fruit. The common practice of pushing young trees with nitrogen fertilizer to "fill their space," coupled with susceptible genetics, raises the risk for severe damage if infection occurs.

Weather

Severe infections are possible when a region experiences summer-like weather while many flowers are open. Daily high temperatures of 75° to 90° F promote rapid pathogen build-up in pear and apple flowers. When these warm days occur consecutively, the danger of infection increases.

Conditions and landscape positions which promote prolonged dew periods also increase the probability of infection.

Background Fire Blight levels

A serious fire blight outbreak requires a nearby source of the pathogen but this source does not have to be large. For example, a single active, overwintering canker can produce enough bacteria to infest a significant proportion of the flowers in a one acre area, even if daily temperatures are relatively cool. Proximity to an overwintering canker increases the risk that new flowers will be infested with the pathogen and diseased with fire blight. Be aware these overwintering cankers can be within the orchard or within a neighboring orchard. Fire blight in the vicinity last year is an important factor in assessing the risk of fire blight in the current year.

Control Principles

Sanitation

In winter, cut out old blight cankers as thoroughly as possible. Cut blight before you prune for tree structure so that the blighted cuttings can be removed from the orchard. Compared to cuts made in summer, winter removal cuts can be made closer to the visible canker edge because the pathogen is confined to the cankered area. Cut at the next "horticulturally sensible" site below the canker. You do not need to sterilize tools when you are cutting on fully dormant trees. Some growers have effectively used blow torches (MAPP gas) to kill cankers that were difficult to remove from the tree. Charring the wood to kill the canker is not necessary.

Late dormant copper plus oil applications may also provide orchard sanitation, reducing inocula levels going into spring (Elkins et al. 2015).

During the summer, cut out blight when you see it. Make summer cuts at least 12" below the edge of the visible canker. Removing a strike can greatly reduce further damage to the tree, especially if you catch the strike early.

Manage the orchard environment.

Heat drives the infection process, and moisture on the blossoms triggers it. You can do little to affect the daily temperature in a way that will reduce the potential for blight infection. Neither can you stop the rain from wetting blossoms, but you may influence the potential for dew. When a period of abnormally high temperature without rain comes and goes, blight outbreaks may occur in low, flat "frost pockets" or valleys in the orchard. In these areas dew forms on flowers earlier and stays longer. Data gathered from leaf wetness sensors shows a wide variation in the presence and duration of dew. It appears that as few as two or three hours of wetting is sufficient to trigger infection if the four-day degree hour total is over the high risk threshold.

Influence the orchard micro-climate to reduce dew. Irrigation, frost control, and the transpiration of trees and cover crops can increase the relative humidity of the orchard. Keep early season irrigation, cover crop and weed growth to a minimum. It is particularly important to limit sprinkler misting which can trigger blight. Of course, your orchard may need some irrigation during May and June. However, studies have shown that trees are not nearly as stressed for water as we think they are in the spring. A little soil drying is beneficial, assuming trees are well watered when the really stressful time of year begins. It is unlikely that you will overly stress trees during the few days of peak fire blight risk. Keep the intervals between irrigation as long as possible, and let the soil surface dry.

Blossom thin if risk is high.

Most blight problems start as blossom infections. You may greatly reduce the chance of infection in a young block by hand removing blossoms. While hand removal may take 2-3 hours per acre on first or second year trees, if the fire blight model says risk is high, and your young trees have scattered blossoms, pulling the blossoms may save you much more than the cost of labor. Many organic growers successfully use the blossom removal method to prevent secondary bloom fire blight on their young pears and apples.

On larger trees, any caustic blossom thinning sprays (e.g., lime sulfur) that burn the stigma tips help to prevent the continued build-up of the fire blight pathogen on the treated blossoms. This stigma tip removal may set back the overall infestation level in the orchard for a few days after application.

Plant apples on fire blight resistant rootstock, whenever possible.

Some blight resistant rootstocks are recently available, and more are coming. These will not make the top of the tree less susceptible to fire blight, but they will help prevent tree death from "rootstock blight." For a nice summary of fire blight susceptibility see: The Organic Center: Fire Blight Control Program in Organic Fruit.

Keep vigor of the tree moderate.

Moderating vigor will not prevent infection, but it will reduce damage done to the tree by fire blight strikes.

Manage pathogen growth on stigmas.

Watch for dangerous warming trends (calculate degree hour potential using the past four days, and project them for the next three days using predicted temperatures). The best way to keep on top of the model predictions is to use the CougarBlight model within the WSU Decision Aid System for Tree Fruit (DAS). If your trees are likely to be blooming during the upcoming high risk period, apply a protective spray.

Watch the model.

Controlling fire blight is difficult unless you apply an effective control product very close to the infection time (Smith and Pusey 2010). Most sprays provide no long-term protection or kickback. This is one important situation where you cannot rely on slow advice to take action. The risk of infection develops much faster than most other pathogens. Advisors can warn you that a high blight risk period is coming, but day to day decisions during the time that risk is high are up to you. Most infections happen during a time that the fire blight model indicates high or extreme danger. During the past ten years, many growers applying sprays as suggested by the Pacific Northwest USA "CougarBlight" model have had good control compared to those who sprayed on a schedule, or not until too late. Whenever blossoms are wetted during a time that the model indicates your orchard is in high or extreme risk, infection is likely in your region, but not always in your orchard. You can get lucky by not having a sufficient local source of the pathogen. As we have no quick test for the presence or absence of *E. amylovora* in blossoms, you should assume they are there, especially if fire blight has been a problem in your region the past season.

Apply preventive sprays when necessary.

See example control strategies below. Remember that coverage is important. Maintain your canopy such that good coverage is possible. Calibrate your sprayer and consider using a tower sprayer which is more likely to provide even spray coverage.

Biological Methods of fire blight suppression

When applied to open flowers, these micro-organisms produce colonies on the stigma surfaces and nectary, and spread by insect to protect newly opened flowers. With biological materials, spray treatments need to be initiated relatively early in the bloom period before high fire blight risk has developed. That is, a biological material (e.g., Blossom Protect) will need to be sprayed in the specific developmental window of 50% to full bloom regardless of fire blight risk model information.

Blossom Protect is a combination of two strains of Aureobasidium pullulans, a yeast that occurs naturally in Pacific Northwest pome fruit flowers. This organism grows on the nectary and stigmas of treated flowers, and competes directing with the fire blight pathogen for the nutritional resource available on these surfaces. Blossom Protect is applied with a companion buffer, Buffer Protect, which reduces the pH of the sprayed suspension and helps the yeast grow faster than the pathogen. In Pacific Northwest trials, Blossom Protect has been the most effective bio-control organism to date. If this product is used, it is important to spray every row at least once.

Bloomtime Biological is the E-325 strain of the bacterium *Pantoea agglomerans*. This bacterium competes with the blight bacteria for space and resources on the stigma, and also secretes natural inhibitory substances that inhibit pathogen growth.

BlightBan A506 is a strain of Pseudomonas fluorescens that competes with the blight pathogen for resources and space on the stigma surface.

Chemical Methods of Fire Blight Suppression

Antibiotics

Kasugamycin (tradename: Kasumin) is a newly labeled antibiotic with good levels of control in recent studies (~80%). *Erwinia amalovora* strains are currently all sensitive to this material but there is an intermediate risk of resistance developing to this antibiotic (Adaskaveg, Forster, and Wade 2011).

Oxytetracycline (tradenames: Mycoshield, FireLine) generally performs well in Washington trials and has a low risk of resistance development.

Streptomycin (tradenames: Agri-Mycin, FireWall): Streptomycin-resistant strains of the fire blight pathogen have been present in Washington orchards since about 1975 (Coyier and Covey 1975; Loper et al. 1991). Recent tests have indicated that the proportion of the pathogen population resistant to this antibiotic has dropped, and expected control levels have improved (Forster et al. 2015). This product should only be used in combination with oxytetracycline, and should not be used unless a serious infection period is under way. Use of streptomycin should be limited to once per season because after its use, remaining pathogen colonies in the orchard should be assumed to be streptomycin-resistant.

Coppers

Copper products can be quite effective, but their use is currently mostly limited to early-season applications due to the risk of phytotoxicity to the developing fruit. New copper formulations are currently being tested.

SARs

Acibenzolar-S-methyl (ASM, Actigard 50 WG), is a synthetic inducer of systemic acquired resistance (SAR). Its mode of action is to mimic the plant hormone, salicylic acid, which is responsible for priming the plant’s defense system. The response is smaller compared to an antibiotic but it lasts longer, approximately a week (Maxson-Stein et al. 2002).

Serenade Optimum

Serenade Optimum is an apparently ‘fruit safe’ material, which is made by fermenting a strain of *Bacillus subtilis*. The antimicrobial activity of Serenade comes mostly from biochemical compounds produced by the bacterium during fermentation, and not because of the bacterium’s colonization of flowers in the orchard (in contrast to Bloomtime or Blossom Protect). Serenade has both antibacterial and antifungal activity.

Example Organic Spray Program

(Johnson and Temple 2013; Johnson et al. 2014)

1. **Prebloom (just prior to green tip):** Fixed copper sanitation if fire blight was in orchard last year (5 to 6 lb/A).
2. **Early bloom apple (crop load thinning):** Lime sulfur (plus oil) during early bloom (20 and 70% bloom). Reapply biological if lime sulfur goes on after biological.
3. **Early bloom pear and apple Blossom Protect:** One full, two half applications, or two full applications if blight was in orchard last year. In apple, apply Blossom Protect immediately after 2nd Lime Sulfur. In smooth-skinned pears in wetter areas, russet risk might be unacceptably high. Bloomtime Biological is an alternative, fruit-safe biological material
4. **Full bloom to petal fall:** Depending on the cultivar russet risk and the CougarBlight model risk apple:
    - <u>Serenade Optimum</u> every 2 to 5 days (<u>most fruit safe</u>);
    - Or for improved control mix Serenade Optimum with Cueva (2 to 3 qts/A), or use Cueva (or Previsto) every 5 to 6 days (3 to 4 qts/A) (<u>This option is least fruit safe for russet</u>).

Example Conventional Spray Program

1. **Early bloom.** Apply biological controls. If blight was in the orchard last year use two applications of the biological. There is some russet risk for smooth skin pears.
2. **Full bloom to petal fall.** Apply antibiotics only as indicated by risk level in the CougarBlight model.

Some trials have shown that a full rate of Kasumin (100 ppm) + a half rate of oxytetracycline (100ppm) provide excellent control; the addition of oxytetracycline provides partial resistance management protection for the potential selection of kasugamycin-resistant pathogen strains.

Orchard Clean up After Fire Blight Infection: Use of Actigard Paints

New research has shown that treatment of trees with the chemical, Acibenzolar-S-methyl (ASM, Actigard 50 WG), may reduce re-occurrence of blight after cutting out infected strikes. Re-occurrence happens when the act of cutting out the disease does not completely remove the pathogen cells that have moved ahead of the expanding canker. As mentioned above, this is generally more of a problem in younger trees (3 to 10 years old) where the residual pathogen cells left in the tree can re-initiate disease development.

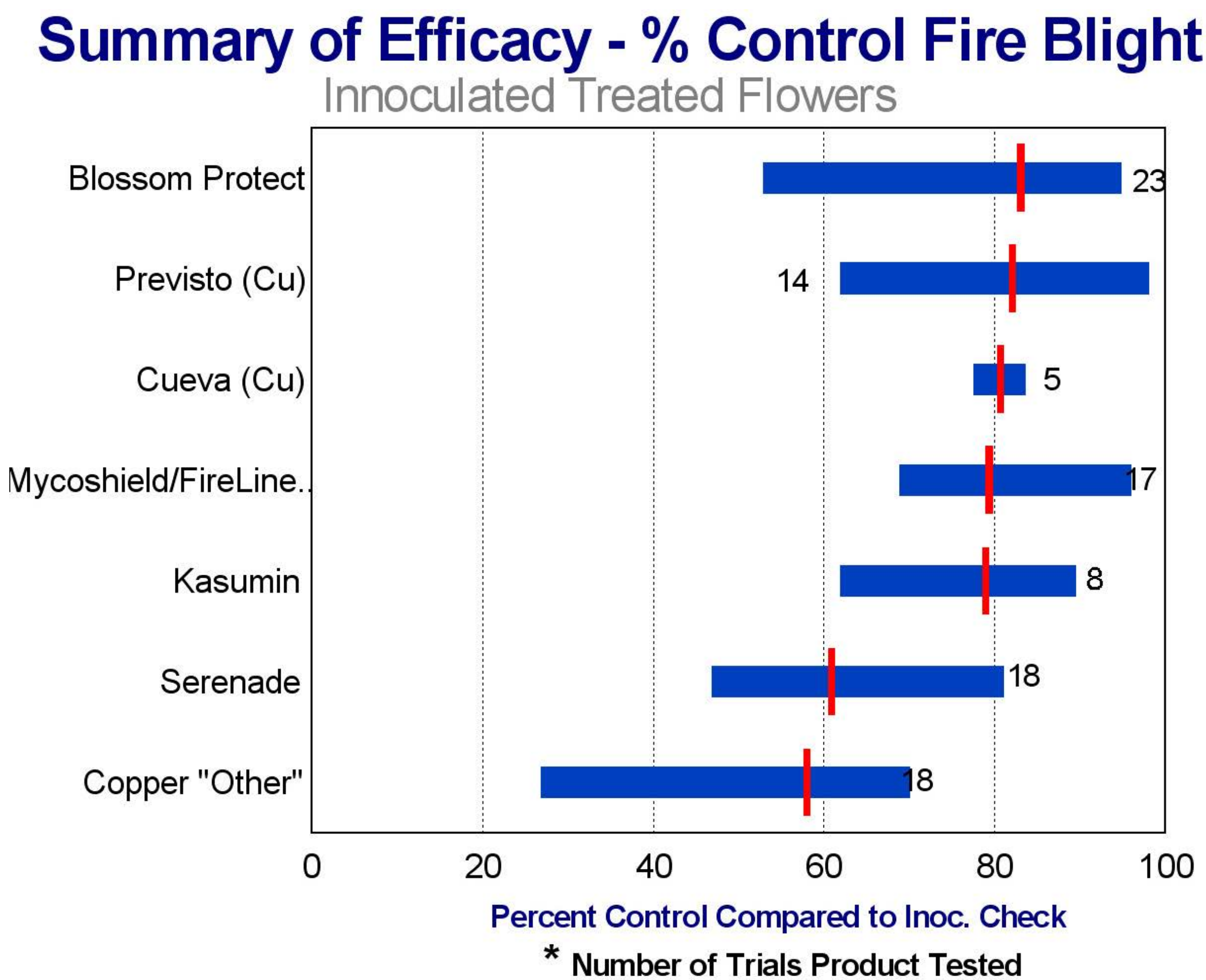
Plants have defense systems. If something stimulates the plant's defense response before the symptoms develop (or re-develop), the plant will be in an active defense mode and will be less affected by disease when it occurs (or re-occurs). Actigard is a compound that has been found to trigger induced resistance. Its mode of action is to mimic the plant hormone, salicylic acid, which is responsible for priming the plant's defense system.

For five years, Dr. Ken Johnson of Oregon State University has found that painting a concentrated solution of Actigard on trees after cutting out infection reduced the severity of re-occurring fire blight cankers in pears. For example, he found that without treatment after cutting out fire blight cankers in young Bosc pear trees, the disease came back 50% of the time and began to run through the tree. With Actigard applications, both the proportion of trees in which fire blight came back and the rate of canker expansion was reduced (Johnson and Temple 2016).

During the summer, cut out blight when you see it. Removing a strike can greatly reduce further damage on the tree, especially if you catch the strike early. ‘Paint’ (generally with a small sprayer) concentrated Actigard with an up and down motion to a ½ meter length of the central leader or major scaffold near where the blight was. Use the labeled rate of 1 oz/ 1 quart with 1% silicone based penetrant. One quart will treat approximately 500 cuts.

Efficacy Data

Many trials have been conducted on the efficacy of fire blight control products. The following graph summarizes the relative efficacy of a number of products. These control levels were attained under severe test condition and do not necessarily reflect the results you would see in the orchard. They are however a good indicator of relative efficacy. These products must be applied at the correct timing to be effective.



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