Bacterial Stem Blight: A Disease That Increases Frost Damage

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Alfalfa farmers count on the first harvest in late spring to deliver the highest tonnage and best quality forage of the year. A late frost can significantly reduce yield and quality. Losses are due not only to physical damage from freezing of alfalfa stems and leaves but also from damage caused by a bacterial pathogen called *Pseudomonas syringae* (Sue-doe-MOAN-as Sigh-RING-a).

When an alfalfa plant breaks dormancy, leaves rapidly become sensitive to frost and freezing injury. Exposure to 25°F for as little as 2 hours will often result in frost injury. Degree of injury depends on many factors, such as soil moisture, soil type, field location, residue on surface, and presence of *P. syringae* on the leaves and stems. The contribution of *P. syringae* to frost damage has largely been overlooked in the past, although the disease has been reported as widespread in the central and western states, including the Pacific Coast, and it occasionally occurs in the eastern United States. In elevated, colder valleys of the western mountainous regions of the United States, forage losses from first-crop harvests have been reported as large as 40-50% for some cultivars. Recognizing bacterial stem blight disease is important for managing the crop to reduce damage, to reduce the populations of *P. syringae,* and to protect the field from future damage.

Figure 1. Frost damage on alfalfa.

Figure 2. Symptoms of bacterial stem blight on alfalfa leaves and stems.

Frost damage and bacterial stem blight symptoms can be separated by close inspection of stems 1-2 weeks after the frost event. A hard frost will cause alfalfa stems to bend over with a "shepherd's crook." If, after a few days, stems straighten back up, the stem is uninjured and will resume growth. However, frost damaged leaves and stems will turn white to tan and start to dry out (Figure 1). Often, the top of the plant is most affected. Bacterial stem blight symptoms appear 7-10 days after frost. Symptoms on stems begin as water-soaked, yellowish to olive green lesions, usually at the point of attachment of a leaf, and then extend down one side of the stem. Lesions become amber and blacken with age. A stem may have more than one lesion, and the lower 3-5 internodes are typically most severely diseased. Leaves become water-soaked and turn yellow and are often twisted and deformed (Figure 2). A field may often have symptoms of both frost damage and bacterial stem blight.

Bacterial stem blight is associated with frost because of a unique protein found in the outer membrane of *P. syringae*. This protein mimics the crystalline structure of ice and acts as a starting point, or nucleus, for ice formation. Pure water can be "supercooled" to -55°F and stay in a liquid form, but ice forms at relatively warmer temperatures when an ice nucleus is present. In the presence of *P. syringae*, ice can form at 28.8°F to 25°F, causing plant damage. The discovery of ice nucleation activity in *P. syringae* led to intense research. Diseases caused by *P. syringae* on annual crops (e.g., snap bean, tomato) have been studied in detail; much less is known about the disease on perennial crops including alfalfa. A mutated form of *P. syringae* unable to nucleate ice was the first microbe genetically engineered and released to the environment to reduce frost damage on strawberry and potato. The ice protein of *P. syringae* is such an efficient ice nucleus, it is used in most artificial snow-making operations. In fact, *P. syringae* is found in clouds and in pristine natural snow and rain, compelling evidence that the bacterium is involved in global water cycles.

Leaf surfaces support large populations of 1-10 million bacteria, usually living in harmony with the plant without causing disease symptoms, and *P. syringae* is often the dominant member of these microbial communities. Based on studies on annual crops, *P. syringae* populations increase during cool moist weather in spring and is moved to emerging leaves by water splash, wind, and insects. Population size depends on host genotype and environmental conditions. When *P. syringae* populations reach a threshold level, the plant is vulnerable to frost damage from ice nucleation activity of the bacterium. This damage creates a break in the leaf surface, releasing nutrients for bacterial growth and an entry point into the plant interior. Recently, several areas with a high frequency of bacterial stem blight and significant crop loss have been identified and research is ongoing to determine the conditions leading to the emergence of this disease. These studies indicate some crop chemicals may influence size and composition of microbial communities leading to bacterial stem blight.

Research by scientists at USDA-ARS in St. Paul, MN, and Beltsville, MD, has investigated the bacterial and plant components of bacterial stem blight. The strain of *P. syringae* causing disease on alfalfa is also a weak pathogen of snap bean, sugar beet, and pear, and shares many of the same genes as *P. syringae* strains isolated from these crops. The complete genome of the bacterium has been sequenced and a small number of genes unique to the alfalfa pathogen identified. A standard test was developed for assessing disease resistance and used to screen a number of alfalfa cultivars. Interestingly, the cultivars with the highest percentage of resistant plants were those with high winter survival ratings and strong fall dormancy. These tools will be useful in selecting resistant plants from elite cultivars for improving resistance to this disease.