Bacteria may hurt plants in many ways

MADISON, Wis. — During late spring or early fall frosts, some strains of bacteria may play a primary role in inciting plant damage. Scientists of USDA's Agricultural Research Service (ARS) and the University of Wisconsin, here, now face the challenge of controlling these bacteria - possibly with other strains of bacteria.

The main culprits, strains of the bacteria, Pseudomonas syringae and Erwinia herbicola, act as nuclei in the formation of ice crystals on plants, says chemist Christen D. Upper of the ARS Disease Resistance laboratory.

The bacteria, ice-nucleation-active (INA), are capable of initiating crystallization of supercooled water - water that remains fluid at temperatures below 0 degrees Celsius.

If no nuclei were on the leaves of young corn, bean or tomato plants, water inside the plant cells would supercool to temperatures as low as −5 degrees Celsius or 23 degrees Fahrenheit rather than freeze and injure the plants, says Upper.

Ice nuclei are important in precipitation processes. Cloud seeding, for example, is adding ice nuclei to clouds.

In addition to their role in frost damage, strains of Pseudomonas syringae and Erwinia herbicola sometimes cause yield-robbing plant diseases as they colonize leaf surfaces of a wide variety of crops throughout the world.

A study by post-doctoral plant pathologists Julianne Lindemann and Helen A. Constantinidou, University of Wisconsin meteorologist William R. Barchet and Upper concluded that plants constitute the major source of bacteria in the atmosphere and that aerosol samples taken at plant canopy levels must represent very local sources.

Basis studies at Madison impinge on the question: Under what environmental conditions will the INA bacteria alight on plants, survive and multiply to populations that cause plant disease or frost damage?

In an earlier field experiment Upper and his colleagues used antibiotics to reduce populations of INA bacteria and they reduced frost damage This control method would not be practical in a farming situation. However, the scientists are hoping more practical ways can be found as a result of their basic studies.

A biological control of INA bacteria that looks promising is seen in competing non-INA strains of the same species as the offending bacteria. Some non-INA strains have been found that will compete with INA strains in nature.

Strategies to control frost injury to plants may depend in part on studying the molecular nature of the active ice nuclei. Such research is being conducted at the University of California, Berkeley, by plant pathologist Steven E. Lindow who as a graduate student at Madison worked with Upper. The study may help scientists devise more sensitive methods than they now have for identifying INA bacteria in the air.

Then it may be possible to determine the extent to which INA bacteria are responsible for atmospheric ice nuclei. INA bacteria are probably the most abundant naturally occurring ice nuclei known that function at temperatures warmer than about-5 degrees Celsius, says Upper.

In their studies on plant sources of airborne bacteria, the scientists found that the bacteria were leaving canopies and mixing with lower levels of the atmosphere. It is probable, Upper says, that the bacteria are carried aloft and mixed throughout the troposhere.

The scientists found that on a dry sunny day, wind transports more live bacteria into the atmosphere from the leaves of plants than from bare soil.

The scientists observed abundant bacteria leaving a field of heading winter wheat and flowing into the air. On the same day just above a field of very young corn, where lots of bare ground and little plant surface was exposed to the wind, bacteria concentrations were only about 2 percent of concentrations over the wheat.

Above the wheat field, concentrations of bacteria sampled on different days varied as much as 10-fold. This sort of variability from day to day or even within a day is common, Upper says.

In an alfalfa field, concentrations only 10 meters inside the field were indistinguishable from concentrations 100 meters into the field.

"We concluded that aerosol samples taken at plant canopy levels must represent very local sources," said Upper.

All of this information may be useful in the quest for economical ways to reduce the gamble that farmers take in northern States as they try to produce corn and other crops between late spring and early fall frosts.

In high-value crops such as citrus, controlling INA bacteria may be an especially attractive alternative to using orchard heaters or other energy- and capital-intensive methods to curb frost damage.

Commercial application of the research may be years away but the study is an example of work that could reduce crop losses, helping alleviate hunger in the future.

But the implications may go even further.

"The overall importance of epiphytic bacteria, that is, the bacteria that live on plant surfaces, as the major source of the bacteria in the air we breathe is not yet known," Upper says. "However, it is likely that bacterial plant pathogens can be spread long distances. The bacteria themselves may be modifying our weather. Who knows? They might even make us sneeze!"