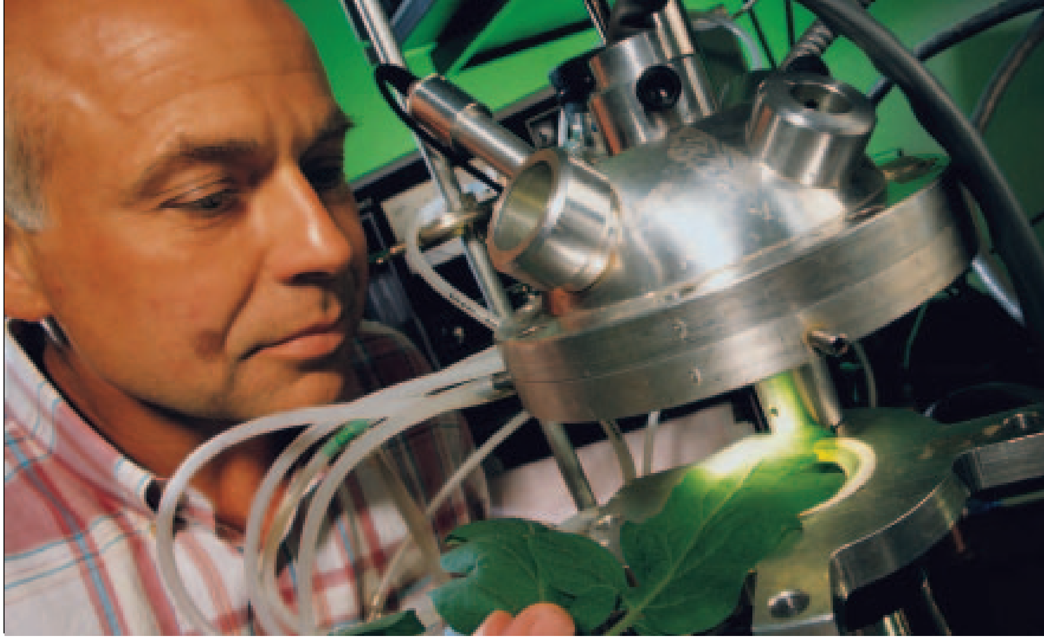
Cool Nightlife Bad for Tomatoes



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Plant physiologist Don Ort will insert the leaf of a tomato plant exposed to cool night temperatures into the airtight sample chamber of a device designed and constructed in his laboratory. Light guides and hoses lead to instruments that simultaneously measure photosynthetic activities in living plants. (K7405-7)

Imagine a footrace in which the runner's feet moved in opposing directions. Mission impossible?

Scientists in the ARS Photosynthesis Research Unit at Urbana, Illinois, have discovered a drop in the overnight temperature below 50ºF can create a biochemical version of mission impossible for some crops like tomatoes, soybeans, and corn. The result is less efficient photosynthesis, reduced yields, and an explanation for the geographic limits imposed on these plants because of their temperature sensitivity.

Don Ort, a plant physiologist at Urbana, says the warm-weather evolutionary origins of plants like tomatoes and corn make them more sensitive to changes in temperature during the growing season.

"Plants have an inborn timekeeping mechanism—a circadian rhythm played out over 24 hours—during which specific chemical reactions take place," Ort says.

The circadian rhythms are important because they regulate the timing of processes within the plant, he adds. "There are specific reactions that are timed to occur at a given period of day or night." If allowed to occur simultaneously, they would compete and stall photosynthesis—just as competing foot movements would paralyze a runner.

In plants such as tomatoes, low temperature disrupts the circadian clock. "The mistiming of the expression of certain genes upsets photosynthetic metabolism, giving rise to the characteristic chilling sensitivity of these crops," says Ort.

Low night temperatures inhibit daytime photosynthesis in these types of plants by effectively delaying until after dawn those reactions and processes that would normally take place at night.

For example, in tomatoes, if the nighttime temperature were to drop below 50ºF at 10 p.m. and not warm up until 8 a.m. the next day, the plant would behave as if it were still night and continue nighttime activities during daylight hours. At the same time, the plant would initiate daytime processes that compete with such ongoing nighttime processes as the breakdown of starch into sugars.

The regulation of phosphoprotein phosphatase gene transcription gives rise to the circadian pattern in activity of sucrose phosphate synthase and nitrate reductase. It is the effect of low temperature on the transcription of this gene that causes delay in the circadian activity pattern of these two key enzymes. Ort says it is very likely that what differentiates a chilling-sensitive plant from a chilling-tolerant one has to do with expression of phosphatase genes.

"What makes it doubly intriguing is, if you look at the same things in a native plant, you don't see this effect," he says.

Using this information, scientists hope to narrow the focus of their research to a specific realm of the photosynthetic process and to use molecular engineering to override low-temperature sensitivity.

"If we're successful, it could have a significant impact on several economically important crops," says Ort. "For instance, an improvement of even one or two degrees Fahrenheit in temperature tolerance would significantly expand the geographic range of these crops to new regions, as well as dramatically improve the year-to-year consistency of yields where the crops are currently grown."—By **Dawn Lyons-Johnson**, ARS.

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