Waking sleeping plants with plasmas

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In late February a grape vine shows the first sign of production; the small bud will grow into a cluster by early summer. Photo by Jaime Tankersley/NRCS Texas Credit: USDAgov via Wikimedia Commons

Commercial crops like grapes, peaches, berries and flower bulbs all go dormant in the winter, essentially sleeping through the seasonal cold before they resume growing, flowering and fruiting again in the warmer months.

A critical concern for commercial farmers is to have good and synchronized tree growth. The problem in mild winter climates is that plants do not receive enough chilling, and growth resumption becomes

spread out with some buds even failing to grow. When orchards of dormant trees start growing at approximately the same time, this generally makes taking care of trees and harvest easier and less costly—but tree growth and its timing is controlled by the unpredictable wiles of winter weather.

Now a group of scientists from Jazan University of Saudi Arabia has discovered an effective new way to control the dormancy of grapes and other fruiting plants, by using high-tech plasmas to wake them from their winter's slumber.

The work may help to extend the cultivation of fruit crops and ornamental plants native to temperate climates to parts of the world where winters are milder, including the southern United States, Mexico, Brazil, South Asia, Southeast Asia and the Middle East. It may also mitigate the problems posed by rising temperatures due to global warming in certain parts of the world.

The work was done by a team of scientists comprising Habib Khemira, a horticulturist; Zaka-ul-Islam Mujahid, a plasma physicist; and Taieb Tounekti, a plant physiologist. "Artificial methods to release dormancy are expected to become more important in the near future due to global warming," said Mujahid, who will present the work next week at the American Physical Society 71st Annual Gaseous Electronics Conference and 60th Annual meeting of the APS Division of Plasma Physics, which takes place Nov. 5-9 at the Oregon Convention Center in Portland.

Though the method worked in the laboratory, it still needs to be field-tested and prove commercially feasible and economically viable to benefit industrial-scale food production.

To Sleep, Perchance to Bud

As cold winter creeps its way toward the lonely orchards, crops feel the longer nights and brisker days and adapt by becoming dormant. Starting in the fall, they shed their leaves, slow down their metabolic activity and enter a "sleepy" state in which they will persist through the chilly months.

Plants are released from their Jack Frost slumber by the chill of winter itself. They sense the cold, keep track of frigid days in the dead of winter, and when enough of those cold days occur, the plants respond by increasing their metabolic processes that leads to bud break and shoot growth when the warmer days of spring arrive.

But when plants are grown in mild-winter regions or the climate becomes warmer, they may not receive enough chilling to release their buds on time. Sometimes with wonky weather patterns, you will find flowers, fruit and dormant buds all on the same tree at the same time. Over an entire orchard, this can cause asynchronous crop maturation—an undesirable outcome for farmers because it complicates operations such as pest control and increases labor costs and lowers the yield.

One of the challenges for modern farming is to find ways to push the maximum number of bud on plants to grow, and to bear flower and fruit all at the same time. This would equate to a larger leaf area to feed the growing fruit, and to a larger crop which will be ready to pick at the same time.

A Novel Solution that Started with a Casual Discussion

The Saudi Arabian team achieved a new way to trick the plants out of dormancy by subjecting them to plasmas, which are special, hot, ionized

gasses sometimes referred to as the fourth state of matter—next to solids, liquids and ordinary gases. You can find plasmas in lightning strikes, stellar cores, heavenly auroras and old-school neon signs.

Scientists use plasmas for everything from powering fusion test reactors to sterilizing medical implants. The team specifically used them to treat dormant grape vines.

They found that plasma exposure causes an oxidative stress within the plant, the exact same signals induced by the cold in the cells of dormant plants to which the buds respond by awakening. By treating grape buds with the plasmas, the researchers found they could release the plant's dormancy—and much faster than the weather and more safely than existing artificial methods, which rely on spraying the crops with chemicals.

Mujahid said the work started from a casual discussion he was having with his colleague Khemira, a senior researcher at Jazan University's Center for Environmental Research and Studies. Khemira was describing his work on oxidative stress in grape buds, and they discovered that no one had ever tried to use plasmas to cause oxidative stress and release them from dormancy. They soon tested the approach, and it worked. Taieb analyzed the samples and figured out that indeed the plasma treatment caused an oxidative stress similar to what is achieved by natural cold and hydrogen cyanamide.

"Some of the results from our first successful experiment were phenomenal, and we could not believe it was true," Mujahid said. Even just a few minutes of plasma treatment on buds that never saw cold weather allowed the plants to achieve similar, if not better, bud break as control plants that experienced optimal cold conditions (60 days of exposure to temperatures about 5 degrees Celsius) did.

They tested the approach on different varieties of grapes sourced from different areas and found that it reliably worked on all of them. Commonly growers remedy the problem of lack of chilling by spraying trees with chemicals such as hydrogen cyanamide. The problem is that hydrogen cyanamide or other chemicals are only effective if the plant secures a significant proportion of its chilling requirement from natural cold. Besides, hydrogen cyanamide is also toxic to humans, wildlife and the plants themselves. Because of this, the chemical has been banned in several countries, Khemira said.

Whether the new, greener approach using plasmas to treat dormant buds takes off will depend on a number of things, including whether it would work effectively in the field as well as it did in the laboratory. It needs to be tested on crops other than grapes, and the cost of the equipment also needs to be accounted for.

"There is still a lot of work to test the effectiveness and feasibility," Mujahid said. "We are in the process of figuring out the proper parameters to take it to the field but it could be in use within just a few years."

Khemira said that if the practical aspects are worked out and the new approach does indeed prove commercially viable it would revolutionize the way we grow many crops. The researchers have applied for a patent for the method and delivery system.

More information: Presentation #PR2.12, "Plasma-aided removal of grape bud dormancy as an effective alternative to natural chilling" by Zaka-ul-Islam Mujahid, Habib Khemira and Taeib Tounekti will be Thursday, Nov. 8, 12:15 p.m. in Room A105 of the Oregon Convention Center. Abstract: meetings.aps.org/Meeting/GEC18/Session/PR2.12

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