Daybreak triggers demise of weeds

Imagine: As the morning sun rises, weeds wither and die. This scenario is being made real by a new type of herbicide that enlists sunlight to unleash a destructive force. Researchers Constantin A. Rebeiz and Herbert J. Hopen of the University of Illinois at Urbana-Champaign, who developed the herbicide, call it "a whole new mechanism of killing plants."

The main ingredient of the herbicide is a biodegradable chemical normally found in both plant and animal cells. Plants use this simple amino acid, called *delta*-aminolevulinic acid (ALA), to make chlorophyll, the green pigment that collects light for photosynthesis. In chlorophyll production, ALA is first converted to more complex chemicals called tetrapyrroles, which in the presence of sunlight form the green pigment.

U. of Illinois

Test cucumber seedlings (right) that received a large dose of ALA (equivalent to 300 grams per acre) are dead after an hour in the light. Plants with no chemical treatment or activator alone (left) remain in good condition.

Rebeiz and Hopen have turned nature's carefully controlled reaction into a powder keg. They spray ALA and a chemical activator on plants just before nightfall, so that during the night the ALA is converted into tetrapyrroles, but in the absence of light, the tetrapyrroles are not processed into chlorophyll. Then, when the sun rises, the excess tetrapyrroles react all at once in a destructive manner.

"We bypass the normal control of the plant by bringing in ALA from the outside," Rebeiz says. "At daybreak, the solar energy is absorbed by the tetrapyrroles, and in 10^{-13} seconds they pass on excitation energy to oxygen in the cell." The energized oxygen initiates a series of chemical reactions that ultimately destroy tissue structures, leading to dehydration and death.

The value of this procedure as an herbicide rests on differences in the biochemistry of chlorophyll synthesis among various plants. "We discovered several years ago that not all plants green in the same way," Rebeiz says. The troublesome weeds lambsquarter, mustard, red-root pigweed, common purslane and some food plants are susceptible to added ALA. But other plants can destroy the excess tetrapyrroles produced or convert them into harmless substances. Wheat, oat, corn and barley crops are not significantly affected by the ALA herbicide. A third group of plants, including cotton, soybeans and kidney beans, suffer damage in some leaves but usually recover and produce new leaves.

Because light triggers the herbicidal action, Rebeiz and Hopen call ALA a "laser" herbicide. "All in all," Rebeiz says, "the laser herbicide treatment showed a promising age-, organ- and species-dependent selectivity." —*J. A. Miller*

AMPTE: Tagging the solar wind

For 20 years, Stamatios Krimigis has been pursuing the mysteries of the radiation belts that circle the earth—where do their charged particles come from, and why are those ions up to a million times more energetic than any conceivable source that might have contributed them? This week, Krimigis, from the Johns Hopkins Applied Physics Laboratory in Laurel, Md., together with colleagues from three countries, is poring over computers full of new data to see whether he may at last have some answers.

It used to be thought that the ions in the belts (which were discovered by the first successful U.S. satellite, Explorer 1, in 1958) came primarily from the sun, as part of the solar wind, although it was deemed possible that some came from earth's own ionosphere. The problem has been that the solar wind and the ionosphere have many kinds of ions in common, making it difficult to determine where any of the ions in the belts actually came from.

In 1964, as a graduate student at the University of Iowa, Krimigis joined the belts' discoverer, James Van Allen, on the team of a satellite named Injun 4. His goal was to measure the ratio of alpha particles (helium nuclei) to protons in the belts, a number that was known for the solar wind and assumed to be different for the ionosphere. The ratio measured by Injun 4 was different, all right, but subsequent study showed to Krimigis's surprise that the ionosphere's ratio should actually have been the same, meaning that it was a useless way of distinguishing between the two possible sources for the belts.

Four years later, Injun 5 was sent up to measure ions of carbon, hydrogen, oxygen and other species, but that number, too, was "funny," he says, due to the difficulty of distinguishing between, for example, the oxygen and the carbon ions.

Finally, Krimigis says, he hit on the idea of artificially "seeding" the solar wind well outside the radiation belts with ions of lithium, an element thought to be extremely rare in earth's ionosphere, so that any traces detected in satellite measurements of the belts could clearly be seen to have come in with the solar wind. His proposal to the National Aeronautics and Space Administration in June of 1971 is now a key element in AMPTE—the Active Magnetospheric Particle Tracer Explorers—a complex, trinational family of satellites that was launched on Aug. 16.

Two of the satellites—West Germany's Ion Release Module (IRM) and the United Kingdom Subsatellite (UKS)—were positioned outside the magnetosphere, beyond the shock wave formed where the solar wind collides at more than a million miles an hour with earth's magnetic field and well beyond the radiation belts. The IRM would deploy rapidly expanding clouds of lithium ions (from a girdle of converted scuba tanks) and the UKS would monitor the clouds as they grew, while the U.S. entry, called the Charge Composition Explorer (CCE), would wait on the earth side of the shock front to see how much of the lithium got through. The CCE, in other words, would use the artificially provided ions as a tracer, to measure the efficiency of the sun's contribution to the belts in comparison with earth's own.

But there is more to the problem.

In order for the solar wind to penetrate the shock front, for example, the interplanetary magnetic field that carries it must be aligned in a certain way, and that alignment changes often and rapidly. When deciding whether to release a lithium cloud—and the IRM was equipped to conduct its solar-wind experiment only twice—AMPTE's scientists had essentially to predict whether the field would hold its alignment for the hour or two it would take for the cloud to grow and be ionized. In addition, the cloud could be released only with the satellites in certain locations.

Three times the researchers got set to go, beginning on Sept. 5, and three times they held off. Finally, on Sept. 11, the IRM released its first cloud, though a recent magnetic storm had left the interplanetary magnetic field unstable. A quick look at the CCE's data, says Krimigis, showed no trace of lithium inside the shock wave, though analysis is still under way. The second cloud was released on Sept. 20 after only a single postponement. Krimigis, who expected to see from 1 to 200 parts per million (ppm) of lithium if everything worked, says that about 20 ppm of "lithium-like counts" show in the data—but some or all may turn out to be other kinds of ions that can "masquerade" as lithium under certain conditions. About another month of study, he says, should reveal the answer.

Meanwhile, however, AMPTE's probes have yielded a host of other valuable findings, such as the detection of oxygen ions at all ionization states from 0^{+} to 0^{7+}. "The results," he says, "already pose so many questions that they will cause us to revise many of the theoretical models that have been used in this business." And it is possible that in about a year, a lithium canister originally included for another experiment can be reallocated to try the solar-wind test again. —*J. Eberhart*