Agriculture

Killing a killer weed: First with rust...

Yellow nutsedge is a devastating pest affecting producers of fruits, vegetables and most other row crops (including soy beans). Globally, it's been ranked 16th worst by the authoritative *World's Worst Weeds* (Univ. of Hawaii Pr., Honolulu, 1977). And despite massive efforts to curb its growth in the United States, its numbers are increasing. But the tenacious weed's stranglehold on U.S. croplands now appears in jeopardy.

At the Coastal Plains Experiment Station in Tifton, Ga., plant pathologists have found a way to fight the blight naturally by harnessing its arch enemy, the rust fungus *Puccinia canaliculata*. When the rust normally appears in August, this nutsedge—one of the few plants that serves as its natural host—has usually already taken hold of an agricultural plot and wrought serious havoc on that season's crop. Not only does the weed smother young plants and damage roots and tubers, but it also robs crops of nutrients, water and carbon dioxide. Propagated by tubers (fleshy, underground bulb-like stems), the weed has remained amazingly resistant to herbicides and conventional pest-control strategies.

What the University of Georgia's Sharad Phatak and the Agricultural Research Service's Homer Wells have done is to see that a rust epidemic is begun early in the season, and, if necessary, continued throughout the growing season. And what makes this fungus an ideal nutsedge-control agent, Well says, is that as a highly discriminating diner, it has no appetite for any commercial crop grown in the United States.

Since the rust has no known winter host in this country, it is not naturally occurring in the spring. So the Georgia team has had to collect spores, freeze them over winter (at −100°F) and then carefully thaw them before spring field inoculation. Mixed with water and flocculants, they can be sprayed on vulnerable nutsedge sprouts in April—before they have strangled crops.

Rust is not enough, however. Explains Wells, the rust "can't completely kill all its hosts or it'd be out of a home and meal." However, he said major rust infestations will debilitate surviving sedges enough that subsequent dousing with a potent herbicide, such as Paraquat, could cut the weed's numbers by 90 percent between one season and the next.

Still to be worked out is how best to mass-harvest spores. The vacuuming device now used will collect 100 grams — several billion spores — in a half day. A tractor-towed cyclone system, which centrifugally separates material, is under development.

...then with chemicals

Hardy tubers are what makes yellow nutsedge such a tenacious weed. "Each plant might produce up to 1,500 of these tubers if it's not controlled," notes nutsedge expert Dean L. Linscott. The Agricultural Research Service scientist is stationed at Cornell University in Ithaca, N.Y., where he's been focusing on how best to kill "the little beasts."

The nutsedge-tuber eradication strategy he's developed involves covering fields with a post-harvest application of the chemical herbicide, glyphosate. Explains Linscott, "While there are other materials that work as well at controlling the vegetation (the upper growth on these plants), this chemical also moves to the tubers that have formed and keeps them from growing." Application is timed to hit the nutsedge right when the reproductive tubers are forming, he says. "And if any have formed, we move enough chemical into them that they will not germinate the following year." To be effective, he says, it takes about two pounds of the chemical per acre.

Might glyphosate make a more effective teammate than Paraquat in the rust-fungus campaign against nutsedge? "It's possible," he says. "There is no question glyphosate is a safer compound [than Paraquat] as far as its potential impact on the total environment."

Physical Sciences

A clock is a clock is a clock

In 1939 P.A.M. Dirac found that by comparing the fundamental constants of macroscopic astronomical physics with those of microscopic subatomic physics he arrived at ratios that were consistently large (10^{40}) and similar. On this he based his "large numbers hypothesis," which suggests that the universal gravitational constant, "G," is decreasing slowly with respect to the atomic constants in the ratios, as the universe ages.

When atomic clocks were developed during the 1950s, it appeared to cosmologists, because of Dirac's hypothesis, that conventional gravitational clocks should gradually slow down with respect to their atomic proteges by 5 percent per billion years. (Gravitational clocks are based on planetary orbits and atomic clocks are governed by the frequencies of atomic radiation.) Cosmologists have since been trying to collect enough data to either accept or reject the hypothesis, and its timely consequencies.

In the Oct. 31 *Physical Review Letters,* Ronald W. Hellings and his colleagues at the Jet Propulsion Laboratory in Pasadena, Calif., along with Vittorio M. Canuto and Itzhak Goldman at the National Aeronautics and Space Administration's Goddard Institute for Space Study in New York City reported that cosmic effects on atomic events are 10 times less than what Dirac suggested. Using Viking's Mars landing data, they concluded that their data "severely limits the existence of a cosmic influence on local physics at the level expected from Dirac's large numbers hypothesis." Says Canuto, "These data are consistent with other work we have published studying cosmic effects over the last 20 billion years. It appears that the variation could not have been greater than one percent per billion years."

"Until Viking came along it was very hard to test the large numbers hypothesis because the predicted rate of variance in the two clocks is so small," says Hellings. What cosmologists have done up to now — using radar-ranging data between planets—is chip away at the five percent per billion figure implied by Dirac's hypothesis, gradually decreasing the limits at which cosmic effects on local physics can manifest themselves. "We were able to show, by the relative orbits of Mars and Earth, that the inherent strength of gravity in our solar system is not changing," says Hellings.

Irwin I. Shapiro at the Harvard Smithsonian Center for Astrophysics in Cambridge, Mass., originally suggested using radar ranging data to compare atomic and gravitational clocks, thus testing for a variation in "G," in 1964. "We have also used the Viking data to place limits on the possible variation in "G," and we too were able to decrease the limits," says Shapiro. But, his group was more conservative with the limits they set "because of certain unknowns."

The wrench in the gears of cosmic time-telling using Viking data, is the belt of asteroids between Mars and Jupiter and the calculations of its gravitational effect on Mars' orbit. "We just don't know enough about the asteroids to warrant a less conservative estimate on our part," says Shapiro. The asteroid question was answered in Hellings and Canuto's work by their use of large uncertainty terms in their estimates of the gravitational constants. "We tried to model the asteroids but we realized the model could be wrong so we included large uncertainties," says Hellings.

Does all this mean it's back to the drawing board on the large numbers hypothesis? "Nobody's going to be out of a job," says Hellings. "Most people will just change their calculations to include the new limits."

The large numbers that Dirac discovered are still there, but the question still remains whether or not they are a coincidence. "Dirac was hypothesizing that they were not a coincidence," says Shapiro. "What is gradually becoming apparent is that there is no reason to believe they are. As far as we can tell, there is only one clock."