Many Crops Could Benefit

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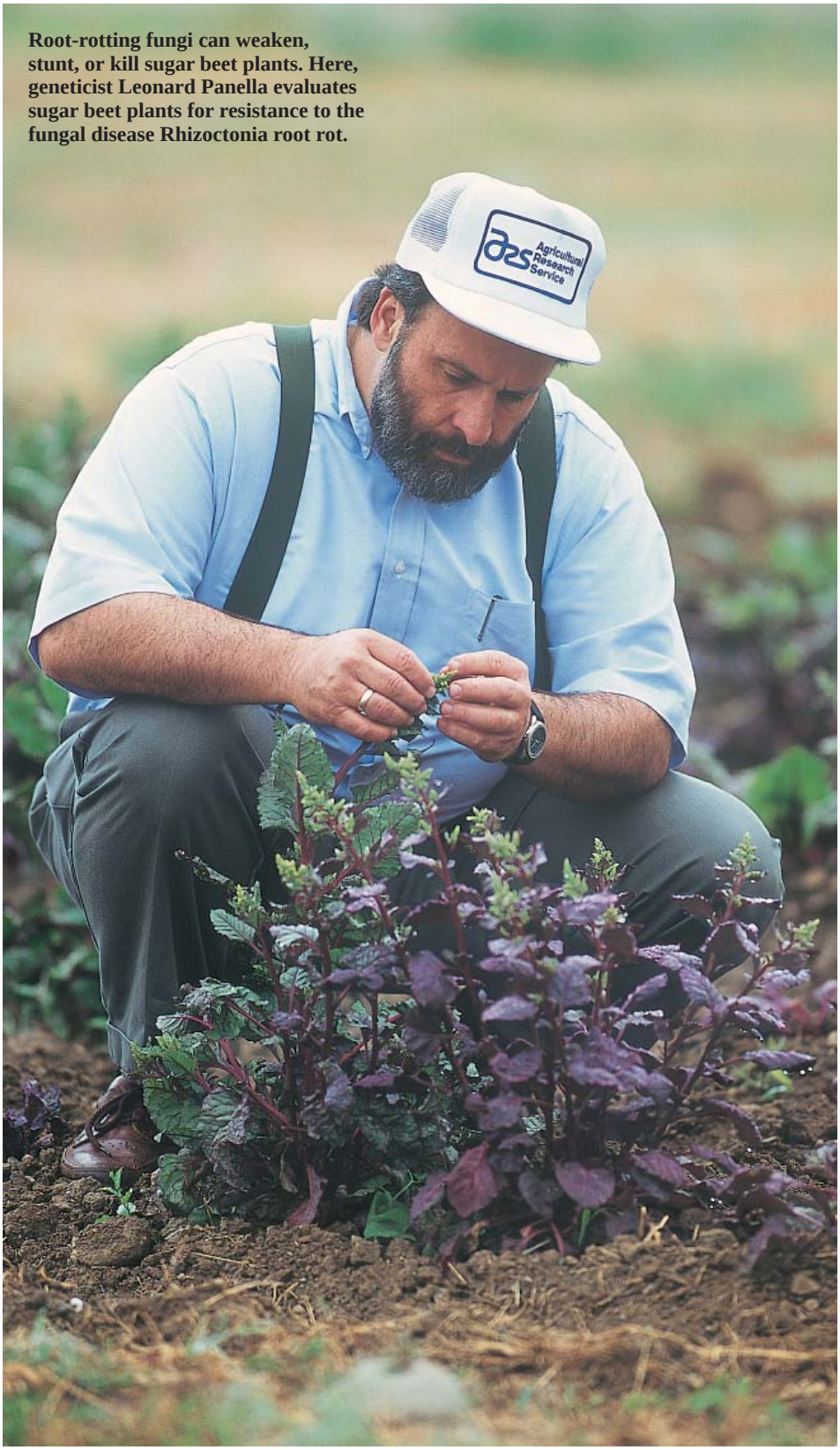

Root-rotting fungi can weaken, stunt, or kill sugar beet plants. Here, geneticist Leonard Panella evaluates sugar beet plants for resistance to the fungal disease Rhizoctonia root rot.

Hungry, microscopic worms called nematodes are the nemesis of dozens of crops—from apricots to zucchini. Nearly transparent and 10 times finer than an eyelash, these pests penetrate roots and suck out plant juices, often reducing the quality and quantity of the harvest. Their voracious feeding also opens the door for root-rotting fungi and bacteria that can further weaken, stunt, or kill vulnerable plants.

Now, ARS plant geneticist Ming H. Yu at Salinas, California, has discovered rare strains of wild beet that resist a half dozen species of notorious nematodes. He says it may be possible—through genetic engineering—to move the genes that convey this natural resistance into crops such as peaches, beans, potatoes, carrots, or tomatoes that are also plagued by the nasty worms. That's in addition to sugar beets—a domesticated relative of the wild beets and the primary focus of Yu's research.

Like Yu's studies, the investigations of other ARS sugar beet researchers should benefit not only sugar beet farmers but also the growers of other vegetable, fruit, and floral crops. "Many of these crops can be attacked by the same species of nematodes that destroy sugar beets," says Yu. He is in the ARS Crop Improvement and Protection Research Unit.

Searching for Resistance at Salinas

A relative of Swiss chard, the versatile sugar beet does more than serve as a reliable source of high-quality sugar to sweeten foods we eat. It provides a nutritious addition to feed for beef and dairy cattle as well as sheep. Its leafy greens are a favorite with some home gardeners. Sugar beet molasses, a processing byproduct, is used for making yeast, chemicals, and pharmaceuticals.

Growers in 14 states produce America's sugar beet harvest, worth more than

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Closeup of a sugar beet with severe galling from root-knot nematodes.

$1 billion annually.

Sugar beet growers helped fund Yu's research. In those tests, he showed that his experimental M6-1 sugar beets, when exposed to very high numbers of nematodes in the greenhouse, suffered little if any damage.

The six different species of root-knot, or *Meloidogyne*, nematodes that Yu used in his studies are heavy hitters. They make up 98 percent of root-knot nematodes in the world's agricultural soils. Yu's discovery is a first: So far, no other researcher has reported any sugar beets—or any crop species, for that matter—that resist all six species.

In addition to nematode enemies, sugar beets can also fall victim to diseases like rhizomania, or crazy root, called that because of the odd-looking roots of diseased plants; Erwinia root rot, caused by a bacterium; and virus yellows, named for the sickly color of leaves of afflicted plants.

Plant geneticist Robert T. Lewellen at Salinas has bred lines of hardy sugar beets that are resistant to these and other major diseases of sugar beets grown in the western United States. Some of the new sugar beets have multiple resistance. That means they can withstand attack by a combination of these microbial villains.

Lewellen is also working with ARS plant pathologist John J. Weiland from Fargo, North Dakota, and others at Salinas to find marker genes for natural resistance to powdery mildew. When uncontrolled, this fungal opponent can reduce yields by up to 30 percent. Somewhat like molecular signposts, markers may indicate the presence of genes that confer valuable traits—in this case, disease resistance.

Finding those genes, says Weiland, will speed development of sugar beets that can shrug off attack by their worst enemies. In fact, molecular biologists could rebuild these naturally occurring genes, then slip them back into plants to "bulletproof" tomorrow's sugar beets. The work should help reduce growers' reliance on fungicides and other farm chemicals.

Foiling Fungal Foes at Fort Collins

Meanwhile, scientists in the ARS Sugar Beet Research Unit at Fort Collins, Colorado, have produced dozens of breeding lines with varying levels of resistance to three other serious diseases: curly top virus, spread by insects known as leafhoppers; Rhizoctonia root rot, a soilborne fungal disease; and Cercospora leaf spot, another fungus.

"We've made a good deal of progress," says ARS geneticist Leonard W. Panella. "We have lines that look good in a severe, artificially induced field epidemic. They're not fully immune, of course, but they're highly tolerant."

Panella's team now aims to combine resistance to multiple diseases. The scientists have already provided growers with new sugar beets that offer excellent resistance to Rhizoctonia root rot plus some tolerance to Cercospora leaf spot, for instance. And they're working on new sugar beets that resist one or both of those fungal diseases—along with curly top virus.

Panella is also studying strains of *Rhizoctonia* to ensure that newly resistant sugar beets won't suffer a surprise attack from an unknown strain. This research should help not only sugar beet growers, but tulip growers in The Netherlands, as well. That's because *Rhizoctonia* can attack tulip bulbs. Panella and Dutch researchers aim to develop a new test that will quickly identify the most virulent *Rhizoctonia* strains. The test may play a key role in strategies for controlling *Rhizoctonia*.

Says Panella, "*Rhizoctonia* has become very damaging to sugar beets in Europe. We've tested our resistant sugar beets over there to make sure the *Rhizoctonia* strains are the same as those we're facing here. So far, our breeding lines hold up well on both continents."

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Geneticist Ming Yu and technician Linda Pakish examine a sugar beet damaged by root-knot nematodes.

Targeting a Maggot Menace at Fargo

The greyish-white sugar beet root maggot gives growers nightmares in Minnesota and eastern North Dakota, a

region with about half of the nation's sugar beet acreage. The maggot larvae chew sugar beet roots, weakening or killing the plants and increasing their susceptibility to root diseases.

To help growers fight back, ARS geneticist Larry G. Campbell at Fargo, along with North Dakota State University colleagues, recently released some impressive new breeding lines to the sugar beet industry. These plants produced root yields 70 to 75 percent as high as those from commercial sugar beets treated with insecticide to kill the maggots.

Recent experiments by Campbell and his colleagues showed that applying a beneficial fungus, *Metarhizium anisopliae,* to the soil may also safeguard plants against the feisty maggot.

"We're doing more tests," says Campbell, "to see whether the fungus could become a commercially successful complement—or alternative to—the few currently available soil insecticides. For example, we need to know when to apply the fungus and how much to use for best results."

Besides researching helpful fungi that may become biological controls, the Fargo scientists are looking for ways to identify and combat pathogenic fungi that can cause multimillion-dollar crop losses.

"If growers could quickly identify offending microbes without having to culture them for days in petri dishes," says John Weiland, "they could start fighting back—with the right tactics—to prevent diseases from getting the upper hand."

Using a technique of modern biotechnology known as polymerase chain reaction, Weiland has developed just such a way to quickly and easily identify six genera of destructive fungi. Now he's narrowing down DNA identification even further to identify species within these genera, emphasizing *Aphanomyces* and *Cercospora*. So far, he can analyze DNA to distinguish between *Aphanomyces cochlioides,* which causes black root disease of sugar beet, and *A. euteiches,* which causes root rot in peas and other legumes.

In other research, Weiland is teaming up with ARS colleagues Panella in Fort Collins and J. Mitchell McGrath in East Lansing, Michigan, to research genes that code for certain enzymes in the fungi. For example, they're interested in fungal genes that enable these microbes to penetrate and infect sugar beet leaves and roots. The studies, says Weiland, "could lead to new ways to subvert fungal infections."

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In Salinas, California, geneticist Robert Lewellen and technician Jose Orozco evaluate sugar beet breeding lines for disease resistance.

Markers Point the Way in Michigan

McGrath and co-researchers in the ARS Sugar Beet and Bean Research Unit at East Lansing are seeking sugar beet marker genes for traits like higher sugar content or bigger yields. The Michigan scientists have already used some markers in scrutinizing experimental breeding lines of sugar beet.

The researchers are also using the markers as a guide in mapping the sugar beet genome. Markers help them pinpoint the location and function of some of sugar beet's 25,000 or so genes.

"Our team," says McGrath, "is one of only a handful of labs in the world doing this type of work with sugar beets."

One target of their genome venture: genes for better germination and establishment, to ensure a strong start for tender seedlings.

"Among this country's major crops," McGrath says, "cultivated sugar beets have the toughest time getting established. Growers plant high-quality seed, but only half germinate and survive to harvest. Sugar beet growers tell me this is a major problem that they need our help with.

"One reason for this dismal germination and survival rate," explains McGrath, "may be the low level of genetic diversity in today's commercial sugar beets. It's one of the lowest of any major crop. Corn varieties, for example, have genes representing about 60 percent of the diversity found in corn's wild ancestors. Commercial sugar beets would be lucky to have even 10 or 20 percent.

"We're using marker genes as part of our breeding program to help us find which 'wild' sugar beet genes to reintroduce into domesticated varieties," says McGrath. "That should broaden the crop's genetic base and may give us truly superior sugar beets for tomorrow."—By **Marcia Wood, Don Comis, Ben Hardin,** and **Kathryn Stelljes,** ARS.

This research is part of Crop Production, Product Value, and Safety, a group of ARS National Programs described on the World Wide Web at http://www.nps.ars.usda.gov/programs/cppvs.htm.

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