LICHENS

An Unlikely Source of New Herbicides

PEGGY GREB (K9228-1)

Chemist Dhammika Nanayakkara observes a crude fraction from a lichen extract.

PEGGY GREB (K9227-1)

Usnic acid, a natural lichen product, is under study as a potential herbicide. Plant physiologist Franck Dayan examines the molecular interactions between usnic acid and the enzyme it inhibits.

In their search for new and more environmentally friendly herbicides, scientists are leaving no proverbial stone unturned. Now Agricultural Research Service scientists in collaboration with the National Center for Natural Products Research, University of Mississippi-Oxford, have found a natural compound in lichens that may be a potential new herbicide.

"Lichens are unusual and intriguing organisms," says Franck E. Dayan, a plant physiologist in the ARS Natural Products Utilization Research Unit at Oxford, Mississippi. "They're a hybrid of two kingdoms—the quintessential symbiosis of a fungus and an alga.

"As a successful alliance between these two organisms, lichens live as a single organism. Both inhabit the same body, or thallus, with each doing what it does best and thriving as a result of the natural cooperation."

After their first meeting—if the fungus and alga are compatible—they can merge. But only certain algae and specific fungi can get together to form a lichen. When it's possible, the fungus creates the thallus to house both organisms. Each fungus-alga union results in a unique type of thallus. Systematists use this structure to help assign names to lichens and to make identifications.

"The scientific names of lichens are based on the fungal parts, which are very diverse taxonomically, with over 20,000 different species," says former ARS plant physiologist Joanne G. Romagni. She worked with Dayan at the Oxford lab and is now on the faculty of St. Thomas University in Houston, Texas.

"In other words, many different kinds of fungi are lichenized over time," she

Usnic acid prevents photosynthesis through a key enzyme involved in pigment biosynthesis. The compound may be useful for weed control.

says. "However, relatively few species of algae are associated with lichens—only 20 to 40 different species—and most of these are common, single-celled green algae."

According to Dayan, "Once the two are joined, the alga will begin to use sunlight to make sugars as food for itself and the fungus. The fungus provides protection from environmental stress, such as excess light." And, unlike the alga, the fungus reproduces sexually.

Dayan says that of the more than 20,000 known lichen species, only a few have been analyzed and identified as containing biologically active compounds. These natural compounds typically arise from the secondary metabolism of the fungal part of the lichen. They are deposited on the surface of threadlike hyphae—the tiny filaments that connect fungi to a food source or host—rather than compartmentalized in the cells. This location makes them easier to extract.

"Most of these compounds are unique to lichens," says Dayan, "with only a small minority—about 60 out of over 600 known lichen compounds—occurring in other fungi or higher plants. While the secondary chemistry of lichen compounds is better documented than that of any other plant-like group, the bioactivity associated with these compounds has been generally ignored."

Although natural lichen products have been traditionally overlooked, the ARS scientists and University of Mississippi natural products chemist Dhammika Nanayakkara discovered that one common lichen metabolite—usnic acid—inhibits carotenoid synthesis. This chemical compound has also been found to have antihistaminic, antiviral, and antibacterial activities. For the first time, the researchers can explain how usnic acid is toxic to plants (phytotoxicity).

"It works by bleaching the first leaves a plant forms, causing a decrease of both chlorophylls and carotenoids in treated plants. Usnic acid does this by preventing photosynthesis through a key enzyme involved in pigment biosynthesis," Nanayakkara says. "This bleaching activity was found to work in several plants, including barley, lettuce, and cucumber. Maybe it could be used to control the growth of weeds, as well."

Although several synthetic compounds inhibit this key pigment enzyme, the scientists found that usnic acid was over 10 times more effective than others tested. Their finding is one of the first examples of a natural product's inhibiting this herbicide target site, which is so critical to the process of carotenoid biosynthesis.

The lichen project provides the basis for developing an entirely new area of research: exploiting lichens as sources of natural herbicides.—By **Hank Becker,** ARS.

This research is part of New Uses, Quality, and Marketability of Plant and Animal Products, an ARS National Program (#306) described on the World Wide Web at http://www.nps.ars.usda.gov.

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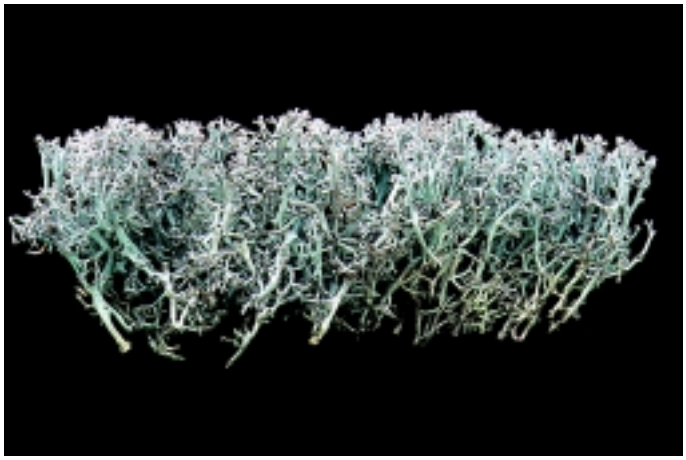
PEGGY GREB (K9230-1)



Closeup of the lichen *Cladina rangiferina* collected by plant physiologist Joanne Romagni.