Researchers plan to double biofuel yield from a non-food oil seed crop

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One of the most promising avenues for reducing our national dependence on imported oil, lowering greenhouse gases and boosting domestic fuel production is biofuel from non-food plant seed oils. Recently, a University of Massachusetts Amherst team started a $2 million project to develop *Camelina*, a non-food oil seed crop related to canola, to dramatically increase seed oil generation for processing into sustainable liquid transportation fuels.

Plant oils can directly convert to biofuels with existing technologies, are compatible with current farm practices and are carbon neutral. As team leader and biochemist Danny Schnell says, "Our goals are to double the current maximum seed and fuel yield from *Camelina* while requiring less than 1 million acres to achieve the 100 million gallons per year target for commercial viability." *Camelina* is an attractive candidate species, he adds, because it will grow in poor soil and not compete with food crops. It is also drought tolerant, has a short growing season and requires little fertilizer.

Boosting oil seed yield to develop commercial biofuels will require increasing their relatively low yield, say Schnell and colleagues. As experts in plant physiology, microbial photosynthesis and chemistry, they plan to genetically engineer *Camelina* chloroplasts, where photosynthesis takes place, to increase carbon photosynthesis capture and fixation rates. They also want to shift the plant toward producing less sugar and more seed oil and terpenes, the building blocks of liquid fuels.

"We'll do this biochemically, following the plant's natural pathways to increase efficiency and divert energy to produce more seed oil, which the plant already makes to nourish its seeds" Schnell says, "We hope to increase the ratio of oil in the seeds from 40 to 80 percent, increase the number of seeds produced, or a combination of the two."

This metabolic approach will also help Schnell and colleagues Jennifer Normanly, a molecular biologist, plus microbiologist Jeff Blanchard and plant physiologists Michele Dacosta and Om Parkash, to engineer *Camelina* to produce more terpenes, chemicals like lemon oil that many plants make to repel insects. Terpenes are of industrial interest as a precursor to many chemicals, from drugs to plastics.

Schnell says the photosynthesis process that plants use to fix carbon to make sugar is quite inefficient because the enzyme that regulates the first step, ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCo), fixes not only carbon dioxide (CO2) but oxygen (O2), a "dead-end reaction," he points out. The UMass Amherst team strategy will be to take advantage of systems evolved by photosynthetic cyanobacteria and algae to out-compete oxygen, introducing them into *Camelina*. These organisms can pump CO2 directly to RuBisCo to increase carbon fixation and generate more biomass.

By altering genes in *Camelina*'s chloroplasts rather than in the nucleus, the researchers will avoid passing genetic modifications to the next plant generation. "Changes are not passed down through pollen to new plants, which eliminates the risk for genetic drift," Schnell says. "The pollen produced by these plants will be normal, not genetically modified." The work will be done at UMass Amherst's new Bowditch greenhouses, which can isolate transgenic organisms.

Schnell and colleagues acknowledge that they'll be creating a genetically modified organism, but it is a self-pollinator, so it doesn't release pollen widely to reproduce. "Any crop that we produce will undergo very strict regulatory approval by EPA, FDA and USDA," says Schnell. "Unlike other genetic modifications that alter the plant's genome, our method will just enhance what the plant already does. With the metabolic pathways, genetic drift is not a concern."

In Phase I of the two-phase project, the team hopes by mid-2013 to demonstrate in the coming 18 months that their approach will work and to identify which techniques are most promising in about 500 plants. "We'll grow several generations and assess the efficiency of carbon fixation and production in intact live plants, harvest seeds and see how they do in increasing carbon fixation. If these methods prove effective, they could also be applied to other crops," says Schnell.

Phase I work is supported by a grant of just over $1.48 million from the U.S. Department of Energy's (DOE) Advanced Research Projects Agency-Energy (ARPA-E) program, with the rest from UMass Amherst, the Massachusetts Clean Energy Council and academic partners at Washington State University, University of California, Berkeley, and Metabolics, Inc., of Cambridge.

At UMass Amherst the project is managed by The Institute for Massachusetts Biofuels Research (TIMBR), representing 35 faculty researchers in 10 academic departments. TIMBR manager Jim Demary says the institute is attractive to funding agencies because it demonstrates that UMass Amherst has an established interdisciplinary structure already in place and featuring key collaborations. "We're very fortunate to have nationally recognized expertise at UMass Amherst," he says.

Provided by University of Massachusetts Amherst