Advancing Field Pennycress as a New Oilseed Biofuels Feedstock that Does Not Require New Land Commitments

John Sedbrook[1]* (jcsedbr@ilstu.edu), Winthrop Phippen,[2] John Ralph,[3] and David Marks[4]
[1]Illinois State University, Normal, Il; [2]Western Illinois University, Macomb, Il; [3]University of Wisconsin-Madison, WI, [4]University of Minnesota, Minneapolis, MN
http://www.wiu.edu/pennycress/ http://cbs.umn.edu/marks-lab/home
https://about.illinoisstate.edu/jcsedbr/ http://www.iprefercap.org/

Project Goals: This project aims to genetically improve the agronomic traits of pennycress (*Thlaspi arvense* L.; Field Pennycress) for its use as an offseason oilseed-producing cash cover crop grown throughout the U.S. Midwest. We have identified and sequence-indexed an array of EMS-induced pennycress mutant lines exhibiting improved phenotypes for all agronomic traits we have assessed. We have also developed and demonstrated the utility of pennycress *Agrobacterium*-mediated plant transformation and CRISPR genome editing, generating pennycress lines with undetectable levels of erucic acid in seed oil, reduced glucosinolate content, reduced seed coat fiber, reduced pod shatter, and reduced seed dormancy. This project aims to identify agronomically-relevant alleles, validated through field testing, and to stack those alleles into top pennycress breeding lines to generate elite varieties having the following traits allowing for commercialization: 1) Harvestable seed yields of at least 1,500 lbs/acre; 2) Reduced sinigrin (glucosinolate) to below the regulatory limit; 3) Reduced seed coat fiber content to improve the seed meal nutritional value 4) Shortened time to maturity to expand the range where pennycress can be harvested in time to plant full-season soybeans.

Pennycress (*Thlaspi arvense*; Field pennycress) is an oilseed plant of the Brassicaceae family closely related to Arabidopsis, carinata, camelina, and rapeseed canola. Pennycress is native to Eurasia and naturalized to North America, growing widespread throughout temperate regions of the world. Domesticated pennycress could be grown as a winter annual oilseed-producing cash cover crop, for example, planted in the fall at or near the time of corn harvest and harvested in the spring in time to plant full-season soybeans throughout the 80 million-acre U.S. Midwest Corn Belt. Elite pennycress varieties could provide additional income to farmers and supply-chain businesses thereby strengthening rural communities. Pennycress could also provide ecosystem services as a cover crop, reducing soil erosion and nutrients runoff and providing habitat and pollinator support on otherwise barren farmland.

Field trials have demonstrated that pennycress can be seeded in upper Midwest cornfields in the late summer/early fall, at which time the plants form ground-hugging rosettes of leaves that overwinter with extreme cold tolerance. Pennycress plants are quick to flower in the spring, producing nectar-generating flowers for pollenating insects and oil- and protein-rich seeds that can be harvested without disrupting soybean planting or yields. As an energy crop adopted throughout the U.S. Midwest Corn Belt, domesticated pennycress could annually produce 3 billion gallons of liquid transportation fuels and 20 million tons of high-protein seed meal. However, to fully realize this potential, more-involved genetic improvements conferring abiotic and biotic stress resilience must be made.

A focus of this USDA NIFA-funded project, in collaboration with participants of the USDA AFRI-funded IPREFER project (Integrated Pennycress Research Enabling Farm and Energy Resilience) and the start-up company CoverCress, Inc., is to develop first-generation pennycress varieties harboring the core domestication traits necessary for commercialization. For this presentation, we will highlight progress we have made in identifying, characterizing, and

field-test-validating pennycress mutations conferring low seed-oil erucic acid content, reduced glucosinolate content, reduced seed coat fiber, reduced pod shatter, and earlier flowering time. Mutations in multiple genes have been generated and stacked in various combinations, providing alternative routes to producing commercially-viable elite pennycress varieties. Trait-improving alleles are being incorporated into our breeding programs and are being evaluated at multiple field sites throughout the Midwest in conjunction with the IPREFER project and CoverCress, Inc., with the aim to establish agronomic practices and supply chains necessary for Covercress™ (domesticated pennycress) commercialization within five years.

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award numbers 2014-67009-22305 and 2018-67009-27374.