Techno-economic, Energy and Greenhouse Gas Emissions Analyses of Pennycress Production and Logistics for Aviation Biofuel

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Project Goals: The main objective of this research is to apply a biodesign strategy for improving oil content in a promising alternative source of jet-fuel, pennycress. To advance towards this goal, we are: 1) Investigating pennycress natural variation to identify candidate genes and biomarkers associated with oil accumulation and fatty acid composition; 2) Identifying targets to improve oil content and composition, and 3) Establishing metabolic engineering targets and develop community resources.

Alternative biobased feedstocks for the production of renewable jet-fuel (RJF) is gaining traction in recent years due to the concerns associated with adverse environmental effect of fossil fuel use in aviation industry and concerns over the energy security[1]. To be a viable alternative, RJF should be economically competitive, have lower environmental footprint, and provide a net energy gain[2]. In addition, it should be producible in large quantities without reducing food supplies[3]. Until now several alternative feedstocks, including canola, camelina, soybean, carinata, and jatropha, have been considered as potential sources for the production of RJF[1]; however, commercial production of RJF from renewable feedstocks is still encumbering due to competition of feedstocks with food resources, high cost of production, and use of limited resources and land. Pennycress (*Thalaspi arvense*) is a winter annual crop with 25-36%w/w oil content[4-5]. It can be planted as cover crop in corn-soybean rotation in Midwestern US to provide both economic opportunity and ecosystem services. In addition, pennycress oil, with high content of unsaturated fatty acids, has acceptable quality for conversion to RJF[6-7].

The goal of this part of the project is to analyze techno-economics, energy use and greenhouse gas emissions of pennycress based agronomic and supply systems to establish targets for pennycress oil metabolic engineering. To accomplish this goal, we evaluated the technical feasibility by estimating the resources (land, infrastructure, machineries, fuel, labor, consumables) requirements for the pennycress production (planting, fertilizer and pesticide applications), harvest and post-harvest logistics (grain handling, transportation, drying and storage) to provide feedstock for a RJF plant in Ohio with production capacity of 5 million gallons per year (~19 million liter per year). Then, we estimated the costs, energy use and greenhouse gas emissions associated with these resources and infrastructure use. We estimated that annual harvest of 90,000-115,000 metric tons (t) of pennycress seeds from 41,000-63,000 hectares of land is needed to meet the biorefinery pennycress seed demand. Cost for production and logistics was estimated to be ~200 $/t, which is ~50% less than the cost of camelina production in Oregon[8]. The energy use and greenhouse gas emissions during the production and logistics of pennycress feedstock were ~3,300 MJ/t, and ~400 kgCO_2eq/t, respectively. The cost, energy use and greenhouse gas emissions for pennycress production and logistics were found to be highly sensitive to the pennycress seed yield, which is currently ranging from

1,200 to 2,500 kg/ha[1,5], and oil content. Although achieving these baseline estimates is promising, further reduction in total production cost, energy requirement and greenhouse gas emissions would be possible by improving the pennycress seed yield, oil content and level of unsaturated fatty acids. Improving these characteristics will advance large-scale production of pennycress as a sustainable feedstock for the development of RJF biorefineries[9].

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