Enhanced Resistance Pines for Improved Renewable Biofuel and Chemical Production

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Project Goals: Our goal is to genetically increase constitutive terpene defenses of loblolly and slash pine to enhance protection against pests and pathogens and at the same time expand terpene supplies for renewable biofuels and chemicals.

Abstract: Today, the southeastern U.S. hosts the world's largest biomass supply chain, annually delivering 17% of global wood products, more than any other country. This well-developed regional supply chain supports southern pine genetic improvement, seedling production and planting, silviculture, harvesting, and transportation annually delivering ~250 million tons of pine wood to integrated manufacturing facilities. In the SE U.S., 39 million acres of land not suited for food production are planted with genetically improved loblolly and slash pine seedlings selected and managed for fast growth and high wood yields. The SE also houses the U.S. pine chemicals industry the oldest and one of the largest renewable hydrocarbon chemical industries with favorable cost-competitiveness with petroleum derived feedstocks. Our focus is on increasing constitutive terpene production to enhance loblolly and slash pine resistance to pests and pathogens. Enhanced resistance in these commercial species is critical to protect against widespread losses as biotic pressures increase due to global warming, landuse change and introduced exotic organisms.

Increasing pine terpenes also is aligned well with the needs of the developing bioeconomy. Today, commercial scale collection of pine terpenes occurs from live trees by tapping, stumps by solvent based steam extraction, and from pulp mills as co-products. US pulp mills recover ~900,000 tonnes y^{-1} of terpenes and fatty acids supporting specialty chemical biorefineries that compete in markets with petroleum derived feedstocks supporting our concept that biofuels from pine terpenes could be profitable without subsidy if supply was increased. Proven technologies exist to efficiently convert pine terpenes to biofuels: a 30 million gallon y^{-1} bio-refinery produces renewable diesel from pine terpenes and fatty acids and pine monoterpenes can be efficiently dimerized to produce a replacement for JP10, the highest density jet fuel. Higher wood terpene content will increase the yield of bioenergy per unit mass in the rapidly developing wood pellet industry. Pine terpene supply is limited by the relatively low average wood terpene content.

Pine terpenes evolved as a primary chemical and physical defense system and are a main component of a durable, quantitative defense mechanism against pests and pathogens. The terpene defense traits are under genetic control and can be improved by breeding and genetic engineering. Our goal is to genetically increase constitutive terpene defenses of loblolly and slash pine to enhance protection against pests and pathogens and at the same time expand terpene supplies for renewable biofuels and chemicals. Objective one will integrate existing and new genome wide association genetic results with RNA expression, QTL mapping, and allele

frequency information in known high oleoresin flow selections and our breeding populations to discover and validate loblolly and slash pine alleles/genes that are important for resistance. Objective two will use information from objective one to accelerate breeding for increased resistance in loblolly and slash pine through marker assisted introgression, and will develop and test genomic selection models to accelerate breeding of resistant slash pine.

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