Rapid domestication of poplar using genomic selection and *P. trichocarpa* X *P.deltoides* hybrids

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Project Goals: The Center for Bioenergy Innovation (CBI) vision is *to accelerate domestication of bioenergy-relevant, non-model plants and microbes to enable high-impact innovations at multiple points in the bioenergy supply chain.* CBI addresses strategic barriers to the current bioeconomy in the areas of 1) high-yielding, robust feedstocks, 2) lower capital and processing costs via consolidated bioprocessing (CBP) to specialty biofuels, and 3) methods to create valuable byproducts from the lignin. CBI will identify and utilize key plant genes for growth, composition, and sustainability phenotypes as a means of achieving lower feedstock costs, focusing on poplar and switchgrass. We will convert these feedstocks to biofuels using CBP with cotreatment at high rates, titers and yield in combination with catalytic upgrading into drop-in hydrocarbon fuel blendstocks.

Populus trichocarpa is an undomesticated woody species with high potential as a bioenergy feedstock, but a long breeding cycle. To rapidly improve biomass yield per hectare we need to optimize gains per generation. Sustainable and uniform yield is a highly complex conglomerate of traits, so genetically modifying or selecting for a few key loci is unlikely to achieve our goals. Genomic Selection models the genetic (breeding) value of genome-wide variants on target traits in a training population, so is a practical solution. Parents from a breeding population are selected solely on their aggregate genetic value for target traits. The same model can be used to predict progeny phenotypes well before they reach maturity, allowing early culling and rapid cycle times. We have developed a computational pipeline that generates virtual recombinant progeny from a given cross, thus allowing a machine-learning prediction of progeny performance as a result of prospective parental selections and crosses. This "virtual progeny trial" can enable us to predict the relative performance of specific crosses (i.e. families) before they are planted in the field. We tested this pipeline using the 7x7 *P. trichocarpa* proof of concept trial at Clatskanie, OR, which contains 49 full-sib families from 49 controlled crosses. We find a strong ability to predict family rankings for height at year 3.

CBI has access to a great range of genetically diverse genotypes of *P. trichocarpa* (Ptri) for the purposes of genomic selection for Ptri X Ptri crosses. However, crossing *P. trichocarpa* with the closely related *P. deltoides* (Pdelt) may have better outcomes. Firstly, Pdelt is naturally resistant to various pathogens that can devastate pure Ptri plantations, so elite lines from hybrid crosses that inherit Pdelt resistance components will be more sustainable in the long term. Secondly, hybrids (Pdelt X Ptri) often outperform within-species crosses (Ptri x Ptri) for growth due to heterosis effects. We are now exploring selections of parental materials for Pdelt X Ptri crosses in order to test these advantages. Hybrids do present new challenges in terms of genomic selection models since markers may be inconsistent between the two species, the effects of common markers can vary, genomic regions present in one species may be absent in another, and heterosis effects are difficult to model.

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