FOOD SECURITY & FUEL INDEPENDENCE

These projects represent a huge effort to determine and improve the mechanisms of photosynthesis that can provide a solution to two of the United States' and the world's most pressing challenges.

RIPE

Realizing Increased Photosynthetic Efficiency for Sustainable Increases in Crop Yield

THE RIPE PROJECT SEEKS TO INCREASE YIELDS OF RICE, GRAIN LEGUMES, AND CASSAVA, SOME OF THE MOST IMPORTANT FOOD CROPS TO DEVELOPING COUNTRIES, BY UP TO 60%. THESE ENVIRONMENTALLY SUSTAINABLE, HIGH-YIELDING CROPS WILL PROVIDE IMPROVED INCOME AND FOOD SECURITY FOR SMALL-HOLDER FARMERS.

Model optimal designs

Computer models that include discrete photosynthetic processes are used to simulate how altering gene expression and importing foreign genes influence photosynthetic efficiency in plants. In parallel, crop canopies are modeled to determine the optimal adaptations to maximize light interception. This allows for the prediction of ideotypes that can be selected for increased photosynthetic productivity and water and nitrogen conservation.

Determine how molecular changes affect photosynthesis

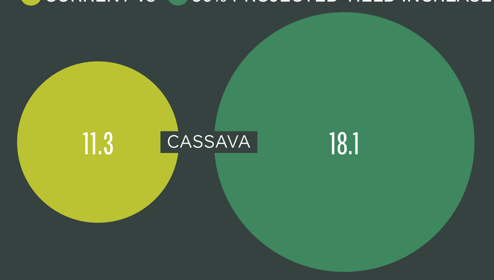
Our models have identified key points of limitation in the overall photosynthetic process. These limitations will be overcome two ways: (1) altering genes to up-regulate of the expression of specific proteins and down-regulate of others to optimize photosynthesis in response to the environment and (2) engineering optimal photosynthetic enzymes, systems, and structures into target crops. These approaches will then be tested in a common cultivar to assess their impact on photosynthesis.

Confirm increased yield in field environments

Yield potential of the most promising approaches will be evaluated in fully replicated controlled field trials. This will ensure that the changes in photosynthesis will translate to increased yield in the target crops: rice, grain legumes and cassava. If successful, this project will enable a yield jump in key staple crops, grown by millions of farmers in sub-Saharan Africa and South Asia.

AVERAGE YIELD (TON/HA)

CURRENT vs 60% PROJECTED YIELD INCREASE WITH RIPE IMPROVEMENTS

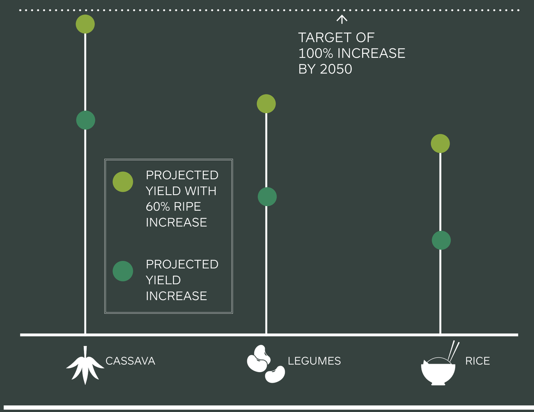


GROWTH IN AGRICULTURE IS **11 TIMES MORE EFFECTIVE AT REDUCING POVERTY** IN SUB-SAHARAN AFRICA THAN GROWTH IN OTHER SECTORS

IN AFRICA **90%** OF AGRICULTURAL PRODUCTION **COMES FROM SMALL FARMS**

GLOBAL DEMAND FOR CROP CALORIES **WILL DOUBLE** BY 2050

WITH THE NEEDED CROP YIELD **INCREASE OF 100%**, RIPE YIELD INCREASES HELP BRING US MUCH CLOSER TO OUR TOTAL GOAL.



SOURCES: Zhu XG, Long SP, Ort DR (2010) Improving Photosynthetic Efficiency for Greater Yield, Annual Review of Plant Biology. 61: 235-261.; Other sectors include, for example, mining and utilities. World Bank. 2007. "World Development Report 2008: Agriculture for Development". Washington, DC; L. Christiaensen, L. Demery and J. Kuhl. 2010. "The (evolving) role of agriculture in poverty reduction – an empirical perspective". Journal of Development Economics.; High Level Expert Forum –How to Feed the World in 2050, The Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) http://faostat.fao.org/; International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). Global Report, side 8; Kaiser Family Foundation http://kff.org/global-indicator/population-undernourished/

PETROSS

GENETICALLY ADVANTAGED OIL-PRODUCING SUGARCANE & SWEET SORGHUM

THE PETROSS PROJECT IS ENGINEERING TWO OF THE MOST PRODUCTIVE CROPS IN THE WORLD—SUGARCANE AND SWEET SORGHUM—INTO ULTRA-PRODUCTIVE BIODIESEL CROPS. BY 2016, OUR GOAL IS TO PRODUCE PETROSS SUGARCANE AND SWEET SORGHUM WITH SIGNIFICANTLY HIGHER YIELDS AND PROFIT MARGINS THAN ANY EXISTING BIOFUEL CROP.

Produce and store oil in the stem in place of sugar

During photosynthesis, sugarcane and sorghum produce mostly sugar, which can be used to make ethanol. Alternatively, PETROSS crops will produce oil that can be used to produce biodiesel. A combination of three overexpressing genes were assembled and co-bombarded into sugarcane. Transgene expression showed lipid accumulation of 5.6% in the sugarcane dry biomass.

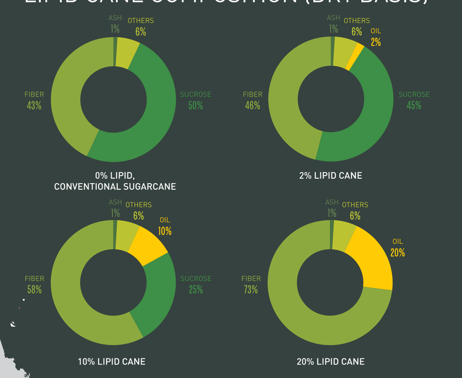
Increase photosynthesis

Within their leaves, plants harness the energy from the sun to make the sugar and oil used to make ethanol and biodiesel. We have identified promising approaches to increase leaf and crop photosynthesis. We have now engineered genes into both crops that have increased the efficiency of the conversion of sunlight by 35 percent. We are on target to achieve a 50 percent increase in photosynthesis, and thus a 50 percent increase in yield, by 2016.

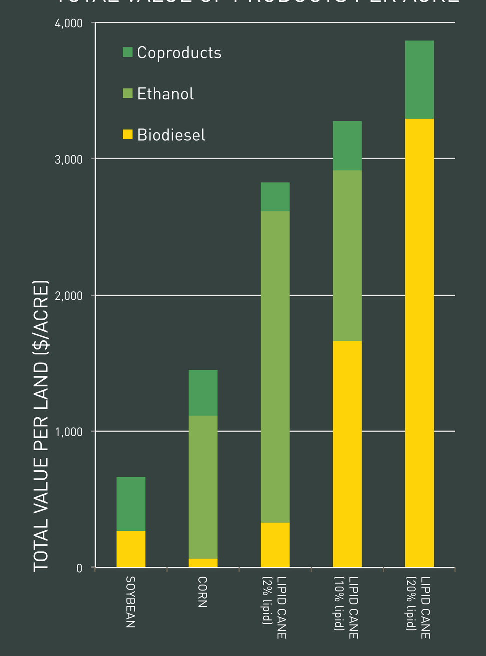
Increase cold tolerance

Right now, sugarcane can only be grown in the tropics and subtropics, including Hawaii, Florida, and the southern edge of the Gulf Coast states. Likewise, sorghum prefers warmer regions, such as Texas and Oklahoma. By making sorghum and sugarcane more cold tolerant, these crops can be grown in more regions of the United States and maximize marginal land productivity. We have identified a sugarcane hybrid derived from a cross with Miscanthus, and have produced several more by using new crossing technologies. These crosses have exceptionally high rates of photosynthesis and leaf growth at low temperature.

LIPID CANE COMPOSITION (DRY BASIS)



TOTAL VALUE OF PRODUCTS PER ACRE



PETROSS CROPS CAN MEET **69%** OF THE RFS2 MANDATE

Using only the 23 million acres of marginal land in the area on the map, we estimate that PETROSS crops will be able to produce 24.67 billion gallons of biodiesel—easily meeting 2/3 of the needs set forth by the Renewable Fuel Standard mandate of 36 billion gallons of biofuel by 2022.

24.67 billion GALLONS OF BIODIESEL

ON ONLY 1.2% OF THE TOTAL LAND AREA OF THE 48 STATES

$2.66 PROFIT PER GALLON

FIGURE ASSUMES NO GOVERNEMENT SUBSIDY

BILL & MELINDA GATES foundation

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