



Maximizing Jatropha: The Science Behind JMax™

Through an advanced platform incorporating breeding, agronomics and biotechnology, coupled with regional optimization of agronomic practices, SG Biofuels is enhancing yields, reducing input costs and increasing profits for Jatropha growers around the world. SG Biofuels' program is led by an industry-leading team including two members of the National Academy of Sciences, the highest honor in the field. Collectively, the team has more than 100 years experience in plant molecular biology and has published hundreds of research articles in the areas of plant molecular genetics, plant physiology, plant development and plant biotechnology, genomics and bioinformatics.



The Value of Germplasm Diversity: Drawing from the Center of Origin

Molecular analyses on *Jatropha curcas* indicate that its genetic diversity is extremely limited among collections from India and Africa, where most of the existing commercial Jatropha material originates. Evidence suggests that the material that has populated Africa and India is likely to have come from just a handful of introductions of the plant some 300 years ago by Portuguese sailors who brought it from Central America, the center of origin for this species of Jatropha. These introductions were typically made based on the plant's purported medicinal qualities and its ability to grow well as a hedge crop, not on its productivity as an energy crop.



Most early investments in Jatropha focused not on the genetic improvement of the crop, but rather on the planting of existing, unimproved cultivars that had not gone through an extensive domestication program. No attention was made to breeding, proper germplasm selection or agronomic trials. More than four years ago, SG Biofuels chose to focus on the genetic improvement of the crop -- a necessary step for the success not only of Jatropha, but any commercial-scale crop. The key foundation of such a program is an extensive and diverse library of genetic material.

The center of origin for a plant represents the part of the world where one can find the greatest genetic variation. This is where evolution has had the most time to push the crop to adapt to a variety of environmental extremes. The center of origin for Jatropha is an area stretching from Southern Mexico into Central America. Collecting varieties of Jatropha from its center of origin, in addition to varieties that have migrated over time to the far reaches of the world, SG Biofuels has developed the world's largest and most diverse library of Jatropha genetic material, including more than 7,000 genotypes of *J. curcas*. Preliminary molecular marker studies suggest that SG Biofuels' Jatropha germplasm collection contains on the order of 5 times the genetic diversity observed in a collection of Jatropha from India, Africa, and Asia (Basha *et al* 2009).



Breeding & Agronomics

At our JMax™ research and development centers in Central America as well as greenhouse facilities in San Diego, Calif., we are using this vast genetic diversity to develop high-yielding *J. curcas* cultivars that are specifically adapted to a range of growing conditions.

- Our JMax™ crop development program contains an unprecedented array of *Jatropha* genetic traits including enhanced fruit yield, pest resistance, soil adaptation, improved flowering capabilities, uniformity and improved harvesting; all of which increase profitability.
- Intensive selection and breeding programs are identifying and developing the most productive, regionally adapted strains from our germplasm collection. From outcrosses to combine important traits and inbreeding to improve uniformity, considerable advancements have already been achieved, including the development of JMax 100™, our first elite cultivar optimized for Guatemala with projected yields of 100 percent greater than existing varieties.
- Through hands-on experience in agronomic field trials, SG Biofuels is focusing on a range of issues related to input cost reduction and increased profitability. Our breeders and agronomists are addressing issues related to plagues and diseases through the development of pest and pathogen resistant plants and improvements in molecular agronomy that take into account soil structure and nutritional factors. In addition, we are exploring the use of plant-growth-promoting micro-organisms to improve nutrient assimilation and combat bacterial and fungal pathogens.



Biotechnology

- SG Biofuels' plant biotechnology program is accelerating the improvement of *Jatropha* through the association of molecular markers with trait genes and the development of plant regeneration, transformation and dihaploid technologies. The company has formed an alliance with Life Technologies Corporation, a leading provider of advanced biotechnology and synthetic biology tools. Those tools, combined with SG Biofuels' extensive germplasm library, provide an unprecedented platform from which to quickly identify and advance commercial traits.
- Our partnership has successfully sequenced the *Jatropha curcas* genome, using the SOLiD™ 4.0 System by Life Technologies. Working with Life Technologies, SG Biofuels has used the sequence to generate a high quality *Jatropha* reference genome. The genome has been used to compare re-sequences generated from SG Biofuels' germplasm library to identify molecular markers and trait genes to accelerate development of elite cultivars. This work has also advanced the introduction of transgenic plants with further improved traits.



By using the best material and advanced biotechnology resources, JMax™ significantly accelerates and improves the optimization process and eliminates the risks associated with planting existing, unimproved commercial varieties of *Jatropha*.