Biotechnology & the Emerging Climate Market

by Charles Margulis, 2009

As agricultural biotechnology stumbles in its quest to develop successful new traits for food crops (having accomplished only herbicide tolerance and Bt resistance on any commercially significant scale), the industry is now pursuing a new front: the need (real or perceived) for crops marketed to solve problems induced by changing climates. Field trial data gives some indication of how strongly big biotech is counting on climate changes for their future sales: recent research is increasing for GE varieties that would be useful for changing climates, while field trials for the "traditional" GE varieties are stagnant or decreasing.

California is likely to be ground zero for development of genetic approaches that aim at the market for climate-ready crop "improvements." In 2007, oil giant BP announced its $500 million deal with the UC system to launch an Energy Biosciences Institute (EBI), primarily for development of new biofuel technologies. The US Energy Department's Joint Bioenergy Institute is located in Emeryville, coordinating biotech energy research from Stanford, the UC system, three national labs, and the Carnegie Institute. Biotech corporations abound in California which is home to at least six leading biofuel and/or synthetic biology developers, most with ties to university and/or government biotech apparatus.

It is early to tell what impact developments in climate-related ag biotech will have on California farmers and consumers. But given the centrality of California as a testing ground, and the risks of these untested technologies to ecological farming and the environment in general, it is important to keep a close eye as the technology develops.

<u>"Climate Ready" Crops</u>

With the mainstreaming of concerns about climate change has come a rush to cash in on the purported need for new crops designed to withstand the more stressful climate conditions of the future. But such stress-related genetic changes are complex and generally involve multiple genes. Thus, developing GE crops that are adapted to changing climates is unlikely to be viable within the limitations of the current single-gene approaches most often used by genetic engineers.

GE crops altered to deal with stressful events need to be different than current GE crops in at least one vital respect: current GE crops exhibit their engineered qualities throughout the life of the plant, and in all its tissues. But in many stress-tolerant varieties, the genetic modification will need to be time- and tissue-sensitive, i.e., traits will be needed at certain times in the plant's life, and in certain parts of the plant, and could be lethal at the wrong time and/or in the wrong tissues. Biotech proponents believe that such complexity could be engineered using promoters that are associated with stress responses.

Even if such complexity could be technically accomplished, viability and productivity are likely to be challenged. In fact, most field trials of experimental “drought tolerant” crops have ignored yields, rating the experiments as “successful” based solely on crop survival. One recent review of field trials for crops engineered to tolerate increased salinity noted that most studies conducted to date have ended at the seedling stage. Furthermore, it seems likely that such plants would suffer severe metabolic costs from this complex genetic manipulation, making them even less productive, especially given varying environmental conditions. Even the relatively simple single-gene herbicide tolerant traits engineered into GE soybeans have failed to match the yields of natural soy. [1]

In all of the R&D on “climate ready” crops, the industry’s essential failure is to misunderstand that chaos is the nature of changing climates. In California, climate change is likely to alter precipitation patterns, average as well as minimum and maximum temperatures, pest and weed ranges, and the frequency of extreme weather events such as droughts and flooding. One researcher noted that environmental stresses such as drought and salinity will vary widely due to local climate conditions and geography, but with particular optimism concluded that with some genetic “fine tuning,” such crops could be practical in the field. Given the level of uncertainty about climate conditions from year to year, and the multiplicity of variables, it seems unlikely that that such multiple varieties of “fine tuning” could be engineered into crops.

GE Biofuels

US government policy support for biofuels dates from the Bush Administration and because several high-level Obama appointees are strong biofuel proponents, it is likely to continue through the current administration. Corn ethanol is currently the only major biofuel in production, yet even with major subsidies, several ethanol operations have been shuttered or forced to dramatically reduce production. Indeed, ethanol production has been widely criticized for failing to provide net energy gains, and for negative impacts on the environment, the food supply, and the economy.[2] One report has suggested that the US investment in ethanol “may go down as one of the biggest blunders in history.”[3]

Nonetheless, biotech promoters promise new and improved biofuels through genetic engineering. Their marketing focuses on cellulosic biofuels, crops whose energy creation comes not from starches in grains (as with ethanol), but from direct use of feedstock from perennial plants such as switchgrass and miscanthus. Genetic engineers seek to increase the yield of feedstock per acre from these plants, and/or to create plants that are easier to process into biofuels.

However, the first enterprise, creating high yield feedstock crops, has barely been researched. Since these plants are not widely used in agricultural settings, there is no history of breeding them and little genetic knowledge about them. One researcher called these potential feedstock crops “essentially wild populations,” and suggested that it will take years of development to determine if they can be useful for feedstock.[4]

Another problem in cellulosic fuel production comes from the costs associated with breaking down the cellulose in these plants for fuel production. This is enormously difficult, involving extremely expensive heating and chemical treatments. Similarly, lignin must also be removed from the plant's cell walls, requiring more costly heating and/or alkali treatments. Biotech companies hope to resolve these problems through genetically "improved" feedstocks, plants that have cellulose enhanced for easier processing, and lignin altered for easier removal.

Both of these potential plant "improvements" raise the specter of severe ecological harm from GE organisms, whose genes have proven uncontainable e.g. Starlink and the southern rice crop contamination with experimental varieties in 2006. Using genetic engineering to weaken a plant's cell walls in order to make them easier to process will also affect the plant's structural stability and undermine its main physical barrier against disease and pests. This bodes ill not only for successful production of the crop, but even worse, would be disastrous if gene flow into related species creates widespread vulnerabilities.

Genetic engineers are also involved in efforts to produce biodiesel from microalgae. Such fuel production would obviate the need to take farmland production away from food crops, and GE proponents promise huge fuel yields from engineered algae. But despite more than 100 companies already founded to produce biodiesel from algae, not a single commercial facility has been built. Indeed, like the wild plants proposed for cellulosic biofuels, genetic experiments on algae are in very early stages, and so far, the plant seems particularly resistant to engineering.

Finally, genetic engineers have re-branded their technology as "synthetic biology." Called "genetic engineering on steroids,"[5] synthetic biology contains all the weaknesses and risks of the traditional GE approach, the difference being added complexity through attempting to insert simultaneously many DNA sequences for a variety of traits. Synthetic biology proponents suggest the technology will produce unlimited quantities of fully lab-created biofuels, from enhanced microbes that will more efficiently produce ethanol, butanol or biodiesel.

But like earlier GE creations, products of synthetic biology will likely suffer unpredictable side-effects due to the unpredictable nature of the living organisms used as raw materials. Likewise, products of synthetic biology are created without regard to the influence of genetic factors outside of DNA (proteins, RNA and other genetic material), and may face unforeseeable problems. Like earlier biotech promises of high yielding crops grown with fewer pesticides, the promises of life from fully inert materials will prove equally false, and potentially even more damaging.

The Real Promise

The considerable venture capital investment, federal and state research funds, marketing campaigns and as yet unsuccessful track record of genetic engineering as applied to providing solutions to the climate crisis has drawn far too many resources away from much more promising and proven solutions. By and large, traditional plant breeding continues to out-perform GE in terms of yields, reliability and adaptability to changing climate conditions. Biotechnologies such as marker-assisted breeding can speed up and enhance traditional breeding techniques without genetic engineering. Agriculture will be much more resilient to climate change, and should be able to sequester carbon to mitigate it, by applying the familiar tools of sustainable agriculture including reduced fertilizer and pesticide inputs, cover cropping, water conservation, conservation tillage and more.

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[1] Doug Gurian-Sherman, "Failure to Yield." Union of Concerned Scientists, March 2009. Online at http://www.ucsusa.org/food_and_agriculture/science_and_impacts/science/failure-to-yield.html

[2] See, eg, Eric Holt-Gimenez, "Biofuels: The Five Myths of the Agro-fuels Transition." Online at http://www.mstbrazil.org/?q=holtgimenezonagrofuels

[3] Cinnamon Stillwell, "Fuel or Folly? Ethanol and the Law of Unintended Consequences", April 2, 2008, San Francisco Chronicle, http://www.sfgate.com/cgi-bin/article.cgi?f=/g/a/2008/04/02/cstillwell.DTL

[4] Mariam B. Sticklen, (June 2008), "Plant genetic engineering for biofuel production: towards affordable cellulosic ethanol", Nature Reviews Genetics 9, 433-443

[5] For basic background on synthetic biology, see the ETC Group publication, "Extreme Genetic Engineering: An Introduction to Synthetic Biology," online at http://www.etcgroup.org/en/materials/publications.html?pub_id=602