Nate Looker, Student Participant
Dowling Catholic High School
West Des Moines, IA

Practical Progress: Sustainability in Food and Biofuel Production in India

Since the Industrial Revolution, humanity has been pushing the planet in a dangerous direction. The rise of global temperatures due to the emission of greenhouse-gases from human activities jeopardizes ecosystems of all kinds. Studies indicate that by 2050, one million species could become extinct if we do not make a concerted effort to stop our contribution to climate change ("The Consequences of Global Warming"). However, we seem to be continuing on the path toward destruction, as we have not yet made any drastic departures from our use of fossil fuels. A great deal will be risked if the response of the global community to climate change is anything less than revolutionary. Paradigm shifts must occur in many aspects of human life, particularly in our modes of production, consumption, and transportation, and we will have to learn to introduce technologies only after we have contemplated the possible repercussions of their use.

In terms of production, this eco-revolution will emphasize energy balances and sustainability to as great a degree as the Industrial Revolution valued minimizing labor inputs and maximizing profits. For some interests, transitioning the global economy from fossil fuels to biofuels will (and must) satisfy both ecological and traditional financial demands. On top of this, the production of biofuels must be coordinated so as to not infringe on food production. The intersection of the factors of fuel, food, and finance is of particular significance in developing nations, where food security must be the primary focus. How exactly the cultivation of food is to be weighed against the production of biofuels is often nationally specific. India, home to some 233 million undernourished people, has recently been able to subsidize the export of wheat (Müller and Patel, USDA, 2001). Clearly, something is amiss here, relating more to policy than to a lack of production. What role, then, might biofuels play in Indian agriculture, and how could biofuels production be feasible for subsistence farmers? Because of the wide availability of labor, the Indian solution to the food-biofuel predicament can involve labor-intensive systems. The labor aspect, in turn, facilitates crop diversification and the use of intercropping to increase yields, practices not as easily executed in a more mechanized setting. Given these conditions, India may move forward in biofuel production without compromising the ability of farm families to eat by choosing regionally appropriate crops and experimenting with agronomic techniques to maximize yields in a sustainable fashion.

The Family Farm

To best incorporate biofuels into the Indian agricultural sector, the primary unit of production, the family farm, must first be examined. Typically, families work in the field together to earn a meager living, which is often supplemented by off-farm labor and the sale of milk or meat (Sahai, 2006). Estimates put the average net income of a relatively small farm at about $700 US per year (Hemme, Garcia, and Saha, 2003). Farm income and those crops which are not grown for market must satisfy the family's dietary needs. A family of two adults, an adolescent, and two children would need 10,600 calories per day (Singh and Chetty, 1984). Animal products are not widely consumed, so pulses must be included in the diet for protein. Since the 1950s, the increasing per capita availability of both grains and pulses has made the recommended diet more feasible (Srikantia, 1984). Family nutrition also benefits from the leafy greens women pick from the field as weeds—which, incidentally, also serve as free fodder and make owning animals economically viable (Sahai, 2006). Educational opportunities are lacking in rural areas, more so for girls than boys, and diminish with age ("Social Context," 2004). Thus, even if families are surviving, they are just barely doing so, without the prospect of achieving stability.

In the wake of the Green Revolution, Indian farmers have been transitioning from subsistence to cash crop production. For some, this has proven a painful adjustment, as evidenced by widespread farmers' suicides since the 1990s. Faced with the demands of a more centralized market, Indian farmers have been expected to grow crops with the technology and mindset of a developed nation. They must do this on relatively small plots of land, as "about 60 per cent [of] farmers have land holding of less than 1 ha and another 20 per cent have 1 to 2 ha" (Chandra, Singh, and Singh, 2006). Also, the cropping systems and seed-saving practices developed over generations by Indian farmers are not compatible with the large-scale, chemical-based production models touted by Western companies which sometimes rely on seed that cannot be saved for the next season. To make farming economically viable in this context, farmers must compromise biodiversity and their own autonomy while taking out loans to adopt technologies with which they are largely unfamiliar. In addition to the stress of debt, farmers must cope with drought, which causes starvation and forces families off the land to find income elsewhere. Nearly seventy percent of the country is susceptible to drought, and drought resistance in crops will only become more imperative as climate change alters precipitation patterns ("Drought in India").

Crop Diversification

Adding biofuels to the amalgam of issues the Indian farmer must confront could be disastrous. The conversion of land from the production of food to biofuel feedstock could inflate food prices and destroy any hope of food security for India's people. But this doesn't have to happen. If appropriate crops are chosen, biofuels could be a boon for rural India. Jatropha and sweet sorghum can be cultivated for processing as biofuels without hurting food security.

Throughout the developing world, *Jatropha curcas* is gaining popularity as a biofuel feedstock. Also used as a living fence, jatropha is a shrub that bears inedible oilseeds. About 2,500 plants can be planted in a hectare, and seed yields range from 0.75 to 2.0 t ha^{-1} (Maheshwari and Raik). One variety of jatropha produces seeds with 40 percent oil content, more than twice that of soybeans (Renner, 2007). A jatropha plant will bear seeds for about fifty years (Tigere et al., 2006). Choosing a crop that will not require replanting each year saves farmers time and money. Proponents also boast of the plant's ability to grow on dry, marginal land. Jatropha, then, can be grown where many grains and pulses cannot, so food cultivation will not be threatened. With regard to food production, it is also significant that there are no competing uses for jatropha. All of the economic yield of the plant (usable parts—in this case, the seeds) can go directly into processing for biofuels.

Sorghum [*Sorghum bicolor* (L.) Moench], on the other hand, has other uses. In the semi-arid tropics (SAT) of India, grain sorghum is the third most vital foodgrain, after rice and wheat (Reddy et al., 2007). The plant's ability to withstand drought and pests, combined with its beneficial food value, has made it a logical choice for farmers with limited monetary resources.

Besides its uses as both food and fodder, sorghum has recently been utilized in biofuel production. Juice from the stalk of sweet sorghum (as opposed to grain sorghum) can be processed into ethanol without compromising grain cultivation (Reddy, Kumar, and Ramesh). Sweet sorghum is gaining favor for several reasons. It uses water more efficiently than other grains, including maize, and requires less water than sugarcane, another ethanol feedstock. Furthermore, sorghum is propagated by seed, while sugarcane is typically grown from cuttings (Reddy, Kumar, and Ramesh; Mullen 53, 2005). Sorghum matures about three times as fast as sugarcane, which takes about 450 days to mature (Reddy, Kumar, and Ramesh; Mullen 103, 2005). In India, ethanol from sweet sorghum is processed for $.29 per liter, so it readily competes with sugarcane-based ethanol, which costs $.33 per liter ("Sorghum cultivation," 2007).

Jatropha and sweet sorghum are simply two examples of a wide variety of crops being considered for use as biofuels. Because of their ability to grow in dry conditions and potential to augment farmers' incomes, these two crops are ideally suited for India. How effective they are in fulfilling their potential depends on the agronomic systems in which they are implemented and can be enhanced through genetic experimentation.

Crop Systems

A farmer transitioning from subsistence to cash crop production can increase yields by growing crops one after another (sequential cropping) or by growing multiple crops simultaneously in a single field (intercropping) (Mullen 41, 2005). Crops are chosen to complement one another's growth. Legumes and cereals are implemented in these systems for this purpose. All plants need nitrogen, so the cereals benefit from the nitrogen fixed by the roots of the legumes. Incidentally, jatropha fixes nitrogen to the soil ("The Jatropha Solution"). As a cereal, sorghum could make use of this nitrogen.

Sorghum can also be intercropped with pulses, which often fix nitrogen. This combination has already proven successful in an intercrop of two rows sorghum to one row pigeon-pea (Singh and Chetty, 1984). Such a system demonstrates the compatibility of biofuels and food production, as, in this case, both crops grow better together. Farm families can also benefit from this intercrop because it produces both the grain and pulses they need for nutritional security.

As interest in jatropha is still young, intercrops involving the shrub are in need of research. In Kenya and Madagascar, jatropha is intercropped with vanilla (Renner). Because of its nitrogen-fixing capabilities, jatropha has the potential to boost the growth of sorghum and food production crops. Additionally, the crops lend themselves to being grown together because of their growing patterns. Sorghum can provide a farm with income in the time between the planting of jatropha and its first harvest, which can be from one to four years depending on whether the jatropha is planted from cuttings or from seed (Balaji, 2004; Tigere et al., 2006).

Technological Innovation

In addition to increasing yields through intercropping, farmers can maintain food security by experimenting with crop varieties and by using various crop parts for multiple purposes. The greater the economic yield of biofuel crops, the less land in need of conversion from food to biofuel production. To achieve these ends, scientists can utilize hybridization and genetic engineering to increase crop productivity, and researchers can find new uses for more parts of the biofuel crop.

Some research is already being conducted on sweet sorghum. Much of the innovation in the arena of sweet sorghum ethanol has come from the work of the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Through hybridization, ICRISAT scientists have developed a variety of sorghum that can be planted year-round rather than only during the crop season ("Eureka," 2007). Hybridization has also increased yields. In the rainy season of 2006 in India, an especially productive sorghum hybrid had cane yields of 57.8 t ha^{-1} and grain yields of 5.08 t ha^{-1}, up from the mean yields of 35.0 t ha^{-1} and 4.6 t ha^{-1} (Reddy, 2007). The institute has shown through studies in Africa that in dry conditions the yield advantage of hybrids over open-pollinated varieties is even greater, sometimes as much as a sixty percent increase ("High hopes," 2007). With hybrids, however, there is a trade-off. Since the seeds produced are hybrids, the desirable traits of parents will not show up consistently in the next generation. As a result, seed-saving practices are not encouraged with hybrids, and seed must therefore be purchased each season.

While hybrids made the Green Revolution possible, genetic engineering could ease the burden on the land of producing food for us, our animals, and our machines. Researchers at Cornell University have discovered a gene in some varieties of sorghum that increases tolerance of aluminum toxicity, which increases yields by allowing the crop to grow in otherwise inhospitable soil (Ramanujan, 2007). This gene can be inserted in the nuclei of other crops, giving them aluminum tolerance.

Despite the promise of genetically modified (GM) crops, issues of policy and research must be worked out first. GM crops, especially Bt cotton, have been controversial in India because farmers are encouraged by government policies and biotech corporations to implement crops faster than the technology is ready. Bt cotton, which is designed to produce a toxin to kill the American bollworm, has not been studied enough in the context of India, where the bollworm sometimes shows resistance to the Bt toxin (Padma, 2006). To avoid resistance, farmers must keep twenty percent of the field in non-GM cotton, but on small farms this is not economically feasible (Sahai, 2006). Weak regulation allows for the sale of fake Bt seed, which is often the cross of GM and non-GM plants and will not even show the Bt trait. If it is to be used with food crops, GM technology must be thoroughly researched before implementation to avoid direct damage to human health. Research on how genetic engineering could benefit biofuels must be conducted with urgency, as increasing oil or sugar content in feedstock could maximize the worth of individual plants and thus diminish the need to genetically engineer food crops, if there is in fact a risk.

Apart from directly changing plant qualities, researchers are offsetting the agricultural strains of growing crops for something other than food or feed by finding ways to utilize more parts of a crop. In the case of sorghum, ICRISAT, along with the International Livestock Research Institute and the National Research Center for Sorghum, has found that the bagasse left after juice extraction can be combined with leaf strippings and the byproducts of ethanol production to make nutritious feed bricks for sale or on-farm use (“Sweet sorghum—more to chew on,” 2007). This can greatly help compensate for the loss of sustainability associated with cash crop production.

Prospects

Researchers are currently experimenting with crop systems and variety adjustments with jatropha and sweet sorghum. This research ought to be funded by the Indian government, especially with revenue from taxes on petroleum. If corporations have a hand in the matter, their expectation of returns on their investment could cause biofuels production to go in a different, possibly less sustainable path. While income for the farmer is a necessity, the desire for profits of investors in multinational corporations cannot be allowed to drive biofuels into a low-labor monoculture setting because in the immediate future, rural India will most benefit from the security of crop diversity and the income landless laborers will receive from labor-intensive systems.

Supportive government policies have already helped biofuels catch on in India. President Abdul Kalam has enthusiastically pushed jatropha as a means of attaining energy independence for his country (Hasan). However, to emphasize sustainability, Indian policy first needs to establish biofuels as a source of energy in rural areas. According to the U.N. Food and Agriculture Organization, nearly sixty percent of cooking in rural households depends on wood for power (Lefevre, Todoc, and Timilsina, 1997). Rather than depleting forest supplies, families can make use of fuel they grow themselves in the form of jatropha and sweet sorghum. Only after villages have achieved energy independence can President Kalam talk seriously about energy independence for the whole nation.

The discussion of future trends in agriculture may involve speculation on details but it is grounded on the certainty that things must change to save the earth’s inhabitants. Jatropha and sweet sorghum are sensible options to transition India into an age of producing biofuels and sufficient food in a sustainable manner. The key to survival in this era depends on cooperation between the earth’s inhabitants and the framework of sustainability upon which they base their actions.

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