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Biotech, African Corn, and the Vampire Weed

by Brian Halweil

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Biotech, African Corn,

A parasitic weed is sucking the life out of East African corn. One way to deal with it would be to engineer corn for herbicide resistance, so that herbicide could be sprayed on the corn to kill the parasite—even though the corn seed and the herbicide would probably be too expensive for poor farmers, the herbicide would pollute, and the weed would likely become resistant. Another way would be to improve soil health. Tough call.

by Brian Halweil

I was hot on the trail of the infamous Striga weed. Though I'd never confronted a live specimen, the plant had been hounding me *in absentia*, and often in public, for several years. Again and again, in various panel discussions on biotechnology, I have listened to my debating opponents hold up Striga as proof that genetic engineering could one day eradicate hunger and poverty in the Third World. The particulars varied, of course, but I had heard the same basic Striga argument from biotech executives, from industry-funded scientists, and from the industry's advocates in academia and government.

Striga hermonthica is a member of the Scrophulariaceae family, a widespread group of about 4,000 plant species that includes a couple of "heirloom"garden favorites, foxglove and snapdragon. But it also includes several important Old World plant parasites—plants that live off other plants. *S. hermonthica* is one of these. It's common in East Africa, where it's called "witchweed" or in Swahili, "buda." It looks innocent enough, standing about 15 centimeters (around 6 inches) tall, and bearing little lance-shaped, pale-green leaves that make a pleasing contrast with its pink-purple flowers. But below ground, the plant is a monster. Its root-like organs, called haustoria, seek out the roots of nearby crops, then rob them of water, nutrients, and life. And those pretty flowers can set as many as 20,000 seeds per plant. The seeds are easily dispersed and can lie dormant in a range of soil conditions for decades.

In a badly infested field, Striga can destroy most of the harvest, perpetuating not only poverty and hunger, but also gender inequity, since it's usually women who must undertake the largely futile task of disentangling Striga from the crop. Throughout East Africa, Striga causes several billion dollars in losses each year.

The solution, according to the biotech advocates, is to engineer varieties of African staple crops to resist herbicides, so that farmers can spray their infested fields—and kill the Striga without killing the crop. This is an extension of agricultural biotech's dominant commercial application: the engineering of soybeans, corn, cotton, and canola by Monsanto to withstand the company's best-selling herbicide, glyphosate ("Roundup").

An anti-Striga niche would make it easier to claim the moral high ground for herbicide-tolerant crops. Such products might eventually seem as humanitarian as the industry's "golden rice"—the beta-carotene enhanced rice variety that is being developed to combat vitamin A deficiency. Beta-carotene is the precursor of vitamin A, an especially important nutrient for children. Worldwide, nearly 134 million children suffer some degree of vitamin A deficiency, a condition that can suppress immune system function, cause

and the Vampire Weed

Striga hermonthica is causing billion-dollar crop losses in Africa, the only part of the world where hunger is both widespread and increasing.

blindness, and in extreme cases, even kill. Little wonder that golden rice has become the emotionally compelling hook for a $50 million public relations campaign launched by the Biotechnology Trade Organization. (It's true that not everyone is sold on this idea. Some nutritionists argue that it would make more sense to help poor people grow green vegetables, which produce more beta-carotene than golden rice—along with various other nutrients completely lacking in rice, golden or otherwise.)

But in any case, I decided that the time had come for me to get a first-hand sense of this expanding moral high ground. From a political point of view, the Striga issue looked especially interesting because Striga, unlike vitamin A deficiency, is almost exclusively an African problem, and Africa is groundzero in the global food debate. Although hunger is sorely persistent throughout much of the developing world, Africa is the only region where it is actually getting worse. In Latin America and Asia, the past two decades have seen a modest decline in malnourishment among children, in terms of both the percentage of children affected and their absolute numbers. In Africa, however, the share of children who are hungry has risen from 26 to 29 percent over the past 20 years, and the absolute number of hungry children has doubled. It now stands at 38 million. That helps explain why, sooner or later, almost any major agricultural development will have to justify itself in an African context.

That, in turn, explains why I was looking at cornfields outside Maseno, Kenya last February. Maseno is a small but rapidly growing town near the Ugandan border, about 30 kilometers northeast of Lake Victoria. And from what I could see, the local harvest was going to be an uncertain affair. In some fields there seemed to be more Striga than corn, which is often called maize in Africa. Spindly corn stalks with pitiful, dried-up ears stood above a carpet of purple flowers. But in other fields, the corn looked good and there was no Striga at all. Several farmers and ag extension agents helped explain what seemed like pure chance. One of them, a farmer named Paul Okongo, put it categorically: "Striga is only a problem in overused and depleted soils."

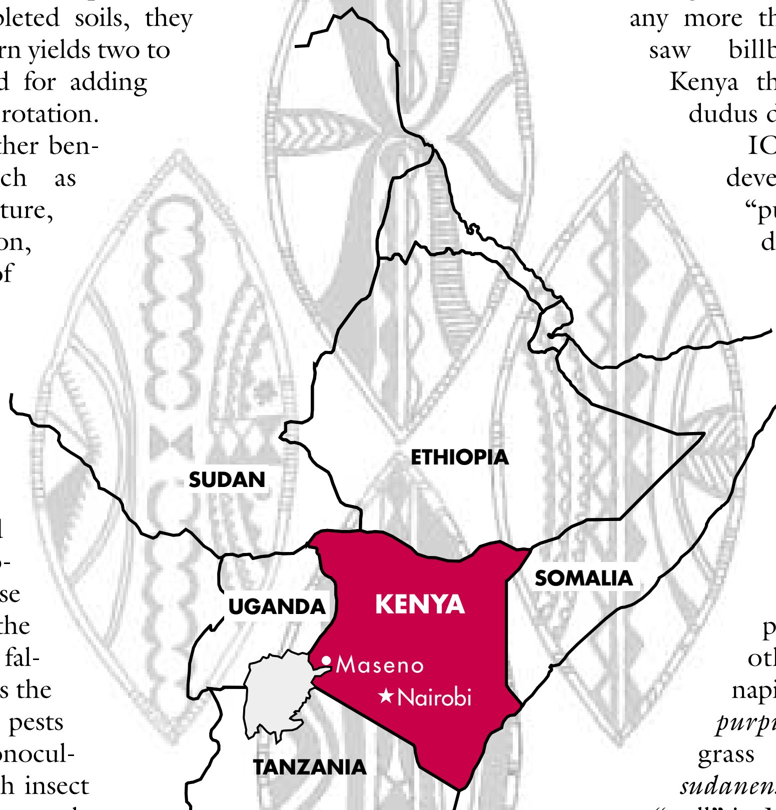
Striga thrives where farmers have grown nothing but corn for decades, especially where fallow periods have been shortened or eliminated. (During a fallow period, land is allowed to "go wild" or soil-building fallow crops are sown. The practice helps maintain long-term productivity by reducing weed and pest infestations and by allowing soil nutrient levels to recover.) But as Kenya's population has grown, the size of the average family field has declined, and farmers have become increasingly reluctant to take land out of production. Of course, fallowing isn't the only way to renew soil; another standard approach is fertilizing. And where farmers are able to do this—whether in the form of manure or artificial fertilizer—Striga is rarely a problem. But most East African farmers can't afford commercial fertilizer. And manure is often scarce because livestock are not generally penned, where their droppings could be collected, but grazed out in the open. No fertilizer and little fallowing: the result is depleted soil, and then Striga moves in. Striga infestation, in other words, is a kind of second-order effect: it's what happens *after* soil health declines. It was obvious that a herbicide-resistant fix wasn't going to get at this problem.

It was also obvious that Paul knew what he was talking about, and I began to wonder what local expertise might have to offer in lieu of a prepackaged, imported solution. And indeed, it turns out that some African farmers have found a way to suppress Striga with a widely available, home-grown technique: planting leguminous tree crops— that is, tree species that are members of the legume family. Plants in this family often have certain microbes on their roots that can "fix" nitrogen: the microbes withdraw elemental nitrogen from tiny air pockets in the soil, and bond it chemically to hydrogen, producing compounds that plants can metabolize. (Pure, elemental nitrogen is useless to plants; fixed nitrogen, on the other hand, is the principal component of fertilizer.)

These nitrogen-fixing trees are grown as a fallow crop, during the one more-or-less obligatory fallow period of the year: from February to April. This is the dry spell between the two rainy seasons—the long rains of late spring, which yield the main corn harvest in July, and the erratic, short rains of fall, which produce the smaller, January harvest. Of course, three months isn't long enough for the trees to get very big; they're usually 2 or 3 meters high when they're pulled to sow the fall corn. But that one season of tree growth can cut Striga infestations by over 90 percent. This is not just the effect of the added nitrogen. Some of the preferred tree crops are native to the region and have co-evolved with Striga; their evolutionary defenses to the parasite apparently include chemicals that they exude into the soil, and that disrupt the Striga lifecycle.

Control of Striga is not the only benefit of nitrogen-fixing crops, according to Bashir Jama, a scientist with the Nairobi-based International Center for Research in Agroforestry (ICRAF), the main promoter of these "improved fallows." Where farmers can be persuaded to employ longer fallows, leguminous trees can accumulate 100 to 200 kilograms of nitrogen in 6 months to 2 years. (The results depend on the species used, soil quality, moisture levels, and whether the fallow is taken all at once or in intermittent periods.) These fertilization rates would satisfy most U.S. and European farmers. In severely depleted soils, they generally increase corn yields two to four times—not bad for adding just one crop to the rotation.

Bashir reports other benefits as well, such as improved soil structure, better water retention, and higher levels of other nutrients besides nitrogen. The fallow crop also shades out weeds—which means fewer weed seeds to cause problems when the field goes back into production. And because it adds diversity to the agroecosystem, the fallow tends to suppress the most serious insect pests of corn as well. (Monocultures foster very high insect infestations; in more complex systems, the pests encounter more predators and less food so their populations tend to be much lower.) Fallow greens are also nutritious livestock feed; the wood is useful for fuel. A six-month tree crop fallow on as little as half a hectare can meet a family's cooking needs for an entire year.



Another Striga control has emerged as the byproduct of an ingenious local response to the most important insect pest of corn, the stemborer. The borer is thought to chew up between 15 and 40 percent of Africa's corn harvest each year. In other corn-growing regions of the world, the borer is the target of extensive insecticide spraying. African farmers generally can't afford insecticide, but they may not need it anyway, to judge from the work of another Nairobi-based organization, the International Center for Insect Physiology and Ecology (ICIPE). ICIPE's work is founded on the idea that pest problems are caused by ecological imbalances; progress is therefore a matter of correcting the imbalances, rather than simply trying to poison the pests. "The long-term solution is generally more insect diversity, not less," says Hans Herren, ICIPE's director. This attitude helps explain why the gates at ICIPE headquarters bear a sign reading "Duduville." "Dudu" is Swahili for bug. Kenyans don't generally seem to like bugs any more than Americans do; I saw billboards throughout Kenya that read, "Raid kills dudus dead."

ICIPE scientists have developed what they call a "push-pull" strategy for dealing with the stemborer. The corn is sown with certain plants, such as molasses grass (*Melinis minutifolia*) and silver leaf desmodium (*Desmodium uncinatum*) that repel, or "push" the borer. The field perimeter is sown with other plants, such as napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanense*), that attract, or "pull" it. Most of the larvae end up trapped in the gummy substances produced by these grasses. This system can cut stemborer losses from 40 percent to below 5 percent. It also offers substantial relief from Striga, because desmodium secretes a chemical that interferes with the parasite's ability to tap into the roots of other plants. (Desmodium is a legume genus from the New World, so this mechanism is not an adaptation to Striga specifically, but perhaps the genus coevolved with a similar parasite.)

Ironically, a major U.S. foundation, which has been funding the "push-pull" research, has asked ICIPE to isolate this chemical—and the related gene. "Part of their interest is to use that gene to come up with molecular biology solutions to the Striga problem," says Zeyaur Khan, who directs work on the push-pull strategy at ICIPE. In other words, they might be interested in funding the development of a corn variety engineered to produce this substance. How would that relate to ICIPE's interest in promoting ecological balance? Presumably, it would tend to undercut it, because it would push the system back towards monoculture—and it would likely do nothing for the borer problem. The full benefits of ICIPE's system are only available if you buy in at the ecological level—not the molecular level. And of course, the ecological level is the one that's available to farmers.

After several days of farm visits in western Kenya, I was beginning to get a better sense of how the biotech approach to Striga compared with the improved fallow technique. The biotech fix would be costly for the farmer, would increase chemical use, would add no other benefits to the system, and in any case, does not yet even exist. On the other hand, improved fallowing is extremely low-cost and confers all the benefits mentioned above. It's also readily accessible. In at least a rudimentary form, the technique is already being used by tens of thousands of farmers in eastern and southern Africa. Pedro Sanchez, who recently stepped down as director of ICRAF, sees improved fallowing at the early stages of an exponential growth curve similar to what happened with Green Revolution rice varieties in Asia. Sanchez envisions 50 million farmers using improved fallowing within the next five to ten years.

One of the most interesting features of the improved fallow system is that it allows for forms of R&D that farmers can do on their own. In 1997, for example, a moth infestation began to threaten a popular East African tree crop known as sesbania (*Sesbania sesban*)—until some farmers discovered that occasional rows of tephrosia trees (either *Tephrosia vogelii* or *T. candida*) would keep the pest in check. This field-level innovation is very far removed from the biotech paradigm, where innovation occurs, not on the farm, but in million-dollar laboratories, and where the principal actors are not farmers, but Ph.D. biologists and patent attorneys.

Reduced Angled Spouted Black Piece, 1990
Magdalene Anyango N. Odundo, (born 1950, Nairobi, Kenya)
Ceramic
Size: 44.5 x 28.6 x 28.6 cm.
(17.5 x 11.25 x 11.25 in.)
Museum purchase, 91-4-1
Photograph by Franko Khoury
National Museum of African Art
Smithsonian Institution

This distinction is critical, and not just for the harvest. The ability to innovate could be crucial to the future of farmers themselves. But if innovation is to contribute to the welfare of farming, it will have to extend beyond issues of yield. After all, many U.S. and European farmers have been teetering on the brink of economic extinction for years, and a substantial number have gone over it—even though they produce some of the highest yields in the world. In most developing countries, agriculture is still the predominant way of life, so the economic health of farming is a basic social issue. This is why the agricultural status quo is a dangerous absurdity. The multinational corporations that sell farmers seed and pesticide are ringing up tens of billions of dollars in sales each year; the multinationals that distribute, process, and retail the harvests are ringing up hundreds of billions. But farmers themselves are now members of the poorest—and ironically, the hungriest—occupation on Earth.

This is the problem that has come to dominate the agenda of another Kenyan NGO, the Association for Better Land Husbandry. ABLH was set up in 1994 to promote a variety of conservation farming techniques, including biointensive farming, a form of organic production popularized by one of organic agriculture's best-known proponents, John Jeavons of Willets, California. When I visited farmers working with ABLH in the Vihiga district of western Kenya, I instantly recognized the neatly laid out "beds" that characterize the biointensive method. In 1996, I had attended a three-day workshop taught by Jeavons, and I knew from direct experience how much effort went into those beds. They are prepared through a deep-digging technique, called "double-digging," which aerates the soil, and permits better nutrient circulation. Jeavons places tremendous emphasis on soil health. "Feed the soil, not the plants" is one of his mantras.

Biointensive farming can boost yield dramatically, and it packs a one-two punch against Striga by enriching soils, then producing a dense, diverse plant canopy that shades out most weeds. But by themselves, such improvements aren't going to bring prosperity to farmers. "Doubling maize yields and tripling kale yields doesn't make much of a difference if you can't get your produce to market, or if a flood of cheap imports squashes your local market," says Jim Cheatle, founder and director of ABLH. To get at these issues, Cheatle expanded the group's agenda to include a kind of farmer empowerment. ABLH now coordinates seven farm cooperatives so that local growers can capture the marketing and distribution advantages that come with scale. (Nine more co-ops should be in operation by the end of the year.) "Instead of each of several thousand farmers buying their own delivery truck and setting up their own marketing offices," says Jane Tum, an ABLH extensionist, "the cooperative can pool its resources for a much larger delivery truck and a marketing staff." This might seem like kind of an obvious thing to do, but *any* concern with marketing is still unusual in places like Kenya. A recent survey of over 200 sustainable farming projects in the developing world found that only 12 to 15 percent had tried to improve marketing or processing.

Co-op produce is now selling in both local and national markets under the "Farmer's Own" brand name. Among the products bearing this label are Mr. Brittle, a macadamia nut energy bar, and Mchuzi Mix, a soup and sauce thickener made from locally-grown beans and corn. "We're competing with the big boys," says Francisca Odundo, the marketing manager for Farmer's Own. Francisca is trying to cultivate allegiance for the new brand, which now sits on shelves alongside the Cadbury and Nestlé labels.

Farmer's Own products also bear the label, "Conservation Supreme," a quasi-organic designation that permits limited use of approved biopesticides, like the insect killing "Bt" bacterium. The designation is a kind of marketing tool to help small-scale farmers make the transition to certified organic production. (Before it can pay off, the transition usually involves several years of uncertainty, in which both the farm and the farmer must adjust to the new regime.)

I got a sense for the tangible results of these efforts when Jane Tum took me to a farm to pick up produce for a Farmer's Own vegetable stand. The farm was run by Flora Mwoshi, a young mother of three. On the day I visited, she was harvesting bright green bell peppers. With a young child resting on her hip, Flora balanced a five-gallon plastic bucket of peppers on her head and bore it to our truck, where it was weighed. Several more buckets followed. Her six-year-old daughter, barefoot but wearing her best white dress because the family had heard that white people were coming to visit, watched in awe as her mother became the center of attention.

Jane paid the woman 600 Kenyan shillings, about $10. That doesn't sound like much, but that money went directly into her pocket—no middleman to pay, no bills for agrochemicals or expensive seeds. And many more veggies remained to be harvested. This simple transaction was the most inspiring moment of my trip. We, the "white people," hadn't arrived with some foreign technology of highly dubious potential. We were there as witnesses and—in a broad sense—as colleagues. What we witnessed was a local response to a local problem. And we could see that the response worked, because the produce was beautiful, and the farmer got paid.

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