

Greenseeder

Hand planter could boost productivity for world's poorest farmers

by Madeline Fisher

Bill Raun was working in El Salvador in 1987 when he snapped a photograph that has haunted him ever since. In it a young Salvadoran balances on a

precipitous slope, a bucket of seeds strapped to his waist. In his right hand, he clenches a stout stick that he'd jabbed into the ground a moment before. With his left, he drops a few seeds into the hole left behind.

The man—a farmer—was planting corn, and Raun was amazed by

both the utility and coarseness of his technique. On the one hand, agriculture in such steep terrain will never be mechanized, says Raun, an Oklahoma State University (OSU) agronomy professor and an ASA and SSSA Fellow. Even animal-drawn planters are risky, which is why poor farmers across

Central America have relied for centuries on the *chuzo*, or stick planter.

On the other hand, the tool was undeniably primitive, and even more astounding is how little it has changed since or how widely it continues to be used. "There are 30 million ha of maize in the developing world, with the majority of it planted



by hand just like the farmer in El Salvador," Raun says. "This is the same acreage we plant to corn in the United States."

He couldn't let it go, and so about 15 years ago, he decided to take action. Throughout his career, Raun has worked with engineers on technologies for boosting farm efficiency and yields. He is co-inventor of the precision agriculture sensor, the Greenseeker. He also helped create a hand-held model that smallholder farmers can use to judge the nitrogen

status of their crops. The modernized hand planter from OSU, or "Greenseeder" as it's also called, is now being developed with the same intent: to make farming easier, more precise, and more productive for the world's poorest farmers who often cultivate the most marginal lands.

This hasn't meant throwing out the *chuzo*; rather, Raun's aim is to enhance the stick planter while staying true to its traditional form. One key upgrade is that the Greenseeder delivers one seed per strike instead of the two to three that are typically planted now—an improvement that agronomists know without question increases yields.

Moreover, because a drum within the device drops the seed, farmers no longer have to handle seeds coated with pesticides or other chemicals with their bare hands. In El Salvador, farmers don't recognize the concern at first, so it takes time to convince them of the health risks, says Edgar Ascencio, a former graduate student of Raun's and his longtime collaborator in Central America. "But the problem, once explained, captures their interest."

Prototype hand planters have likewise gained attention in Uganda, reports Peter Omara, another student of Raun's at Uganda's Gulu University. But a major hurdle must be surmounted before the planter enjoys widespread use: price. Each planter now costs about \$200, although the team thinks this could drop to \$45 if the tool were manufactured in bulk. Even so, this is too much.

"The figure may appear small," Omara says. "But it is still unaffordable to resource-constrained farmers in Uganda whose income is barely \$200 a year."

Replacing an Ancestral Tool

Raun understands well the challenges faced by smallholder farmers. The son of a scientist with the Rockefeller Foundation, he grew up in Mexico City—headquarters today of CIMMYT (International Maize and Wheat Improvement Center)—and then Bogotá and Cali, Colombia. Only in the summer did he live in the States, where he worked on the family farm in Nebraska.

"So for all practical purposes, I was a farm kid," Raun says—albeit one who knew Norman Borlaug, became fluent in Spanish, and was at ease in the Latin culture. That's why it "felt like going home," he says, when he took a job with CIMMYT after completing his Ph.D. at the University of Nebraska.

Raun spent two years in Mexico as a wheat agronomist and then transferred to CIMMYT's maize program and began working from Guatemala as a regional agronomist. For four years, he spent 200 days on the road, traveling throughout Central America and the Caribbean to give advice to other maize researchers and help deploy field experiments. The work,



Clockwise from left: Using the Greenseeder for planting in Lira, Uganda (photo courtesy of Peter Omara/Oklahoma State University); a traditional *chuzo* (photo courtesy of Edgar Ascencio); and a hand contaminated with treated seed. The red color is from one product, and the blue color is from another product. Farmers using the *chuzo* carry the seed and do not wear gloves (photo courtesy of Edgar Ascencio).



Left: Another *chuzo* type used in some flat lands. **Above:** A comparison between the Green-seeder (left) and the *chuzo*. Photos courtesy of Edgar Ascencio.

though grueling, gave him intimate knowledge of the region's agricultural challenges—particularly those of planting corn by hand on extremely steep slopes. Among the biggest problems was erosion, and Raun became fixed on interseeding legumes with maize to help hold the soil.

The legume he chose was cowpea, or black-eyed pea, a species that grows well in the shade of other crops. There was a hitch, however. The local people despised cowpea's flavor, much preferring their traditional food, the common bean. The issue simply could not be overcome, and Raun came to view the interseeding project as a failure. "It's not that I didn't work hard or have good intentions," he says. "But it wasn't the right solution."

In 1991, Raun took an assistant professorship at OSU, where he might have forgotten all he'd seen in Central America amid the toil of achieving tenure and then a full professorship. But he didn't. In fact, as soon as he felt he'd earned the freedom to pursue what was essentially a service project, his thoughts returned full force to the experience and the lingering sense that he hadn't done enough.

"As a regional agronomist, I felt like I needed to work on erosion," he

says. "But I should have been working on planters."

Others weren't so sure. Ascencio, for one, "was skeptical," when Raun first disclosed his idea about modernizing the stick planter. "He was talking about replacing an ancestral tool," says Ascencio, who worked for CARE International in El Salvador until last year, "which is cheap and requires little or no maintenance."

What eventually won him over was the planter's potential to take chemically treated seed out of the hands of smallholder farmers—a longstanding problem with few solutions. But his point about the *chuzo* being ancient and cherished was well taken.

"One of Bill's driving factors when we started this was that these countries are planting seed with a stick now, and Bill wanted to stay with that concept," says Randy Taylor, an OSU expert in seeding equipment who has collaborated on the planter since 2004. "It was a focus of his to hopefully speed up adoption."

Building the Planter

Launched on a shoestring budget, development of the tool progressed slowly, with most of the early designs showing substantial

flaws. Yet, the project may have stalled completely, Raun says, if not for his engineering colleagues: First, John Solie and Marvin Stone, and later, Taylor. Several of Taylor's agricultural engineering students lent their expertise, but the "big breakthrough" came when a Swiss Ph.D. student named Adrian Koller joined the project, Raun says. "The reciprocating drum cavity design that the group conceived of moved us ahead overnight. Adrian really made that happen."

When Koller graduated, Taylor began working on the project himself, with a focus on simplifying the Green Seeder and improving its metering system—the internal drum that grabs a seed and drops it. Although the prototype at the time was functional, Taylor explains, it had a square shaft with two external springs in the metering system, which had to be machined. And the springs, in turn, required several screws and other parts to hold them in place.

At his urging, the team has returned now to a round housing, letting them swap an "off-the-shelf," internal spring for the external ones while also removing several other parts. The hand planter is now much cheaper and easier to build. "With

the [older] device, there were several ways to put it together, only one of which was correct," Taylor says. "But the current model only goes together one way, so you can't put it together wrong."

Getting a relatively simple device to dispense one seed at a time, or "singulate" it, has been surprisingly tricky, Taylor notes. The issue is the various sizes and shapes of corn seeds, and handling them turns out to be easier in mechanized systems. "On most row crop planters right now, seed is singulated with a rotating disc and some kind of airflow, either a vacuum or pressurized system," Taylor says. "You don't have the luxury of either of those things if you're going to carry [the planter] around."

The current lead student on the project, ASA, CSSA, and SSSA member Jagmandeep Dhillon, is now testing which of two drums in the hand planter provides singulation over the greatest range of seed sizes. Although he has just one year of data, he cautions, both seed delivery and seedling emergence are better so far with a drum called the 450s.

Meanwhile, Raun has been looking at the agronomic implications. In a study published in 2014, for example, he, Omara, and others found that planting single corn seeds at half-foot intervals with the Greenseeder increased yields by an average of 1.15 Mg ha⁻¹ over the usual strategy of sowing two to three in holes spaced a foot apart.

And most recently, ASA, CSSA, and SSSA member Becca Harman at the University of Tennessee has been testing the OSU planter against seven other competitors, including the dibble stick (crow bar), Haraka Rolling Planter, and the Brazilian Jab manufactured by the company, Fitarelli. In no-tillage corn and soybean systems in Ohio, she found that the dibble stick and Greenseeder produced the highest yields across all the treatments. The Greenseeder also topped the rest in usability.

While Raun is pleased by her results, what he finds even more gratify-

ing is Harman's simple involvement. She started working with the planter of her own accord, he points out, after hearing him speak about it at the Societies' Annual Meeting in 2014.

"For me, that's a critical component of this: It takes teams, it takes people—people who are willing to listen and willing to work," he says. "We have had no shortage of that, and what a gift."

More Precision, Less Labor

When another team member, Omara, became Raun's master's student in 2011, the Ugandan native had a request. "I remember telling Dr. Raun that I would participate in any project that was of relevance to farmers in my home country," recalls Omara, who in addition to lecturing at Gulu University works with farmers—mainly women's groups—in the region. Similarly, Lawrence Aula, another Ugandan who was a student on the hand planter project with

Some Ugandan farmers use an ox-drawn plow to prepare their fields for planting, Omara explains. But, more commonly, one farmer digs holes with a stick or hoe while a second walks behind, dropping seeds and covering them with a foot. This means that, as in Central America, the Greenseeder should improve productivity via singulation and precise seed placement. And farmers won't have to handle chemically treated seed.

There are other benefits in Uganda, as well. The labor needed to plant maize is cut in half—from two persons to one. And farmers report that the new tool is less tiring to use, Aula says. "The OSU planter has a spring that serves as a shock absorber, which means one can use less energy to penetrate the soil and plant maize." This is obviously not true of the heavy sticks that farmers in his area typically use, he notes.

Another advantage is that the Greenseeder's drum is easily modified to dispense fertilizer instead of seed.

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Lawrence Aula

Omara, says he came aboard "without hesitation."

"As a child, I worked with a rudimentary planter that caused calluses, pain, and had high labor demands," says Aula, who as an agroforestry project officer with the Lutheran World Federation has introduced the OSU tool to several Ugandan maize growers. "So I wanted to make a contribution to a technology that would change the way we do farming [in a positive way]."

Most maize farmers in El Salvador today toss ammonium sulfate onto the soil midseason without incorporating it, Ascencio explains. But if rain doesn't fall soon afterward, the nitrogen won't move into the rooting zone, causing yields and nitrogen use efficiency to plummet. This has become especially concerning as rainfall patterns have shifted with climate change, he adds.

The Greenseeder, in contrast, automatically incorporates fertilizer, meaning farmers could switch to

urea—a better, but more expensive, N source—without suffering losses from volatilization or having to rely on timely rains. And rather than flinging fertilizer randomly over the soil, they can use the tool to apply nitrogen only where they see a seedling emerging. “So it’s like precision agriculture,” Raun says, “where the precision comes from the guy who is out there handling the planter.”

These points can’t be overemphasized, Ascencio says. “If a farmer applies fertilizer, it is a huge expense. Thus, maximizing the value of this input is money in producers’ pockets.”

Challenges Remain in Bringing the Tool to Market

For all he believes in the hand planter now, though, Ascencio thinks getting more farmers on board will take significant effort. Last year, roughly 25 Salvadoran maize farmers tried out a single planter and provided valuable feedback to the team. But to truly convince them of the advantages, he thinks its performance must be compared against the *chuzo* now on a much bigger scale.

“A larger validation is required because the hand planter is oriented toward small farmers whose economies are very sensitive,” he says. “Changes in tools or inputs are not easily accepted because they involve risk.”

Their caution means that experiments will have to be accompanied by extension activities, adds Ascencio, and these trials will of course require expensive inputs of seed and fertilizer. Still, the most expensive item remains the planter itself, and its cost is most out of reach precisely where it could have the greatest impact: Africa. “Central America, that’s 2 million ha [of hand-planted maize]. Two million out of 30 million,” Raun says. “Sub-Saharan Africa? We’re talking 8, 9 million ha. That’s a ton.”

Its current \$200 price tag can likely be reduced by further simplifying the tool, including moving from machined to injection-molded parts, Taylor



Left: The Greenseeder’s drum is easily modified to dispense fertilizer instead of seed, and it automatically incorporates fertilizer, resulting in greater nutrient use efficiency, and allows farmers to be more precise in where they apply. **Above:** The Oklahoma State University (OSU) group is now trying to find an overseas partner willing to bring it to market. Bill Raun, OSU, estimates a total market size of 30 million planters. *Photos courtesy of OSU.*

says—although as university researchers, the team is reaching the limits of the design work it can do. Increasing the volume of planter production will also cut the cost, but then the question is: Who will manufacture it? AGCO of Duluth, GA, built 200 hand planters in the past, helping the OSU researchers get the Greenseeder tested in many other countries in Central America, Africa, and East Asia. But a key collaborator there, Nyle Wollenhaupt, has since retired, Raun says.

Besides, it makes little sense to manufacture a steel-tipped tool in the United States—where the price of steel is sky high—only to ship it to a poor nation, Taylor adds. So the group is now trying to find an overseas partner willing to bring it to market (businesses in Honduras and Uganda have expressed interest), perhaps aided by NGOs that would subsidize the cost for farmers. Raun notes that OSU holds a patent on the equipment, and in looking around the world, he estimates a total market size of 30 million planters. In other words,

a company could make money selling the Greenseeder.

As much as he’d like for this to happen, however, Raun is clearly reluctant to let the hand planter go—at least until a few more tweaks and tests are done. Farmers in the developing world have been eking out a living for far too long; the last thing he wants is to deliver a tool that doesn’t function well or fails to meet their needs. “What I want to hear them say is that somebody put together a planter that *worked*, that they were proud of and happy with, and identified as theirs,” he says.

The words in Spanish are *mi sembradora*, or “my planter,” he adds. “This is *mine*.”

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