Tiny Weed-Killing Robots Could Make Pesticides Obsolete

This swarm of robots may herald a chemical-free food revolution

Farmer Georgie Jul 1, 2020 · 12 min read ★

The fleet of Greenfield Robotics weedbots ready and waiting for beta test trials. Photos courtesy of Greenfield Robotics.

Clint Brauer's farm outside of Cheney, Kansas, could be described as Old MacDonald's Farm plus robots. Along with 5,500 square feet of vegetable-growing greenhouses, classes teaching local families to grow their food, a herd of 105 sheep, and Warren G—a banana-eating llama named after the rapper—is a fleet of ten, 140-pound, battery-operated robots.

Brauer, the co-founder of Greenfield Robotics, grew up a farm kid. He left for the big city tech and digital world, but eventually made his way back to the family farm. Now, it's the R&D headquarters for the Greenfield Robotics team, plus a working farm.

food could be grown without harmful chemicals and by embracing soil- and planet-friendly practices. He did just that, becoming one of the premier farmers growing vegetables in Kansas without pesticides, selling to local markets, grocery store chains, and chefs.

But it wasn't enough to make the difference Brauer was hoping for. Sure, he was growing a lot of environmentally friendly, pesticide-free vegetables. But a few acres in chemical-free vegetable production was nothing compared to miles and miles of broadacre, arable farmland that make up the majority of America's agricultural lands.

Brauer was especially intrigued by no-till solutions for soil health. No-till is exactly what it sounds like: farming without using techniques like plowing and cultivation, which "disturb" the soil to kill weeds. Many U.S. farmers, especially those in America's heartland of corn, soy, and wheat production, have already switched to or are looking to embrace no-till practices. Over 104 million acres were farmed no-till in 2017, an increase of 8% since 2012. Just over 900 million acres, including no-till land, were farmed in the United States in 2017, according to the 2017 Census of Agriculture.

I'm a fourth-generation farmer. Easily half, if not more, of my time farming and certainly a huge portion of my expenses are spent on weed control. Right now, there are three basic solutions. None of them are perfect.

You can pull weeds out with good old human toil, an expensive and physically debilitating task. It's increasingly hard to find help because frankly, hardly anybody wants to do it.

But parking machinery to improve soil health often comes with a trade that didn't sit well with Brauer: dependence on chemical weed control. No-till works to improve soil health, but the trade-off in chemical use is not much better for the environment than conventional farming. Regardless of the type of farming, the problem is the same.

You can cultivate or "till" using mechanical solutions, like tractors pulling plows, discs, shovels, and rototillers that kill weed seedlings. But, as the no-till farmers have discovered, tillage disturbs the delicate microbial life of the soil, leading to decreasing yields, loss of topsoil, species diversity, and watershed destruction.

"You got to start with weeds. It's the number one thing that farmers are fighting," Brauer says.

Then there's door number three: herbicides. They are still expensive, but cheaper than labor. You can skip the tillage, but still control your weeds. Chemicals aren't a perfect solution, but they have worked — sort of.

That's where the robots come in.

U.S. farmers choose the chemical option overwhelmingly often. According to the USDA, more than 95% of the U.S. corn and soybean crop was sprayed with herbicides in 2010 and 2012. A study published in the *Environmental Health Journal* last June showed that a whopping 1.2 billion pounds of pesticides were used in U.S. agriculture in 2016.

Glyphosate, aka "Roundup," is the most commonly used herbicide in the world and the one most consumers have heard of. It was designated a probable human carcinogen by

unclear whether established "safe-use" levels are safe in the long term.

Overuse has led to glyphosate-resistant "superweeds." In recent years, U.S. farmers have increasingly turned to less publicly known but potentially even more problematic chemical solutions, using pesticides that aren't used in many other nations. Out of 25 of the most commonly used pesticides in U.S. agriculture, at least 10 are banned in one or more of the big three farm-producing regions of China, Brazil, and the European Union.

Dicamba is notorious for drifting and affecting nontarget crops miles away, yet manufacturers reported increasing sales until a June 4 ban in a U.S. appellate court. Atrazine is another popular herbicide. Found in 94% of all U.S. drinking watersheds, the Pesticide Action Network has raised concerns over its potential for endocrine disruption. Then there's paraquat, a herbicide so deadly the CDC lists it on its "Chemical Emergency" website and it garners a fact sheet alongside arsenic, hydrogen cyanide, and mustard gas. Even though there's currently a push to ban it internationally, paraquat has seen a recent resurgence in the U.S. as a solution to glyphosate-resistant weeds.

Keep in mind, farmers don't use chemicals because they want to. Nobody understands better than farmers that the dependence on weed-killing chemicals is nothing but a sliding-scale deal with the devil. Not only do they pay for the chemicals, the labor and equipment to spray it, and (in some cases) the seeds that have been genetically modified so they can withstand them; farmers risk their own personal health every time they spray.

I have never met a farmer who looked forward to mixing tanks of hazardous chemicals and sitting on their butt on a tractor spraying for days on end. There are plenty of more fulfilling tasks to do on a farm.

But those dang weeds.

The Greenfield robotic solution is based on a simple idea: Keep mowing.

first enemy. The pain-in-the-ass weed, also known as Palmer amaranth, claims the annoying weed holy grail — it is invasive, adaptive, and herbicide-resistant. A single plant, undeterred, can grow over six feet tall and produce up to half a million tiny seeds. It distributes easily, and young seedlings continue to germinate even after the cash crop is planted. Farmers have to keep working to get rid of it even after their crop starts growing, otherwise, it quickly takes over. Because it has become glyphosate-resistant, desperate farmers have increasingly turned to more aggressive chemical solutions.

A Greenfield Robotics 'broadleaf weedbot' gets busy.

On a whim, Brauer threw a mower on his tractor and took it to a field that had been overtaken by the weed. He discovered that if mowed repeatedly, a few inches off the ground, the pigweed would eventually give up the fight and die.

But when you mow down a field of pigweed, you're mowing everything down. Including, technically, the crop you're trying to grow. A standard-size tractor and mower won't fit between rows of soy, corn, cotton, or any other broadacre crop, which are

otherwise known as getting stuck.

Plus, staying in front of pigweed's lightning-fast growth rate would require an almost nonstop mowing regime.

So, Brauer turned to robots. Autonomous mowing machines were small enough to fit between rows, light enough to work in muddy fields, and, the best part — they could do it by themselves. Better yet, a whole fleet of them could.

Brauer reached out to an old friend, Steven Gentner, founder of RoboRealm, a machine vision software company. Unlike most industries looking for "machine visioning" solutions, teaching robots to see crop rows would be relatively easy.

"His exact words, 'I get pitched stupid ideas all the time that aren't going to work for a long time. This one is doable,'" Brauer says.

Gentner started out his career with a degree in robotics and was temporarily distracted by the dot-com explosion, where he met Brauer. Eventually, he switched back into robotics. Now, he gets positively giddy talking about the combo of robotics and farming, especially as it applies to Big Ag.

Large-scale agricultural production is already well suited for robots because it is so hyper-controlled. Large-acreage farmers plant straight rows that go on for miles of exactly the same thing, exactly the same distance apart.

"Agriculture right now is just booming in terms of robotics. It makes so much sense," Gentner says.

To envision Brauer's idea, Gentner started first with a remote-controlled mower, the operator walking behind it like a toy race-car driver. The second-generation model added the machine vision feature and moved the operator out of the field.

This summer, they added the final "full automatic with onboard computing" component combined with out-of-the-field computer monitoring.

Each "broadleaf weeding bot" has a sensor that allows it to sense depth. It can "see" the

thing with a real-time kinematic GPS map. There is still an operator onsite, but sitting out of the field. They monitor the robots remotely in the case of an unforeseen incident the robots can't traverse (like a bit of netting wrapped up in the mowing blades).

The robots see and follow the "depth" of the rows, know how much space should be between each row, and follow a preprogrammed precision map if anything goes awry. Whatever is in front of them? They mow it.

Across the Atlantic in the British Islands, farmers have similar weed problems but even fewer chemical control options, making robotics even more attractive.

Many of the herbicides popular in the United States, including atrazine and paraquat, have been banned in the U.K. because of a European Union crackdown on chemicals deemed to be of human health and environmental concerns. Even glyphosate is under close scrutiny. U.K. farmers believe it will soon be restricted as well, leaving them even more desperate for a nonchemical solution, says Suffolk County farmer Tom Jewers, a member of a farmer's advisory board for the Small Robot Company.

Not that the type of herbicide you use matters when it comes to fighting the bane of Jewers' existence — black grass, or *Alopecurus myosuroides*. At least in Jewers' experience.

Black grass, like pigweed, is a highly adaptable weed that seems to circumvent all control methods except for hand-weeding. It has taken root in U.K. farmlands due to years of intensive tillage that compacted the soil, creating ideal conditions for the weed to take root. Jewers believes that if he can transition to no-till farming practices, his soil will improve enough to naturally reduce his black-grass infestation. But to do so, he still has to control the black grass in the years it will take for the soil to improve. It's a chicken-and-egg problem with no good solutions. Except robots.

"I have the entire family out in a field today, pulling black grass out by hand because we haven't got a robot yet, and we can't control it chemically," Jewers said.

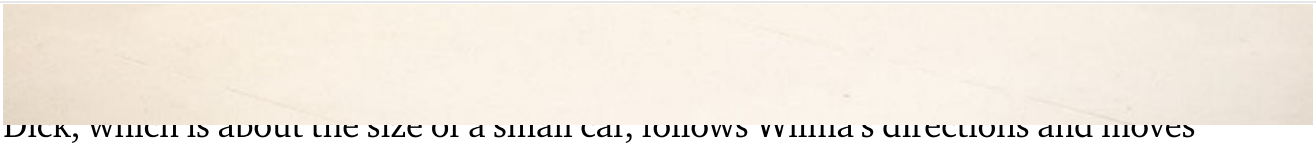
The Small Robot Company tech team with the weed mapping robot Tom during its first outing. Photo: Small Robot Company

The Small Robot Company is a UK-based agricultural robotic startup that makes robots that electrically "zap" weed seedlings. It finalized a €2.1 million ($2.4 million) crowd-equity funding round, bringing its venture capital fund-raising up to €5 million to date.

Founded in 2015 with a four-robot crew — Tom, Dick, Harry, and Wilma — it initially focused on robotic field mapping and planting solutions. But it quickly got the same message from farmers that Greenfield heard: weeds, please.

The Small Robot Company differentiates between weeds and crops differently than Greenfield. Instead of relying on established rows of crops for the robots to see and follow, it focused instead on highly advanced "better than the eye can see" scanning and photographic technology.

Tom starts off the process by rolling through the field and mapping it. That information is uploaded to Wilma. Then Wilma tells "Dick," the weed zapper, to get to work, explains Sarra Mander, CMO of the Small Robot Company.



Dick, which is about the size of a small car, follows Wilma's directions and moves through the field at a walking pace, identifying each weed seedling based on the prior mapping data. Then, it sends a mini "lightning strike" through each weed seedling, leaving the cash crop seedlings unzapped.

"The point isn't speed; it's accuracy," Mander says. This solution is more complicated than Greenfields mowers, but it allows for weed control in crops that are planted much more closely together. The Small Robot Company will be going into field trials with its weed-zapping "Dick" robot this fall.

In its early trials back in Kansas, the Greenfield team ran into some unforeseen obstacles: A shovel. Netting. A gopher hole. When that happens, the robot turns off the mower, then the off-site operator backs it out and navigates the problem remotely. But nature sometimes has different ideas.

A robot got stuck in a no-till field filled with debris and sticks and attempted to back out and try again, but a stick torqued at just the right angle to hit the power button, turning it off in the middle of the field.

"In a million years you could never get that work if you tried, but it just randomly happens," says Gentner. "Nature has a fascinating way of teaching you how to be humble and to respect it."

Now solidly into year three, Greenfield has learned from those mistakes. It has currently signed up several farms for the 2020 growing season for "beta test" field trials. With Brauer's background in farming and close familiarity with tight agricultural budgets, the company priced the trials to cost no more than a farms' current chemical annual weed control expenses, roughly $30 an acre. Instead of paying for a chemical weed control solution (typically around $25 to $60 an acre), farmers contract with the Greenfield robotic fleet to accomplish the same objective, at no additional cost, sans chemicals.

The company has raised $500,000 in an angel investment round and will start a push for $8 million in additional funding this fall, but doing so has required educating investors about how revolutionary a robotic weed solution could be. Educating them has been an

"How do you explain the benefits of no-till to someone who doesn't know what 'till means?" Kalle asks. But people can learn: Not so long ago Kalle too was a farming newbie who was called in for a company emergency: The sheep were out — again.

"I think we are the only tech startup that has to worry about chasing runaway sheep at night," Kalle says.

Greenfield is working on a second-generation model that offers a similar level of precision as the Small Robot Company but uses a different technology. Gentner doesn't seem to mind the competition: There are so many potential applications for robotics in agriculture, he says, that there's plenty of room for competition. There's certainly no dearth of weeds.

As a farmer, I have both a highly attuned sense of skepticism for the latest new "solution" that will "save" my farm. Yet, like all farmers, I am constantly evaluating ways to do it better. Should I purchase a new tool or piece of equipment? Try that new organic pesticide or herbicide my neighbors had luck with? Or do I simply need to rethink my way of doing the work?

Certainly, farmers aren't opposed to new tech or new ideas. We all know that's the name of the game; we just need them to work in the real world of food production. And not cost a gazillion dollars. Successful farming is a constant process of tweaking and adjusting, adapting to a new problem, or finding the solution to fix an old headache. Like weeds.

Even if robots end up doing nothing else for farmers but just controlling weeds, that alone has the potential to revolutionize agriculture.

If I was a Big Ag chemical company, I'd be worried. The farm bots are coming.

Editor's note: *While it's generally true that pesticides are used to kill pests and herbicides are used to kill weeds, the U.S. Environmental Protection Agency defines both agents for killing pests and weeds as "pesticides." By the government's definition, pests can be both bugs and weeds.*