Science Societies

Soybean gall midge: How do you solve a problem you know little about?

By Megan Sever

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Soybean gall midge larvae are small white- to orange-colored maggots. Photo by Bruce Potter, University of Minnesota.

The soybean gall midge, identified as a new species in 2018, has already affected growers in Iowa, Minnesota, Missouri, Nebraska, and South Dakota. And it's threatening the $41 billion soybean industry in the U.S. Scientists studying the pest have far more questions than answers. This article will discuss what we know and don't know about soybean gall midge.

A once-in-a-lifetime situation has arisen in the upper Midwest, but it's not the good kind farmers might hope for. Instead, it's that a new species of pest has evolved—scientifically fascinating, but for farmers on the ground trying to combat it and save their fields, it's terrifying.

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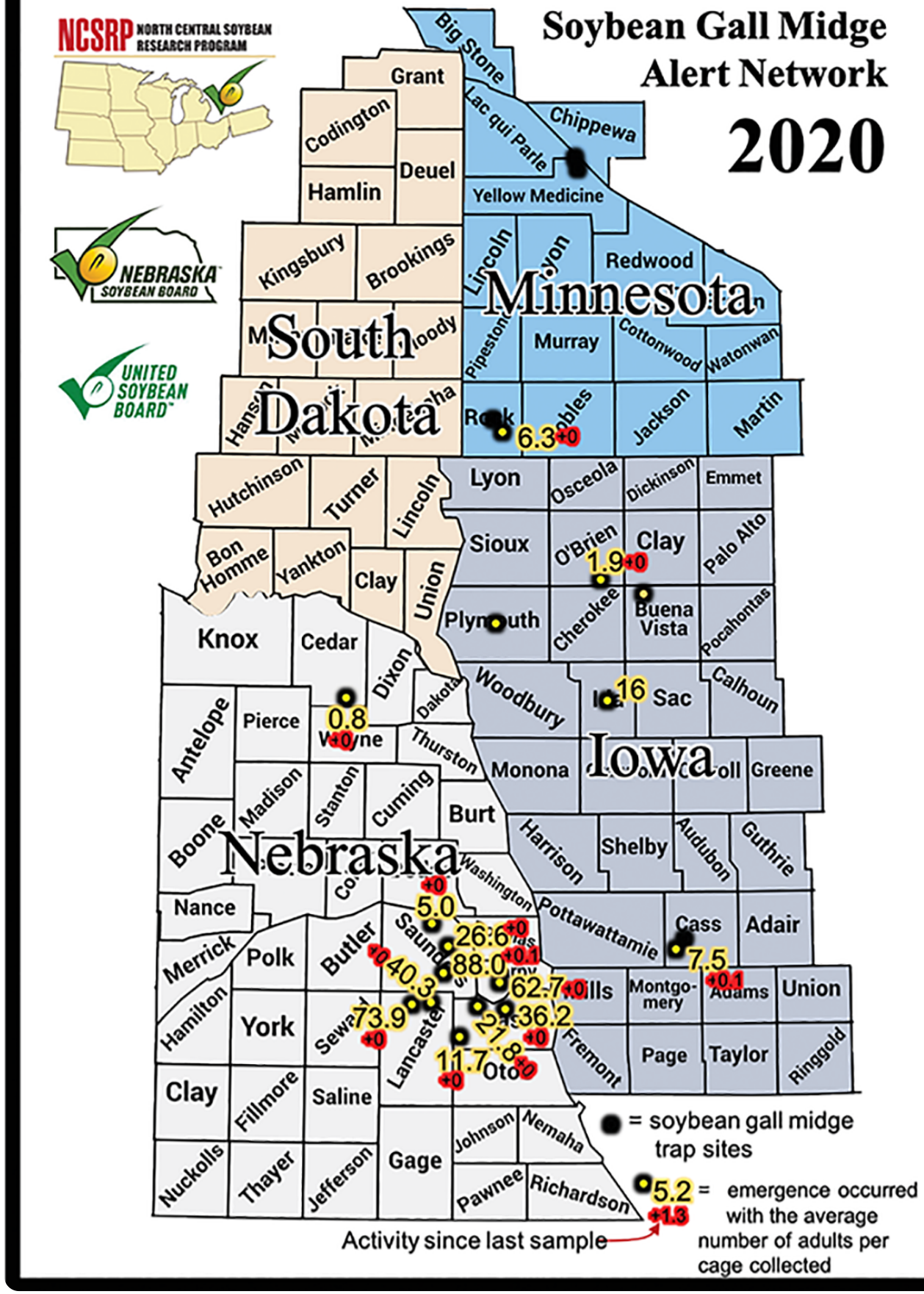
Scientists studying the soybean gall midge have far more questions than answers. Farmers, to date, have found *zero* management techniques to spare their crops—except for abandoning soybean crops altogether. But there is hope on the horizon, scientists say. They're throwing everything they can at the research—more than two dozen open lines of inquiry at last count, from basic life-cycle analyses to genome sequencing, says Justin McMechan, an entomologist and plant pathologist at the Eastern Nebraska Research and Extension Center of the University of

Nebraska–Lincoln. Although there is still much more to learn, a clearer picture of these pests is starting to emerge.

1st Generation Emergence
(Adults Emerging from this Year's Soybean)



Locations affected by soybean gall midges as of Sept. 4, 2020. Source: Soybean Gall Midge Alert Network.

New Species with Lots of Questions

Scientists think the soybean gall midge was first discovered in Nebraska in 2011, but it was thought to be an opportunistic pest that fed on diseased or injured plants. It was also initially confused with the well-known white mold gall midge because the larvae look similar. The white mold gall midge, however, feeds on fungi, not the plant itself, so it is not an economic pest. In 2018, experts realized that soybean gall midge was an economic pest when it was found invading otherwise-healthy soybean fields in 65 counties in Iowa, Minnesota, Nebraska, and South Dakota. Even once it was identified, it took the chance catching of some adult bugs to get the pest genetically analyzed and morphologically described by Raymond Gagné of USDA and Junichi Yukawa of Kyushu University to confirm it as a new species of the genus *Resseliella*.

Sixteen of the 56 known species of *Resseliella* live in North America. *Resseliella maxima* , the soybean gall midge, is a tiny fly: Adults are only one-quarter of an inch long and really hard to find, according to McMechan, who is as close to an expert on the soybean gall midge as anyone. He is leading the research into the pest.

One of the first research questions was about the soybean gall midge's basic biology, its life cycle, says Erin Hodgson, an extension entomologist at Iowa State who collaborates with McMechan. When you have a new species, you start at the very beginning, she says.

So far, scientists have learned that the soybean gall midge's life cycle is a complete metamorphosis: egg, larva, pupa, and adult. They emerge as adults in June, fly to the next soybean plant, and lay eggs into the cracks or crevices, "what we call fissures," in soybean stems, McMechan says. "Those eggs hatch—we don't know the time frame to

hatch, but it's estimated to be a couple of days based on other species."

An emergence cage (left) can be used to trap adult soybean gall midges (right) in the field after they emerge in June. Photos by Justin McMechan.

Once they hatch, they go through three instars, or stages. The first two are white maggot-like larvae. "That can be troubling for identification because they look similar to other things we find in soybean" like the white mold gall midge, McMechan says. In the last stage, they turn orange. "And that orange on soybeans is a pretty diagnostic feature for soybean gall midge," he says, even though the white mold gall midge also turns orange as it synthesizes carotenoids. After turning orange, the soybean gall midge larvae fall off the plants to pupate, after which they again emerge as adults.

Soybean gall midges are only damaging to soybean plants as larvae. The active larvae eat the soybean stem tissue, causing infested plants to wither and die. The pests

appear to produce two or three generations each growing season, Hodgson says. They seem to mature at different rates, and adults emerge nearly every day during most of a growing season, starting the life cycle over again continuously. That is “a bad scenario” for growers, McMechan says, because it makes the pests difficult to treat with insecticides. It also makes it harder for researchers to track.

Even though adults are delicate and poor flyers—and thus only fly to the next row or so of soybeans—they can be blown on the wind from one field to the next, spreading infestations locally. Also, because the adults don’t travel far, they start infesting plants at the edge of a field and work their way inward. If a field is infested, McMechan says, you’ll know it by looking at just the outside few rows of plants.

Though the adults are fragile, the mature larvae must be pretty hardy, as soil cores have shown that the larvae overwinter predominantly in the top inch and a half of soil in fields planted with soybean the year before. “My guess is that the population suffers greatly over the winter … but they quickly multiply come summer,” McMechan says.

Crop damage caused by soybean gall midge. Photo by Justin McMechan.

Though scientists have learned a lot in the two years since the species was identified, there are still many unanswered questions.

For example, Hodgson says, “it’s frustrating that we haven’t figured out what conditions [the soybean gall midges] need to complete a life cycle, mate, and start it all over again. We haven’t been able to replicate it,” predominantly because entomologists

haven't been able to generate or maintain a soybean gall midge colony in the lab. So scientists don't have even a basic understanding of "how long a generation takes, how many offspring each female can produce, why she picks certain plants—it's disappointing that we still don't know some of those basics," Hodgson says.

However frustrating it is for the scientists studying the little pest, they know it's far more frustrating for the growers dealing with it.

Identifying and Reporting Infestation

What should growers do when they find evidence of soybean gall midges in their fields? As of right now, scientists have no answers for management techniques. Nothing that's been tried has consistently worked to kill the soybean gall midges.

Female adult soybean gall midge. Photo by Justin McMechan.

McMechan recommends looking at the edges of fields once soybeans reach V2 stage and later. If you see dying plants or cracked, brittle, blackening stems near the base of the soybean plants at the edges of the fields, peel back the outer layer of the stem. Chances are you'll see larvae.

The soybean gall midge larvae are the same size as the white mold gall midge larvae, and both are orange in later stages, says Bruce Potter, an entomologist and integrated pest management specialist at the Southwest Research and Outreach Center of the University of Minnesota. The best way to tell them apart in the field is to look at damage patterns, which are distinctive, Potter says. The white mold gall midge larvae and damage

can be found throughout a field, anywhere the fungus itself is found on a plant. The soybean gall midge larvae are found only in the plant stem from the ground surface to 6 to 8 inches high and, so far anyway, only at the edges of fields, working their way inward, he says.

Within about three weeks of adult emergence in June each year, infested soybean plants will start to wither as the larvae feed off the stems. (Adults do not feed on soybeans.) If growers see withering only at the edges of their fields or see the larvae on plants, they should call their local extension offices, Potter says.

In 2019, farmers lost 17 to 31% of yields from impacted acres, McMechan says. "That's [financially] catastrophic," putting fields at a loss. But what also worries him is what the yield losses might look like from damaged but not-yet-dead plants. Scientists have no information on that yet.

So, if growers can estimate their total or partial yield losses at various distances into the field, that would help too, McMechan and Hodgson say. Right now, it's really hard to tell what yield losses will look like for an infested field. Scientists are asking all growers affected by the soybean gall midge to enter their field "injury scores" at this website: **https://soybeangallmidge.org/**.

Managing the Infestation

So far, Hodgson says, farmers have tried various insecticidal seed treatments, foliar pyrethroid insecticides (and changing the timing of these treatments), tilling fields to try to destroy pupae, planting fields 20 ft in from the edges, changing planting dates (both earlier and later), and probably many more techniques to try to manage the pests. "We haven't seen anything really work," she says, short of abandoning soybeans and only planting corn, which some farmers have done.

Anecdotally, it looks like pyrethroids have at least limited success, Potter says, but there are three problems: one, these only work for about 10 days, which isn't long enough to kill off the soybean gall midges because of their long life cycles; two, the larvae are largely protected from the pesticides inside the stems; and three, scientists don't recommend repeated or blanket applications because soybean aphids and spider mites become resistant to the treatments—and those insects are even bigger concerns than the soybean gall midge, he says. Plus, Hodgson adds, you don't want to kill off pollinators and you don't want to spend the money to spray insecticides when they aren't doing any good.

McMechan encourages farmers to keep trying to manage the pest—integrating multiple tactics. Just because one approach didn't work in one place doesn't mean it won't in another. Potter agrees, especially recommending trying different cultural management techniques.

Deep into the second full year of research, the scientists say they are hopeful they'll have a few more answers—or at least *suggestions* for next year — this winter. This year's research and data should be published before spring, McMechan says, "and we're approaching a band-aid fix in the next year or two, which is some acceptable level of control with probably every year some surprises geographically."

Open Questions

Entomologist Justin McMechan (University of Nebraska–Lincoln), principal investigator of a 12-state project researching the soybean gall midge, says his team has at least 26 research objectives about the new pest. Number 27 might be: Where do we even begin?

McMechan and his collaborators started with trying to answer basic questions about biology and ecology. They also want to figure out things such as what environmental factors affect the midges, like why was infestation lighter in 2019 than 2018 and 2020? Does soil type matter? Does wetter weather or drier weather make a difference? Warmer or cooler? Among these questions, though, are some "really exciting" lines of inquiry, McMechan says, like how genetics might change the picture entirely. Here are two examples of cutting-edge research.

How Does a New Species Suddenly Emerge? (Or Did It Even?)

Toxicologist Ana Maria Velez Arango of the University of Nebraska–Lincoln (UNL) is using mitochondrial DNA to understand the soybean gall midge's population structure. She and her team have collected insects from soybean, sweet clover, and alfalfa fields in Nebraska and are getting samples from Minnesota and Iowa to compare their mitochondrial DNA to see if the insects on all three plant types are the same or different biotypes. This line of research may also explain how the soybean gall midge emerged, McMechan says; for example, was it on sweet clover and alfalfa for years and just shifted to soybeans, and if so, why and what was the original host? Or is it truly a brand-new species, and if so, how did it develop?

Velez and her team are also using the genetic data mentioned above to determine how much gene flow happens between the populations. For example, she says, is a southern population mating with a northern population? Are adjacent populations mating? Knowing that would help entomologists know how much the insects are moving, she says.

Could Different Varieties of Soybeans Be Resistant?

This past summer, entomologist Erin Hodgson (Iowa State) and others planted historic species of soybeans in small plots in Iowa and Nebraska to see how different varieties fare against the soybean gall midge. She's working with George Graef, an agronomy and horticulture professor and head of the soybean-breeding program at UNL, to see if the plant germplasm in these historic no-longer-grown varieties might tolerate midges. Preliminary results from this summer indicate a wide range of damage to the plants, she says, with some holding up better than others.

Germplasm screening, as this line of research is called, is a technique that "holds a lot of promise," she says, because "a lot of midges in other crops are managed through host-plant resistance. When the larvae feed inside the plants, it's really hard to manage them. But hopefully with genetic selection, variety screens, we will be able to grow a better host plant that tolerates midges." The goal would be to find a plant with some characteristic that makes it more tolerant to the midges or that makes it less attractive for the soybean gall midge. For example, some alfalfa breeds are hairy and some pests avoid them because they don't like hairy plants. You never know if that could be the factor for soybeans and the gall midge. Then, once scientists know what characteristics are important to resistance, they could breed the plant that has those characteristics with some high-yielding soybean plant to create a hybrid breed that is both high yielding and resistant to the midge.

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