

Soybean Aphid

Soybean aphids can reduce soybean yields by as much as 40 percent, sapping and weakening plants, making them further susceptible to other diseases and pests. Aphids can be a challenge, but they can be managed with vigilance, management tools and realistic expectations.

Research Update



The North Central Soybean Research Program (NCSRP) was established in 1992 by state checkoff organizations in the North Central states. The program's mission is to maximize producer returns by coordinating research efforts across state boundaries, minimizing regional duplication of research expenditures and assuring regional research projects are targeted at problems of the North Central soybean producer.

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Letter from the President

Farming has changed over the years but the issues that challenge the production of high-yielding soybeans have not. Diseases, weeds and insects continue to rob farmers of top-end yield that often determines the profit/loss of soybean production for the year.

Weeds are predictable, diseases are manageable with available genetic resistance, but the soybean aphid remains as elusive and unpredictable as ever. The soybean aphid remains the most significant yield-robbing insect pest of soybean production.

NCSRP has supported a broad array of soybean aphid research over the past decade. The checkoff-funded development of the economic threshold used to manage the soybean aphid with insecticide sprays saves farmers millions of dollars each year.

However, there are more questions that need to be answered and more tools that need to be fine-tuned before the soybean aphid no longer triggers alarm bells in fields across the region.

In January, NCSRP and the United Soybean Board sponsored a national workshop to identify and prioritize research that MUST be completed in the next half-decade to minimize yield loss to the soybean aphid. Highly prioritized research includes development of best management practices for the use of varieties resistant to the aphid.

NCSRP remains focused on providing solutions to problems that impact Midwest soybean production.



*Ed Cagney
President,
North Central
Soybean Research
Program*



Photo: Iowa State University

The discovery of soybean aphid in the United States mobilized a massive research and product development effort throughout the Midwest. During the decade-long campaign to learn about the pest and manage it, the soybean aphid has proven itself to be a challenging enemy – unpredictable and adaptable.

“It’s a constant battle,” says grower Mike Cerny of Walworth, Wis. “And just when you think you’ve got them figured out timing-wise, they change things up on you, and you find out you don’t know as much as you think you do.”

Left unchecked, soybean aphid (*Aphis glycines*) can reduce soybean yields by as much as 40 percent, weakening plants by removing vast quantities of sap and covering them with honeydew that is quickly darkened with photosynthesis-blocking sooty mold. The costs of managing soybean aphid tally up quickly: hours spent scouting, money spent on insecticide applications, and the buried costs of disrupting integrated pest management (IPM) programs that can impact other pests such as spider mites.

But despite the formidable foe, American researchers have gained a lot of ground over the past decade on solving the mysteries of soybean aphid and managing the pest. Seed with host plant resistance – varieties that inhibit aphid population growth – is more widely available this year. Foliar insecticides remain effective on large infestations. Researchers are studying the effect of insecticidal seed treatments on soybean aphid populations. And a growing understanding of the aphid’s life cycle is helping entomologists fine-tune management strategies.

The bottom line is that soybean aphid can be managed. It takes vigilance, an assortment of management tools and realistic expectations.

It's a Numbers Game

Managing soybean aphid is a numbers game – starting with the skyrocketing population growth curve of the pest and working through cumulative aphid days, a calculation that tallies the number of aphids on a plant over time.

“Yield loss occurs when populations grow very quickly,” says entomologist Brian McCornack at Kansas State University. “If you quickly accumulate aphid days over a short period of time, it causes a lot of stress to the plants. When stress occurs and for how long is very critical in determining final yield.”

That’s especially true during the R1-to-R4 stages of the crop, when blooms and young pods are highly susceptible to stress. During that period, racking up a high number of aphid days can cause infested plants to abort flowers or pods, McCornack explains. On the other hand, the crop may withstand a longer period of feeding if the population is growing slowly.

Soybean aphids are masters of reproduction, real-life monsters that seem to have been lifted straight out of a science fiction movie. All the soybean aphids you see in your crop are female. They’re born pregnant, and they can pop out as many as eight offspring per day for 10 to 20 days. When the weather is favorable – in the 70s, with moderate humidity – soybean aphid populations on the average crop can double every 72 hours.

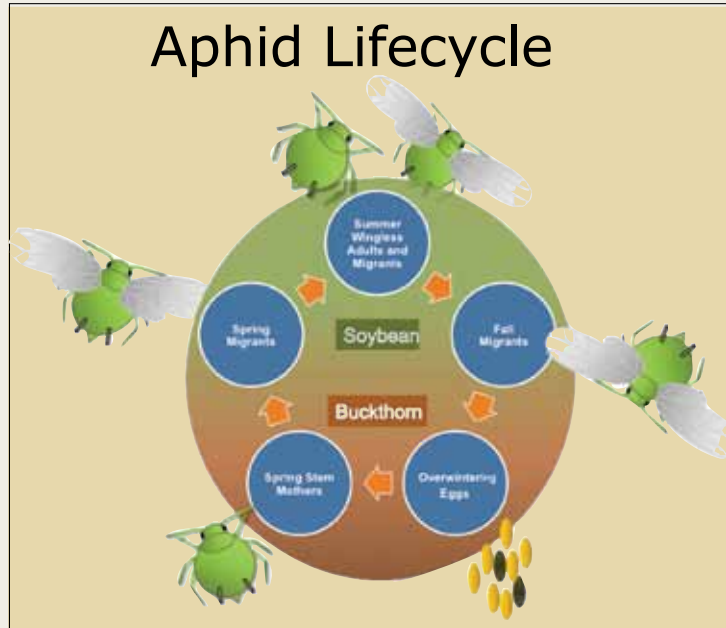
As a result, the key tools for managing soybean aphid revolve around beating the numbers. Relatively early in the last decade, entomologists set a treatment threshold of a field average of 250 aphids per plant, with 80 percent of the plants infested.

From that number, populations could easily explode to yield-damaging levels – 675 aphids per plant – in a few days. Below the injury level, beneficial insects, fungal disease or vigorous crop growth can often defeat the aphids. Above it, foliar insecticide treatments can protect yields. The 250-aphid-per-plant economic threshold helps growers know when to take action to avoid losses, says McCornack.

New varieties with bred-in host

plant resistance to aphids are also proving to reduce population growth for many aphid outbreaks.

“Slowing an aphid down and having it reproduce less could allow natural enemies to come in and clean up the pest,” notes entomologist Chris DiFonzo at Michigan State University. “If you can slow an aphid down by even half – instead of reaching 250 aphids per plant by mid-July, it takes a couple of weeks longer – then the plant is still growing, so it’s much bigger, and there are more natural enemies around. The combination of natural enemies and host plant resistance could be the perfect solution.”



Artwork: Ohio State University

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Chris DiFonzo, Michigan State University

Host Plant Resistance



Photo: Iowa State University

Genes that help soybean plants combat aphids are being harnessed to confer host plant resistance in commercial varieties. The first of the aphid-resistant genes were pulled from a pair of Southern varieties. Since then, geneticists have been combing the DNA of commercial and wild plants from the soybean aphid's native Asian habitat for more sources of host plant resistance. In genetics terms, host plant resistance can take several forms:

- **Antibiosis** – the plant influences the biology of the pest, which can't thrive on the variety.
- **Antinexosis** – a "non-preference effect." Pests don't like the plant and, when possible, choose other plants to infest, though they could develop on the resistant variety.
- **Tolerance** – the plant can withstand the effects of feeding.

The new wave of host plant resistant varieties for soybean aphid management appears to work primarily through antibiosis, though there may be some antinexosis and tolerance, too.

"No one knows exactly how they affect the aphids at the biological or molecular level," notes Curt Hill, principal research specialist at

the University of Illinois. "But most resistances have attributes of all three [modes]."

So far, university researchers have published papers on four resistant gene packages, each referred to as "Rag" genes, for "Resistance: *Aphis glycines*." Rag1 is the resistance package available this year in some commercial varieties. Rag2 is in testing, and Rag3 – which was trade-named Sparta by Michigan State University and the Michigan Soybean Promotion Committee – is on the way to commercial availability in the next couple of years. Rag4 is farther down the pipeline. The search continues for more genes, as does the effort to zero in on the exact bits of DNA that confer the resistance traits.

"I've seen situations where we've had 5,000 aphids per plant on standard soybeans and maybe a few hundred on a resistant plant. As researchers, we're excited about having that in our pack of tools."

Kelley Tilmon, South Dakota State University

Research indicates host plant resistance can be very effective at inhibiting aphid development and reproduction. In fact, populations typically grow slowly enough on resistant varieties to stay below threshold or give growers enough time to arrange a timely insecticide application.

"In a year when you need it, it can be very beneficial," says soybean entomologist Kelley Tilmon at South Dakota State University. "I've seen situations where we've had 5,000 aphids per plant on standard soybeans and maybe a few hundred on a resistant plant. As researchers, we're excited about having that in our pack of tools.

"It's not a silver bullet, because you can get high enough populations, in Rag1 anyway, to cause economic damage," Tilmon adds.

"I've seen upwards of 500 per plant. Producers shouldn't have unreasonable expectations that they'll have no aphids."

Stacking Boosts Effects

Stacking resistance genes promises even better results.

Iowa State University Entomologist Matt O'Neal led a 2010 outdoor cage study of four soybean lines, all closely related. One line was susceptible to soybean aphid; another contained Rag1 resistance; a third contained Rag2; and the fourth featured a Rag1/Rag2 stack. The team introduced soybean aphids from Story County, Iowa, to each individual plant in the test.

"On the susceptible variety, they grew – boom!" O'Neal says. "On Rag1 and Rag2 alone, they grew slower than what we saw on the susceptible variety, but they grew. They reached economic threshold over two to three weeks, compared to about a week on the susceptible variety. The remarkable thing about this study was that in the line that had the two genes together, the populations grew a little bit, then they flatlined. They reached the economic threshold, but didn't get much beyond that.

"What's remarkable here is that Rag1 and Rag2 each slow the growth, but combined, they stop the growth," O'Neal adds. "Also, these aphids were in cages, so there were no ladybugs or other beneficials feeding on the aphids." O'Neal wonders whether this would work even better if those critters were out in the soybean field.

Another interesting result of the study, O'Neal points out, is that even when aphid populations exceeded the typical damage threshold on the Rag1 line, yield loss in the plants with the Rag1 trait was not substantial.

"On Rag2, as populations built up, we saw less yield, but we didn't see that same level of response with the Rag1 gene," he says. "Something's different about Rag1. It will allow aphids to grow on it, but you



Photos this page: Iowa State University



Iowa State University Extension field demonstrations showcase new management tools like aphid-resistant soybeans.

don't see the same amount of yield loss. Rag1 may give us two kinds of resistance – antibiosis, something about the biology of the aphid, and it

may also be tolerant to the aphid. It suggests that the whole relationship between aphids and yield loss may be different with Rag1."

O'Neal says further research may allow entomologists to revise treatment thresholds for Rag1 and other resistant varieties, but for now, they're sticking with the standard 250-aphids-per-plant threshold. They're also exploring whether rotating among Rag genes will be more effective than

stacking them when it comes to developing an insect resistance management plan for host plant resistance.



Rag Genes Are Already Challenged

Stacking Rag genes and scrambling for new sources of resistance are a desperate race – because of the enormous genetic diversity among soybean aphids, some populations are already able to overcome Rag1 or Rag2 resistance. Those aphids, called virulent biotypes, can breed successfully even where resistant genes are in use.

Scientists classify known soybean aphids into three biotypes (so far):

- **Biotype 1**, originally called the Illinois biotype, is avirulent, or susceptible to any of the Rag resistance genes currently being researched.
- **Biotype 2**, formerly called the Ohio biotype, is a virulent strain that can overcome Rag1 resistance.
- **Biotype 3**, which was collected on glossy buckthorn in Indiana, can overcome Rag1 and Rag2.

Researchers stopped using terms like “Ohio biotype” to remove the illusion that virulence is a local phenomenon. Aphids can move several miles per day, and they gather every fall on buckthorn in the upper Midwest to mate and swap genes, then re-disperse to far-flung soybean fields the following spring and summer.

“You can have a mix of Ohio and Illinois biotypes in Wisconsin,” says Brian McCornack at Kansas State University. “I think the original naming of the biotypes, ‘Ohio’ vs. ‘Illinois,’ can be confusing to growers. Either one could pop up almost anywhere in the Midwest. The big question is where different biotypes overwinter and how far they can travel. It can happen anywhere.”

A sobering fact is that virulent biotypes emerged even before host plant resistance was available commercially. (That’s no small feat – at the University of Illinois, Hill points out that it took Russian wheat aphid nine years of exposure to overcome commercial resistant wheat varieties.) The presence of virulent populations underscores the need to better understand aphid dynamics.

Hill says the genetic diversity in soybean aphids may indicate that several populations have been introduced to the United States. Getting a handle on how varied the gene pool is, how mobile the aphids really are during the growing season, whether there’s any local mating that could help confine resistance in pockets or spread it around, and what sort of gene swapping goes on in the fall and spring will be vital to predicting virulence in your field. In the meantime, it all comes down to old-fashioned legwork.

“The presence of virulent populations underscores the need to better understand aphid dynamics. We must be sampling. We need to know how fast a population is growing.”

Brian McCornack, Kansas State University

“We need to be sampling,” says McCornack. “Just putting out a resistant line and assuming we’re not going to have aphids out there is not realistic. We need to know how fast the population is growing. If you’re at five aphids per plant today and you come back a week later and you’re at 400, chances are you have a resistant biotype in your field, as opposed to if that doubling time was a lot longer. If it’s taking much longer for aphid populations to double on Rag1 soybeans, chances are you have a susceptible population. Right now, the only way to know is to scout your fields regularly.”



▲
Buckthorn is the overwintering host for soybean aphids.

Photo: Ohio State University

Scouting: The Heart of the Strategy

Erin Hodgson, Extension entomologist at Iowa State University, underscores the importance of scouting.

“Regardless of whether you’re using Rag1 or not, scouting is one of the cheapest and most effective tools for IPM,” Hodgson says. “Get out there early and see what’s going on in your field. If you see aphids building up to threshold levels, you can schedule a timely treatment and know those products are going to work.

“Secondary pests are out there, too,” she adds. “You never know what’s going to pop up.”

Start scouting just before bloom and continue through seed set – the period the crop is most vulnerable to damage from aphid feeding, suggests Hodgson.

Earlier-planted fields tend to be colonized more heavily, and crops suffering from moisture stress or low potassium levels may be at greater risk of infestation. Soybean grower Gene Stoel of Lake Wilson, Minn., adds that he typically sees aphid problems begin along rivers and woods, many of which are home to buckthorn which hosts overwintering aphids.

“If aphids start showing up in the river valleys and along wooded areas, that’s when you need to start scouting your fields,” Stoel says.

Once 70 percent of the plants along the field edge have been colonized by aphids, start checking the rest of the field.

The speed scouting system can make relatively quick work of scouting and provide a clear-eyed view of whether an insecticide treatment would be worthwhile.

Wisconsin grower Cerny says scouting – and



Photo: Iowa State University



Early scouting pays dividends. It is best to begin scouting when soybean begins flowering.

using the results to decide whether to spray – is the heart of his aphid management program.

“You’ve got to be religious on the scouting,”

he says, noting that he hasn’t sprayed an insecticide on his 500 acres of soybeans over the past four years, though he probably should have treated some fields one of those years.

“Do the counts,” he urges. “Don’t spray too soon. But don’t wait too long, either.”

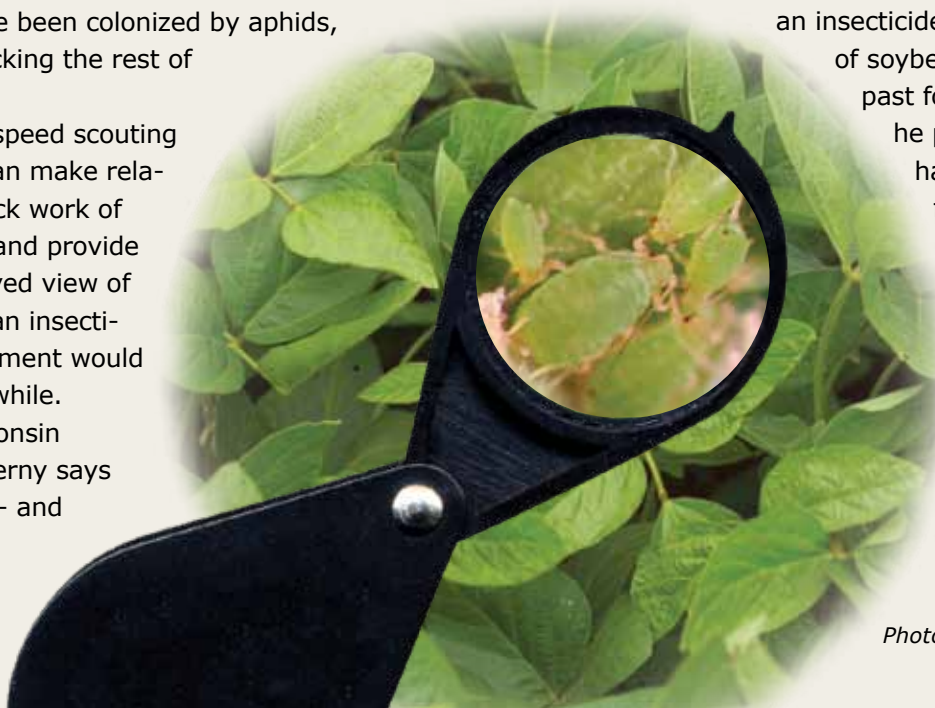


Photo: Iowa State University

Foliar Insecticides Remain Effective

The one piece of news about soybean aphid management that remains straightforward and positive is that the suite of labeled foliar insecticides – pyrethroids like Asana and Warrior, organophosphates including PennCap and dimethoate, and Furadan, a carbamate – remain highly effective for aphid control.

“If you’ve got good coverage, using sufficient volume and pressure so you actually reach the aphids, any of the labeled products will give you 98- to 99-percent control,” says Hodgson.

In addition to rate and application details, pay attention to pre-harvest interval regulations if you’re making a late-season application, she warns. Consider secondary pests, too – if caterpillars or Japanese beetles are present, choose your insecticide accordingly, and remember that pyrethroids can flare spider mites in hot, dry conditions.

In Minnesota, Stoel says he’s encountered aphids every year since 2005, but every season, he scouts carefully and makes a thoughtful decision on whether to spray. He says sticking to the thresholds is a long-term strategy to keep aphid-fighting tools effective.

“I know some people question the 250-aphid threshold, especially with high-priced beans, but I think that’s still a good number,” he says. “If you’re not going to lose yield, there’s no sense in treating. The more we use insecticides, the sooner the aphids will become resistant. Unnecessary treatments are a sure way the bug’s going to win.”

Insecticidal seed treatments present more of a question. Bruce Battles, agronomy research manager for Syngenta Seeds, says seed treatments could help delay aphid buildup, introduce another mode of action against aphids and aid IPM programs by minimizing the need for an early foliar insecticide application.

Hodgson takes a more cautious stance, noting that soybean aphid management isn’t the principal benefit of seed treatments.

“Seed treatments can curb populations early if you get an early infestation,” she says. “But after flowering, you can’t depend on seed treatments for aphid control.”

At South Dakota State University, Kelley Tilmon isn’t recommending seed treatments – she’s watching a series of ongoing seed treatment studies. “We’re starting to get a little data trickling in,” Tilmon reports. “Treatments have largely worn off by the time the aphids have moved into the field. We’re skeptical, but we’re trying to do the research to get some more solid information.”

“If you are not going to lose yield, there is no sense in treating. The more we use insecticides needlessly, the sooner the aphids become resistant. Unnecessary treatments are a sure way the bug will win.”

Gene Stoel, Minnesota farmer



Photo: Iowa Soybean Association

▲ Properly applied insecticides can provide control of aphids.

Stay Alert, Stay Ahead

In some parts of the Midwest, soybean aphid has become a fact of life. “We thought it was going to be a problem once in a while, but it’s gotten to where we have to deal with them every year,” says Stoel in Minnesota.

The good news, says Michigan State’s Chris DiFonzo, is growers have the tools to effectively manage aphids.

“I don’t see soybean aphid as something to fear anymore,” DiFonzo says. “We have insecticide tools that we know how to use. Natural enemies – insects and fungi – have accumulated to the point that they can keep aphids under control. We’re not thinking about soybean aphid as much because we can manage it.”

“Growers have the tools to manage aphids. We do not see aphids as something to fear anymore, but knowing what is going on in your fields is the best defense.”

Chris DiFonzio, Michigan State University

On the other hand, when aphid populations explode, growers can’t afford to be unaware.

“There is no substitute for walking fields,” DiFonzo notes. “It doesn’t have to just be for aphids. You’ve got SDS and other things to look for in that early-July timeframe. You can walk pretty quickly if you’re not seeing anything.

“But if you get out there and you’re seeing those new shoots coming out and they’re covered with those Mountain Dew-colored aphids, that’s when you want to spend time looking,” she says. “You want to catch them before the real ‘holy cow’ moment.”

At this stage, soybean aphid management has evolved to set the standard for good overall crop management, notes Tilmon.

“In my experience, this is just a very unpredictable pest,” Tilmon says. “Knowing what’s going on in your fields is the best defense you can have.”

Regional Research is Highly Effective



Photo: South Dakota State University

Across the Midwest, entomologists and breeders say the regional scope of checkoff-funded soybean aphid research made it possible to mount a full-court press against the aphid and assemble a highly effective set of tools to combat it in a surprisingly short time.

Soybean grower Mike Cerny of Walworth, Wis., is secretary/treasurer of NCSRP. He says, “There are more questions that need to be answered and more tools that need to be fine-tuned before soybean aphid no longer triggers alarm bells in fields and labs across the region.

“I don’t know which way any of this is going to go, which is why it’s important we look in every direction we can,” he notes.

2011 Seed Choices Include More Host Plant Resistance Options

Last year saw the introduction of the first commercial soybean varieties with host plant resistance, featuring aphid-inhibiting traits conferred by the Rag1 gene. Rag1, the first of several resistance genes ready for grower use, can slow the development and breeding of soybean aphids enough to keep populations below economic thresholds or at least make it easier for growers to react to growing infestations with a timely insecticide treatment.

This year, Monsanto, Syngenta and several regional seed companies – including organic seed producer Blue River Hybrids – are offering soybeans with Rag1 genetics.

Aaron Robinson, product development manager-soybean traits for Monsanto, says his company has released three Genuity Roundup Ready 2 Yield aphid-tolerant varieties with the Rag1 trait. These new products will be available from Asgrow, Channel, Kruger, Gold Country, Rea and Trelay brands, as well as several independent seed companies, in 2011. The varieties – spanning maturities from mid-group 1 to early group 2 – include Rag1 host plant resistance in addition to soybean cyst nematode (SCN) resistance and tolerance to iron deficiency chlorosis, says Robinson.

Robinson says Monsanto is not charging a technology fee or premium for the host plant resistance trait. The company's Rag1 varieties are available with or without Acceleron seed treatment.

Future Monsanto releases will include stacks of Rag genes, as well as a new package that should be on the market after the middle of the decade, he says.

Meanwhile, Syngenta's 2011 NK brand soybean lineup includes Rag1 varieties in 1.2, 1.7, 2.1 and 2.5 maturity groups as part of the company's Aphid Management System (AMS).

"Aphid-tolerant varieties slow growth of the [aphid] population, but it's still going to be necessary for growers to get out and scout these varieties and monitor the population to make sure they're not under such severe populations that they have to make an insecticide application."

Jessie Alt, Pioneer Hi-Bred

AMS combines Syngenta genetics with the Rag1 trait, CruiserMaxx Beans seed treatment and a program to cover most of the cost of a foliar

A comparison of a soybean aphid-resistant variety (left) to a soybean aphid-susceptible variety (right). Note the susceptible plants have black sooty mold from heavy soybean aphid feeding.



insecticide treatment if a spray is warranted, according to Bruce Battles, agronomy research manager for Syngenta Seeds.

Battles says the AMS approach brings several modes of action against soybean aphids, including thiamethoxam insecticide in the seed treatment, Rag1 host plant resistance, beneficial insects preserved by not having to spray a foliar insecticide most years, and Warrior II or Endigo insecticide if aphid populations grow to exceed treatment thresholds. The company recommends charging up to an approximately 10-percent price premium for the AMS package.

Pioneer is working on host plant resistance in groups 1 through 3, according to Jessie Alt, a research scientist with the company, and plans to release them commercially within the next couple of years. In the meantime, Pioneer has rated its soybean varieties for antibiosis, the biological effect of inhibiting aphid population growth. A numerical scale rates each variety from Exceptional to Below Average to help growers prioritize their scouting and spraying programs.

"Our recommendation is that folks use ratings as a 'where to scout first' tool," Alt says. "If you have a variety that's rated Below Average, which is low, and one that's an Above Average, which is higher, you should be looking for aphids first in that Below Average variety."

Alt says Pioneer is working with Rag1, Rag2 and some proprietary resistance genes as part of a long-term strategy for soybean aphid management. "We're going to take an integrated approach like we do for *Phytophthora* and SCN," she says.

Seed company agronomists share the view of university entomologists when it comes to setting realistic expectations for aphid resistant varieties. The bottom line: don't expect complete, Bt-style control from aphid host plant resistance.

"They're just another tool for growers to manage under moderate aphid populations," says Robinson. "Aphid-tolerant varieties slow growth of the population, but it's still going to be necessary for growers to get out and scout these varieties and monitor the population to make sure they're not under such severe populations that they have to make an insecticide application."

Photo: Mary Gardiner, Ohio State University



Soybean Aphid Resources Online

The internet hosts a treasure trove of information about soybean aphids, from identification guides to scouting protocols to the latest on research.

Some key resources include:

- **NCSRP's Plant Health Initiative soybean aphid site:** www.planthealth.info/aphids_basics.htm
- **Iowa State University's soybean aphid site:** www.soybeanaphid.info
- **Iowa Soybean Association Production Research Library:** www.iasoybeans.com/production_research/
- **University of Minnesota's soybean aphid resource:** www.soybeans.umn.edu/crop/insects/aphid/aphid.html
- **Kansas State University's soybean aphid decision-support system:** www.soypod.info
- **Buckthorn Watch and Aphid Hunt site:** www.buckthornwatch.org

www.planthealth.info

This publication and research would not be possible without the financial support of the 12 NCSRP member states.

The North Central Soybean Research Program (NCSRP) is comprised of state soybean checkoff boards in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota and Wisconsin. Established in 1992 to coordinate soybean production research efforts on a regional level, NCSRP invests soybean checkoff funds in research programs to better understand and manage soybean pests and diseases.



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