



# SOYBEAN APHID

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Update*



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# A multi-pronged attack on soybean aphids

## Biological control, aphid-resistant varieties and aphid tracking systems

**NCSRP**



### NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

*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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*For more information or to order copies of this soybean aphid research update, contact David Wright at 800-383-1423.*

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Every initiative at the North Central Soybean Research Program has the same goal: helping producers improve their profitability.

That's why checkoff-funded researchers spent years tracking down and studying *Binodoxys communis*, an exotic natural parasitoid from Asia that was released throughout the North Central region in 2007. This tiny, stingless wasp effectively controls soybean aphids in China, and we're hoping it'll do the same for U.S. soybean growers.

If *Binodoxys* establishes itself here and helps keep aphid numbers low, it also may lower the number of insecticide applications needed. This is a classic case of natural biocontrol, and if it works, it'll be one of the most successful in history.

In another area, thanks to checkoff support for germplasm screening at public institutions, aphid-resistant soybean varieties are on the way. Several universities are developing resistant lines, using different genetic sources of resistance. The more

resistant sources there are, the tougher it will be for aphids to overcome them.

Checkoff dollars helped build the suction trap network that tracks aphid migrations and populations, as well as the Sentinel Plot Program, an early-warning system for rust and aphids.

NCSRP also funded research on soybean aphids' native natural predators and treatment thresholds so growers know when to spray and when to hold off calling the custom applicator.

From biocontrol and genetic resistance to early warning systems and treatment recommendations, your checkoff dollars cover a lot of ground when it comes to helping you manage aphids. That's your soybean checkoff. Delivering results.



**Jerry Wyse**  
NCSRP President  
Haven, KS

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# Reuniting old enemies

Courtesy of Roy Sontz, SDSU

## Releasing aphid enemies from Asia into Midwest soybean fields

After three years of safety testing in quarantine laboratories – and another one and a half years getting the government permits – checkoff-funded researchers got the go-ahead to release an “exotic biological control agent” that attacks soybean aphids. This tiny, stingless wasp, called *Binodoxys communis*, hails from China and Japan, where it has been a long-time natural enemy of soybean aphids.

During the summer of 2007, wasps were released in 30-plus locations throughout Minnesota, Michigan, Iowa, Illinois, Indiana, South Dakota and Wisconsin. Release sites were a mixture of ag experiment stations and farmers’ fields, near buckthorn whenever possible because that’s where soybean aphids overwinter.

“The first step was to see if *Binodoxys* would attack soybean aphids in U.S. soybean fields,” says Bob O’Neil, Purdue University entomologist. “We can’t prove it at every location, but for the most part they did.”

The next step will be for *Binodoxys* to make it through the Midwestern winter. “They have to find something to live on during the winter,” says O’Neil, who visited Asia several times looking for parasitoids (insects that use other insects as hosts) that attack soybean aphids. Fortunately, *Binodoxys* is from a region that has the same climate, so weather shouldn’t be a problem.

### It’s not a yellow jacket

What could have been a problem – public discomfort with the idea of scientists introducing a wasp into the Midwest – has been minimal. “I’ve received a few e-mails,” says George Heimpel, University of Minnesota entomologist leading the *Binodoxys* release.

“When you say ‘wasp’ people think yellow jackets. But *Binodoxys* is completely different,” he adds. “That’s why we call them tiny, stingless wasps.”

O’Neil points to biological control examples in other crops. “Parasitoids from the Mediterranean have been successfully introduced to control alfalfa weevil,” he explains. “Thanks to biological control, alfalfa weevils went from being a significant pest problem that farmers were spraying most years, to no problem at all.”

### It won’t eat Toledo

Researchers also spent years testing the host range of *Binodoxys* to make sure it won’t disrupt non-target aphid species. According to O’Neil, “When you release a natural enemy, one of the big questions is, ‘Is it going to eat Toledo?’ We’ve done a lot of host specificity testing because we didn’t want to release something that attacks everything. *Binodoxys* has a narrow host range, and soybean aphid is by far its No. 1 target.”

Scientists also have 15 to 20 other parasitoid species still in quarantine. “It looks like a couple of those also have high host specificity to soybean aphids,” says O’Neil. “We’re looking at those, too.”

### How the wasp works

*Binodoxys* lays an egg inside the soybean aphid. “As the egg hatches, the larva eats the aphid from the inside out, starting with the blood and ending with vital organs,” says Minnesota’s Heimpel. (The larva also spreads glue to keep the aphid stuck on the soybean plant.)



Courtesy of David Hansen, U of Minn.

Researchers hope this *Binodoxys communis* parasitoid – an enemy of soybean aphids – establishes itself throughout the North Central region.



## Releasing *Binodoxys communis*

University of Minnesota Entomologist George Heimpel says researchers tried several different methods of releasing *Binodoxys communis* last summer.

“Early in the season when aphid levels were low, we used a mesh-covered insect cage over a square meter of soybean plants. We removed the soybean aphid predators (i.e., Asian lady beetles) from the cage, so aphid numbers built up enough for the *Binodoxys* wasps to parasitize. Then we added potted soybean plants from a greenhouse that had lots of *Binodoxys* about to hatch from aphid mummies.

“The idea was to get *Binodoxys* to establish within the cages and reproduce, so we tried waiting 10 days for one generation of wasp, and three weeks for two generations before removing the cages,” Heimpel explains. “What worked best was waiting three weeks, when we had 100 to 500 mummies per plant – and 40 to 50 plants – inside the cage. Adult wasps were taking off from second-generation mummies and dispersing through the field.”

Once the larva is done feeding, it goes through the pupal stage, which involves spinning silk on the inside of the dead aphid skin. The aphid skin hardens, partly due to the silk, to form a puffy shell called a mummy.

Mummies look like puffy brown versions of the aphid, or sesame seeds. The adult wasp cuts a “poptop” hole in the mummy and emerges. The mummy stays attached to the plant, thanks to the glue. “What’s nice about the mummies is they’re easy to detect in the field, so you’ll know whether you have *Binodoxys*,” Heimpel explains.



*Binodoxys* emerging from mummified aphid body

Courtesy of Matt O’Neal, IA State

## Keeping aphid levels low

Heimpel says if we do eventually get aphid control from *Binodoxys*, it’ll take a few years. “Aphid densities in China are very

low. So I think *Binodoxys* is probably better adapted to low levels of aphids.

“I don’t think they’ll be very good at knocking down high aphid levels. But once levels are low, they’ll keep them low,” he continues. “If aphid levels spike, then Asian lady beetles have a better chance of knocking them back.”

The problem with that tag team – Asian lady beetles and *Binodoxys* – is that they’re competitors, not partners. “The beetles don’t mind munching on *Binodoxys* eggs within mummies,” Heimpel adds. “My hope is that eventually, *Binodoxys* can keep aphid numbers so low that lady beetles aren’t interested in visiting soybean fields.

“Asian lady beetles tend not to lay eggs in fields with low aphid numbers,” he explains. “I’m hopeful that *Binodoxys* will also suppress them, because I think Asian lady beetle numbers are out of whack from feasting on aphids. And other than farmers, most people hate Asian lady beetles.”

## What’s next for *Binodoxys*

O’Neil says checkoff-funded researchers will continue releasing *Binodoxys* in aphid overwintering habitats, to continue establishing the population. “It’s up to the bugs, but we’ve given them every chance.

“If *Binodoxys* takes off,” O’Neil adds, “farmers won’t be paying attention to aphids anymore.”

**Read more about it**

*Dan Mahr, entomologist at the University of Wisconsin, developed a Web site specifically about the *Binodoxys communis* release, as well as other biological control efforts. Visit [www.entomology.wisc.edu/sabc](http://www.entomology.wisc.edu/sabc) to read more about these projects, and to view photographs of *Binodoxys*, mummies and other beneficial natural enemies to look for in your soybean fields.*



Courtesy of David Hansen, U of Minn.



## Host plant response and a new predictive model

While some scientists are tracking whether *Binodoxys communis* survives and thrives in the Midwest, others are researching the soybean plant itself – and when it serves as the best host for soybean aphids.

“Picture a graph that resembles the mouth on a smiley face,” says David Ragsdale, University of Minnesota entomologist. “You’ve got high points at both ends, and a low point in the middle. That’s what we get when we look at the quality of the soybean plant as an aphid host over the course of the growing season. Early in the season (vegetative growth stages) and again late in the season when seeds are filling, soybeans are great aphid hosts.

“The poorest plant quality is when pods are forming (R3), elongating (R4) and seeds begin to develop (R5). The vegetative growth has stopped, and the plant is putting all its emphasis on reproduction, on the pods. That’s the low point.”

Ragsdale says that’s when farmers see white dwarves. “Aphids get smaller and don’t reproduce very well because the plant isn’t a very good host. Their lifetime reproduction is reduced by 70 percent.”

Then the plant starts to mobilize all the stored photosynthate and seeds begin to fill (R6). “At R6, the soybean plant is again as good a host as it was

when it was in the vegetative growth phase,” he explains.

### New online aphid population predictor

Ragsdale’s team is developing a new mathematical model that will predict aphid population growth and include the smiley face phenomenon.

“The current model is solely driven by temperature,” he says. “It tells you what the maximum possible growth rate could be, given those temperatures. It gives you the worst-case scenarios, but doesn’t take into account plant quality, natural predators, plant variety or bad weather.

“The new model will incorporate the concept that the soybean plant is not a great host during part of its growth phase,” Ragsdale adds. “It also takes rainfall into account. For example, if a one-inch rainfall occurs in one hour in association with high winds accompanying a thunderstorm, aphid mortality can exceed 60 percent – especially in the vegetative growth stage, when aphids are at the top of the plant and exposed. They get knocked down and thrown into the mud, and they can’t get out.”

You can find the University of Minnesota’s newly revised aphid population predictor at [www.soybeans.umn.edu](http://www.soybeans.umn.edu).

## Aphid feeding is a double-edged sword

When they feed, aphids’ piercing mouthparts (called stylets) are inserted between the soybean plant’s cells, where they tap into the nutritious phloem sap.

“Aphids suck the nutrition out,” says John Reese, Kansas State University entomologist. “They also pump salivary secretions into the plant, and we think what they’re injecting is very damaging. The combination of what they’re taking out and pumping in reduces the plant’s rate of photosynthesis, and causes all sorts of plant responses.”

Researchers are studying these responses, and how different varieties vary in their sensitivity to aphids. “The goal is to find varieties that are more tolerant to aphids,” Reese adds, “so the plant can continue to produce in spite of an aphid attack, and without placing selection pressure on the aphid population.”



Courtesy of Greg Zaherovich, KSU

*This aphid is hooked up to an EPG (an electrical penetration graph, which is the aphid equivalent of an EKG). By passing an electrical current through the plant and the aphid, researchers can tell what cell the aphid is feeding in, how long it’s feeding, and how the cell responds.*

# An increase in natural parasites

## Researchers report seeing more native parasitoids in 2007

Besides the exotic *Binodoxys communis* parasitoid that researchers imported from Asia and released in the Midwest last summer, native parasites also have been popping up in North American soybean fields. “Scientists in several states report seeing more parasitoids in 2007,” says Chris DiFonzo, entomologist from Michigan State University.

“It was very striking, even in Michigan. We had this little black parasitoid that I’d never seen before,” DiFonzo says. “In Ontario, they were seeing the same thing.”

Tracey Baute, entomologist with the Ontario Ministry of Agriculture, Food and Rural Affairs, identified two types of parasitoids in 2007. “We believe the dominant one was *Aphelinus* spp., though taxonomists are still determining which species it is. It wasn’t released here, so we’re wondering if it came along with soybean aphids from their origin country. Initially we thought it was *Aphelinus albipodus*, which was originally released in the United States to control Russian wheat aphid.”

In Minnesota, researchers discovered something else entirely. “They’re called *Lysiphlebus testaceipes*, and we first found them at relatively high levels back in 2003,” says University of Minnesota Entomologist George Heimpel.

“I thought they’d move into soybean fields, but then we didn’t see them again until 2007,” he adds. Although there were more of them than in 2003, “Even at higher numbers the total percentage was still very low. In one-third to one-half of fields, we saw 2 percent native parasitism.”

### Good guys winning in Canada

In Ontario, parasitism levels are significantly higher. “We did a survey in 2007, and preliminary results show between 10-25 percent parasitism rates by the *Aphelinus* spp. alone at several locations across the province,” Baute says.



*Aphelinus albipodus*



*Lysiphlebus testaceipes*

“It’s interesting,” she adds. “Our cropping system here is very similar to Michigan and Ohio, yet they’re not seeing the same levels of parasitoids. We’re investigating why.”

As for aphid infestations in Ontario, “In 2007, we experienced an outbreak early, in late May/early June, on early emerged beans,” Baute says. “We had good weather here and planted early, and we think they may have blown in from the United States.”

“We found unifoliate stage soybeans that already had mummies on the plant. The parasitoids reacted immediately to the early aphid infestation. The good guys knew where to go, and I’m referring to

How important are natural predators for suppressing aphid populations? “Pretty important,” says Matt O’Neal, Iowa State University entomologist. Several researchers just completed a study on the impact of predators and whether their impact varies with the landscape. In 22 locations, more than 50 percent of fields were kept below threshold by predators. “In fields where the predators’ impact was not as great, the area was surrounded by corn and soybeans. When you have more diverse landscapes, predators can find food and a place to spend the winter, so there are more of them and their impact is greater.”

Courtesy of Craig Grau, U of Wis.

Courtesy of Bob Ellingson, U of Wis.

Courtesy of JK Clark, U of Cal.

the parasitoids, not the aggressive lady beetles.”

Baute says growers hesitated to spray and gave beneficials time to work because they were seeing such a difference in the levels of natural enemies. “Growers are taking the time to identify natural enemies in the field, observing their impact and, in many cases, watching them take aphid populations down below threshold.”

### The immigration problem

According to David Ragsdale, University of Minnesota entomologist, “Natural enemies can do a great job of controlling aphids as long as there isn’t an influx of winged aphids. I’ve had consultants call and tell me, ‘I’ve checked a field seven times, and the aphid population is staying the same.’ That’s because the natural enemies are keeping the aphid population in check.

“You can tolerate a moderate number of aphids for many weeks and not have a yield response,” Ragsdale says. “It’s those immigration events – where aphid populations build and produce winged aphids, which fly off to colonize other fields – that we can’t get a handle on. At that point, no natural predator in the world can keep up.”

Ragsdale doesn’t think researchers will ever be able to predict mass migration



Winged soybean aphid

Courtesy of Roy Scott, SDSU

events, but they can identify fields that are at greater risk for explosive aphid growth. Later planted beans are at higher risk, for example, because aphids are attracted to plants in vegetative phases as opposed to reproductive phases. Early (April) planted beans in Michigan and Ontario have gone over threshold in the vegetative stage after infestation by large numbers of winged migrants from buckthorn.

“Unfortunately, the only way to detect an immigration event is to be in your fields counting aphids and checking them regularly,” Ragsdale says.

### Speed scouting

Entomologists at the University of Minnesota have developed a soybean aphid “speed scouting” method to help you save time sampling and making treatment decisions. The new method is used to estimate when fields are at the 250 aphid threshold. The sampling cut-off point is 40 aphids per plant. If a plant has less than 40 aphids, consider it non-infested. If you’ve counted 40 aphids (counting above 40 isn’t necessary), consider the plant infested. Gathering several speed scouting counts – scattered randomly throughout a field – will lead you to one of three decisions: treat, don’t treat, or resample in 3-4 days. For more information and

a speed scouting worksheet, visit [www.soybeans.umn.edu/crop/insects/aphid/aphid\\_sampling.htm](http://www.soybeans.umn.edu/crop/insects/aphid/aphid_sampling.htm).



Courtesy of Chris DiFonzo, MSU

## Guides to the good guys

A new publication that helps farmers identify beneficial insects in soybeans is available. Funded by the NCSRP and written by University of Wisconsin Entomologist Dan Mahr, it’s publication #NCR481 – *Biological Control of Insects & Mites*. Contact your Extension soybean entomologist for a copy, or download a PDF from the UW Extension Web site at <http://learningstore.uwex.edu>.

You also can order a small pocket flip guide to carry in the field, called *Identifying Natural Enemies in Crops and Landscapes*. It’s Michigan State University Extension Bulletin E-2949, by Mary Gardiner, C. DiFonzo, M. Brewer and T. Noma. It was developed as a result of grower requests for more biocontrol information after soybean aphids arrived. Order a copy or download a PDF at [www.emdc.msu.edu/inventorysearch.cfm](http://www.emdc.msu.edu/inventorysearch.cfm).

Courtesy of Eileen Cullen, U of Wis.



### What’s with white dwarves?

“Typically, a baby aphid is green or yellow and grows fast,” says George Heimpel, University of Minnesota entomologist. “White dwarves are a lighter color, smaller and grow more slowly.” Why are they produced? “One theory is that the host plant quality is low,” he explains. “You tend to get white dwarves on old, yellow leaves.” Another theory is natural enemies. “If you expose a colony of aphids to Asian lady beetles, they produce more white dwarves. Predators don’t recognize them as well.”

# Monitoring aphids via the suction trap network

## Measuring fall migration helps predict what you'll face next summer

"We have 42 suction traps collecting soybean aphids in 10 states," says Dave Voegtlin, the Illinois Natural History Survey entomologist in charge of the checkoff-funded suction trap network.

The traps are basically big tubes roughly 25 feet tall, high enough to catch winged, migrating aphids. At the base of each tube is a jar filled with preserving fluid. Fans suck aphids into the tube, and aphids are preserved in the jar.

"Every week, we monitor the traps and count the aphids, beginning the end of May and running through mid-October," Voegtlin says. Results are reported on a Web site – [www.ncipmc.org/traps](http://www.ncipmc.org/traps) – where growers, entomologists and crop consultants can track soybean aphid populations.

### Fall counts forecast future outbreaks

The number of winged aphids caught in September and October during their fall flight back to buckthorn is used to forecast aphid outbreaks the following year.

Generally, high fall flight counts mean aphid problems in the coming year. Low fall flight numbers mean aphids will be more scarce next year.

"Of course, it isn't always so clear-cut when there are high aphid numbers,

because a lot of biology happens between fall and spring," Voegtlin explains. "Weather, planting time and natural predators are all factors that can influence what happens."

### Other factors affecting aphids

During the fall of 2006, for instance, "We saw an unprecedented fall flight of aphids making it back to buckthorn and laying eggs. In Indiana, Illinois and southern Michigan, we found places where 100 percent of randomly selected buckthorn twigs were infested.

"So all these aphid eggs hatched the last week of March 2007, and then we had a hard freeze the first week of April. That killed all the leaves and the aphids as well," Voegtlin says. "Quite frankly, I don't know how bad the summer of 2007 would have been without that hard freeze."

In Michigan, summer heat attacked the aphids. "They appeared early and in high numbers in 2007," says Chris DiFonzo, Michigan State University entomologist. "Then the first week in July, we had unseasonably high temperatures before rows closed, and the aphids literally baked on the soybean plants. They never recovered."

Western Wisconsin had high aphid numbers in 2007, while the eastern part of



### Aphids a problem in other crops

"Aphids don't just affect soybeans," says Chris DiFonzo, Michigan State University entomologist. "They're affecting the whole farming community, spreading viruses like cucumber mosaic, zucchini yellow, and watermelon mosaic in vegetable crops. Infected pumpkins look lumpy, and rot from the inside out. Potato viruses are a concern, too." And at the University of Wisconsin, researchers are looking into whether soybean aphids are a vector for viral diseases in snap beans and green beans.

Courtesy of Chris DiFonzo, MSU

Courtesy of Chris DiFonzo, MSU



Aphid eggs on buckthorn

Courtesy of Dave Voegtlin

the state generally had very low densities, well below economic threshold.

“I view this as a regional pest in scope,” says Eileen Cullen, University of Wisconsin entomologist. “Even in an aphid year, there are fields that don’t reach economic threshold. And in a low aphid year, there are fields that do. Region-wide, there is a lot of variability. That’s what makes field scouting so important.”

Cullen reports very low fall trap captures in 2007. “We have seven suction traps in Wisconsin, and we captured only 11 winged soybean aphids in September and October,” she says.

### The every other year pattern

For the most part, researchers report an “every other year” situation with aphid outbreaks. “I think what happens is when aphids numbers are high, the predators notice, just like we do,” says Bob O’Neil, Purdue University entomologist. “The Asian lady beetles come into soybean fields and hammer aphids. So the high numbers become low numbers for the fall flight. And next year, there aren’t as many aphids, so the predators don’t notice and don’t attack, allowing aphid numbers to build up again.

“That’s the hypothesis, that the pattern is associated with predation late in the season,” O’Neil adds. “The alternative is

that aphid numbers would keep building every year, and we don’t see that. So I think it has to be the predators.”

### Not so great for hot spots

In Minnesota, where buckthorn thrives, farmers in some areas face aphid outbreaks every year. “We were hoping the suction traps could help us predict summer hotspots and immigration events,” says David Ragsdale, University of Minnesota entomologist. “Unfortunately, that hasn’t been the case. The traps can tell us what just happened, but they don’t help us predict much about aphid populations in a specific location. They do work very well telling us what’s moving in the fall and spring.”

Much like Wisconsin, Minnesota’s fall 2007 trap capture was the lowest researchers had ever seen. “Based on that, we expect low aphid populations in 2008. But be careful – this does not mean aphids will be absent in 2008,” Ragsdale says.

It also doesn’t mean scouting won’t be necessary. “If you count 200 aphids one week, and 275 the next, predators are doing a good job,” Ragsdale adds. “If you jump from 200 to more than 600 aphids in a few days, then the predators aren’t keeping up with the aphids.”

### 2008 looks like a light year for aphids

According to the suction trap network, record low numbers of soybean aphids headed back to buckthorn (where aphids lay eggs and overwinter) in the fall of 2007.

State (# sites)	Sept.-Oct. 2006	Sept.-Oct. 2007
WI (7)	213	11
MN (5)	376	104
IL (9)	1762	9
IA (4)	532	5
IN (6)	8322	59
MI (5)	209	156

Numbers in the table show total soybean aphids captured from all sites per state. The data summarized are from the suction trap network Web site: [www.ncipm.org/traps](http://www.ncipm.org/traps).

## Put that in your PIPE...

The Pest Information Platform for Extension and Education (PIPE), [www.sbrusa.net](http://www.sbrusa.net), now includes soybean aphids. Land-Grant University Extension and Integrated Pest Management (IPM) specialists monitor soybeans for soybean aphids from late vegetative through full pod stages. The IPM PIPE aphid map provides a real-time picture of soybean aphid densities in sentinel soybean fields. “PIPE takes the pulse of soybean aphid trends in the North Central region, but you still need to scout fields on your farm to make a treatment decision,” says Eileen Cullen, University of Wisconsin entomologist. Extension entomologist commentary shared via the PIPE helps farmers become informed quickly about soybean aphid IPM practices. Explore the soybean aphid page at [www.sbrusa.net/cgi-bin/sbr/public.cgi?pest=soybean\\_aphid](http://www.sbrusa.net/cgi-bin/sbr/public.cgi?pest=soybean_aphid).



A new publication helps farmers identify soybean aphids and similar-looking insects. Identification of Soybean Aphids and Look-Alike Species was written by Ames Herbert, Sean Malone, Eileen Cullen and Susan Ratcliffe. Contact your Extension soybean entomologist for a free copy, or download from the NCIPM Web site: [www.ncipm.org/alerts/soybeanaphidid.cfm](http://www.ncipm.org/alerts/soybeanaphidid.cfm).

# Aphid-resistant varieties are on the way

## Not a silver bullet – a good management tool

Checkoff-funded researchers throughout the North Central region have been testing new genetic sources of aphid resistance, and the results look promising.

“We’re screening different lines from several university breeding programs,” says Kelley Tilmon, South Dakota State University entomologist.

“We test them on small plots in multiple states, with varying growing conditions and varying levels of aphids, and monitor aphid population growth and yield on the different lines. That’s what we call Tier 1 screening,” she says. If a line looks good in Tier 1, it moves to Tier 2 testing, which involves larger plots and insecticides – basically mimicking how growers raise soybeans.

### Aphid biotypes

“In general, there’s definitely a big difference between lines bred for resistance and the susceptible control varieties,” Tilmon says. Unfortunately, there’s a catch: aphid biotypes that can break host plant resistance.

Scientists already have identified one new aphid biotype – called biotype 1 – with some ability to overcome the source of resistance known as Rag1. “We captured biotype 1 in 2006, but there weren’t a lot of reports in 2007,” says Glen Hartman, the University of Illinois/USDA-ARS researcher who co-discovered the Rag1 and other sources of resistance with another UI researcher, Curt Hill. “What we don’t know is how predominant biotype 1 is, or how widely dispersed it is.”

### Resistance: antibiosis, antixenosis and tolerance

“There are three forms of resistance,” says Matt O’Neal, Iowa State University entomologist. “Antixenosis is a fancy Latin term that means the insect doesn’t attach itself to the plant. The aphid may not recognize the plant, or sometimes it might be that the plant has very hairy leaves.”

According to Dechun Wang, plant breeder at Michigan State University, “If you give aphids a no-choice test, where they must feed on a soybean plant with antixenosis resistance or starve, they can still survive. For unknown reasons, they don’t like to feed on those plants. If there’s another plant available, aphids will move on.”

Antibiosis is the second form of resistance. “Aphids may feed, but somehow feeding interferes with aphid reproduction,” says Wang. “We don’t know the mechanism causing it.”

The third type of resistance is tolerance. “In this situation, the plant can have a lot of aphids feeding on it, but you won’t see a yield decrease,” O’Neal adds.



Courtesy of Curt Hill, U of Ill.

*This photo shows susceptible vs. resistant plant lines. Plants and plots are under a severe aphid infestation.*

Courtesy of Roy Scott, SDSU

These pictures show the difference between E06902 (top photo), an aphid-resistant variety and Skylla (aphid susceptible) in a no-choice test. Each variety was individually caged, and photos were taken four weeks after inoculating 5-10 aphids on each plant. E06902 was released as an aphid-resistant germplasm in 2007.



Tilmon says, “In most of our trials, those lines with the Rag1 gene performed well. The wild card will be the aphid biotypes that can overcome the resistance and how quickly they can evolve or spread. So now we have to consider how that will affect management in various states.”

According to Dechun Wang, a plant breeder at Michigan State University, “We don’t know how many biotypes there are in the United States, but we know there are differences in aphids in different locations.” He doubts that aphids have already managed to overcome resistance, “since we haven’t had a resistant variety available commercially yet.”

### Many sources of resistance

Nature’s ability to overcome resistance eventually, however, is one reason researchers have so many different sources in the pipeline. “The Rag1 source may be available in commercial seed in 2008, and there’s a lot more material to look at,” says Hartman.

“We have material transfer agreements with several companies for the Rag1 and another resistance source,” Hartman adds. “We have about 50 different PIs (plant introductions) that look very different from the Rag1 and other known sources. We need to do genetic tests on them, and that will take a couple years.”

Breeder Bill Schapaugh from Kansas State University also has lines in testing, including one – K1639 – that is resistant to aphids and soybean cyst nematode. “That will be a good germplasm line,” Schapaugh says, “because it also has decent agronomic traits.”

Michigan State’s Wang has new sources of resistance in the trials as well. One source, E06902, is already being crossed with commercial germplasm by Syngenta. “Our studies show that E06902 has two two recessive genes controlling aphid resistance,” says Wang. Sources of resistance with more complicated genetic

background will be more difficult for aphids to find a way around.

“This was the first year we looked at Dechun’s lines,” says Matt O’Neal, entomologist at Iowa State University who is leading the host plant resistance project. “Central Iowa was hit hard with aphids in 2007, and his lines looked remarkable. There was one case in Wisconsin where one of his lines didn’t do very well – and that may be due to aphid biotypes.”

### One more tool in your toolbox

O’Neal adds that, even with aphid biotypes that can overcome some sources of resistance, it’s not a total loss. What this means is that resistance is going to be a good tool for soybean aphid management, but not the only tool.

“Scout and consider an insecticide if aphid populations go above the 250 threshold, even on resistant plants,” O’Neal continues. “The frequency of spraying will drop, and growers will be able to use less insecticide. But you can’t just plant aphid-resistant soybeans and walk away.

“You don’t want only one hammer for aphids, you want a lot of hammers,” he says. “That’s why we’re working on different resistance sources, and why we released *Binodoxys communis*. Maybe if we have several aphid-resistant soybean varieties available, we can lower the number of aphid migration events. If fewer aphids are flying in, maybe Asian lady beetles and other predators can catch up, and the resistance can hang in there.”

## Tweaking the 250 treatment threshold?

Now that North Central Soybean Research Program scientists have confirmed the 250 aphid treatment threshold and published their findings, they’re considering some fine-tuning.

“Will we need to adjust thresholds to incorporate the new aphid-resistant varieties?” asks Matt O’Neal, Iowa State University entomologist. “What about the release of *Binodoxys communis*?”

“If there’s one field at R1 and one at R6 when aphids reach threshold, would they both experience the same yield loss?” he wonders. “Later in the season, the aphids’ impact is reduced.” O’Neal experienced this firsthand in 2007.

“We sprayed an insecticide at the 250 threshold in July. Then aphid populations reached threshold again in mid-August. So we sprayed some acreage again, and left some with one application. In terms of yield, we couldn’t see a difference. We need to explore that further, but it does suggest that later-stage beans are more tolerant, and it may take more aphids to reduce yield.

“Another thing we need to look at is 15-inch and 7-inch row spacing,” O’Neal adds. “That’s not to say the threshold isn’t valid. We’re just checking on fine-tuning it.”

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