

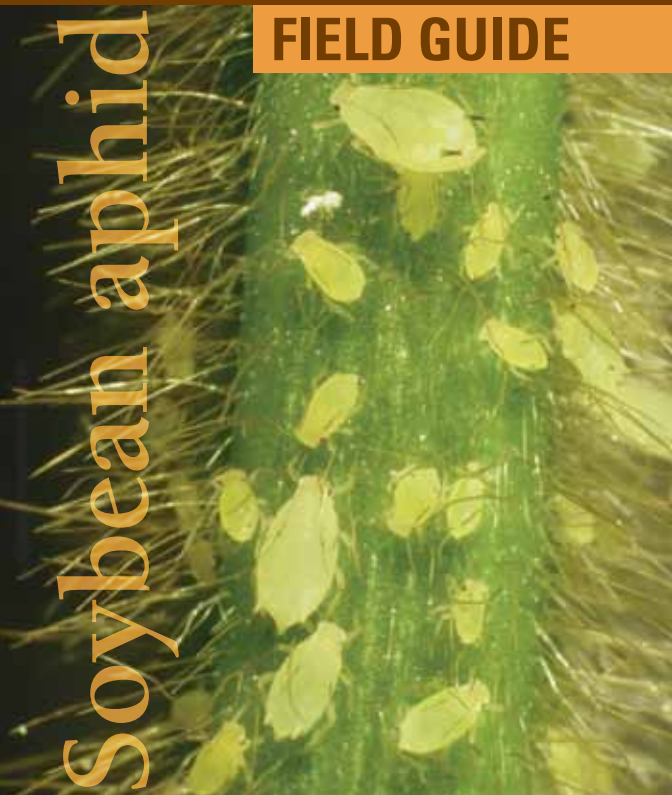
NCSRP



**NORTH CENTRAL SOYBEAN
RESEARCH PROGRAM**

Soybean aphid

FIELD GUIDE



*A reference for soybean aphid management
in the north central region*

CSI 0060 May 2013

Since 2000, soybean aphid has been the primary soybean pest in the north-central region of the United States. Although infestation can be sporadic and unpredictable, this aphid has demonstrated the capacity to cause significant yield loss if not managed properly. This regional field guide reviews current knowledge about the biology and management of soybean aphid and offers recommendations for profitable decision making in soybean.



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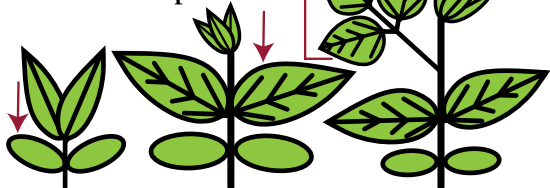
Note: Information in this field guide is intended for general soybean aphid management in the north-central region of the United States. Management recommendations in other regions (i.e., southern or eastern United States) may differ. More specific management guidelines are available from your state extension entomologist. See page 53 for contact information.

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SOYBEAN GROWTH STAGES

Soybean Growth and Development



VE

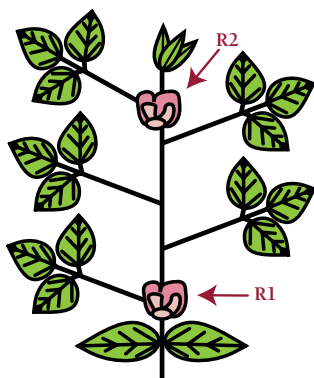
Cotyledon emergence

VC

Cotyledons expanded and unifoliate leaves unrolled (not touching)

V1

First trifoliate leaves unrolled (not touching)



V(n)

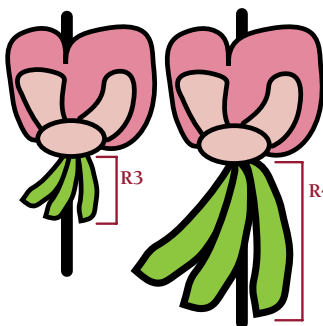
The number of fully expanded trifoliolates

R1

Beginning bloom: open flower at any node on main stem

R2

Full bloom: open flower at one of the two uppermost nodes on main stem



R3

Beginning pod set: pods <5/16 in. long at four uppermost nodes

R4

Full pod set: pods >3/4 in. long at four uppermost nodes

R5

Beginning seed set: seed is 1/8 in long at one of four uppermost nodes

R6

Full seed set: green seed that fills pod capacity at one of four uppermost nodes

R7

Beginning maturity: one pod on main stem has reached mature color

R8

Full maturity: 95% of pods have reached mature color

FOR MORE INFORMATION



Electronic version of this book

<http://planthealth.info>

Blank copies of the *Speed Scouting* form

www.ent.iastate.edu/dept/faculty/hodgson/extension

Iowa State University soybean aphid podcast

www.soybeanaphid.info

Suction trapping network

www.ncipmc.org/traps

Biology of the soybean aphid

<http://dx.doi.org/10.1603/IPM10016>

Soybean aphid management

<http://dx.doi.org/10.1603/IPM11019>

CDMS pesticide labels

www.cdms.net/LabelsMsds/LMDefault.aspx

SoyPod

www.soypod.info



BIOLOGY

Soybean aphid is a relatively recent invader of soybean in the United States. This invasive pest has a complex life cycle, and its population dynamics are highly influenced by weather, both during the growing season and winter.

APHIDS

Wingless

Like many aphid species, soybean aphid has both winged and wingless adult forms. The wingless form is most commonly found on soybean. Wingless adults have pear-shaped bodies and are about $\frac{1}{16}$ inch long. Healthy aphids are generally light green with red eyes, pale antennae and legs. Soybean aphids have dark-tipped cornicles at the end of the abdomen, often referred to as “tailpipes.” These dark cornicles are useful to distinguish this species from other green aphids. Wingless nymphs look very similar to the adults except are smaller in size. Sometimes later in the season and during periods of stress (i.e., very high population densities or drought), soybean aphids may be smaller and appear almost white.



Wingless, female soybean aphid



Colony of wingless, female soybean aphids

Winged

Winged aphids have two pairs of wings and a similar body shape and size as wingless forms. The clear forewings extend well past the end of the abdomen and act like sails for catching wind. The head, thorax and cornicles are black in winged adults. Nymphs that will eventually develop into winged adults will have broad “shoulders” that produce wing pads. These nymphs can have an orange coloration on the head and thorax.



Winged, female soybean aphid



Soybean aphid nymphs with wing pads

LOOK-ALIKES

Although there are no other aphids that colonize soybean in the north-central region of the United States, there are other insects that can be confused with soybean aphid. It is important to distinguish soybean aphid from other insects, especially beneficial species. Remember, only aphids have cornicles, and this is an easy diagnostic feature that can often be observed without magnification.



Soybean thrips adult (left) and nymphs

Thrips

Immature thrips may be the insect most commonly confused with soybean aphid. Soybean thrips nymphs and adults are cigar shaped. The nymphs are usually yellow or orange but also can be colorless, and the adults are white with black banding. The adults are smaller than soybean aphid, usually less than $\frac{1}{16}$ inch. Thrips are fast-moving insects and are extremely common on the undersides of soybean leaves. As a general rule, any fast-moving insect found on soybean is not a soybean aphid.



Stink bug nymphs

Stink bugs

Both plant feeding and predatory stink bugs can be found in soybean. First instar stink bugs could be confused with aphids; however, even the smallest nymphs are larger than aphids (up to $\frac{3}{8}$ inch long) and oval shaped. Nymphs are wingless and dark, often with vibrant contrasting coloration of black with bright green, yellow, or red markings. Adults are shield shaped and may be brown or green in color.

Whiteflies

Whiteflies are common soybean pests, particularly in hot, dry years. The adults are small ($\frac{1}{25}$ inch long), fragile and have white wings that are laid over the body at rest. Whiteflies colonize the undersides of soybean leaves, and the adults will often fly up in a cloud when the leaves are disturbed. The nymphs look like pale, featureless discs on the undersides of soybean leaves. The nymphs are not mobile and are usually off-white to pale green. Unlike soybean aphid, no cornicles or eyes are readily visible on whitefly nymphs.



Whitefly adults



Whitefly nymphs

Potato leafhoppers

These soybean pests can be easily confused with soybean aphid. Potato leafhopper nymphs are bright green with prominent white eyes. Nymphs and adults have heads that are wider than the abdomen. Potato leafhoppers have spiny legs and a tapered abdomen. Nymphs are generally larger than soybean aphid, and the adults are $\frac{1}{8}$ inch long. Like soybean aphid, they usually colonize the undersides of the newest leaves. Potato leafhopper nymphs and adults move very quickly. If disturbed, the adults will attempt to jump or fly away, and the nymphs will try to avoid contact by moving sideways in a "crablike" fashion.



Potato leafhopper nymph



Pirate bug nymph

Pirate bugs

These small insects are important beneficial insects in soybean and other crops and can help regulate soybean aphid populations. The nymphs are yellow or orange with red eyes and are highly mobile. Pirate bug nymphs have developing wing pads. Adults are off-white with black patterning and $\frac{1}{16}$ inch long. Pirate bugs will often attempt to bite humans. The bite is harmless but noticeable.



Mealybugs

Mealybugs

These pests are close relatives of aphids and can be common in isolated soybean fields. Mealybugs could be confused with whitefly nymphs as well. They are generally not considered economic pests. Mealybugs are oval and usually covered in a fine, white waxy powder. They move very slowly, if at all, and can be found on the undersides of leaves. Some species are found feeding on soybean roots. Adults are $\frac{1}{8}$ inch long.



Lygus bug nymph

Lygus bugs

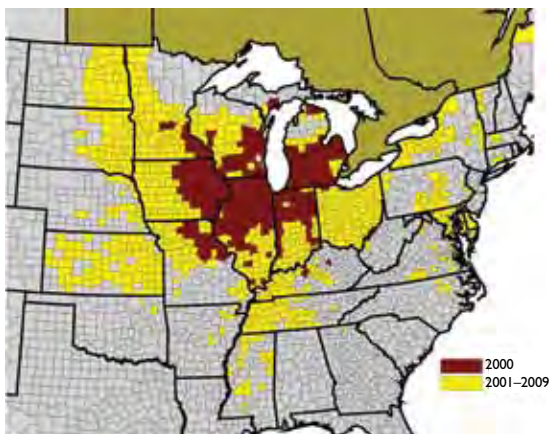
This is not a common soybean pest, but lygus bugs are frequently collected in sweep nets. These insects are very active compared to soybean aphid. Adults are winged, drab brown and are excellent fliers. Lygus bug nymphs are yellow-green, wingless, and have dark spots on top of the body. Lygus bugs are larger than soybean aphid, and reach up to $\frac{1}{5}$ inch long.

LIFE HISTORY

Soybean aphid is native to eastern Asia where soybean was first domesticated. Its native range includes China, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan, and Thailand. Soybean aphid is a sporadic pest in China but is not considered an economic problem throughout most of Asia.

The first soybean aphid colonies in North America were confirmed in Wisconsin in 2000. Soybean aphid expanded its range rapidly and was detected in 22 states and three Canadian provinces within four years.

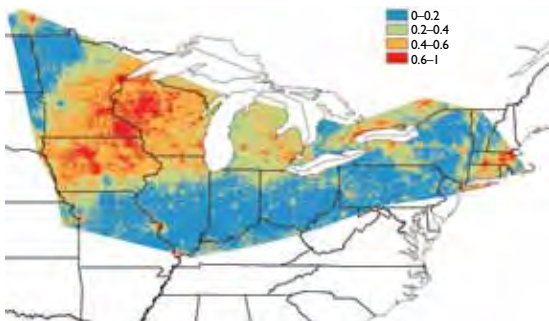
We do not know how soybean aphid was introduced to North America, but they were likely transported as overwintering eggs on ornamental plant material.



North American distribution of soybean aphid from 2000–2009

The rapid expansion of soybean aphid across the United States and Canada was facilitated by the wide establishment of the overwintering host, common buckthorn. Buckthorn is a critical part of the soybean aphid life cycle; without this plant, they cannot spend the winter in a given area. Buckthorn is a deciduous shrub common in shelterbelts and woods in northern states.

Also native to Asia, common buckthorn is considered an invasive weed. Buckthorn was prevalent in many parts of the north-central region for years before the confirmation of soybean aphid in 2000. It is now possible to find soybean aphid outside of the Midwest, including Virginia, Pennsylvania, Ontario, and Quebec.



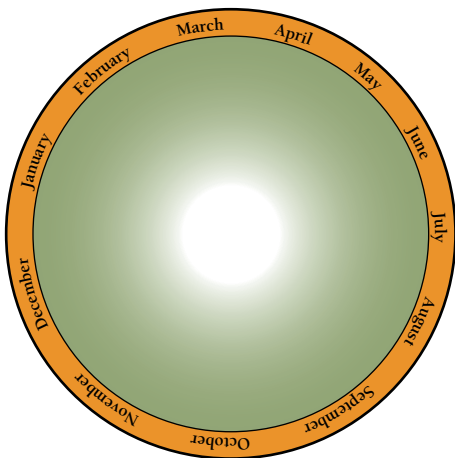
Probability of buckthorn distribution in North America
(Values greater than 0.2 have known occurrences for buckthorn.)



Buckthorn has simple leaf venation and dark red berries that persist into the fall and winter

LIFE CYCLE

The life cycle of soybean aphid is complicated and involves asexual and sexual reproduction in addition to host alternation. Like many other aphid species, soybean aphid requires two host plants to survive, including a primary host (buckthorn) and a secondary host (soybean).



Annual life cycle of soybean aphid

Egg hatch occurs in the spring, and timing depends on accumulating temperatures and increasing photoperiod. Several wingless generations occur on buckthorn in the spring before the first winged aphids are produced.

Although winged aphids are not strong flyers, they can move long distances by gliding passively along jet streams. Spring migration usually occurs during soybean emergence. Soybean located near buckthorn stands is more likely to get colonized by spring migrants.



Winged aphids on buckthorn indicate spring migration to soybean

In the summer, all soybean aphids are female and reproduce asexually. Both wingless and winged individuals are produced on soybean. Populations of winged aphids may rapidly enter or leave soybean fields, depending on the time of year and condition of the host plants.

As plants mature and the photoperiod decreases, a change in offspring production is triggered. Winged males are produced for the first time, and they migrate to buckthorn. Winged females move to buckthorn and generate a wingless, sexual female. The sexual females mate with the males; this is the only time of year sexual reproduction occurs. Mated females deposit eggs near the base of buckthorn buds to overwinter. The eggs are a cold-hardy life stage and can survive temperatures as low as -29°F .



Wingless, sexual female deposits eggs near buckthorn buds in the fall

POPULATION DYNAMICS

Eggs hatch happens inside the female, and adult females give live birth to nymphs in the summer. Producing live offspring without sexual reproduction greatly reduces the generation time, or the number of days it takes for an egg to become an adult. Nymphs start feeding shortly after being born.



Soybean aphids give live birth to nymphs

Soybean aphid can produce up to 15 generations every summer, but this number is highly dependent upon many factors, including environmental conditions and plant vigor. The range of acceptable temperatures for soybean aphid survival is 47–95°F. Optimal offspring production occurs at 82°F, where an adult can produce nine nymphs a day. Under ideal conditions, populations in the field can double every 6–7 days. During persistently high temperatures (over 90°F), soybean aphid reproduction generally declines in an effort to conserve resources.



Crowding can stimulate the production of winged aphids

Throughout the summer, soybean aphid can produce winged individuals. These migrants can move within field or longer distances to new areas. The factors that trigger winged offspring development are not fully understood but can be induced by crowding, the presence of predators, poor food quality, and changing photoperiod and temperature.



Winged aphids on soybean before dispersal

PLANT INJURY

Soybean aphids have a piercing-sucking stylet and feed on sap from plant phloem. They feed on any above-ground plant parts, including leaves, stems, and pods. They are generally most abundant on the newest growth, where plant nutrients are most highly concentrated. Soybean aphid colony size depends on host quality, and nitrogen is typically the limiting nutrient. As nitrogen becomes more available or concentrated, the population growth rate of soybean aphid also increases. More concentrated nitrogen is common in potassium-deficient soils.



Aphids use a flexible stylet to pierce plant cells and remove sap

As with many fluid-feeding insects, plant injury often goes undetected until severe symptoms and yield loss occurs. Even at moderate infestations of 50 aphids per leaflet, significant reductions in gas exchange and photosynthesis are possible. Heavy aphid feeding can result in stunted and discolored plants. Nymphs and adults excrete sugar-rich honeydew as they feed. This honeydew accumulates on all aboveground plant parts and can be particularly severe during prolonged aphid infestations. Honeydew can promote growth of black sooty mold that interferes with photosynthesis. The combination of removing sap and photosynthetic reduction can cause a synergistic yield loss. Soybean aphid can impact seed quality and size, pod number, and plant height. Heavily infested plants, if left untreated, can lead to yield reductions of 40 percent or more.



Aphid honeydew is sugar-rich, shiny, and sticky

As with many other aphids, soybean aphid can transmit plant viruses while feeding. They can vector *Soybean mosaic virus* and *Alfalfa mosaic virus* to soybean, and other nonpersistent viruses to other crops. However, the economic importance of soybean aphid as a vector of viruses is not fully understood in North America. The impact of soybean aphid virus transmission in soybean has not been significant to date.



Typical sooty mold growth (top) from soybean aphid honeydew compared to a healthy leaf



Visual symptoms of Soybean mosaic virus

A man wearing a blue plaid shirt and a white baseball cap is shown from the side, looking down at a field of green soybean plants. The background is a blurred field of similar plants under a bright sky.

SAMPLING

Most profitable pest management programs rely on regular sampling of pests. This is especially true for a multigenerational and sporadic pest like soybean aphid.

SCOUTING TIPS

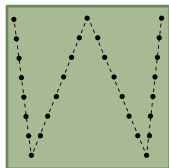


For the past decade, soybean aphid has been an erratic and occasionally a severe problem in the north-central region of the United States. Widespread outbreaks do not happen consistently, but soybean aphid is still capable of causing yield loss every year and is considered our primary soybean insect pest. Regular sampling will help farmers track population trends and improve the timing of insecticides.

The period when fields are first colonized is highly variable between locations and years. Some locations, like southeastern Minnesota and southern Ontario, will experience first colonization at soybean emergence and continued immigration until seed set (R5). Other soybean growing regions, including Nebraska and Kentucky, may not see aphids until after bloom (R1). The timing and severity of soybean aphid colonization is dependent on proximity to buckthorn and long distance movement of winged aphids throughout the season.

Colonies are typically found on the undersides of soybean leaves and prefer the newest leaves. For most of the season, they can be found near the top of the canopy, but as plants develop lateral stems, aphids become more common in the middle canopy. Most people usually start looking at the bottom of the plant and move up to the top. As you are looking for aphids, note not only the density, but also the presence of winged adults, natural enemies, and other soybean pests. Finding aphids on lateral stems can be an indication of populations that are at or near the economic threshold.

The most common method for sampling soybean aphid is to try and estimate the number per plant. It is recommended to sample 38 plants for every 50 acres of soybean to see a range of potential densities throughout the field. After sampling, estimate the number of aphids per plant and use the economic threshold to make a treatment decision (see page 31).



Sample the entire field by walking a "W" or "Z"



Aphid colonies on the undersides of soybean leaves

Other visual cues

Sometimes the presence of other insects can be helpful for the first detection of soybean aphid. Look for ants and natural enemies, such as lady beetles and pirate bugs, during early-season scouting trips. Ants will “tend” aphids in a mutualistic relationship. The ants collect honeydew excreted by the aphids and use it as a sugar-rich food source. In return, the ants provide protection from predators. Pirate bugs and lady beetles can find small aphid colonies, so use them as possible aphid indicators while scouting.



Soybean aphid colonies can be tended by ants



Speed Scouting

Crop consultants and others sampling many fields throughout the summer may prefer to use another decision-making tool called *Speed Scouting*. This is a binomial sequential sampling plan that recommends foliar insecticides based on a tally threshold of 40 aphids. Consider a plant infested when it has 40 or more aphids. This is a conservative sampling plan because most of the plants have to be infested to reach a “treat” decision. To access blank *Speed Scouting* forms, see page 6 for the website address. Alternatively, a web-based option called SoyPod (see page 6 for the website address) is available for smart devices. This free management tool uses *Speed Scouting* to make treatment decisions and keeps historical records.

Speed Scouting for Soybean Aphid

For blank forms and an interactive example, go to www.soybeanaphid.info

Directions for Speed Scouting:

1. Go to a plant at random and start counting aphids. If less than 40 aphids are on the ENTIRE plant, mark a minus [-] for that non-infested plant. If you reach 40 aphids, STOP COUNTING (this is the speedy part!) and mark a plus [+] for that infested plant.
2. Walk 30 rows or paces at random to find the next plant. Repeat Step #1 until 11 plants are sampled in different areas of the field. Total the number of infested plants [+] to make a treatment decision.
3. If you must 'CONTINUE SAMPLING' (7-10 plants with a [+]), sample 5 more plants and use the new total number of plants to make a decision.
4. If no decision is reached, sample additional sets of 5 plants until 31 plants are sampled. Remember, always use the total number of infested plants [+] to make a decision. If no decision can be made after sampling 31 plants, resample the same field in 3-4 days.

5. A "TREAT" decision must be confirmed a second time 3-4 days later. If confirmed, apply an insecticide in 3-4 days.

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16						
17	18	19	20	21						
22	23	24	25	26						
27	28	29	30	31						

Remember: Use [+] or [-] notations for each plant sampled.

— = < 40 aphids/ plant ('non-infested')

+ = ≥ 40 aphids/ plant ('infested')

Remember: If you have to continue sampling, add the previous number of infested plants [+] to the next 5-plant count to make a treatment decision.

	+			
	+			
	+			
	+			

Field Location: _____

Average Plant Stage: _____

Date: _____

Treatment Decision: _____

Field Notes: _____

DO NOT TREAT, resample in 7-10 days	CONTINUE SAMPLING 5 more plants	TREAT, confirm again in 3-4 days
6 or less	7 to 10	11
10 or less	11 to 14	15 or more
14 or less	15 to 18	19 or more
18 or less	19 to 22	23 or more
22 or less	23 to 26, Stop sampling! Return in 3-4 days.	27 or more

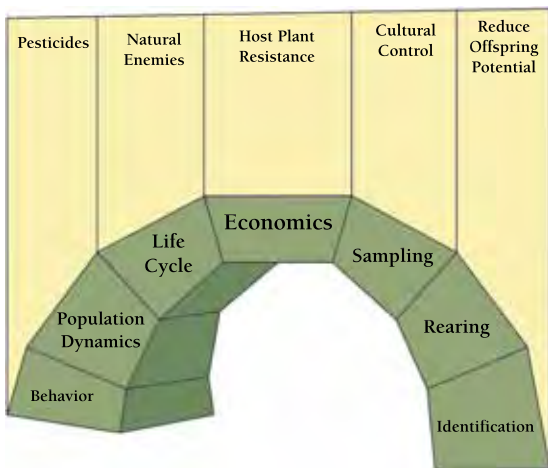


INTEGRATED PEST MANAGEMENT

Soybean aphid is most effectively managed when using IPM, or Integrated Pest Management. IPM promotes the use of multiple, proactive tactics to protect yield and increase profit margins.

IPM BASICS

Farmers should focus on the goal of keeping field crop pests at tolerable levels. For a persistent, widespread pest like soybean aphid, we must incorporate several tools to sustain the effectiveness of any one management strategy. The collective term for incorporating multiple tactics is often referred to as IPM, or Integrated Pest Management. A successful IPM program will include several strategies and likely result in higher profits and better environmental conservation.

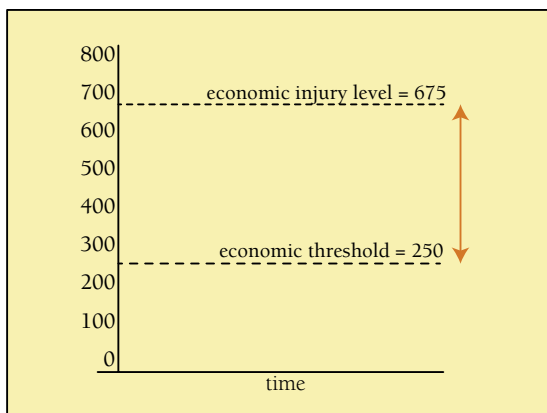


Major components of a soybean aphid IPM program (adapted from Pedigo and Rice 2008)

ECONOMIC THRESHOLD

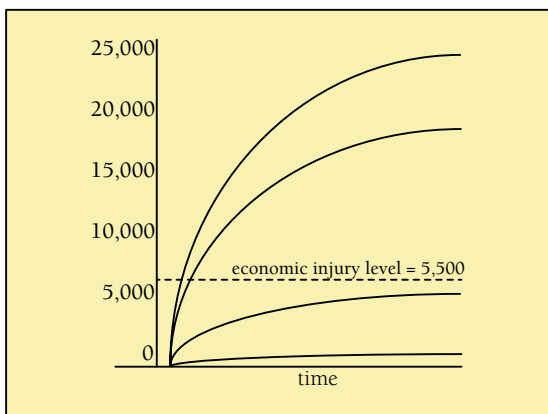
Establishing treatment guidelines for a widespread and potentially damaging pest like soybean aphid is essential in developing a successful IPM program. To understand the economics of profitable decision making for this pest, we must understand the economic injury level and then derive the economic threshold to protect yield. A multistate research and extension effort in the north-central region helped determine these values, and these thresholds are now widely accepted as management recommendations for insecticide applications. **A projected net benefit of \$1.3 billion from 2003–2018 will be saved because of the development and adoption of the economic threshold for soybean aphid.**

In many cases of field crop production, there is a linear relationship between yield loss and pest density meaning that as pest density increases, there is an equal decrease in yield. The economic injury level, or the point at which the crop starts to lose yield, is estimated to be approximately 675 aphids per plant. Insecticide treatments must be applied before that time in order to avoid economic injury. Therefore, an economic action threshold of 250 aphids per plant is recommended. This should provide enough time to make a foliar insecticide application and protect yield. Although market values and control costs can vary by year, we recommend using the “250” as a benchmark to time applications. Keep in mind most plants should be infested (> 80 percent) before applying treatments, and plants should not have entered full seed set (R6). Yield responses after R6 have not been consistently positive and would only be justified if aphid populations were drastically increasing during this plant growth stage.



The most cost effective approach to managing soybean aphid is to treat with a foliar insecticide after reaching the economic threshold but before reaching the economic injury level. The orange arrow indicates the ideal window for treatment.

For many university research programs, daily count data are converted into cumulative aphid days. This calculation estimates the seasonal accumulation of aphids over the growing season. It is particularly helpful because soybean aphids have 15+ overlapping generations. This equation is similar to calculating temperature degree days. The economic injury level for cumulative aphid days is approximately 5,500 aphids. For soybean aphid, there is a yield decrease of 6 percent for every 10,000 cumulative aphid days.



Examples of different cumulative aphid days for soybean aphid.

CULTURAL CONTROL

Cultural control should be one of the first considerations for an IPM program. Integrating multiple, proactive tactics can discourage pests from building up to outbreak levels. Regardless of pest pressure, select for high-yielding seeds appropriate for your maturity group. Other common cultural control practices that can influence field crop pests like soybean aphid are listed here:

- **Soil fertility and soil texture** can play a role in host plant quality. Soybeans grown in sandy soils that are potassium deficient can develop high soybean aphid populations more readily than other soil types.
- **Date of planting** may be an important consideration for those areas with dense buckthorn stands. Spring migrants are attracted to freshly emerged plants to start new colonies. So depending on when spring migration happens, early-planted field may be colonized or bypassed. Ultimately, planting date recommendations are highly varied in the north-central region and should be based on optimal growing conditions for quick plant emergence rather than for soybean aphid control.
- **Weed control** is not known to benefit soybean aphid control since the host range is extremely narrow and does not include any common weeds. However, soybean aphids can survive on clover and could serve as a bridge host plant if soybean is not available in the spring.
- **Crop rotation and tillage** are not known to be effective soybean aphid management tools. Aphids in the north-central region are not in or near soybean field during the winter since they need to move to buckthorn every fall and migrate back to soybean in the spring.
- **Row spacing** is not known to influence soybean aphid population dynamics.

BIOLOGICAL CONTROL



Soybean with lady beetles

The north-central region has a diverse community of beneficial insects and pathogens. Common beneficial insects include lady beetles, predatory bugs, lacewings, and predatory flies. Parasitic wasps and fungi also can help curb soybean aphid populations. Early-season natural enemies can help regulate spring colonization and prevent outbreaks later in the summer. However, the impact of biological control is limited once aphids have colonized most plants (> 80 percent plants with aphids). Biological control agents cannot effectively regulate soybean aphid when most plants are infested and populations are increasing.

Broad spectrum insecticides used to suppress soybean aphid can negatively impact natural enemy populations. Foliar insecticides can be lethal to beneficial insects and reduce the likelihood of biological control. Scouting and adopting the economic threshold for soybean aphid are recommended to minimize these negative effects.

PREDATORS

Lady beetles

These predators are the most important soybean aphid natural enemy. The adults and larvae feed on aphids and will move from soybean to buckthorn to continue feeding. There are several lady beetles in the north-central region, consisting of both native and exotic species. The most common species found in soybean fields is the multicolored Asian lady beetle. Adult lady beetles can be round or oval in shape. Body color ranges from orange to red or pink, often with dark spots on the forewing. Larvae resemble black or gray alligators with orange markings. They often have spines on the abdomen.



Sevenspotted lady beetle



Sevenspotted lady beetle larva



Multicolored Asian lady beetle



Twelvespotted lady beetle



Multicolored Asian lady beetle larva



Variegated lady beetle



Convergent lady beetle



Polished lady beetle

Pirate bugs

Pirate bugs are a common predator in soybean. Both the adults and nymphs are predatory and feed on the fluid of aphids and other soft-bodied insects. Adults are $\frac{1}{8}$ inch long and oval shaped with black and white contrasting colors. In some areas of the north-central region, pirate bugs are abundant and considered important for early-season control.



Adult pirate bug feeding on a soybean aphid



Pirate bug nymph

Damsel bug

These predatory bugs are brown and slender with long antennae. The adults and nymphs feed on soft-bodied insects like aphids. Adults are about $\frac{1}{2}$ inch long. Nymphs look similar to adults but are wingless. Both adults and nymphs are very active and move very quickly on plants.



Damsel bug

Lacewings

Lacewing larvae can be important soybean aphid predators. Larvae look like alligators with large pincer-like mouthparts. They can be up to $\frac{1}{2}$ inch long and are pink to brownish in color. Adults are typically not predaceous and feed on aphid honeydew, nectar, and pollen. Both brown and green lacewings can be found in soybean.



Green lacewing adult



Lacewing larvae feeding on soybean aphid



Hover fly adult



Hover fly larva feeding on soybean aphid

Hover flies

Hover flies, also called syrphid flies, are common around flowering plants. Adults mimic bees with their black and yellow coloration on the thorax and abdomen. Adult hover flies feed on nectar and pollen and appear to hover in mid-air while flying. The larvae are voracious aphid predators. Larvae can be up to $\frac{3}{4}$ inch long.

PARASITIDS

Parasitoids are minute, stingless wasps that use aphids as a host for their developing larvae. The wasps lay a single egg in an aphid. When the egg hatches, the larva feeds internally on the aphid, eventually killing it. The developing larva causes the aphid to become bloated and change color from green to black or tan. These dead and puffy aphids are called aphid “mummies.”

Parasitoids can be effective at controlling aphid populations. In Asia, these natural enemies are important soybean aphid regulators. Currently, parasitoids are not a significant source of biological control in North America, but attempts are underway to introduce soybean aphid parasitoids to the United States. One parasitoid, *Binodoxys communis*, was introduced in 2007 but has not been successful in establishing. Other parasitoid species are currently being explored for introduction.



Soybean aphid being parasitized by a wasp



Soybean aphid mummy in a colony



Black soybean aphid mummies



Mummies mixed in a soybean aphid colony

PATHOGENS



Pandora neoaphidis



Aphids infected with beneficial fungi are often bloated and fuzzy

Several beneficial fungi have been found to infect and kill soybean aphid in the north-central region. These fungi are naturally occurring but require specific environmental conditions to flourish. Ideal temperatures and humidity levels vary by fungal species, but cool and wet conditions are generally required for sporulation of the fungi. The most common species is called *Pandora neoaphidis*. When scouting for aphids, look for powdery-looking individuals in the colony.

The increased use of foliar fungicides in soybean can negatively impact beneficial fungi. Fungicides in the strobilurins and triazole groups are both very frequently used in soybean and have been shown to reduce aphid-attacking fungi. Fungicides should not be applied unless soybean diseases are present, as the prophylactic use of fungicides decreases the likelihood of successful natural control from fungi.

HOST PLANT RESISTANCE

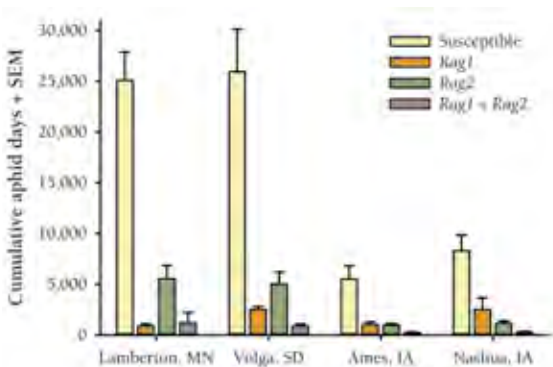
The search for naturally occurring host plant resistance for soybean aphid started shortly after its confirmation in North America in 2000. Two forms of host plant resistance, antibiosis and antixenosis, were discovered through university and USDA soybean breeding programs.

Antibiosis affects the biology of the insect in a way that pest abundance and resulting plant damage are reduced compared to the insect feeding on a susceptible plant. In other words, the insect feeding on a plant expressing antibiosis can have a reduced life span, reproductive potential, or die.

Antixenosis affects the behavior of an insect pest and usually is expressed as nonpreference of the insect for a resistant plant compared with a susceptible plant. In other words, insects avoid or are repelled by the plants expressing antixenosis. These approaches are often complementary and co-occurring in plant breeding programs.

Several naturally occurring genes in soybean and its close relatives are known through extensive germplasm screening of soybean. These host-plant resistant genes are prefixed with Rag for “Resistance to *Aphis glycines*.” The first gene discovered was called *Rag1*, and other genes have since been identified (e.g., *Rag2*, *rag3*, *rag4*, etc.). In 2010, *Rag1* seed became commercially available for Roundup Ready® soybean. Although currently available only in limited quantities and select maturity groups, *Rag1* seed should be available in most north-central

states. Please note that while *Rag1* fields will not be aphid free, they can have significantly reduced aphid reproduction. A pyramid of *Rag1* + *Rag2* is available in organic seed for producers in Iowa and southern Minnesota. This combination of these two host-plant resistance genes provides exceptional soybean aphid suppression.



Impacts of *Rag1* and *Rag2* host plant resistance on cumulative aphid days

In some areas, genetic biotypes of the soybean aphid are documented. These biotypes have rapidly overcome the expression of some host plant resistance genes. At least three biotypes exist in the north-central region, although their distributions are not clearly defined and may overlap. The appearance of biotypes within the first decade of soybean aphid establishment in North America indicates that there is substantial genetic variability in the population.

CHEMICAL CONTROL

For the first decade of soybean aphid establishment in the north-central region, insecticides were the primary strategy for suppression. Insecticide use in soybean has increased by about 130-fold since 2000, due in large part to the establishment of soybean aphid. Soybean aphid control has increased overall production costs by \$10–20/acre. Along with increased insecticide applications, there are increased risks for exposure and negative environmental impacts.



Seed treatments

Currently, neonicotinoids are the only class of insecticides used for soybean seed treatments. Three active ingredients are registered in soybean and include clothianidin, imidacloprid, and thiamethoxam.

Neonicotinoids are systemic and are absorbed through the roots and translocated through the xylem. This within-plant movement of neonicotinoids is ideal for pests with piercing-sucking mouthparts that feed on plant sap.

Seed treatments in soybean are widely adopted throughout the north-central region. Most seed treatments are commercially applied and application costs range from \$10–14/acre. Typically, soybean seed treatments now include a combination of an insecticide and several fungicides.

Seed treatments are most effective during the vegetative stages or within 40–50 days of planting. They are well-suited to late-planted or double-cropped soybean in the north-central region. If aphid immigration is high during the reproductive stages, the seed treatment is no longer present in the plant tissues in sufficient concentration to suppress colonization and population growth. If aphid populations reach the economic threshold, foliar insecticides may be required in fields to protect yield. In years and locations with low soybean aphid pressure, seed treatments do not consistently provide a yield return.

The use of seed treatments is more of an insurance policy than an IPM strategy. The constant use and exposure of seed treatments can promote genetic resistance to soybean aphid and other pests.

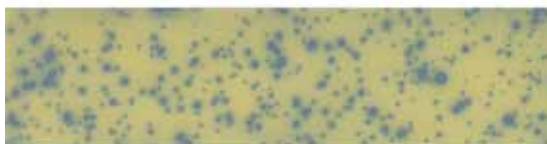


Insecticidal seed treatments are becoming widely adopted throughout the north-central region

Foliar insecticides

There are many effective products for soybean aphid management, including several different insecticide chemistries (e.g., carbamates, neonicotinoids, organophosphates, and pyrethroids). Currently, more than 20 active ingredients are available for foliar-applied insecticides. Visit the CDMS website for current labels (see page 6 for address).

Product selection for foliar applications should be based on efficacy, residual activity, resistance management, applicator safety, reduced negative environmental impacts (e.g., bees and other nontarget species), price, availability, and preharvest interval. University research consistently shows foliar insecticides significantly protect yield when soybean aphids reach the economic threshold. At this time, there are no strong differences between products or chemistries.



Turbo flat fan TT11002 at 30 psi (10 gpa at 5 mph)



Hollow cone TX-3 at 60 psi (10 gpa at 5 mph)

A small droplet size is ideal to make contact with aphids

Because soybean aphids are most commonly found on the undersides of leaves, insecticide efficacy is strongly related to coverage of foliar applications. The greatest knockdown is attained when droplets make contact with the aphids. Sufficient coverage is dependent on spray nozzle, water volume, and spray pressure. Increasing volume (e.g., 20 gallons per acre by ground application or 5 gallons per acre by aerial application) and pressure (e.g., 40 pounds per square inch) with a small droplet size. Spraying too early can reduce natural enemies and flare other soybean pests, like twospotted spider mite, and potentially result in multiple applications in a single growing season.

Examples of foliar insecticides labeled for soybean aphid

Product/Formulation	Active Ingredient(s)	Class ¹	REI ²	PHI ³
Asana® XL ⁴	esfenvalerate	P	12	21
Belay® SC ⁴	clothianidin	N	12	21
Baythroid® XL ⁴	beta-cyfluthrin	P	12	21
Brigade® 2EC ⁴	bifenthrin	P	12	18
Cobalt® Advanced EC ⁴	lambda-cyhalothrin + chlorpyrifos	P + O	24	30
Declare® CS ⁴	gamma-cyhalothrin	P	24	30
Dimethoate 4E ⁴	dimethoate	O	48	21
Endigo® ZC ⁴	lambda-cyhalothrin + thiamethoxam	P + N	24	30
Lannate® LV ⁴	methomyl	C	48	14
Leverage® 2.7 SE ⁴	imidacloprid + cyflurthrin	N + P	12	45
Lorsban® Advanced EC ⁴	chlorpyrifos	O	24	28
Mustang Max™ EW ⁴	zeta-cypermethrin	P	12	21
Warrior II® CS ⁴	lambda-cyhalothrin	P	24	30

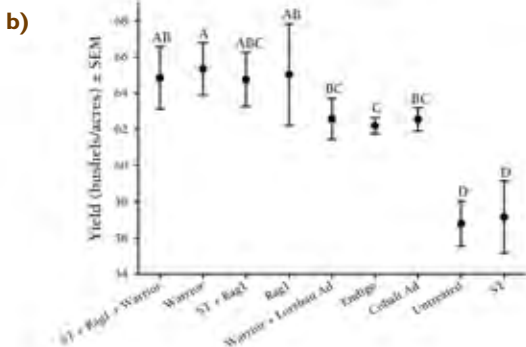
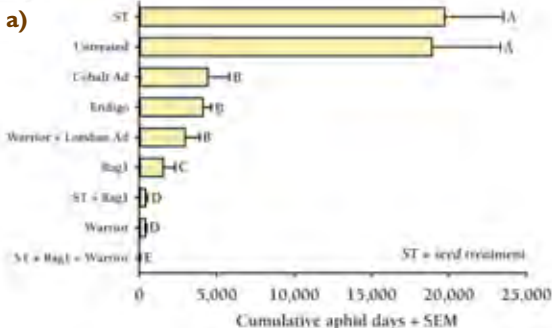
¹C – carbamate; N – neonicotinoid; O – organophosphate; P – pyrethroid.

²Restricted entry interval: the number of hours after an application people are not allowed in a field without PPE (personal protective equipment).

³Preharvest interval: the number of days that must occur between an application and harvest.

⁴Restricted-use product.

Although insecticide resistance has not been reported in soybean aphid, resistance to any pesticide can develop with repeated exposures. Farmers can help delay resistance development by minimizing the number of applications in soybean. Only treating when populations exceed the economic threshold and rotating insecticidal chemistry classes will prolong the effectiveness of available products. We strongly encourage rotating chemistries if more than one application is warranted in a single growing season.



Soybean aphid efficacy evaluation at Sutherland, Iowa, in 2011, where a) is the cumulative aphid days for the entire growing season, and b) is the corresponding yield for each treatment. Differing letters between bars indicate there is a significant difference among the treatments.

Tank mixing insecticides

If an application is warranted, we recommend using full rates of a single product rather than tank mixing partial rates of two products. Partial rates can lead to multiple applications and increase the risk of developing genetic resistance.

Foliar fungicides in soybean have increased over the last decade. The timing of fungicides may overlap with soybean aphid management and the ideal droplet sizes are comparable. Tank mixing insecticides with fungicides is only recommended if the target pests are present at the same time; prophylactic applications have not consistently showed yield benefits.

Herbicide applications in soybean are optimal when weeds are less than four inches tall. In the north-central region, the ideal timing for weed control is generally not compatible with soybean aphid management. The suggested droplet size for glyphosate and other herbicides is larger than for insecticides. Therefore, sufficient coverage of an herbicide-insecticide tank mix is difficult to achieve.

Management summary

Within a relatively short time, soybean aphid has become a dominant pest in soybean. As a result of the potential for yield loss, many research and extension programs have been developed for this pest. Rather than relying solely on chemical control, incorporating multiple tactics will improve long-term soybean aphid management and also reduce production costs. A management plan with an IPM focus is now available with the following recommendations:

- Incorporate host plant resistance if available.
- Plant when seeds can germinate quickly.
- Scout for soybean aphid every 7–10 days, with the most attention focused on R1–R5.
- Consider the presence of biological control, weather, and plant quality factors when making treatment decisions.
- Base treatment decisions on the economic threshold of 250 aphids per plant or *Speed Scouting* to make treatment decisions.
- If more than one application is needed, consider alternating chemistry classes.
- Leave an untreated check strip to compare yield.

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SOYBEAN APHID FIELD GUIDE

*A reference for soybean aphid management
in the north central region*

