NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Soybean aphid

FIELD GUIDE
2nd Edition

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

IPM 0060 June 2018

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.

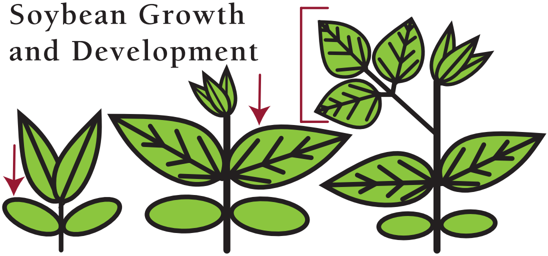
Table of contents

This publication is a regional cooperative effort between 11 land-grant universities, the USDA, and the North Central Soybean Research Program. This 2nd edition has been updated to reflect new developments in the understanding of soybean aphid biology and management. Portions of this field guide were adapted from the *Soybean Aphid Field Guide* (2nd edition) published by Iowa State University and the Iowa Soybean Association.

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 59 for contact information.

This publication is funded by the North Central Soybean Research Program.

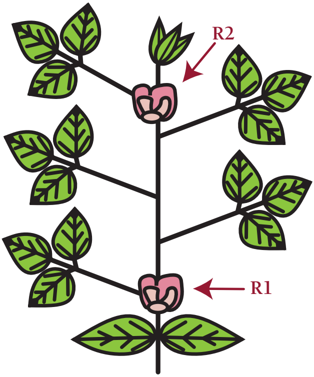
Soybean Growth and Development



VE
Cotyledon emergence

VC
Cotyledons expanded and unifoliolate leaves unrolled (not touching)

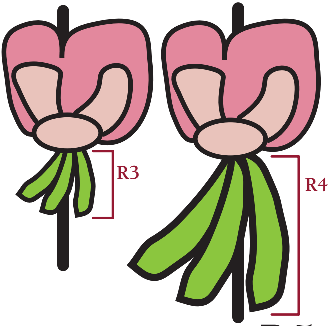
V1
First trifoliolate leaves unrolled (not touching)



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

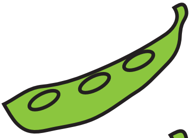


R3

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

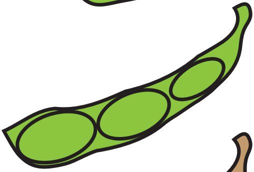
R4

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



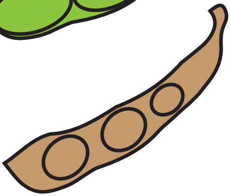
R5

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://soybeanresearchinfo.com

Blank copies of the *Speed Scouting* form
https://www.ent.iastate.edu/soybeanresearch/content/extension

Iowa State University Soybean Pest Podcast
https://www.ent.iastate.edu/soybeanresearch/podcasts/soybean-pest-podcast

Iowa State University Insecticide Evaluation Summaries https://www.ent.iastate.edu/soybeanresearch/content/extension

Biology of the soybean aphid
http://dx.doi.org/10.1603/IPM10016

Economics of Soybean Aphid Management
doi:10.1094/PHP-RV-16-0061

IRAC, Insecticide Resistance Action Committee
http://www.irac-online.org

Management of insecticide-resistant soybean aphids
https://tinyurl.com/ResistantAphids

Soybean aphid management
http://dx.doi.org/10.1603/IPM11019

CDMS pesticide labels
www.cdms.net/LabelsMsds/LMDefault.aspx

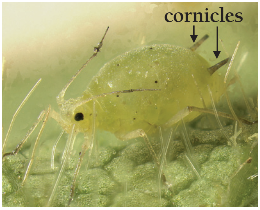
Biology

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.

Description

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 1⁄16 inch long. Healthy aphids are generally light green with red eyes and 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 adults except smaller. 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 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 $\frac{2}{5}$ 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 (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

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 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 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 1⁄8 inch long.

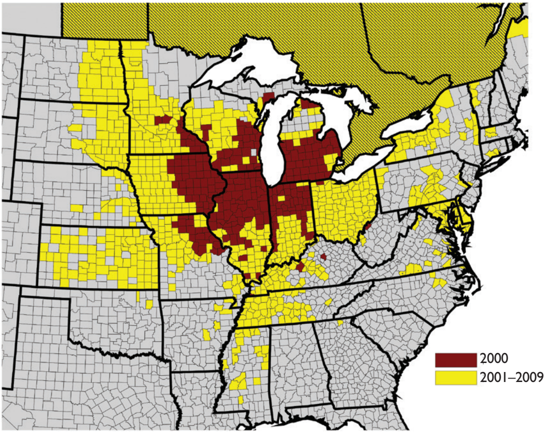
Lygus bug nymph

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 1⁄5 inch long.

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.

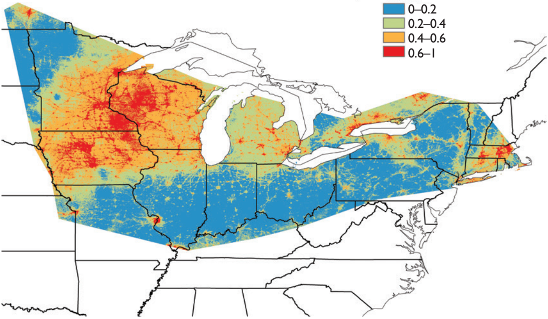
The first soybean aphid colonies in North America were confirmed in Wisconsin in 2000. Soybean aphid expanded its range rapidly and was detected in 22 states and three Canadian provinces within four years. We do not know how soybean aphid was introduced to North America, but they were likely transported 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.

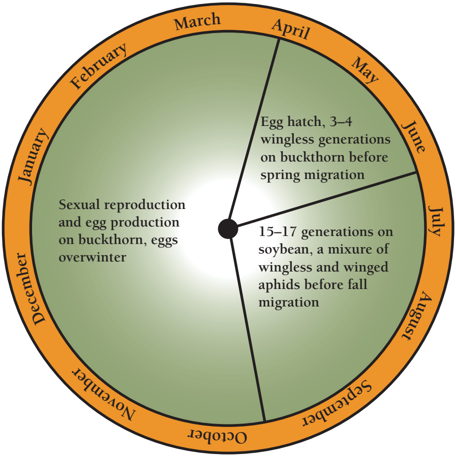


Probability of buckthorn distribution in North America
(Values greater than 0.2 have known occurrences for buckthorn.)

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

During the summer, embryos develop inside the females and adult females give live birth to nymphs. 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. Soybean aphid survives best between 47–95°F and optimal offspring production occurs at 82°F. 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

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.

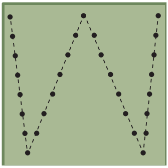
Scouting tips

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 the region's 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, may experience first colonization at soybean emergence (VE) 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.

Speed Scouting for Soybean Aphid

For blank forms, go to https://www.ent.iastate.edu/soybeanresearch/content/extension

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.

Field Location: ______________________

Average Plant Stage: ______________________

Date: ______________________

Treatment Decision: ______________________

Field Notes: ______________________

____

____

____

___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___ 8 ___ 9 ___ 10 ___ 11 ▶ [ ] ▶

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

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

+ = ≥ 40 aphids/ plant ('infested')

___ 12 ___ 13 ___ 14 ___ 15 ___ 16 ▶ ___ + ___ [ ] ▶

___ 17 ___ 18 ___ 19 ___ 20 ___ 21 ▶ ___ + ___ [ ] ▶

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.*

___ 22 ___ 23 ___ 24 ___ 25 ___ 26 ▶ ___ + ___ [ ] ▶

___ 27 ___ 28 ___ 29 ___ 30 ___ 31 ▶ ___ + ___ [ ] ▶

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

Speed Scouting was originally developed by Erin Hodgson, Brian McCornack, and David Ragsdale, University of Minnesota Entomology Department.

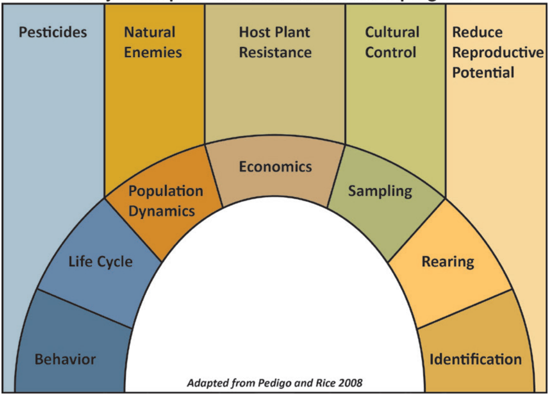
Integrated Pest Management

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 successful IPM program

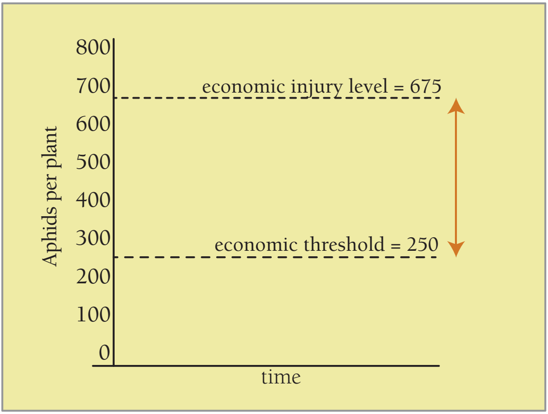


Economic threshold

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 damage boundary, 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. **An estimated net savings of $1.3 billion from 2003–2018 was because of the development and adoption of the economic threshold for soybean aphid.**

The relationship between aphid infestations and crop yield loss is often best characterized by converting weekly aphid count data 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. For implementation in management programs, cumulative aphid days can be converted to numbers of aphids per plant (see page 32).

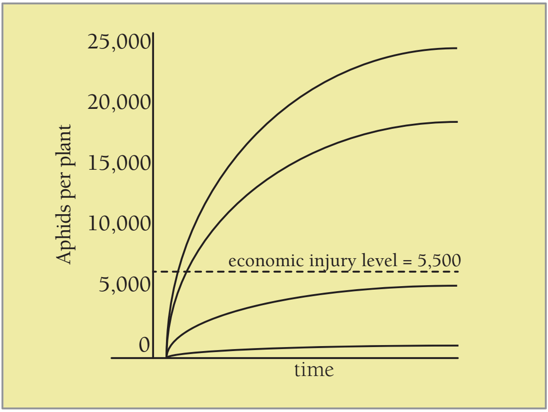
The damage boundary is the lowest pest abundance that will cause measurable yield loss. For soybean aphid, the damage boundary is about 4,000 to 5,000 cumulative aphid days (or 485–600 aphids per plant). Therefore, soybean plants can tolerate some infestation by aphids before experiencing any yield loss, let alone economic yield loss. Economic losses begin to occur at the eco-



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

nomic injury level, which is the point at which the value of yield loss equals the cost of a management action. The economic injury level for soybean aphid has been estimated at 5,500 cumulative aphid days (or 675 aphids per plant). See page 33.

Insecticide treatments must be applied before that level of pest infestation in order to avoid economic injury. Therefore, an economic threshold of 250 aphids per plant is recommended as the "trigger point" for making insecticide applications to prevent infestations from reaching the economic injury level. This should provide enough time to make a foliar insecticide application and protect



Examples of different cumulative aphid days for soybean aphid.

yield. 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. Although market values and control costs can vary by year and can affect the economic injury level, the damage boundary is a biological relationship between the plant and pest and is not affected by economics. The economic threshold of 250 aphids per plant remains valid as it is conservatively below the damage boundary. If implemented with regular scouting, it will protect from yield loss regardless of economic conditions.

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 some clover species and these weeds 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 fields 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. 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.

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

Lady beetles, continued

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 ⅛ 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 ½ 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 ⅘ 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

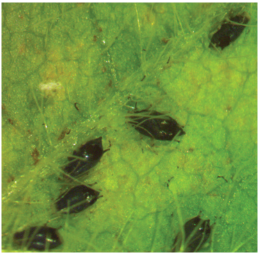
Hover flies

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 ¾ inch long.

Parasitoids

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. Initially in North America, parasitoids were not a significant source of biological control, so attempts are underway to introduce parasitoids of soybean aphid from Asia to the United States. Recently, however, an Asian parasitoid called *Aphelinus certus* is spreading through the northeastern United States and southern Canada and appears to be contributing to biological control of soybean aphid. It remains unknown how *A. certus* arrived in North America.



Black soybean aphid mummies

Soybean aphid being parasitized by a wasp

Soybean aphid mummy in a colony

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.

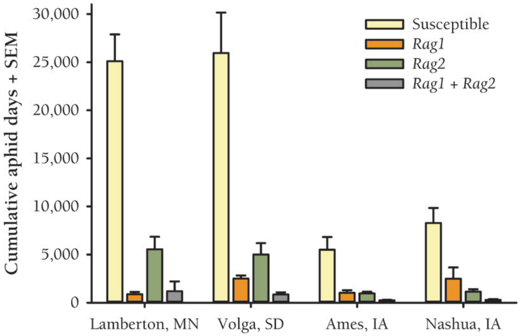
Host-plant resistance

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, reduced 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. Specifically, 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.). There are a few non-herbicide tolerant varieties with single and pyramided gene options in the north-central region. Although not common yet, we anticipate host-plant resistance to become a more widely available tool to manage soybean aphid. The Rag1+2-pyramid offers excellent suppression throughout most of the north-central region and greatly reduces the likelihood of needing foliar insecticides.



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 four 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.

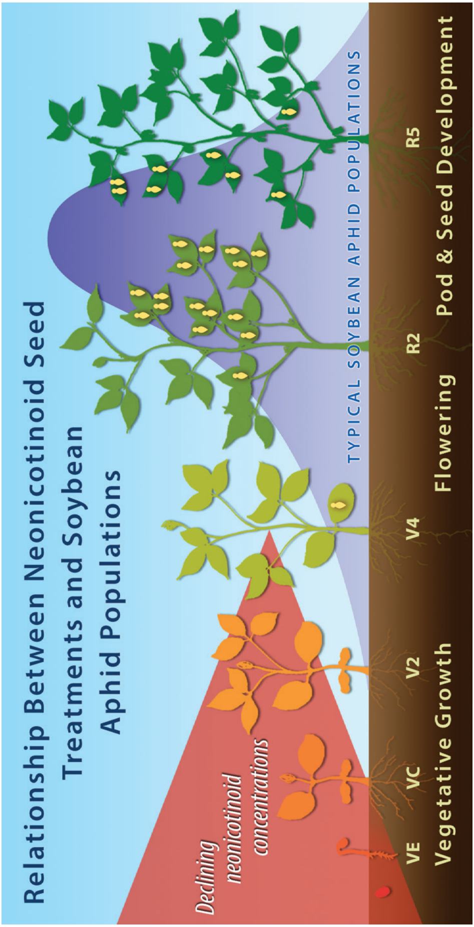
Chemical control

For the first decade of soybean aphid establishment in the north-central region, insecticides were the primary strategy for suppression. Organophosphates (Group 1B) and pyrethroids (Group 1A) are the most commonly used foliar insecticides for soybean aphid. 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 in places where soybean aphid is a persistent pest (e.g., Minnesota and Iowa). Reliance on and potential unnecessary use of insecticides increases risk for development of insecticide resistance in soybean aphid and secondary pests, as well as negative environmental and human health 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. 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 per acre. Typically, soybean seed treatments now include a combination of an insecticide and several fungicides.

Neonicotinoids are systemic and are absorbed through the roots and translocated through the xylem. This within-plant movement of neonicotinoids is ideal for protection from some early-season pests. Seed treatments are most effective during the early vegetative stages. Because colonization of soybean fields by soybean aphid typically occurs after this period, benefits of seed treatments for management of this pest may not be realized.



Purdue University Extension Entomology

A multistate research project has shown that use of scouting and threshold-based application of foliar insecticides provides higher return on investment than reliance on seed treatments for soybean aphid management. However, certain conditions or circumstances that decrease the duration of time between planting and colonization by aphids (such as late planting or fields that are historically colonized early), can increase the chances of positive return on the investment in seed treatments.

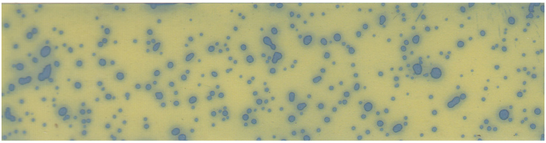
Insecticidal seed treatments offer soybean a narrow window of protection from seed and seedling pests. They are useful in targeted, high-risk situations that are not related to soybean aphid. Examples of high-risk soybean include (1) fields recently transitioned from pasture or grasslands, (2) recently incorporated manure or green cover crops, (3) double crop of soybean, and (4) specialty crop, like food grade or seed fields.

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

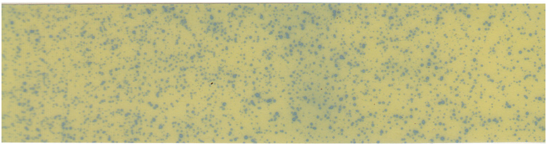
Foliar insecticides

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 (see page 51). 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 protect yield when soybean aphids reach the economic threshold (see pages 52–55). However, soybean aphid resistance to pyrethroid insecticides has recently been documented in the north-central region. When resistant populations of soybean aphid are suspected, insecticide choice, application methods, and follow-up scouting require special attention.



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



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

A small droplet size (bottom image) 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.

Through 2017, failures of some pyrethroid insecticides to control soybean and confirmed pyrethroid resistant aphids had been documented from Minnesota, North Dakota, South Dakota, and Iowa. Recommendations for preventing development of further resistance and for management of already resistant aphids are as follows:

- Treat field for soybean aphids only when indicated. Use scouting and the 250-aphid-per-plant threshold or *Speed Scouting* to determine when pesticide application is necessary.

- When insecticide application is required, do it well. Choose effective products, apply products at full labeled rates, use recommended volumes and pressures, avoid making applications under environmental conditions that could favor drift or compromise control, and scout field 3–5 days after application to ensure adequate pest suppression was achieved.

- If the insecticide application fails to control soybean aphid, rule out other factors that could cause a failure (e.g., applicator error, unfavorable environmental conditions, recolonization by the pest, etc.) to determine if population may be resistant. Report suspect cases of soybean aphid resistance to insecticides to local/state extension staff. If the field must be treated again to protect yield (i.e., populations exceeding threshold), alternate to a product containing an insecticide from a different labeled and effective insecticide group. For example, if the first application with a pyrethroid insecticide fails to provide adequate control, alternate to a product containing an organophosphate or neonicotinoid for the second application.

Examples of foliar insecticides with single active ingredients labeled for soybean aphid

Group No.[1,2]	Active Ingredient	Examples of Trade Names
1A (C)	methomyl	Lannate LV, Nudrin LV, others
1B (O)	acephate	Acephate 97, Orthene 97, others
	chlorpyrifos	Govern 4E, Hatchet, Lorsban 4E Warhawk, others
	dimethoate	Dimethoate 4E, Dimate 4E, others
3A (P)	alpha-cypermethrin	Fastac CS
	beta-cyfluthrin	Baythroid XL
	bifenthrin	Bifender FC, Bifenture EC, Brigade 2EC, Discipline 2EC, Sniper, Tundra EC, others
	cyfluthrin	Tombstone Helios
	deltamethrin	Delta Gold
	esfenvalerate	Asana, Zyrate, others
	gamma-cyhalothrin	Declare, Proaxis, Proaxis-Insecticide
	lambda-cyhalothrin	Grizzly Too, Karate, Lambda-Cy AG, LambdaStar, Province, Silencer, Warrior II, others
	permethrin	Permethrin, Perm-UP 3.2 EC, Arctic 3.2 EC, others
	zeta-cypermethrin	Mustang Maxx
4A (N)	clothianidin	Belay
	imidacloprid	Admire Pro, Alisa 4F, Nuprid 4F Max, others
4B (B)	flupyradifurone	Sivanto Prime

[1] Class and group number defined by IRAC; see page 6.

[2] C – carbamate; O – organophosphate; P – pyrethroid; N – neonicotinoid; B – butenolides.

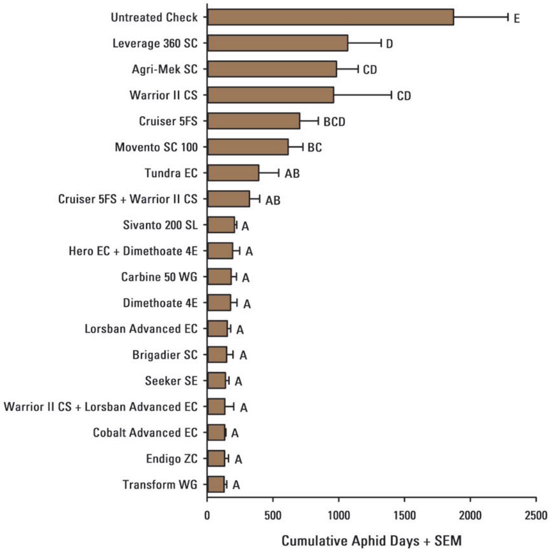


Figure 1. Aphid populations in insecticide efficacy trial A performed at the Northeast Research Farm in 2017. Trial was performed as a randomized replicated experiment with insecticides applied at the economic threshold. Means with a unique letter are significantly different at alpha = 0.10.

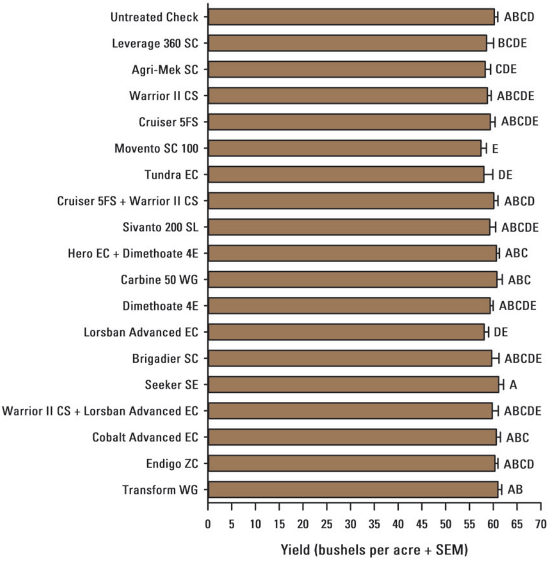


Figure 2. Yields from insecticide efficacy trial A performed at the Northeast Research Farm in 2017. Trial was performed as a randomized replicated experiment with insecticides applied at the economic threshold. Means with a unique letter are significantly different at alpha = 0.10.

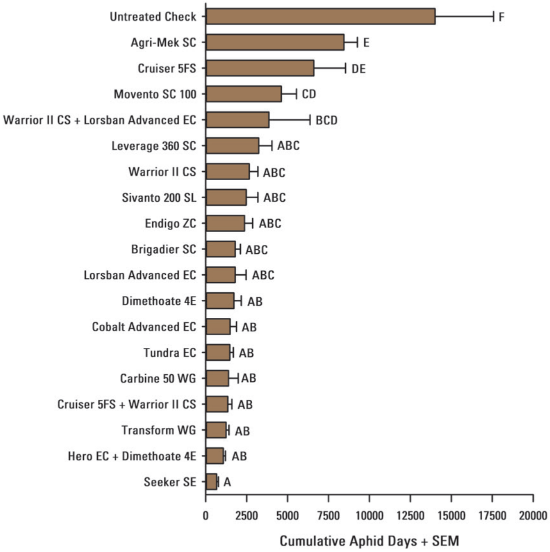


Figure 3. Aphid populations in insecticide efficacy trial B performed at the Northwest Research Farm in 2017. Trial was performed as a randomized replicated experiment with insecticides applied at the economic threshold. Means with a unique letter are significantly different at alpha = 0.10.

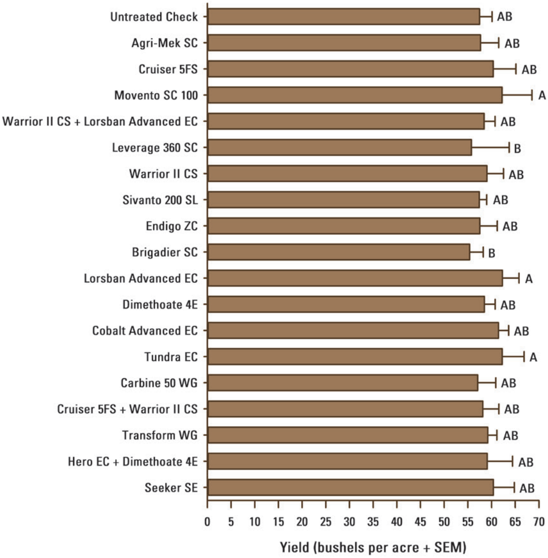


Figure 4. Yields from insecticide efficacy trial B performed at the Northeast Research Farm in 2017. Trial was performed as a randomized replicated experiment with insecticides applied at the economic threshold. Means with a unique letter are significantly different at alpha = 0.10.

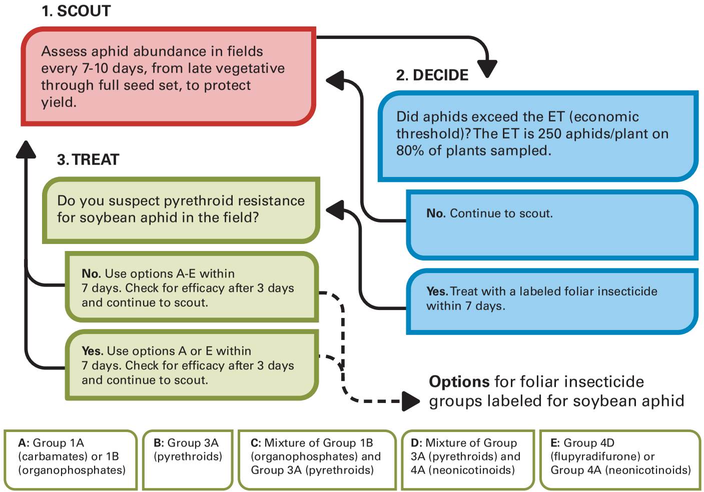
Tank mixing insecticides

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. When a field requires more than one application of insecticide in a season, alternation of products with individual insecticide active ingredients is generally more effective for insecticide resistance management than use of formulated mixtures (i.e., premixes) or tank mixes.

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. However, tank mixing insecticides with fungicides is only recommended if the target pests are present at the same time; prophylactic applications have not consistently shown 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.

Decision-Making Chart for Soybean Aphid



If more than one treatment is needed in the same growing season, use a different group number.

Sarah Carney, Iowa State University

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.
- Check fields for surviving aphids 3–4 days after an application.
- 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

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