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WS-36

EXPERT REVIEWED

Winter Annual Weeds and Soybean Cyst Nematode Management

With a Guide for Identifying Known Weed Hosts

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Support for the research for this publication was provided by the Indiana Soybean Alliance; USDA-Cooperative State, Research Education and Extension Service; North Central IPM Competitive Grants Program; and the Purdue University Botany and Plant Pathology Department.

Support for printing this publication was provided by the Indiana Soybean Alliance and Missouri Soybean Association & Missouri Soybean Merchandising Council.

A Destructive Duo

On their own, winter annual weeds and soybean cyst nematode (SCN) can cause significant problems in soybean fields. But now, six winter annual weeds have been identified as alternate hosts to SCN, and we have observed that SCN can reproduce in the field on purple deadnettle and henbit.

This means that fields with these weed hosts may be increasing SCN population densities at a faster rate than fields without these weeds. A recent study in Indiana found that known SCN weed hosts were prevalent in 93 percent of the fields surveyed (Creech and Johnson, 2006), indicating the possibility of a statewide increase in nematode population densities due to weeds.

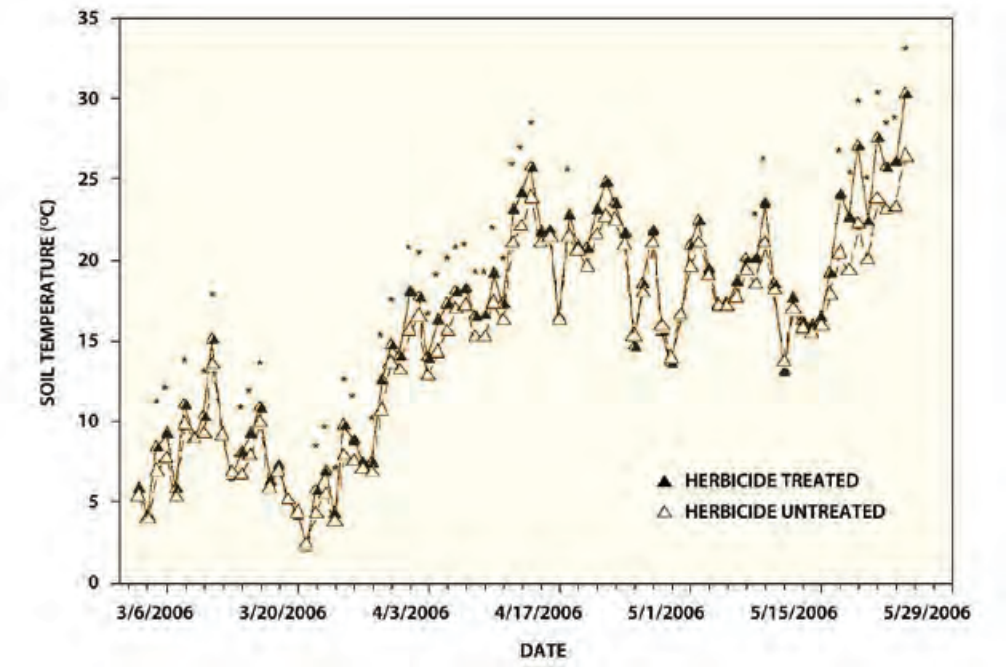
This publication will discuss the potential problems associated with winter annual weeds and SCN, examine weeds that are SCN hosts, and offer management practices aimed at reducing winter annual weed and SCN populations. A weed identification guide and glossary also are provided.

Winter Annual Weeds

Purdue Extension surveys indicate winter annual weeds are an increasing problem in crop production fields (Nice and Johnson, 2005). Adoption of conservation tillage, reduced reliance on herbicides with residual soil activity, and the recent trend of mild winters are factors that have contributed to the increase of winter annual weeds.

Figure 1.

Comparison of fall herbicide treated and untreated soil temperatures from two locations in Missouri during the corn planting season. Measurements began in early March and proceeded through the end of May. Asterisks indicate significant differences ($P<0.05$) in soil temperatures between weed free and weedy fields. Weedy fields had significantly lower soil temperatures in 41 out of 88 days compared.



Most winter annual weeds can germinate any time between late summer and early spring, but typically they emerge in the fall, over-winter as small seedlings, and complete their life cycles in the spring. Winter annual weeds can negatively affect cropping systems in a number of ways. For one, dense winter annual weed populations can slow the drying and warming of soil in the spring (Figure 1), which can lead to delayed planting and lower yields.

In conventionally tilled fields, the presence of winter annuals can increase tillage, labor, and fuel costs required for spring seedbed preparation. In no-till systems, these weeds can be difficult to control with late spring herbicide applications because they are often at an advanced growth stage. Similarly, winter annual weeds can interfere with crop seeding depth and crop establishment in high residue areas (Figure 2).

Figure 2.

Winter annual weeds can be especially difficult to control in conservation tillage systems during late spring.

Soybean Cyst Nematode

SCN consistently ranks as the most economically important soybean pathogen in the United States (Wrather and Koenning, 2006). SCN has been verified in most soybean producing states, and an ongoing Purdue Extension study has shown that it infests 82 of Indiana's 92 counties (Faghihi and Ferris, 2006).

The nematode's life cycle includes the egg, juvenile, and adult stages. After hatching from the egg, the juvenile enters a nearby root, feeds, and grows to an adult. During reproduction the female nematode becomes a cyst on the root that can

contain up to 500 eggs and serves as the survival stage (Figure 3). Under optimal field conditions (proper water and warmth) SCN's life cycle is about 28 days, so many generations are possible in one season.

Yield losses from SCN can be minimal to near-total depending on the severity of infestation, soil type, soybean cultivar, weather conditions, and presence of other soybean pests, such as weeds, insects, and fungal pathogens. SCN's "classic" visible symptoms include stunted and yellowed plants. These symptoms do not always occur, and yield losses up to 30 percent have been reported when there are no visible foliar injury symptoms (Noel, 1992). Regular soil sampling is the most reliable means of confirming and monitoring SCN infestations (Faghihi and Ferris, 2006).

Figure 3.

An SCN cyst on a purple deadnettle root.

Winter Weed Hosts of SCN

Six winter annual weed species have been documented as alternative hosts for SCN:

- **Purple deadnettle** (strong host)
- **Henbit** (strong host)
- **Field pennycress** (moderate host)
- **Shepherd's-purse** (weak host)
- **Small-flowered bittercress** (weak host)
- **Common chickweed** (weak host)

SCN reproduction on purple deadnettle and henbit in the greenhouse is so efficient, that it often equals or exceeds SCN-susceptible soybean (Figure 4).

Figure 4.

In greenhouse studies, SCN reproduction on purple deadnettle was more efficient than on SCN-susceptible soybean.

It is noteworthy that although just six weed species have been confirmed as hosts, many of the other commonly occurring winter annual weed species have not been screened for SCN host status. Therefore, other winter annual weeds may be capable of allowing SCN to infect and reproduce.

A recent survey assessed the prevalence of winter annual weeds in Indiana's SCN-infested production fields (Creech and Johnson, 2006). It found that 93 percent of SCN-infested fields surveyed contained winter annual weed hosts of SCN, often at very high densities. In fact, three of the top five most frequently observed weed species that occurred at the greatest densities are SCN host species: common chickweed, henbit, and purple deadnettle. Table 1 shows the frequency and density of winter annual weeds that host SCN, observed in Indiana fields.

Table 1.

Frequency and density of winter annual weeds in Indiana. Both of these species have been identified as alternative hosts of SCN.

	FREQUENCY	DENSITY
	% of fields with weed	plants/ft^2
Common chickweed	87	5.4
Henbit	53	2.6
Purple deadnettle	49	1.4
Small-flowered bittercress	42	0.5
Shepherd's-purse	40	0.4
Field pennycress	27	0.2

Implications for SCN Management

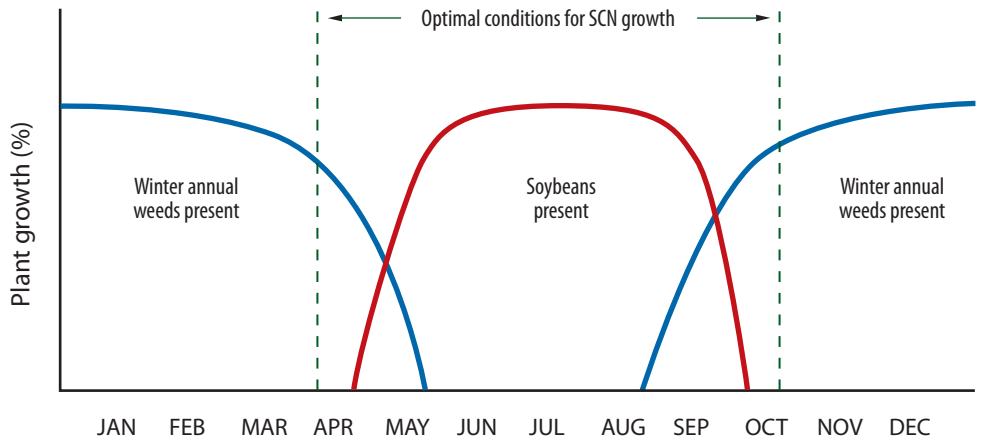
Long-standing SCN management practices include rotating to a non-host crop (such as corn, wheat, etc.) and using SCN-resistant soybean cultivars (Faghihi and Ferris, 2006). However, the widespread occurrence of winter annual weed species that can host SCN suggests that winter weed control may also be an important component of an SCN management program.

The Importance of Soil Temperature

In the field, the soil temperature's effect on SCN is particularly important. Alston and Schmitt (1988) found that SCN fails to develop at soil temperatures below 50°F. So, there is a window of time in the early fall and late spring when conditions favor both high SCN activity and winter annual weed growth (Figure 5).

Figure 5.

Timeline of winter annual weed and soybean growth.



For example, one study confirmed SCN reproduction on purple deadnettle at a site in southern Indiana in early fall (Creech et al., 2005). A separate experiment sampled fields in Indiana, Illinois, and Ohio to determine the geographical distribution of SCN on winter annual weeds (Creech et al., 2007a). Although SCN cyst and egg production on purple deadnettle was widespread (occurring in nine of the 10 surveyed fields) it was more common in the fall than the spring.

These findings suggest that management tactics designed to minimize the impact of winter weeds on SCN population density would probably be most effective if implemented in the fall, particularly early fall.

Herbicides that control winter annual weeds are typically applied in October and November. However, in field experiments, SCN population densities were unaffected when herbicides were applied in October (Creech et al., 2007b). The failure may have occurred because the herbicide was applied too late in the year and soil temperatures by October had already fallen below the threshold for SCN activity (Figure 1).

Three Management Practices

There are three winter weed management practices that will most likely reduce SCN population densities.

First, apply fall herbicides right after the combine leaves the field or as early in the fall as feasible. These early applications are necessary to disrupt the SCN life cycle while temperatures are still favorable for SCN development, but before egg production. Fall-applied glyphosate+2,4-D would be ideal and relatively inexpensive.

Fall-applied herbicides containing glyphosate+2,4-D+Canopy EX® (for fields going into soybean) or simazine (for fields going into corn) are effective in keeping winter weeds in check until late April or early May the following year.

Second, apply residual herbicides in soybean as preplant or postemergence treatments to reduce winter annual weed emergence in the late summer to early fall. Herbicides that have residual activity on some winter annual weeds include those that contain chlorimuron (Classic®, Canopy®, Synchrony®), imazethapyr (Pursuit®, Extreme®), imazaquin (Scepter®), cloransulam (FirstRate®, Gangster®, Sonic®, Authority First®), and metribuzin (Sencor®, Canopy DP®). Herbicide uses vary by state, so always read herbicide labels.

Third, apply residual herbicides in corn to reduce winter annual weed growth late in the growing season and early fall. Atrazine applied postemergence in corn (at least 1 pound of active ingredient per acre) and early fall-applied simazine (Princep®) for fields going into corn the following year, can provide useful residual activity on many winter annual weeds.

Control Weeds Before Planting

Although present inside purple deadnettle and henbit roots in both the fall and spring, SCN juveniles were generally found in greater numbers in the spring. The influx of SCN juveniles inside the roots of winter weeds in spring may highlight another management strategy: the importance of removing winter weeds prior to planting.

Delayed winter weed removal (spring burndown application timing), whether due to a wet spring or an attempt to control winter and summer annuals with a single application, may provide SCN juveniles the additional time they need to complete a reproductive cycle. In southern Indiana mid- to late March will probably be the best time to target spring burndown herbicide applications to affect SCN population density.

Summary

Winter annual weeds are an increasing problem and some winter annuals are alternative hosts for SCN, the most yield-limiting soybean pest in the United States. Planting SCN-resistant soybeans and rotating crops are proven SCN management options.

However, failure to control winter annual weeds may provide additional resources that allow SCN to reproduce and increase its population density in a field. So far, studies suggest that winter annual weeds are most vulnerable to SCN parasitism in the early fall and late spring. Therefore, controlling winter annual weeds at harvest and prior to planting may disrupt the SCN life cycle, and may prevent nematode population densities from increasing due to winter annual weeds.

Winter Annual Weed Identification

This section is designed to assist growers and crop specialists in identifying the six winter annual weeds that are alternative SCN hosts. They are arranged by host status (strongest host to weakest) and family (Riggs, 1992; Venkatesh, et al. 2000).

Alternative Weed Hosts of SCN

Weed	Scientific Name	Family	Host Status
Purple deadnettle	*Lamium purpureum*	Lamiaceae	strong host
Henbit	*Lamium amplexicaule*	Lamiaceae	strong host
Field pennycress	*Thlaspi arvense*	Brassicaceae	moderate host
Shepherd's-purse	*Capsella bursa-pastoris*	Brassicaceae	weak host
Small-flowered bittercress	*Cardamine parviflora*	Brassicaceae	weak host
Common chickweed	*Stellaria media*	Caryophyllaceae	weak host

Purple deadnettle

Henbit

Field pennycress

Shepherd's-purse

Small-flowered bittercress

Common chickweed

Family: Lamiaceae

Purple Deadnettle *(Lamium purpureum)*

SEED: Oblong-shaped with triangular edges, and primarily brown with light- to white-colored spots.

SEEDLING: Purple deadnettle germinates primarily in the fall. The cotyledon has a white tip, and is oval with a notch where the petiole connects. Its first leaves are opposite, hairy, and have a circular outline with rounded teeth along the edges.

LEAVES: Mature leaves are opposite and on short petioles. Leaves are dark green and have prominent venation, resulting in a crinkled look. Leaves at the base of the stem are hairy and circular in shape. Leaves at the top of the stem are hairy and triangular in shape.

STEMS: Square and greenish-purple in color, with the upper stems generally more purple. Stems tend to branch at the base of the plant and have hairs that point downward.

HEIGHT: 4-18 inches.

FLOWERS: Purple deadnettle blooms between April and October. Blooms are purple, ¼ inch long, and occur in upper leaves in whorls of 3 to 6.

SIMILAR SPECIES: Most often confused with henbit. Their cotyledons look alike, however, purple deadnettle's first true leaves have more venation. At maturity, purple deadnettle leaves are triangular, tinged purple, and compact near the top of the stem with petioles, while henbit has round to heart-shaped leaves that are sessile and not compact. Also, henbit leaves are generally more deeply lobed than purple deadnettle.

Purple deadnettle seedling with the cotyledon and first true leaves fully exposed

Seeds: 1.9 mm (0.075 inches) long

Purple deadnettle at flowering

Family: Lamiaceae

Henbit *(Lamium amplexicaule)*

SEED: Oblong-shaped with triangular edges, and primarily brown with light- to white-colored spots.

SEEDLING: Germinates in spring and fall. Cotyledons are oval, have a white tip, and notched where the leaf and petiole meet.

LEAVES: First leaves have opposite petioles. They are circular with rounded teeth along edges and slight venation causes a crinkled look. Leaves have hair on their upper surfaces and hair along the veins on their lower surfaces. Leaves at the top of the stem are sessile.

STEMS: Stems are square, tend to branch near the base of the plant, have hairs that point downward, and are green or purple.

HEIGHT: Up to 16 inches.

FLOWERS: Flowers are purple to pink and have a fused tube that is 2/3 inch long. Henbit can flower from March to November.

SIMILAR SPECIES: Most often confused with purple deadnettle. The petioles of henbit's cotyledons are generally longer and more vertical than purple deadnettle's. Henbit has leaves that are more deeply lobed than purple deadnettle, and generally does not have as much venation. Mature purple deadnettle has leaves on a petiole that are triangular and purple at the top of the stem, whereas henbit has sessile leaves that are generally not purple.

Henbit seedling with the cotyledon and first true leaves fully exposed

Seeds: 1.8 mm (0.071 inches) long

Henbit at flowering

Family: Brassicaceae

Field Pennycress *(Thlaspi arvense)*

SEED: Oval and black to reddish brown with grooves that look like a fingerprint pattern that run from the hilum to the middle of the seed. The base may have a piece of white seed stalk remaining.

SEEDLING: Plants that germinate in the fall can over-winter. Cotyledons are oval and have a bluish-green tinge with a long petiole. Young leaves are smooth and round to oval with petioles. When the basal rosette forms, the leaf margin is wavy and slightly toothed.

LEAVES: Leaves are egg-shaped, light green, and hairless. At maturity, no basal leaves are present. After bolting, leaves on the stem are oblong to lanceolate, have no petioles (sessile), have toothed leaf edges, and have lobes that are pointed and clasp the stem. Leaves emit a strong odor when disturbed.

STEMS: Stems have no hairs. The leaves generally fall off the stem as the plant matures and can be branched in the top part of the stem.

HEIGHT: 4-24 inches.

FLOWERS: Flowers are white with four petals. Flowers from April through June, and has a round seed pod (silicle) with a winged margin that is notched at the tip.

SIMILAR SPECIES: Often confused with thoroughwort pennycress (*Thlaspi perfoliatum*); however, thoroughwort pennycress stem leaf lobes are rounded, not pointed like field pennycress. Also, the notches at the tips of thoroughwort pennycress seed pods are more wide than deep. Field pennycress would have the opposite appearance. Field pennycress also is confused with field pepperweed (*Lepidium campestre*), but this weed has hairs on the leaves and more rounded seed pods.

A field pennycress rosette

Seeds: 1.6-2 mm (0.063-0.079 inches) long

Field pennycress at flowering

Family: Brassicaceae

Shepherd's-Purse *(Capsella bursa-pastoris)*

SEED: Reddish brown to yellowish brown with a groove that runs from the hilum to the seed tip, then curves back to the hilum. Seeds are oval in shape and may have a remnant of white seed stalk.

SEEDLING: Cotyledons have long petioles, and are egg shaped to round and narrower at the base. Young leaves are round and slightly hairy on surface with slightly toothed margins.

LEAVES: Generally, deeply lobed to deeply toothed leaves form around the 5th to 7th leaf and are dark green to silvery-gray.

STEMS: Stems are unbranched and slender with gray hairs.

HEIGHT: 6-18 inches.

FLOWERS: White with four petals. Flowers from spring to early summer and sometimes in autumn. Seed pod is heart-shaped.

SIMILAR SPECIES: Often confused with horseweed (*Conyza canadensis*), but horseweed seedlings generally have more hair than shepherd's-purse. Also confused with Virginia pepperweed (*Lepidium virginicum*), but this weed has a seed pod that is round, not heart-shaped like shepherd's-purse.

A shepherd's-purse rosette

Seeds: 0.9-1.2 mm (0.035-0.047 inches) long

Shepherd's-purse seedpods

Family: Brassicaceae

Small-Flowered Bittercress *(Cardamine parviflora)*

SEED: Oval to circular in shape, yellowish-orange, with a slightly notched hilum.

SEEDLING: Basal leaves are deeply lobed, which gives the appearance of 3-6 pairs of leaflets with a rounded terminal leaflet.

LEAVES: There are 4-10 stem leaves and no basal leaves at maturity. Leaves are generally hairless, but can be slightly hairy.

STEMS: Branched with some leaves.

HEIGHT: Up to 8 inches.

FLOWERS: Flowers are white with four petals. The seed capsule is a silique, which is long and narrow.

SIMILAR SPECIES: Often confused with hairy bittercress (*Cardamine hirsuta*), but this weed has persistent basal leaves and 2-5 stem leaves. Hairy bittercress leaves generally have more hair than small-flowered bittercress leaves.

A small-flowered bittercress rosette

Seeds: 1 mm (0.039 inches) long

Small-flowered bittercress at flowering

Family: Caryophyllaceae

Common Chickweed *(Stellaria media)*

SEED: Circular and grayish brown to reddish brown. The surface is covered with short rounded bumps. The hilum is slightly notched and a deep groove runs inward from it.

SEEDLING: Cotyledons are slender and ovate. Young leaves are opposite and round to egg-shaped with pointed tips. The hypocotyl is red.

LEAVES: Mature leaves are oppositely arranged, light green, egg-shaped, pointed at the tips, and hairless. Hairy petioles occur on most leaves, but petioles are not present on the upper leaves.

STEMS: Stems start to branch when five leaf pairs form. Stems are light green and generally smooth, but may have 1-2 rows of hairs.

HEIGHT: 1-4 inches tall and creeping stems that can grow up to 11 inches long.

FLOWERS: Flowers have five white petals that bloom from early spring to autumn.

SIMILAR SPECIES: Often confused with corn speedwell (*Veronica arvensis*), but speedwell has blue flowers and leaves with rounded teeth along the edges. Also confused with mouseear chickweed (*Cerastium vulgatum*), but this weed's leaves are oblong and densely covered in hair.

A common chickweed seedling

Seeds: 1.1-1.3 mm (0.043-0.051 inches) long

Common chickweed at flowering

Glossary

basal rosette	Leaves radiating from the stem of the plant in a circular cluster at ground level.
cotyledon	The seed leaf.
hilum	The scar on the surface of the seed where it was connected to the seed stalk.
hypocotyl	The stem below the cotyledons.
leaflet	One subunit of a compound leaf.
petiole	The stalk between the stem and leaf blade.
sessile	Lacking a petiole.
silicle:	Fruit of the Brassicaceae that is not much longer than wide (if at all).
silique	Fruit of the Brassicaceae that is an elongated capsule.
terminal leaflet	Occurs at the tip of the main compound leaf as a single subunit.
winter annual	Plant that germinates in late summer to early spring, flowers, produces seed in mid- to late spring, then dies.

References

Alston, D. G. and D. P. Schmitt. 1988. Development of *Heterodera glycines* life stages as influenced by temperature. J. Nematol. 20:366-372.

Bradley, K., and S. Hagood. Virginia Tech Weed Identification Guide. http://ipm.ppws.vt.edu/weedindex.htm. Accessed: 2/19/2007.

Britton, N.L., and H.A. Brown. 1970. An Illustrated Flora of the Northern United States and Canada. Vol 2. Dover Publications Inc. N.Y. pp. 184-185.

Creech, J. E., and W. G. Johnson. 2006. Survey of broadleaf winter weeds in Indiana production fields infested with soybean cyst nematode (*Heterodera glycines*). Weed Technol. 20:1066-1075.

Creech, J. E., W. G. Johnson, J. Faghihi, V. R. Ferris, and A. Westphal. 2005. First report of soybean cyst nematode reproduction on purple deadnettle under field conditions. Online. Crop Manage. doi:10.1094/CM-2005-0715-01-BR.

Creech, J. E., W. G. Johnson, J. S. Webb, B. G. Young, J. P. Bond, S. K. Harrison, A. Westphal, J. Faghihi, and V. R. Ferris. 2007a. Fall and spring development of soybean cyst nematode (*Heterodera glycines*) on henbit and purple deadnettle in the eastern Corn-Belt. Weed Technol. (in press).

Creech, J. E., W. G. Johnson, J. Faghihi, V. R. Ferris, A. Westphal, and T. J. Vyn, J. B. Santini. 2007b. Influence of winter weed management and crop rotation on weed growth, the weed seedbank, soybean cyst nematode (*Heterodera glycines*) population density, and crop yield. Weed Sci. (in press).

Delorit, R.J. 1970. An illustrated Taxonomy Manual of Weed Seeds. Agronomy Publications. WI. pp.78-151.

Faghihi, J., and V. R. Ferris. 2006. Soybean cyst nematode. Department of Entomology. Purdue University. Web page: http://www.entm.purdue.edu/Entomology/ext/targets/e-series/EseriesPDF/E-210.pdf. Accessed: October 20, 2006.

Nice, G., and B. Johnson. 2005. Indiana's top ten most problematic weeds. Purdue University Weed Science Extension Bulletin. Web page: http://www.btny.purdue.edu/weedscience/2005/topten05.pdf. Accessed: October 20, 2006.

Noel, G. R. 1992. History, distribution, and economics. Pages 1-3 in Riggs, R. D. and J. A. Wrather, eds. Biology and Management of the Soybean Cyst Nematode. St. Paul, MN: American Phytopathological Society.

Uva, R.H., J.C. Neal, and J.M. DiTomaso. 1997. Weeds of the Northeast. Cornell University Press. South Korea. pp. 172-248.

Venkatesh, R., S. K. Harrison, and R. M. Riedel. 2000. Weed hosts of soybean cyst nematode (*Heterodera glycines*) in Ohio. Weed Technol. 14:156-160.

Wrather, J. A., and S. R. Koenning. 2006. Estimates of disease effects on soybean yields in the United States 2003 to 2005. J. Nematol. 38:173-180.

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