Cultivar maturity
CK
MG
LB
2000
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990
1989
1988
1987
1986
1985

University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, Marc A. Johnson, Director.

Late-planted/double-cropped
Late (MG V)

CR
KWPR
KM

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Soybean Cyst Nematode

Although SCN was discovered in 1985, it is still an emerging problem in Kansas. Historically, SCN has primarily been a problem for southern corn belt states. In the last several years, SCN has been observed with increasing frequency in Kansas, particularly in the southeastern area of the state.

The soybean cyst nematode (SCN) or Heterodera glycines is a microscopic, worm-like organism ranging in length from 0.3 to 0.5 mm. The female nematode has a white, pear-shaped body 0.25 to 0.5 mm in length. Upon fertilization by the male, the female nematode swells and becomes sedentary, remaining attached to the plant root.

Upon hatching, juveniles (Fig. 2B) migrate short distances through the soil and enter plant roots near the tips. They burrow into the root and begin feeding on young root cells. Eventually, the nematode mature and fertilize the female, whose body swells and the rear of the female becomes indurate, or hardened.

The female then settles in the soil and soon dies. The male dies within a few days. Following mating, the males are usually exhibited less yield loss due to SCN than earlier-maturing cultivars (Fig. 8b). A similar relationship has been documented for SCN in Iowa. In southeastern Kansas, maturity group V varieties usually exhibit less yield loss due to SCN than earlier-maturing cultivars (Fig. 8b). A similar relationship has been documented for SCN in Iowa.

The most commonly observed symptom associated with SCN is reduced yield. Identifiable symptoms of plant damage are often difficult to observe, especially in high-yielding environments such as irrigated soybeans. The visual symptoms of SCN injury that do occur can usually be confused with other soybean production problems including plant disease, herbicide injury, Phytophthora root rot, and soil compaction. In Kansas, SCN is usually not the primary cause of yield loss on susceptible soybean crops. Likely, yield loss occurs on a susceptible soybean crop following 3 years of rotation with nonhost crops and resistant soybean varieties.

Unlike females, males do not become sedentary nor do they return to the soil and soon die. Males are rarely observed in the field. Fertilization by the male is necessary for reproduction. Following mating, the males return to the soil and die.

IELD SYMPTOMS

The soybean cyst nematode is a microscopic, worm-like organism ranging in length from 0.3 to 0.5 mm. Upon hatching, juveniles (Fig. 2B) migrate short distances through the soil and enter plant roots near the tips. They burrow into the root and begin feeding on young root cells. Eventually, the nematode mature and fertilize the female, whose body swells and the rear of the female becomes indurate, or hardened. The adult female’s body swells, and the root portion breaks through the surface of the root (Fig. 2C). A female produces an average of 200 to 200 eggs (Fig. 2A) in about 30 days. A few eggs are ingested into the soil in a jelly-like mass, but the majority are retained within the body. The oviparous body starts out white, but then yellow, then brown, forming cysts as the female ages and dies. As maturity and death, the cysts are broken off from the root.

Unlike females, males do not become sedentary or do they form cysts. Adult males do not feed, but move into the root where they remain for a few days, during which time they may or may not fertilize the females that have begun egg production. Eggs do not develop without fertilization by the male. Following mating, the males return to the soil and die.

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Unlike females, males do not become sedentary or do they form cysts. Adult males do not feed, but move into the root where they remain for a few days, during which time they may or may not fertilize the females that have begun egg production. Eggs do not develop without fertilization by the male. Following mating, the males return to the soil and die.
nutrient deficiencies or other disease. In heavy infestations, symptoms may first appear at the soil line and move up the plant stem toward the leaf sheaths. Infested areas may increase in size annually and through local seed dealers. The only spread of SCN occurs by any means of soil movement. Local spread of SCN occurs primarily by the movement of seed lots and through local seed dealers.
Cultivar maturity

Field symptoms associated with SCN attack in soybean include a range of plant growth and development symptoms (Fig. 2) that may be observed in the field from the time of flowering through harvest. SCN infection may lead to dramatic reductions in yield and quality. The ability of SCN to reduce soybean yield is influenced by a variety of factors including the stage of infection, cultivar maturity, crop growth stage, and SCN population density. Below is a discussion of the impact of each of these factors on soybean yield.

**Cultivar Maturity**

The impact of SCN on soybean yield is strongly influenced by the stage of plant development at the time of attack. SCN generally causes greater yield loss in earlier-maturing cultivars than in later-maturing cultivars. This is illustrated in Fig. 8, which shows that late-maturing cultivars are generally less susceptible than early-maturing cultivars to SCN attack. The difference in susceptibility between early and late-maturing cultivars is due to the different stages of maturity at which SCN infection occurs. Early-maturing cultivars are generally more susceptible to SCN infection than late-maturing cultivars because they are more vulnerable to attack during the early stages of growth when their root systems are more susceptible to infection. Late-maturing cultivars, on the other hand, are more resistant to SCN infection because they are less susceptible to attack during the later stages of growth when their root systems are more resistant to infection.

**Cropping System**

The impact of SCN on soybean yield is also influenced by the cropping system used. SCN can be effectively managed by incorporating resistant cultivars and/or nematicides into the cropping system. Recent research has shown that SCN population densities can be reduced by up to 90% when a susceptible cultivar is planted in a rotation with a non-host crop such as corn or fallow. This is illustrated in Fig. 8, which shows that the yield loss caused by SCN is greatest in continuous soybean fields and decreases in rotations with non-host crops. The benefits of SCN management are greatest when a susceptible cultivar is planted in a rotation with a non-host crop, as this reduces the risk of SCN infection and increases the yield of the subsequent soybean crop.

**Year**

The impact of SCN on soybean yield is also influenced by the year in which the crop is grown. SCN populations can increase rapidly on susceptible cultivars, even when low levels of SCN are present, and these populations can increase rapidly on susceptible cultivars. Several factors, such as the availability of host plants and environmental conditions, can influence the growth and development of SCN populations. The impact of these factors on SCN population densities and soybean yield is illustrated in Fig. 8, which shows that SCN population densities and soybean yield decrease in years with favorable environmental conditions and increase in years with unfavorable environmental conditions.

**Table**

<table>
<thead>
<tr>
<th>Cultivar Maturity</th>
<th>Late (LMM)</th>
<th>Early (LSM)</th>
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<tr>
<td>Yield (kg/ha)</td>
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**Diagram**

Fig. 1. Distribution and spread of SCN in Kansas. Susceptible varieties treated with nematicides produce yields comparable to, but not better than, susceptible varieties that are not treated with nematicides. The benefits of SCN management are greatest when a susceptible cultivar is planted in a rotation with a non-host crop, as this reduces the risk of SCN infection and increases the yield of the subsequent soybean crop.
Fig. 3. Female index does not represent SCN populations based on root cyst numbers as it uses an index of the number of cysts that develop on a set of four different susceptible soybean cultivars. Population diversity can be calculated as follows:

\[
\text{Female index} = \frac{\text{Number of cysts on the susceptible variety}}{\text{Number of cysts on the resistant variety}}
\]

The female index is the ratio of the total number of cysts on a susceptible variety compared to the number on a resistant variety. A female index of 0 indicates no difference in cyst production between the two varieties, while a female index greater than 1 indicates that the resistant variety is producing more cysts than the susceptible variety. A female index less than 1 indicates that the susceptible variety is producing more cysts than the resistant variety.

Fig. 4. Effect of SCN resistance genes on rice yield. A, line N12A shows significantly higher yield than N12E in all environments tested. B, compared to the standard susceptible cultivar, female index was significantly higher in line N12E compared to N12A in all environments tested.

Fig. 5. Yield advantage of soybean varieties with SCN resistance derived from planting a resistant variety on moderately-infested, irrigated sands. Data from planting a resistant variety on moderately-infested, irrigated sands.

Fig. 6. Decline in SCN egg levels during a rotation of nonhost crops with soybeans. Egg numbers are averages of four nematode-infested locations in Kansas. Pf/Pi = number of eggs and nematode populations. Indices are calculated as the % cyst production on each PI 88788 over a susceptible variety in the presence of SCN populations. Indices are calculated as the % cyst production on each PI 88788 over a susceptible variety in the presence of SCN populations. Indices are calculated as the % cyst production on each resistant variety compared to the standard susceptible cultivar. Female index does not represent SCN populations based on root cyst numbers as it uses an index of the number of cysts that develop on a set of four different susceptible soybean cultivars. Population diversity can be calculated as follows:

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Nutrient deficiencies or other problems. In heavy infestations, symptoms may be more obvious. By mid-season (or late June to early July), signs may be evident.

Infested areas may increase in size annually and develop a yellow cast to the leaves or wilting of the plants. By late season, plants may be stunted, and roots may be discolored. Infestation levels must be carefully monitored to optimize the output of the population. For each line, the yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

Resistant Varieties. Resistant soybean varieties work by limiting the reproduction of SCN on roots, which typically results in nematode population declining during the growing season. SCN population densities are usually lower on resistant varieties than susceptible varieties because SCN populations increase from large egg densities in spring to much lower densities in fall. Because SCN infestations reduce nematicidal activity by several orders of magnitude, SCN populations on resistant soybean lines are often very low. The percent yield advantage of SCN-resistant varieties is often great (e.g., PI 88788 over a susceptible variety in the presence of three SCN populations). Data are averages of eight environments. The amount of yield loss in a soybean crop is usually related to the SCN egg density at planting. The damage threshold is the population density at which a significant yield loss occurs. Threshold levels vary with environment, but are lowest under conditions that favor large population increases such as warm seeded beds, long growing seasons, and warm temperatures. In Kansas, economic damage in crop seeded soils can occur with an average of 300 eggs/100 cm $^3$ of soil. For planting a resistant variety in a contaminated soil, the planting area should be reduced below damage thresholds, so susceptible varieties become a

DOB (days after planting) vs. SCN population (eggs/100 cm $^3$ of soil) for each of the four SCN populations. The data points represent population densities at planting or one year later. Data are averages of four environments.

**Figure 5. Yield advantage of soybean varieties with SCN resistance derived from different sources.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 6. Decline in SCN egg levels during a rotation of nonhost crops.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 7. Host status of four soybean varieties and seven other crops for two SCN populations.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 8. Effect of resistance on SCN populations in soybean and nonhost crops.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 9. Effect of SCN population densities on crop yields.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 10. Effect of SCN population densities on crop yields.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 11. Effect of SCN population densities on crop yields.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.

**Figure 12. Effect of SCN population densities on crop yields.** The data points represent population densities at planting or one year later. Data are averages of four environments. A significant yield advantage over the susceptible standard Lee can be calculated as the percent yield of the resistant variety compared to that of the susceptible variety. Error bars represent minimum and maximum values.
The soybean cyst nematode is a microsymbiotic, worm-like organism ranging in length from 1/64 to 1/16 inch. Upon emergence from its cyst, the primary female undergoes transformation into a third-stage juvenile. This is the infective juvenile stage that infects the roots. The larger nitrogen nodule can be used for size comparison.

A female produces an average of 100 to 200 eggs during her lifetime. Unlike females, males do not become sedentary nor do they form cysts. Adult males do not feed, but move into the root where they remain for a few days, during which time they may or may not fertilize the females that have begun egg production. Eggs do not develop without fertilization by the male. Following mating, the males return to the soil and soon die.

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The most commonly observed symptom associated with SCN is reduced yield. Identifiable symptoms of plant damage are often difficult to discern, especially in heavily infested fields with high yields. Aboveground symptoms associated with SCN include seedling blight damage, iron chlorosis, charcoal rot, drought, Phytophthora root rot, and soil compaction. Yield loss may occur for several years before visible symptoms appear. The first noticeable symptoms are roughly circular spots in the field in which soybean plants may show signs of stunting, yellowing or nutrient deficiency (Fig. 2). Roots have fewer lateral roots and nitrogen-fixing root nodules.

In heavily infested soils, the direct nematode may return from the root zone. Field symptoms may be more difficult to discern because SCN is often detected in field collections at low population levels. The greatest management benefit from no-till may be expected for areas of the state where the adapted soybean varieties are all of the indeterminate growth type (e.g. maturity groups II through IV). The same pattern is not expected for areas of the state where the adapted soybean varieties are all of the indeterminate growth type (e.g. maturity groups II through IV).

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