The soybean cyst nematode is a microscopic, worm-like organism ranging in length from 1/64 to 1/16 inch. Upon hatching, juveniles migrate short distances through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells. Females become immobile as they continue to feed and mature. The adult female forms a ruptured cyst in the root, and fertilizes the eggs contained within. Several generations of SCN can occur in a single growing season. Yield losses as great as 30% occur on a susceptible soybean crop following 3 years of rotation with nonhost crops and resistant soybean varieties. Nematode populations can increase rapidly on susceptible cultivars. Several years without infestations or tillage can result in confusion about the host status of a number of crop and weed plants, making general recommendations difficult.

The most commonly observed symptom associated with SCN is reduced yield. Identifiable symptoms of plant damage are often difficult to diagnose, especially in years of high yielding environments such as irrigated soybeans. The visible symptoms of SCN injury that do occur can be confused with other soybean production problems including poor drainage, herbicide injury, wind or frost 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die. Above-ground symptoms associated with SCN injury 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die. Above-ground symptoms associated with SCN injury include: seedling blight damage, iron chlorosis, charcoal rot, drought, Phytophthora root rot, and soil compaction.

Fig. 1. Stages of development of a soybean cyst nematode infection.

- **First stage juvenile**. This is the organism ranging in length from 1/64 to 1/16 inch. Upon hatching, juveniles migrate short distances through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells.
- **Second stage juvenile**. This is the second stage juvenile. This is the form that feeds on soybean roots,mates and produces eggs.
- **Third stage juvenile**. This is the third stage juvenile. This is the form that is most active in cornfields.
- **Adult female**. This is the adult female. This is the form that produces eggs and returns to the soil to dies.
- **Egg mass**. This is the egg mass. The larger orange-red colored eggs are often found in this mass.
- **A heavily infested root system**.
- **Flotation of a cyst**. This is the flotation of a cyst. When a cyst is used, the cyst is floats to the top of the water.
- **A female produces an average of 100 to 200 eggs**. This is the number of eggs produced by a female soybean cyst nematode.
- **The soybean cyst nematode is a microscopic, worm-like organism ranging in length from 1/64 to 1/16 inch. Upon hatching, juveniles (Fig. 2B) migrate short distances through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells.**

The most commonly observed symptom associated with SCN is reduced yield. Identifiable symptoms of plant damage are often difficult to diagnose, especially in years of high yielding environments such as irrigated soybeans. The visible symptoms of SCN injury that do occur can be confused with other soybean production problems including poor drainage, herbicide injury, wind or frost 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die. Above-ground symptoms associated with SCN injury 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die. Above-ground symptoms associated with SCN injury 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die. Above-ground symptoms associated with SCN injury 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. 2A). A heavy infestation produces yellow or dark green leaves, and the plants may die.
nutrient deficiencies or other diseases. In heavy infestations, symptoms are most evident from the mid to upper portion of the plant, and in lighter infestations, symptoms may not be apparent until the plants are 2 to 4 weeks old. Infested areas may increase in size annually and oval in shape, expanding laterally as long as nematodes are present in the soil. Damage is most severe in sandy soils where the water film is thin and drainage is poor. In heavier soils, nematode numbers are more variable, however, serious SCN damage also occurs in heavier soils.

DIAGNOSIS

Accurate diagnosis of the problem may be delayed several years because of the similarity of symptoms to other production problems. Frequently, SCN is suspected only after eliminating all other possibilities. The only sure way to identify SCN damage is to use a soil test. Soil samples can be collected throughout the year, but county extension offices have soil profiles available to loan if you do not own your own. Collect 10 to 20 soil cores in a tight pattern across the entire area to be sampled. Collect cores to a depth of 6 to 8 inches. Ideally, a sample should be taken from each 10- to 20-acre area of the field. Separate samples should be submitted when several areas of the field are to be sampled. When soybean stumps are present, probing directly in the row will maximize the chances of finding SCN. A population of SCN can vary from race to race, and it is a good practice to sample both the primary and secondary races. In some areas, a soybean seed sample bag and label are provided with the bag of wheat with which you pair your field. Field populations traditionally have been classified as resistant, moderately resistant, and susceptible. Each race is found in different parts of the world. The goal of SCN management is to minimize the risk of soybean yield damage. This is achieved by reducing and maintaining SCN egg numbers below economic damage levels.

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 level at which 25 percent of stems are damaged. The percentage of stems damaged is calculated as the number of stems damaged divided by the total number of stems counted. The threshold level is expressed as the number of viable cysts per 100 grams of soil at planting or 1,000 eggs per 100 grams of soil at initial soil sample collection. Seed should be treated with an effective seed protection product, or the SCN population should be reduced to levels below threshold. SCN populations usually are reduced by following sound SCN management practices. SCN populations in the United States are primarily composed of the Eastern race, R1. The R1 race is resistant to most commonly used SCN seed products. SCN populations in the western United States are primarily composed of the Western race, R2. The R2 race is more susceptible to commonly used SCN seed products. SCN populations in the southeastern United States may have races R1 and R2 or may be composed primarily of R1. The R1 race is resistant to most commonly used SCN seed products. SCN populations in the southeastern United States may have races R1 and R2 or may be composed primarily of R1. The R1 race is resistant to most commonly used SCN seed products.
A female produces an average of 100 to 200 eggs during her lifetime. Upon hatching, juveniles (Fig. 2B) migrate short distance through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells. Females become immobile as they continue to feed and mature. The adult female organism ranging in length from 1/64 to 1/16 inch. Upon fertilization by the male. Following mating, the males sperm pass through the ruptured cyst and fertilizes the eggs in the cyst (Fig. 2C). Gametes develop into infectious juveniles which can then invade new soybean plants. A heavily infested root system.
nutrient deficiencies or other diseases. In heavy infesta-
tions, symptoms are most easily seen as a result of a 6 to 12 inch tall nodule. In lighter infections, symptoms may not be apparent until the soybeans reach the ear size. Infested areas may increase in size annually and be more evident in the top one-third of the field. Damage is usually most severe on lower-lying, well-watered areas. In infested areas, leaves tend to turn the margin of leaves yellow to brown. Yellowing symptoms are more severe in furrows and other low areas. If plants are infested, the leaves may also become stunted and die, reducing the growth rate and yield. Infestations can be controlled by repeated tillage and planting on moderately-infested, irrigated sands. \[\text{Populations of SCN are genetically diverse, varying in their ability to reproduce on different plant species and environments and their ability to resist management by any means of soil movement. Local spread of SCN occurs primarily by being carried on equipment or in soil attached to the bottom of tillage equipment.} \]

**Cyst Nematodes**

These nematodes are most commonly found on roots near the perimeter of a severely affected area. The glossy, enlarged bodies of female cyst nematodes are most common, but as the season progresses, all stages of cyst colors are present. Attached cysts may be easier to find on roots near the perimeter of a severely affected area, than on the more severely damaged plants. Do not rely upon visual inspection of attacked cysts for diagnosis.

**GENETIC DIVERSITY**

Populations of SCN are genetically diverse, varying in their ability to reproduce on different plant species and environments and their ability to resist management by any means of soil movement. Local spread of SCN occurs primarily by being carried on equipment or in soil attached to the bottom of tillage equipment. The glossy, enlarged bodies of female cyst nematodes are most common, but as the season progresses, all stages of cyst colors are present. Attached cysts may be easier to find on roots near the perimeter of a severely affected area, than on the more severely damaged plants. Do not rely upon visual inspection of attacked cysts for diagnosis.

**POPULATION INCREASE AND SPREAD**

The amount of yield loss in a soybean crop is usually related to the level of SCN infestation at planting. The damage threshold is the level in population size at which measurable yield loss occurs. Threshold levels vary with environ-
ment, but are lowest under conditions that favor large population increases such as warm-soaked seed, long growing seasons, and warm temperatures. In Kansas, economic damage in crop soya is usually the result of infestations greater than 50 cysts per 100 cm of seed line. Damage thresholds may limit adaptation of SCN populations in some areas. This strategy, while often recommended, has not been proven to be effective.

**MANAGEMENT**

The goal of SCN management is to minimize the risk of soybean yield loss and to prevent the development of resistance to soybean variety (Fig. 6). soybean crops. SCN-resistant soybean varieties have been developed to resist SCN populations in the southern United States, where the nematode has already spread throughout the field. SCN populations in soybean crops is being incorporated into adapted soybean varieties by breed- ers. These resistant varieties, derived from the soybean variety derived from the soybean variety Delsoy 4500, are available at K-State Research and Extension offices. These resistant varieties, derived from the soybean variety derived from the soybean variety Delsoy 4500, are available at K-State Research and Extension offices. These resistant varieties, derived from the soybean variety derived from the soybean variety Delsoy 4500, are available at K-State Research and Extension offices. These resistant varieties, derived from the soybean variety derived from the soybean variety Delsoy 4500, are available at K-State Research and Extension offices. These resistant varieties, derived from the soybean variety derived from the soybean variety Delsoy 4500, are available at K-State Research and Extension offices.
nutrient deficiencies or other factors. In heavy infestations, symptoms may be more apparent and severe 4 to 6 weeks after establishment. In lighter infestations, symptoms may not be apparent until 2 to 3 months after establishment. Nutrient-deficit areas may increase in size annually and become oval shaped, expanding in the direction of tillage. Damage is usually most severe in the central infested areas, because loss occurs closer to the margins of infested areas, and nematodes tend to locate in areas of lower nutrient levels as well. However, severe SCN damage also occurs in heavier soils.

**DIAGNOSIS**

Accuracy of diagnosis of the problem may be delayed several years because of the similarity of symptoms to other production problems. Frequently, SCN is suspected only after eliminating all other possibilities. The only sure way to identify SCN damage is by a soil test. Soil samples can be collected throughout the year, but the best time is immediately following soybean harvest is the optimum time since SCN numbers tend to be highest when the plants are almost mature. If SCN population densities are very high, it may be necessary to sample several different fields for the following growing season. Soil samples should be submitted when several areas of a large field are to be sampled. When soybean plants or stubble is present, the surest way to identify SCN damage is by a soil test. Bulk the cores in a container (bucket) and mix thoroughly. Place about 1 pint of mixed soil in a labeled bag with a waterproof marker with your name and field identification information. Whenever samples are submitted to the Plant Disease Diagnostic Laboratory at Kansas State University, but generally is recommended only for new infestations. The glossy, enlarged bodies of female cyst nematodes on roots near the perimeter of a severely affected area, rather than on the most severely damaged plants. Do not rely upon visual inspection of attached cysts for an accurate diagnosis.

**GENETIC DIVERSITY**

Population of SCN are genetically diverse, varying in their ability to reproduce on different plants species. Different populations may damage crops differently. For most SCN populations in the state. To obtain the adapted, high-yielding resistant varieties are available from planting a resistant variety on moderately-infested, irrigated sands. Black bean (PI 88788 over a susceptible variety in the presence of three SCN populations. Data are averages of eight environments.

**POPULATION INCREASE AND SPREAD**

Two of these differentials, Peking and PI 38788, are especially important because nearly all (99 percent) commercial, SCN-resistant soybean cultivars adapted for Kansas currently derive their resistance from one (primarily PI 38788) or both of these sources. Female indices on Peking and PI 38788 are shown for representative SCN populations in Fig. 5. Most SCN populations in Kansas can be classified as Race 1, and do not react to either one of these races. Race classification of SCN populations was determined by the Plant Disease Diagnostic Laboratory at Kansas State University, but generally is recommended only for new infestations. SCN populations increase starting from low egg densities in resistant crops and are most difficult to evaluate. Several SCN infestations precede noticeable damage by several years so that by the time a problem is detected, the nematode has already spread throughout the field.

**DAMAGE THRESHOLDS**

The amount of yield in a susceptible crop is usually related to the SCN population at planting. The damage threshold is the population level at which measurable yield loss occurs. Threshold levels vary with environment, but are lowest under conditions that favor large population increases such as warm, wet soils, long growing seasons, and warm temperatures. In Kansas, economic damage in crop-destroyed soils can occur with as low as 5,000 eggs per 100 g of soil in the top 15 cm of the seedling root zone. When SCN egg counts exceed 15,000 per 100 g in course textured soils or 5,000 eggs per 100 g in fine textured soils, a resistant cultivar should be considered in place of resistant variety. The goal of SCN management is to minimize the risk of soybean yield loss by reducing and maintaining egg numbers below damage economic thresholds. This goal is best achieved by using SCN-susceptible crops with lower nematode populations when a Race 3 dominant population is present. Pekin-derived resistance was clearly better than resistance from PI 38788. Neither resistance provided a significant yield improvement over the susceptible population in the presence of a Race 4 population. The ability of SCN populations to adapt to resistant soybean varieties, major yield losses have not been observed when SCN populations have been reduced below damage threshold levels, susceptible soybean varieties become a serious threat to crop production.
The soybean cyst nematode (SCN) or *Heterodera glycines* is the most serious disease threat to soybeans in the United States. In the north central United States, it has been estimated that the nematode causes an annual loss of 48 million dollars. Kansas may be as high as 40% in individual fields, making soybean production uneconomic without effective control measures. In Kansas, SCN was first reported in 1985 in Doniphan County. Since then, the range of the nematode has continued to expand. Through 2001, 42 counties from all but the three western crop reporting districts were infested (Fig. 1).

**THE NEMATODE**

The soybean cyst nematode is a microscopic, worm-like organism ranging in length from 0.01 to 0.1 mm. Upon hatching, juveniles (Fig. 2B) migrate short distances through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells. Males become immobile as they continue to feed and mature. The adult female organism ranging in length from 1/64 to 1/16 inch. Upon hatching, juveniles (Fig. 2B) migrate short distances through the soil and enter plant roots near the tips. They burrow into the roots and begin feeding on young root cells. Females become immobile as they continue to feed and mature. The adult female

**Cultivar Maturity**

The ability of some additional Kansas crops to serve as a host for SCN in shown in Fig. 3. In these cases, the number of nematode reproduction on a given plant species will vary from one SCN population to another. This has resulted in confusion about the host status of a number of crop and weed plants, making general recommendations difficult. Planting Date and Cultivar Maturity. Delaying planting, such as in a wheat-soybean double-cropping rotation, can result in lower SCN egg numbers at the time of planting compared to nematode numbers for an earlier, full-season soybean crop. This difference in nematode numbers generally has little influence on soybean yields, with nearly identical levels of yield loss occurring in both cropping systems in Kansas (Fig. 4).

In southeastern Kansas, market maturity group V varieties usually exhibit less yield loss due to SCN than earlier-maturing market maturity (Fig. 5). A similar relationship has been documented for ch�ural soil in this region of the state. In the case of SCN, differences in yield loss among varieties from maturity groups III through V are partly related to differences in growth development type (determinate vs. indeterminant). 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 III through V).

**Delaying Planting**

Recent research at Iowa State University has documented lower SCN population numbers in no-till compared to tilled soybean fields across the north central United States. This relationship is dependent upon soil moisture; however, with the highest numbers observed in clay soils and no differences observed in sandy soils. Other research suggests that double-crop soybean following wheat may suppress the nematode population better than no-till.

**Fertility and Weed Management.** Good soil fertility and weed management are necessary to achieve the yield potential of any soybean variety. This relationship can be manipulated in fields infested with SCN because the nematode interfaces with water and nutrient uptake by the plant.

Numerous weed hosts have been described for SCN. As noted earlier, however, the host status of individual plant species can vary among SCN populations. Recent studies in Ohio have demonstrated that perennial weeds and bulbs can serve as alternate hosts, causing new concern about control of winter annuals in soybean fields. As a rule, effective weed control is necessary to ensure optimum SCN management.

**Nematocides.** Nematocides are not recommended for SCN control in Kansas. Susceptible varieties treated with nematocides produce yields comparable to, but no better than, resistant soybean varieties. The reduction in nematode numbers immediately following nematocide application is usually short-lived; and numbers return to their pre-treatment levels by harvest.

**Fig. 1. Distribution and spread of SCN in Kansas.** a) Current distribution. b) Increase in number of infested counties since the initial discovery of SCN in 1985. (a) and four (b) environments.

**Fig. 2. Stages of development of a soybean cyst nematode infection.**

A. Eggs being released from a released cyst. B. Second stage juvenile feeding on the root. The largest nematode male can reach 8 mm in length.

**Fig. 3. Effect of relative cyst (a) and cyst/maturity on SCN yield loss in contrasted Kansas. (Data are average of six environments.)**

**Fig. 4. The soybean cyst nematode (SCN) or *Heterodera glycines*, is the most serious disease threat to soybeans in the United States. In the north central United States, it has been estimated that the nematode causes an annual loss of 48 million dollars. Kansas may be as high as 40% in individual fields, making SCN production uneconomic without effective control measures. In Kansas, SCN was first reported in 1985 in Doniphan County. Since then, the range of the nematode has continued to expand.**

**Fig. 5. Distribution and spread of SCN in Kansas.** a) Current distribution. b) Increase in number of infested counties since the initial discovery of SCN in 1985.