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Soybean Cyst Nematode in South Dakota: History, Biology, and Management

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History and importance of SCN

Soybean cyst nematode (SCN) was first detected in the USA in 1954 in North Carolina and has since been moving northwards up to Canada. SCN was first found in South Dakota in 1995 in Union County. As of 2019, SCN has been detected in 34 counties spanning most of the east river region (Fig. 1). It is probable that in counties that grow soybean but with no SCN detected yet, SCN may already be occurring in these areas. SCN is the most important soybean yield constraint, accounting for annual losses estimated at over $1 billion in the U.S. The SCN damages soybeans by robbing the plants of nutrients, stunting or dwarfing the plant roots, reducing the number and efficiency of nitrogen fixing nodules, and providing wounds for other pathogens (such as sudden death syndrome and brown stem rot pathogens) to enter the roots. SCN can be present in soybean fields without causing obvious symptoms. Because of this, yield loss caused by SCN is usually under-estimated and growers may not be preventively applying measures that would help to keep the SCN population below injury levels.

Symptoms and signs

Symptoms of plants infected with SCN are highly variable and will depend on a number of factors including; the SCN population density, soil type, soil pH, soil moisture, soil fertility and field history (rotations and use of SCN resistant cultivars). Often

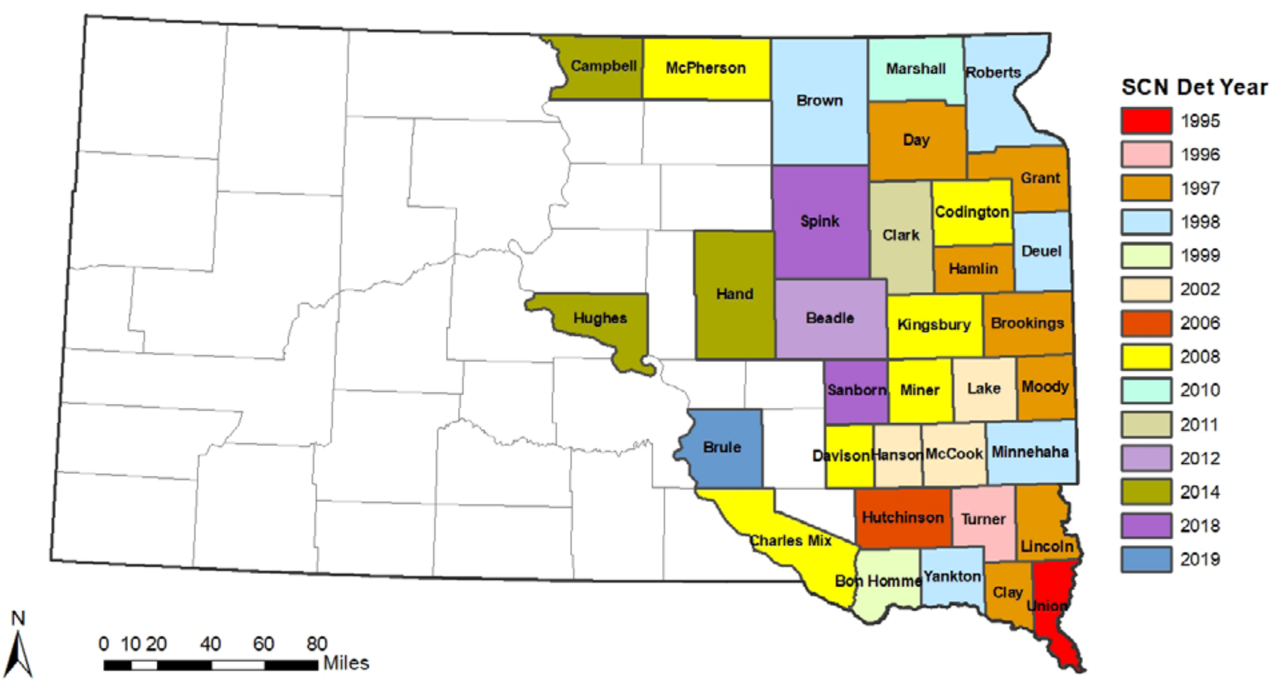

Fig. 1. Counties in South Dakota with soybean cyst nematode (SCN) and year detected.

times, soybean plants can be heavily infested with SCN without necessarily displaying visual symptoms (Fig. 2). The best identifying sign of SCN infection is the presence of adult females with egg filled sack (cysts) on the plant roots. SCN females can be observed clinging to the sides of roots especially in July and August (inset Fig. 2). Another indication of the presence of SCN may be declining yields in some parts of the field. Typical severe symptoms of SCN infection may include circular to oval patches of stunting, yellowing, and unclosed rows of early maturating plants (Fig. 3). Over the years, affected areas may increase in size mainly in the direction of tillage. In most cases, yield reduction can occur with no visible symptoms. For corn-soybean rotations, it may take longer (up to 12 years) for SCN population densities to increase to damaging levels. This period may be extended even further with the inclusion and rotation of soybean cultivars with various sources of SCN resistance. Soybean cyst nematode injury

Fig. 2. A soybean field with no visual foliar symptoms but heavily infected with SCN (in-set) (Photo credit: Emmanuel Byamukama).

Fig. 3. An irrigated soybean field with stunted, yellowing plants infected with SCN. Notice the unclosed canopy in the foreground (Photo credit: Connie Tande).

Fig. 4. Soybean plants showing potassium deficiency symptoms. These can be confused with SCN symptoms (Photo credit: Emmanuel Byamukama.

symptoms can be confused with symptoms caused by other stresses like nutrient deficiencies especially potassium (Fig. 4), water logging, drought, soil compaction, herbicide toxicity, or other diseases. The best way to know that symptoms are caused by high SCN population density levels is to sample the soil and have it analyzed for SCN.

Soybean cyst nematode life cycle

The SCN life cycle has three stages namely; egg, juvenile, and adult. The egg and the juvenile stages are microscopic. The juvenile stage is further subdivided into four stages. The first juvenile stage develops within the egg and molts to form a second stage juvenile. The second stage juvenile worms (J2) hatch from eggs and are attracted to the actively growing soybean roots. Once inside the roots, the juvenile injects secretions that transform the plant cells into a feeding site called syncytium. As the juveniles feed, they swell and enlarge and become 'sausage-shaped and molt three times before turning into adults. The male nematodes change back to slender and motile worms during the last molt. They stop feeding, mate with the females and migrate out of the roots. The female adults take on a lemon-shape and will eventually become so large that they burst the root tissue and are exposed on the surface of the root. The adult females are equivalent to the size of a period at the end of this sentence and can be seen with the unaided eye (Fig 5). Each SCN female produces 50 to 100 eggs outside the body in a gelatinous matrix but also continues to produce 200 eggs or more internally. Shortly after the female body is filled with eggs, the female dies and its body toughens to form a protective cyst around the eggs and changes color from white to dark brown (Fig. 6). Eggs in a cyst do not hatch at the same time and the eggs can survive up to 10 years. The SCN life cycle can be completed between 24 to 30 days, giving rise to 2-3 generations in a soybean growing season.

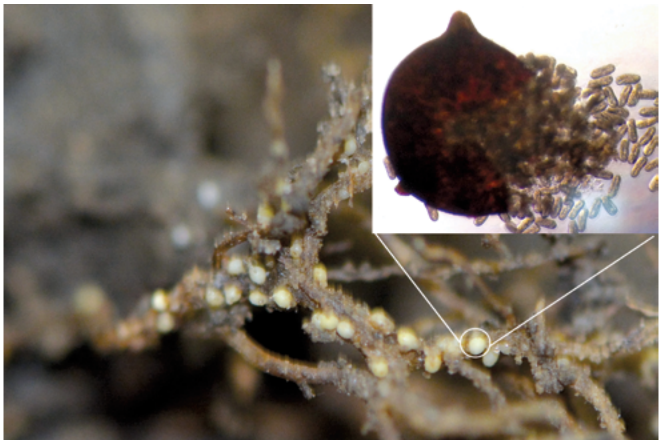

Fig. 5. Soybean cyst female nematodes clinging on the root surface (magnified 10 times). The cysts are the size of a period (.) and can be seen with the unaided eye. Inset: Magnified cyst, raptured to expose eggs (Photo credit: Emmanuel Byamukama).

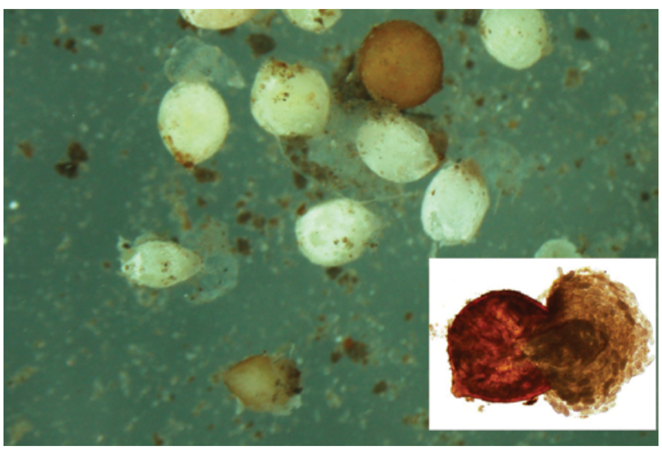

Fig. 6. Female soybean cyst nematodes dislodged from the soybean roots. Notice the color change from young (white) to mature (dark brown). Inset: A mature cyst burst open to force eggs out. (Photo credit: Connie Tande).

Modes of spread

The juveniles move short distances, through soil on the water film surrounding soil particles to young growing roots. If they do not find roots within a few inches of where they hatched, they will die shortly due to lack of food. The eggs and cysts are unable to move on their own but they can be moved by anything that moves soil. Soil can be moved within-field and from field-to-field through farm implements, soil peds in soybean seed, flood water, and wildlife such as ducks, geese and deer.

SCN and other pests

SCN can interact with other pests to cause severe damage than when each of the pests can cause when infecting alone. Research out of Iowa State University showed that yield loss occurred in soybeans at a lower aphid population density when soybean plants were also infected with SCN than plants that were not infected with SCN. Work in the Mathew research laboratory at South Dakota State University has shown that the damage caused by certain Fusarium species and Phytophthora sojae to soybean in the presence of SCN may be synergestic.

Scouting for SCN

The female SCN can be seen on soybean roots 4-5 weeks after planting but are more abundant in July and August (Fig. 2). However, finding SCN on roots can be difficult if the SCN population density is low. Therefore absence of cysts on soybean roots doesn't necessarily indicate the absence of SCN. When sampling roots for visual assessment of SCN, care should be taken to gently dig out the plant without damaging the roots. Pulling the plant from the soil will leave most of the feeder roots in the soil and can dislodge the cysts from the remaining roots.

Another method that is commonly used to sample for SCN is soil sampling. Soil sampling serves more than one purpose: a) to determine if observed symptoms, low yield in some spots, less vigorous plants etc., are due to SCN infection, b) to monitor SCN population density build up, and c) to determine if resistance/management strategies are reducing the SCN numbers. Soil sampling can be done at any time of the year but most often it is done in the fall following the soybean harvest or just before harvest. If monitoring SCN population density changes is the main purpose of soil sampling, sample before planting and again after harvest.

SCN soil sample results can be highly variable, depending on how a soil sample is collected. This can affect the detection and/or the number of cysts found in the soil sample because SCN cysts are small and usually clustered but found in spotty areas of the field. Ensuring a representative soil sample will give a better estimate of the SCN population in the field. When sampling soil to estimate SCN population, divide the field into 10-20 acre sections. In an arbitrary zigzag pattern (Fig. 7), collect a soil core (about ¼ cup of soil) to a depth of 6-8 inches from about 20 locations using a soil probe or a shovel. Collect soil samples directly in the soybean row whenever possible by angling the soil probe within the root zone of soybean plants especially in the SCN suspected parts of the field. The soil cores from each section should be mixed thoroughly, placed in a soil sampling bag or plastic zip- lock bag (labeled with a permanent water resistant marker) and be sent to the SDSU Plant Disease Diagnostic Clinic for analysis at:

SDSU Plant Diagnostic Clinic
SPSB 153, Box 2108
Jackrabbit Lane
Brookings, SD 57007-1090.
Tel. 605- 688-5545

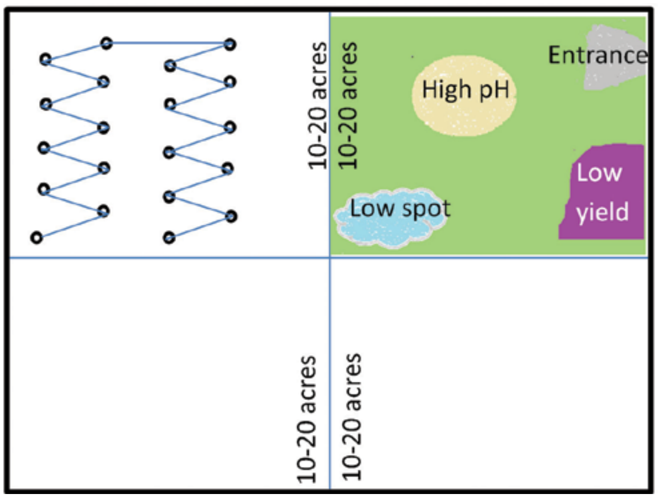

Fig. 7. Sampling for SCN population: a field should be divided into 10-20 sections and for each section, collect 20 soil cores in a zigzag form. Special attention should be paid to previously flooded and/or low spots, high soil pH areas, consistently low yielding, and entrance areas

Currently soybean growers in South Dakota are not charged for SCN testing, the sample analysis fees are under written by the South Dakota Soybean Research and Promotion Council. When soil sampling, particular attention should be paid to field entrance areas, fence line, low yielding spots, wet spots, high pH spots, areas where weed control was not good and areas of high waterfowl activity (Fig 7). Avoid collecting soil cores when the soil is frozen or too wet, keep soil samples at room temperature or in a cooler until shipped, and thoroughly mix the soil cores from 10-20 acre areas to increase the chances of detecting SCN in the soil. SCN population between 1-2000 eggs/100 cm3 soil is considered low, 2001 to 12,000, medium, and >12000 high, if the current crop is soybean.

Management

Once SCN is discovered in a field, it is impossible to completely eliminate it from an infested field. However, SCN can be managed to minimize yield loss by keeping the SCN population densities at low levels. It is important to sample and determine if SCN exist in a field and implement management programs if SCN are found. SCN populations can increase up to 30 fold in a single growing season. It is easier to keep SCN population densities at low levels than to bring high SCN population densities down.

Steps in SCN management:

Step 1: Sample fields to identify which have SCN and to monitor populations. The best time to sample is in the fall after soybeans have been harvested.

Step 2: Rotate-rotate-rotate.

Rotate 1 is for crop rotation, rotate to non-host crops. A non-host crop prevents SCN from increasing in the soil but also reduces SCN numbers due to lack of food for hatched juveniles. Some of the non-host crops include corn, small grains, sunflowers, flax, canola, and alfalfa. If the SCN population densities are high (>12,000 eggs/100 cm3 of soil), a longer rotation or continuous non-host crop like alfalfa and collection of soil samples every fall to monitor SCN egg load is recommended. Once the SCN numbers have decreased (<12,000 SCN eggs/100 cm3 of soil), a crop rotation scheme like the one in Fig. 8 can be followed to keep SCN population density from reaching damaging levels.

Rotate 2 refers to including SCN resistant soybean cultivars in the rotation. SCN-resistant soybean varieties prevent SCN population densities from increasing yet still give high yield. SCN juveniles can still penetrate roots of SCN resistant cultivars but they are not able to feed and will eventually die without completing their life cycle. SCN resistant genes were derived from different plant introduction (PIs) lines (identified by different numbers). Most of the SCN resistant cultivars available have been developed from PI 88788 and just a few from Peking.

Rotate 3 refers to rotation of resistant cultivars with different SCN resistance gene sources (Table 1). It is important to rotate sources of SCN resistance in order to avoid selection for a SCN population that can overcome a given resistance source.

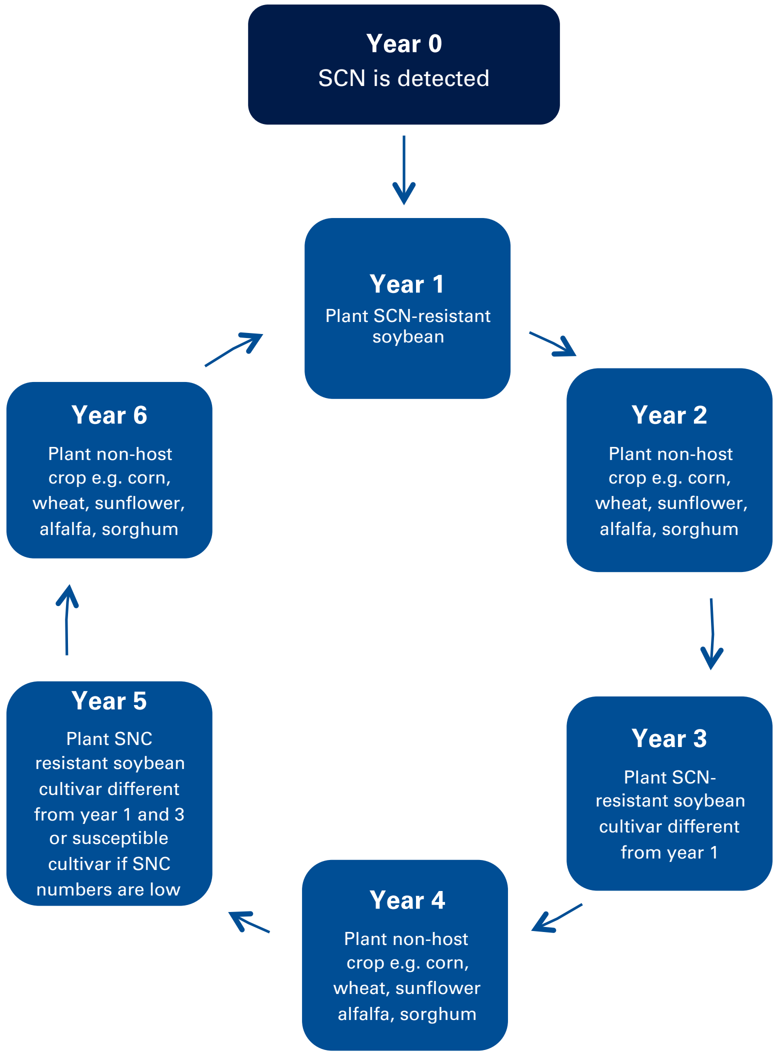

Fig. 8. A six-year rotation scheme for managing SCN. Inclusion of a SCN susceptible cultivar in year 5 is to avoid selection for SCN population that can overcome resistance sources planted in the previous years.

HG types

The level of controlling SCN using resistant soybean cultivars depends on the genetics of both SCN populations in a particular field and the genetics of the soybean cultivar (i.e., where the source of resistance was derived). Some SCN populations can overcome a given resistance source when exposed to the same source over and over. A test that is used to evaluate how well a given resistant cultivar can limit SCN's population reproduction is called HG type test. "HG" stands for Heterodera glycines, the SCN scientific name of the soybean cyst nematode. The test involves determining the percent increase in the number of eggs on a given resistant cultivar, relative to a common susceptible cultivar. A female index equal to or greater than 10% would indicate that the SCN population can overcome that resistance. HG type 0 indicates that this SCN population does not reproduce on any source of resistance. HG type 2 can reproduce >10% on PI 88788 source and so on. Monitoring SCN population densities in a field may help to indicate if a different HG type has developed in the field when a resistant cultivar is being used and still the SCN population is increasing in the soil.

HG types in South Dakota

A study was carried out in 2013 and 2014 to determine the predominant HG types found in South Dakota. Seventy three SCN populations collected from 15 counties were inoculated to seven SCN differential lines that are sources of SCN resistance genes under greenhouse conditions. The predominant HG types found among the tested populations were HG type 7 (36%), 0 (29%), and 2.5.7 (16%). These results indicate that a low percentage of SCN populations in South Dakota can reproduce on PI #2, which is PI 88788. Therefore, this source of resistance should be rotated with Peking (PI #1) as the resistance gene, to avoid buildup of SCN in heavily infested fields.

Table 1. Soybean indicator lines used for determination of Heterodera glycines (HG) type. For example a SCN population of HG type 1 indicates that the SCN population had at least 10% reproduction on Peking.

HG type index number	HG type Indicator line
1	PI 548402 (Peking)
2	PI 88788
3	PI 90763
4	PI 437654
5	PI 209332
6	PI 89772
7	PI 548316 (Cloud)

Step 3. Promote good plant health.

A well-managed soybean crop will yield higher and can withstand low levels of SCN infection. Maintain optimum fertility, control weeds (weeds such as pennycress and henbit are hosts of SCN), and ensure proper drainage.

Step 4. Evaluate the need for nematicide seed treatment

Several products that provide early protection against SCN infection are available on the market. While deciding on a nematicide seed treatment, consider the extent of yield loss caused by SCN, the susceptibility of the cultivar being grown, the effectiveness of the product being used, and the value of the soybean crop.

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