SOYBEAN CYST NEMATODES IN WISCONSIN

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Biology of SCN:

The USB refers to the soybean cyst nematode (SCN), *Heterodera glycines*, as the most important pathogen of soybean in the U.S. Four factors earned the SCN this title: the wide-spread incidence of SCN across all soybean production areas, the chronic persistence of SCN eggs in the soil, the absence of distinctive symptoms that alert soybean producers to take appropriate management actions, and the destructive capacity of this plant parasite. Most producers will never be able to totally eradicate SCN from infested fields, but any producer farming SCN-infested land can minimize the effect of this nematode pathogen.

The SCN Life Cycle: Compared to most nematodes, the SCN has a limited host range. Soybean, dry beans, and snap bean are the primary hosts for the SCN. Eggs of SCN lie dormant within the dead body of the mother nematode until a host crop is planted. Exudates from germinating soybean plants signal SCN eggs to hatch; nonhost crops such as corn do not produce these signals and SCN eggs remain unhatched in the soil until soybean is planted again. Juvenile nematodes emerging from eggs locate young soybean roots and enter at the root tips. Once inside, SCN transform root cells to serve as permanent feeding sites. As the contents of the cells are removed by a nematode, the contents of surrounding cells are drawn in so that every nematode has a never-ending food supply. Comfortably in place, feeding SCN divert their energy into egg production and lose the ability to move any part of their body except their mouthparts. The first eggs laid are deposited outside the mother's body. By this stage, females have broken through the root and their white pearly round bodies are visible to the naked eye. Eventually females turn brown and die with up to 300 eggs remaining inside their bodies. Female cadavers, termed "cysts", fall off roots into the soil. Eggs inside the cyst are somewhat protected from the harsh soil environment, but they are never totally safe from natural enemies such as certain fungi and small soil animals.

The Relationship Between Nematode Feeding and Crop Damage: The damage inflicted on the soybean plant by SCN is more extensive than can be accounted for by the amount of plant material eaten by nematodes. The establishment of the special nematode feeding cells, as well as the act of feeding itself, cause alterations in soybean physiology that affect plant growth and the plant's investment of energy into seed production. Seed production is the most sensitive parameter to SCN feeding and plant growth is jeopardized only when many nematodes are present, which is why yields can decline even if plants are not stunted. The number of nematodes in a root system determines the burden of SCN infection to a single plant. Analogous to parasites in an animal, a light nematode load causes no or only minor alteration of plant function whereas a heavy nematode load causes plant disease. At the crop level, there is a strong relationship

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between the population density of SCN eggs and soybean yield. A crop grown in soil with a low number of SCN eggs shows no or little yield loss. Once some minimum egg population density is surpassed, there is a negative relationship been yield and the number of SCN eggs present - i.e., the more eggs, the less yield. The SCN has evolved the strategy to never entirely wipe out a soybean crop because it is their only food source. Population densities of SCN in fields, which have been infested for many years, tend to plateau, providing a cap to yields, which is almost impossible to overcome by any strategy other than decreasing the number of nematodes present.

The Biological Basis for Host Resistance and Crop Rotation Management Strategies: The scenarios described above are based on soybean varieties not specifically bred for SCN resistance. The soil phase of the SCN life cycle is essentially the same when an SCN-resistant variety is planted. What differs among SCN-resistant and susceptible varieties is the plant's reaction to nematode feeding activity. Feeding SCN juveniles are not capable of transforming root cells of resistant varieties into permanent feeding sites so the cells provide only a temporary meal. The nematode does not "realize" this until the permanent changes that paralyze its body have begun and it starves to death once the contents of the initial feeding cell are gone. There is sufficient variation among populations of resistant plants and SCN that a small proportion of nematodes will obtain sufficient nutrients to produce eggs. In general, however, SCN egg production is severely limited on resistant varieties and an extremely small second generation is produced. After several SCN-resistant soybean crops (the number depends on how many SCN are present when host resistance is first employed), population densities decline to low enough levels that a SCN-susceptible variety can be grown for at least one year with no damage.

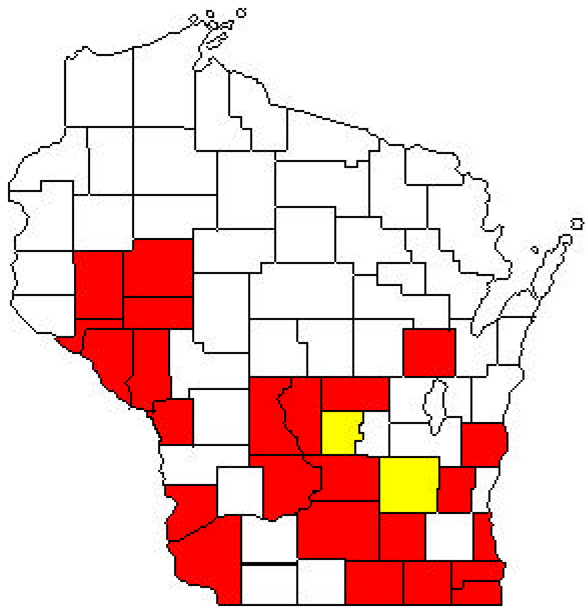
Crop rotation serves to break the SCN reproductive cycle. No new eggs are produced because the nematodes do not enter and feed on plants other than soybean or edible beans. There is very minimal egg hatch during the nonhost phase of the rotation, but every soil harbors some natural enemies of SCN. On average, about 10% of the eggs are eaten or destroyed by fungi every year. In combination with the trap-crop effect of SCN-resistant soybeans, crop rotation helps to accelerate the decline of SCN population densities in an infested field. Accounts by producers indicate that some crop rotations are more effective than others in accelerating SCN decline, presumably because of differences in soil microflora and fauna.

Distribution of the SCN in Wisconsin:

Twenty-six counties in Wisconsin are known to be infested with the SCN. Two counties, Marquette and Dodge, were added to the distribution list in 2001. Approximately 20% of the samples submitted to the UW for nematode assay tested positive for SCN in 2001. This estimate of SCN-infested acreage in the state is consistent with data collected over the previous four years.

The range of SCN egg densities in infested fields varies, but most fields have fewer than 5000 eggs per 100 cm^3 soil present and many have egg densities lower than 1000 eggs per 100 cm^3. Research funded by the Wisconsin Soybean Marketing Board in 2001 demonstrated that the distribution of SCN within a field is often patchy so that some portions of the field escape damage.

Figure 1. Counties known to be infested with the SCN (Adams, Buffalo, Chippewa, Columbia, Crawford, Dane, Dodge, Dunn, Eau Claire, Grant, Jefferson, Juneau, Kenosha, LaCrosse, Marquette, Milwaukee, Outagamie, Pepin, Racine, Rock, Sauk, Sheboygan, Trempeleau, Walworth, Washington, Waushara)



Research Results from 2001: Damage Thresholds:

We monitored population densities of the SCN and collected yield data from commercial soybean fields in 2001. Sampling sites were georeferenced using GPS/GIS technology so all data represent the same locations within a field. The sites fields were selected on the basis of the initial SCN egg density at the time of planting (Pi) and were located in Marquette, Rock, Walworth, and Racine counties.

Yield data were collected from two fields planted with both SCN-resistant and susceptible varieties. In both cases, there was a statistically significant yield gain from planting the resistant variety.

Table 1. Yield (bu/A) of SCN-susceptible and resistant varieties grown in two fields infested with the SCN at initial egg densities (Pi) less than 2000 per 100-cm3 soil

	Susceptible	Resistant	Yield gain (*P* = 0.10)	Pi
Racine - No. 3	41	65	37%	1180
Marquette - West	29	39	26%	72

One of the fields, Racine – No. 3, was from a farm that participated in the same study in 1999 and 2000. The field studied in 1999 had a Pi of 3069 eggs per 100 cm^3 and showed a 15% yield gain from planting a resistant variety. Another field, studied in 2000, showed a yield gain of 38% for a Pi of 908 eggs per 100-cm3 soil.

Yield data were also collected from another two fields planted with a susceptible variety. In these fields there were a number of sampling locations that tested negative for SCN. Yield data from these fields were placed into two categories – sites positive and negative for the SCN. There was no apparent yield penalty due to SCN pressure in one field, but there was a 12% yield differential among the infested and noninfested sites in another.

Table 2. Yield (bu/A) from sampling sites within two fields testing positive and negative for SCN at the time of planting. The Pi represents only those sites testing positive for the SCN.

	Pi = 0	**Pi > 0**	**Yield Difference (*P* = 0.10)**	**Pi**
Marquette - East	66	70	-	52
Rock - Clinton	59	52	12%	486

Data from these four sites indicate a benefit of planting a SCN resistant variety when Pi is at 1000 or fewer eggs per 100-cm3 soil. This damage threshold is lower than the current recommendation for Wisconsin. None of the SCN-resistant varieties planted in our research fields showed evidence of "yield drag" in the absence of the nematode.

Research Results from 2001: Rotation Effects

We compared the initial SCN population densities for soybean crops (1999, 2001) interrupted by a non-host rotation in 2000. The fields were from five soybean farms located in Rock, Marquette, Walworth, and Racine counties. Populations declined for three of five fields planted with an SCN-susceptible variety in 1999 and for four of five fields planted with an SCN-resistant variety (**Figure 3**). The percentage of the decrease was greater for fields planted with SCN-resistant varieties.

These data show that the benefit of planting an SCN-resistant variety is twofold. Resistant soybean varieties offer a yield benefit the year they are planted and provide protection for future soybean crops by preventing a large increase in the nematode population. We have no explanation for the lack of decline in SCN populations, but suspect there may have been weed hosts present in the rotation year.

Recommendations for Managing SCN:

Our results indicate a benefit to planting an SCN-resistant variety at Pi densities as low as 1000 eggs per 100-cm3 soil. This threshold may vary according to certain soil characteristics. For example, soil pH appears to have predictive value for variety performance in SCN-infested fields. Sampling for soil characterization, nutrient status, and SCN populations can be combined into a single activity. Soil assays provide information critical for the essential components of a SCN management program: planning crop rotations, selecting appropriate soybean varieties, and monitoring for the build-up of resistance-breaking SCN populations.

Figure 2. Change in population densities of SCN after one year of rotation in fields planted with a variety susceptible (s) or resistant (r) to SCN. Each color represents a different farm enterprise.