CCA ADVANTAGE

Continuing Education Self-Study Course

ROTATION CROP

FOR MANAGEMENT OF THE SOYBEAN

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The soybean cyst nematode, *Heterodera glycines* Ichinohe, was first detected in Minnesota in 1978 (MacDonald et al., 1980). Since then, SCN has been detected in 55 counties in southern and central Minnesota where soybean [*Glycine max* (L.) Merr.] is grown. The nematode has become a major yield-limiting factor in the state.

Management of the nematode has been dependent on planting resistant cultivars and the use of crop rotations. A number of studies have reported on the effect of rotation crops on SCN populations and soybean yields. In these studies, however, only one or a few nonhost (mainly corn [*Zea mays* L.], wheat [*Triticum aestivum* L.], and sorghum [*Sorghum bicolor* (L.) Moench]) or poor-host crops were compared with soybean.

In general, SCN population densities following a nonhost or poor host were lower than following soybean. The effectiveness of crop rotation depends on the host status of crop species, the number of years of rotation crops and geographical location. For example, in North Carolina, one to two years of a nonhost in a rotation was generally sufficient to lower SCN population density to below damaging levels. In contrast, five years of nonhost and SCN-resistant soybean may be needed in Minnesota to reduce the SCN population density to a lower level where a susceptible cultivar can be grown without significant yield loss.

Annual ryegrass (*Lolium multiflorum* Lam.) was more effective than other nonhosts in reducing infectivity of soybean by SCN. In a field study, corn appeared to be more effective than sorghum in lowering SCN second-stage juvenile population densities at the end of the following soybean season.

The mechanisms through which rotation crops affect SCN populations are not fully understood. Some nonhost and poor-host crops may be effective in lowering nematode population densities by producing root exudates or decomposition products toxic to the nematodes. Therefore, growing a poor-host crop may reduce SCN population density.

Riga et al. (2001) looked at the potential of plant residues and plant root exudates to protect soybean from SCN and found that incorporation of residues from a number of plant species into the soil reduced nematode population densities compared with incorporation of soybean residues alone.

In southern Minnesota, corn is almost exclusively used as the nonhost crop in rotation with soybean. The SCN egg densities were reduced 20 percent to 80 percent during a year when corn was grown. The overwinter survival rate of SCN is high in the northern regions of the U.S., however, and consequently more frequent use of nonhost crops is necessary compared with the southern U.S. Increasing the number of years of corn in a rotation sequence to reduce SCN is not advisable due to the yield penalty associated with corn following corn. Therefore, a need exists to find alternative, economically acceptable nonhost crops for use in rotation with soybean for long-term effective management of the nematode.

Field crops commonly produced in Minnesota that were classified as nonhost or poor-host crops for the SCN include alfalfa (*Medicago sativa* L.), barley (*Hordeum vulgare* L.), canola (*Brassica napus* L.), corn, sorghum, oat (*Avena sativa* L.), pea, potato (*Solanum tuberosum* L.), rye (*Secale cereale* L.), red clover (*Trifolium pretense* L.), sugarbeet (*Beta vulgaris* L.), sunflower (*Helianthus annuus* L.), and wheat. Our objective was to evaluate crops common to Minnesota for their potential use as rotation crops with soybean in the management of the SCN.

MATERIALS AND METHODS

This research was conducted on three commercial farms in south-central (Waseca), southwest (Lamberton), and west-central (Morris) Minnesota in 2001 and 2002. At each location, a field was selected and planted with SCN-susceptible soybean in 2000. In the spring of 2001, the Waseca, Lamberton and Morris fields had natural SCN infestations of 4,120; 20,700; and 26,300 SCN eggs per 100 cm^3 of soil, respectively.

The experiment consisted of 24 treatments in a completely randomized block design with six replicates. The 24 treatments were combinations of crops and fallow with appropriate herbicides. The experimental unit was a 4.57 by 3.05 meter (15 ft. by 10 ft.) plot. The 16 crops commonly produced in Minnesota or having potential use in the state were selected as rotation crops for this study: barley, flax (*Linum usitatissimum* L.), oat, sorghum, wheat, buckwheat (*Fagopyrum sagittatum* Gilib), canola, corn, rye, sugarbeet, potato, sunflower, alfalfa, hairy vetch (*Vicia villosa* Roth), red clover and pea. The controls included an SCN-resistant soybean cultivar (Pioneer 9234), an SCN-susceptible soybean cultivar (Parker) and fallow ground with each

EVALUATION

CYST NEMATODE IN MINNESOTA

KLOSSNER, and G. A. NELSON


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Red clover

herbicide commonly used for these crops (fallow with Buctril, fallow with Liberty, fallow with Prowl, fallow with Pursuit, fallow with hand weeding and fallow without weed control).

Nematode egg densities were determined at planting (Pi), at midseason (Pm, two months after planting), and at harvest (Pf) both years. In 2001, a composite soil sample consisting of 20 cores was taken with a 2.5-cm-(1 in.) diameter soil probe to a 20-cm (8 in.) depth across the central area of approximately 3.5 by 1.5 m (12 by 5 ft.) of each plot. In 2002, the soil samples were taken from near the soybean root zone of the two central rows of each plot.

To determine nematode population change during the crop season, population change factors (PCF) were computed. The PCF at midseason 2001, at harvest 2001, and at planting 2002 were determined by dividing the egg densities from Pm01 (at midseason in 2001), Pf01 (at harvest in 2001), and Pi02 (at planting in 2002), respectively, by the egg densities from Pi01(at planting in 2001). The PCF at harvest of soybean in 2002 was determined by dividing the egg densities from Pf02 (at harvest in 2002) by the egg densities from Pi02.

The data were initially analyzed using SAS repeated measures Analysis of Variance (ANOVA) with whole plots at the three locations, blocks within locations, and treatments within blocks. At Lamberton, severe iron-deficiency chlorosis affected late season growth across two blocks and consequently these two blocks were removed from the data set before analysis. To determine differences among groups of crop treatments, the data were averaged in four groups:
(i) monocots (barley, oat, sorghum, wheat, corn, and corn-rye);
(ii) nonleguminous dicots (flax, buckwheat, canola, sugarbeet, potato and sunflower); (iii) leguminous nonhosts or poor hosts (alfalfa, red clover and pea); and (iv) fallow with herbicide treatments. Soybean and hairy vetch were hosts of the nematode and were excluded from any of the groups.

RESULTS AND DISCUSSION

All rotation crops resulted in lower SCN egg population density, PCF or both than susceptible soybean at least at one sampling occasion. This suggests that these crops can be used in rotation for SCN management in Minnesota.

After one year of any of these crops, however, the nematode population densities were still greater than 1,000 eggs per 100 cm^3 of soil, which can cause significant yield loss to a susceptible soybean. These results were similar to the results of previous studies with corn as the rotation crop, which did not reduce SCN egg population densities to below damaging levels in one year.

In general, five years of a corn and resistant soybean rotation were needed for effective SCN management. A similar rotation period may be needed with any of these crops, but further studies are necessary to develop a rotation scheme including any of the alternative crops for SCN management.

Subtle differences in SCN populations among the rotation crops were detected in this study. Leguminous nonhosts and poor hosts appeared to be the best crops for reducing the SCN population density, while monocots appeared to be the least effective. Similar results have been obtained in greenhouse studies.

Pea as a trap crop has been shown to reduce SCN population density compared with non-trap-crop treatments in the corn-growing season. The leguminous nonhosts and poor hosts may release root exudates to stimulate the SCN to hatch, but the nematodes are not able to develop and reproduce well in these crops, resulting in a population decline. Pea is presently grown in many parts of southern Minnesota and is sometimes double-cropped with soybean. Although it may not be cost effective to use pea as a trap crop interseeded with corn for SCN management, it may be a preferred crop for use in rotation with soybean and corn for SCN management.

Alfalfa and red clover are perennial crops, and they can be used in rotation with soybean for SCN management where practical. These crops are currently being studied for their potential as cover crops in corn-soybean production systems. Their agronomic and economic potential in the production systems in Minnesota will be further evaluated.

Fallow is rarely used in corn-soybean production in the region. We included fallow with different weed control treatments for the purpose

of identifying any herbicide effect on SCN, which might confound the rotation crop effect when different herbicides were used in the different crops. Although the effect of herbicides on SCN population has been reported, no effect of herbicide on SCN population density was observed in this study except that the Pf02 was higher in the no-weeding treatment than in treatments with either Buctril or Pursuit. Thus, the rotation crop effect on SCN was unlikely to be due to herbicide treatment.

Hairy vetch, a leguminous crop, supported the development of SCN females on the roots in the field and was probably a moderate host of SCN. This is probably why the PCF for hairy vetch was relatively high across the three sites. High PCF was also observed for buckwheat, but the reason is unclear.

Theoretically, the nematode population increases if PCF is greater than 1. In this study, however, PCF was greater than 1 for a number of the rotation crops at some sampling occasions, especially at the Lamberton site. This doesn't mean that the nematode population increased in these crops. The higher PCF than what we expected was due to experimental error in soil sampling and sample processing. At the Lamberton site, the average Pi01 was lower than Pm01 and Pf01. The reason for this is unclear.

In the 2002 soybean growing season, predicted equilibrium population density was similar among the three sites. Nematode equilibrium population density is a function of the size of the food source and the efficiency of a nematode population using that food source in producing offspring. Both the size of the food source and the efficiency of use are affected by many factors including cultivar and environment.

The predicted equilibrium population density was the sum of the effects of factors that may have affected food source and the SCN's efficiency in using the food source at the three sites. These factors can be different among sites although the sum of the effects was similar. The equilibrium population density can also be different among years at the same site. The population densities at harvest in 2002 were lower than the population at planting in 2001 at Lamberton and Morris, suggesting that the environmental conditions were more favorable for SCN population development in the 2000 soybean growing season than the 2002 season.

Yield response to the rotation crop was also limited. Soybean yield was not (at Lamberton and Morris) or weakly ($r = -0.19$, $P = 0.02$ at Waseca) correlated with SCN population density, suggesting that there was little yield benefit from SCN management with the rotation crop for one year.

The response of soybean yield to the treatments, however, varied between sites probably due to different environmental conditions. Yields were highest at Waseca, but no difference was detected except for the corn-rye treatment, which had a lower yield than most other treatments at this site, probably due to poor germination of the soybean in this treatment due to the rye residue effect.

At Lamberton, the soybean yields following corn or corn-rye were lowest; they were significantly lower than the yield following potato and sunflower treatments. By group, fallow treatments resulted in the highest yield followed by nonleguminous dicots, monocots, leguminous nonhosts and poor hosts. Iron-deficiency chlorosis in the field was a major factor influencing soybean yield, which was negatively correlated with the iron-deficiency chlorosis rating ($r = -0.74$, $P < 0.0001$). Complete yield loss occurred in 47 out of the 144 plots at this site.

At Morris, heavy rainfall in June affected early season plant growth and consequently reduced yields. The hairy vetch and sunflower treatments produced higher yields than the canola, flax, or oat treatments. By group, treatments of leguminous nonhosts and poor hosts and monocots resulted in higher ($P < 0.05$ or 0.01) yields than nonleguminous dicots and fallow.

The difference in yield among some crop treatments in Lamberton and Morris was probably due in part to agronomic factors. There were greater differences in soybean yields among crop treatments in Lamberton and Morris, but the trends appear to be opposite between the two sites. At Lamberton, yields following nonleguminous crops and fallow were higher than leguminous nonhosts and poor hosts or monocots; at Morris, the leguminous nonhosts and poor hosts and monocots resulted in higher yields than nonleguminous crops or fallow. The reason for the difference between the two sites is unclear. At Lamberton, however, these treatments may have affected the development of iron-deficiency chlorosis; treatments with monocots apparently increased iron-deficiency chlorosis compared with nonleguminous dicots, especially sugarbeet and canola (data not shown). Subsequently, the soybean yield following monocots was lower than following nonleguminous dicots.

In conclusion, there was large variability in the SCN populations and soybean yields at the three sites. Nevertheless, significant treatment effects were detected at all sites. While all of the rotation crops lowered SCN population compared with SCN-susceptible soybean, there were subtle differences among the individual rotation crops and among different groups of crops. Leguminous nonhosts and poor hosts were probably the best crops in reducing SCN population density. Corn, the most common rotation crop in Minnesota, was in the group that was the least effective in reducing the nematode population. AG

Rotation crop evaluation for management of the soybean cyst nematode in Minnesota

October Self-Study Examination

DETACH HERE

1. Factors that can influence SCN populations include all of the following EXCEPT

[ ] a. specific crop rotations.
[ ] b. weather conditions.
[ ] c. the time of year.
[ ] d. SCN asexual reproduction.

2. The crop used most commonly in rotation with soybeans in SCN areas is

[ ] a. sorghum.
[ ] b. corn.
[ ] c. wheat.
[ ] d. rice.

3. An objective of this study was to

[ ] a. evaluate rotation crops for their potential use in managing SCN in Minnesota.
[ ] b. rate the relative effectiveness of nematicides in northern conditions.
[ ] c. measure how climate affects SCN populations.
[ ] d. develop crop varieties that better resist nematode populations.

4. A characteristic of the research methods of this study was

[ ] a. four locations.
[ ] b. mixtures of natural and introduced SCN populations.
[ ] c. 16 crops evaluated.
[ ] d. different sources of genetic resistance to SCN.

5. The standard used for reporting SCN populations is

[ ] a. eggs per 100 cm^3 of soil.
[ ] b. active larvae index.
[ ] c. parts per million.
[ ] d. root exchange ratio.

6. A factor that severely impacted soybean yields at one location was

[ ] a. weed patches.
[ ] b. iron deficiency chlorosis.
[ ] c. sudden death syndrome.
[ ] d. high organic matter soils.

7. The reason for including fallow in the study was to

[ ] a. identify any herbicide effects separate from crop effects.
[ ] b. test to see if SCN populations could be eliminated.
[ ] c. analyze nutrient/SCN interactions.
[ ] d. ensure the soil was uniform between crop treatments.

8. In addition to soybean, a crop that supported SCN female development on the roots was

[ ] a. wheat.
[ ] b. hairy vetch.
[ ] c. alfalfa.
[ ] d. oats.

9. The crop that reduced SCN egg populations below damaging levels in one year was

[ ] a. canola.
[ ] b. sorghum.
[ ] c. sugar beet.
[ ] d. none of the above.

10. The best crops at reducing SCN populations in this research were

[ ] a. leguminous nonhosts and poor hosts.
[ ] b. monocots.
[ ] c. non-leguminous dicots.
[ ] d. monecious root crops.

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