INTRODUCTION

In Idaho, plant parasitic nematodes that are economically important on sugar beet are the sugar beet cyst nematode, root knot nematodes, and stubby root nematodes. The sugar beet cyst nematode is widely distributed in Idaho sugar beet growing regions and can cause significant yield reductions. Severely infested fields can potentially undergo nearly 100% yield loss. Although sugar beet is a poor host for the Columbia root knot nematode, it is a good host for the Northern root knot nematode, and if sugar beet is planted after hay yield losses due to Northern root knot may be worsened. Stubby root nematodes also affect yield and are a special challenge because they tend to migrate deep into the soil (20-24 inches) and they undergo dormancy. Consequently, soil samples for stubby root nematode should be taken ideally during fall or early spring and as deep as 24 inches. Since stubby root nematodes are predominantly found deep in the soil, a non-fluigan nematocide is generally recommended for its management. Sugar beet cyst nematodes, on the other hand, can be managed effectively with green manure crops.

Green manure crops, particularly specially developed oil radish and white mustard varieties, are very effective in reducing populations of the sugar beet cyst nematode. Other benefits include improved soil tilth and water holding capacity, reduced nitrogen leaching into groundwater, weed suppression, reduced soil erosion by wind and water, potential suppression of seedling diseases, and increased yield and recoverable sugar of the subsequent sugar beet crop (Table 1).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Root Yield (T/A)</th>
<th>% Yield Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radish (Adagio)</td>
<td>31.3</td>
<td>24.7</td>
</tr>
<tr>
<td>Mustard (Metex)</td>
<td>30.5</td>
<td>21.5</td>
</tr>
<tr>
<td>Fallow</td>
<td>25.1</td>
<td>—</td>
</tr>
</tbody>
</table>

Presented at the University of Idaho Sugarbeet Schools, January 26-29, 1998.
THRESHOLD LEVELS AND CALCULATING NUMBER OF SUGARBEET CYST NEMATODES IN SOIL

The threshold level for the sugar beet cyst nematode is 2 eggs and larvae per cc soil for the Treasure Valley, and 3 eggs and larvae per cc soil for the Magic Valley. These tolerance values are based on temperature and on the amount of time the sugar beet cyst nematode requires to complete its life cycle (a newly hatched juvenile can infect the root, develop into a female, and produce eggs from which more juveniles emerge within 4 to 6 weeks). To determine whether treatment with a green manure or nematicide is necessary, the number of eggs and juveniles per cc soil should be calculated. When a soil sample is submitted to the University of Idaho Nematology Lab, the information provided to the grower is the number of viable cysts per 500 cc soil. The number of eggs and juveniles per cyst can be as high as 500, and the number of viable eggs and juveniles decreases by approximately 40% each year in the absence of a host plant. With this in mind, the following formula can be used to estimate the number of viable eggs and larvae per cc soil for any given year after sugar beet or another host was grown:

\[(\text{viable cysts}/x \text{ cc soil}) \times (500 \text{ eggs and juveniles/cyst}) \times (0.6)^n\]

where \(x\) is the amount of soil used in the laboratory analysis (this value varies from one lab to another), and \(n\) is the number of years since beet or another host was planted. The example below demonstrates how to use the formula:

1. Multiply the number of viable cysts per \(x\) cc soil (you will find this value on the form returned to you by the University of Idaho Nematology Lab) by 500 eggs and juveniles per cyst:

\[(\text{viable cysts}/x \text{ cc soil}) \times (500 \text{ eggs and juveniles/cyst})\]

If you submit a soil sample to the University of Idaho and are informed that you have 4 viable cysts per 500 cc soil, then:

\[(4 \text{ cysts}/500 \text{ cc soil}) \times (500 \text{ eggs & juveniles/cyst})\]

In our example, the 500’s divide and the unit cyst divides, which gives the number of viable eggs and juveniles per cc soil.

\[= 4 \text{ viable eggs & juveniles}/1 \text{ cc soil}\]

2. Multiply the number of viable eggs and juveniles per 1 cc soil (obtained in Step 1) by \((0.6)^n\), where 0.6 represents a 60% survival rate (or a 40% decrease) of eggs and larvae for each year without a host plant and \(n\) is the number of years since beet or another host was planted:

\[\text{Number of viable eggs and juveniles}/1 \text{ cc soil} \times (0.6)^n\]

3. The result is an estimate of the number of viable eggs and larvae per 1 cc soil
remaining after \( n \) years without beets or another host plant. If this value is higher than the tolerance level described earlier, then management strategies for the sugar beet cyst nematode are recommended.

In Table 2, a hypothetical example of the potential effect of planting non-hosts for up to 7 years on the number of eggs and larvae of the sugar beet cyst nematode is presented using the above equation.

<table>
<thead>
<tr>
<th>Year after a sugarbeet crop (Year ( n ))</th>
<th>Total viable eggs after ( n ) years</th>
<th>Calculation: ( 4 \times (0.6)^n )</th>
<th>No. of viable eggs &amp; larvae remaining per 1 cc soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100 %</td>
<td>( 4 \times (0.6)^0 )</td>
<td>4.0</td>
</tr>
<tr>
<td>1</td>
<td>60 %</td>
<td>( 4 \times (0.6)^1 )</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>36 %</td>
<td>( 4 \times (0.6)^2 )</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>22 %</td>
<td>( 4 \times (0.6)^3 )</td>
<td>0.9</td>
</tr>
<tr>
<td>4</td>
<td>13 %</td>
<td>( 4 \times (0.6)^4 )</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>8 %</td>
<td>( 4 \times (0.6)^5 )</td>
<td>0.3</td>
</tr>
<tr>
<td>6</td>
<td>5 %</td>
<td>( 4 \times (0.6)^6 )</td>
<td>0.2</td>
</tr>
<tr>
<td>7</td>
<td>3 %</td>
<td>( 4 \times (0.6)^7 )</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**GREEN MANURE CULTURAL MANAGEMENT**

Green manures should be cultivated as carefully as a main crop since they are primarily a plant protection measure. The following should be considered in managing the green manure crops:

1. **Planting date**
2. **Field preparation**
3. **Fertilization**
4. **Green manure variety, seeding rate, and sowing options**
5. **Irrigation**
6. **Weed control**
7. **Incorporation**

**1. Planting date**
Sow as early as possible either in spring (first two weeks of March) or fall (last week of July to second week of August). If a green manure is planted in the spring, it can be followed with a short season crop such as sweet corn or beans. If planted in the fall, a green manure is usually preceded by grain, early potatoes, peas, or after the second year of onion seed production. An
eight to ten week growing period with soil temperatures above 60° F is critical for nematode control. With the advent of oil radish varieties that mature earlier, the necessary growing period may be shortened in the near future. Figure 1 below clarifies planting date options.

![Diagram showing planting date options](image)

**Figure 1.** Green manure planting date options for managing sugarbeet nematodes.

2. **Field preparation**
   If the green manure follows a cereal crop, prepare the field by removing the straw by baling, burning residue, or chopping as short as possible and incorporating into the soil immediately after harvesting the grain. If time permits, irrigate to germinate volunteers and weeds. Be sure to control the volunteers and weeds. Loosen soil deep enough to allow dense root penetration and optimal aeration for egg hatching. This can be achieved by discing 2-3 times. Standard seedbed preparation is recommended.

3. **Fertilization**
   A minimum of 50 units of nitrogen per acre is recommended, since nitrogen aids in the decomposition of straw and enhances establishment of the green manure crop.

4. **Green manure variety, seeding rate, and sowing options**
   Choosing the right variety of green manure is very important since the level of resistance to the sugar beet cyst nematode varies among the different varieties of oil radish and white mustard. The varieties with the highest resistance to sugar beet cyst nematode should be selected. Recommended varieties include 'Adagio' for oil radish (*Raphanus sativus*) and 'Metex' for white mustard (*Sinapis alba*). Radish 'Coloner' and Mustard 'Concerta' are two additional promising varieties that are currently under investigation. The recommended seeding rate is 25 pounds per acre. The dense seeding rate is critical because it reduces weed populations and increases nematode egg hatch. Sowing options include using a grain drill and packer, planting at a depth of 1/2 inch to 1 inch, or using a fertilizer spreader. If the seed is mixed with the fertilizer in a fan spreader truck, a light harrowing would be necessary to cover the seed.
5. Irrigation
Adequate soil moisture is important for nematode egg hatching and green manure root establishment. Good irrigation practices will also maintain good aeration in the soil, another factor that is important in stimulating egg hatch and seed germination. A minimum of four irrigation events is recommended, but avoid over-watering.

6. Weed control
To enhance weed control, irrigating before planting the green manure is recommended if time permits. Other tactics include dense planting of the green manure and the use of labeled herbicides. Treflan is a herbicide that can be used pre-plant for broadleaf weeds and grasses, including grains. Assure 2 or Poast can be applied post-plant, and are effective against grasses (including grains). Be sure to follow the labeled recommendations.

7. Green manure incorporation
To prevent seed production, it may be necessary to mow at pod formation stage (when plants are about 12 inches in height). It's important to prevent moisture loss during this period. To incorporate, the green manure should be chopped first and turned, then plowed under to mix the green foliage and the roots with the soil. Discing 2 to 3 times, plowing, ripping, and harrowing are recommended.

FITTING GREEN MANURES INTO YOUR CROP ROTATION SCHEME

Deciding when to plant a green manure, in fall or spring, depends partly on your rotation program and on the availability of irrigation water. Figure 2 diagrams how green manures planted in the fall can be incorporated into current rotation programs, and Figure 3 provides examples as to how current rotations can accommodate green manure crops planted in the spring.

![Diagram](image-url)

**Figure 2.** Fitting green manure crops planted in fall into a sugarbeet rotation program.

To effectively reduce sugar beet cyst nematodes, green manure crops do require 8 to 10 weeks growth with soil temperatures above 60°F. This long growing period can cause concern when the danger of frost is present (oil radish tolerates frost as low as 22°F, while mustard cannot go
below 26° F). However, this concern may soon be alleviated for green manure crops planted in the fall when fast growing varieties become available.

Planting radish in fall can be followed by beets the following spring, but another season with a non-host crop such as winter wheat, onion, potato, corn, or beans will provide better nematode control. Nematode control will be extended by this practice, and the rotation needed for a good crop of sugar beets the following year will be provided.

![Diagram of sugar beet rotation program]

**Figure 3.** Fitting spring-planted green manures into a sugar beet rotation program.

**WHAT TO AVOID IN MANAGING GREEN MANURE CROPS**

If green manures are to be effective against nematodes, avoid the following:

- Planting late
- Poor seedbed preparation (e.g. leaving straw or stubble on the soil surface)
- Over-watering and under-fertilizing
- Weeds and volunteer grain
- Inadequate seeding rate