



# Conducting Root Digs for Corn Rootworm in Corn

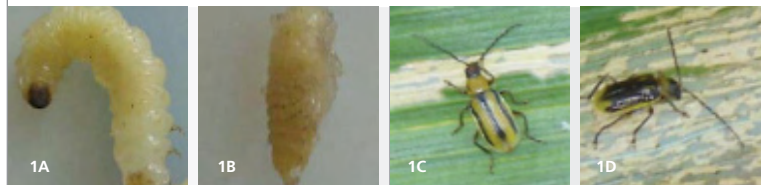
Whether evaluating rootworm pressure or comparing different control measures, root digs can be helpful in managing corn rootworm. To help maximize the usefulness of the information captured, root digs should take place at the optimum time and the standard 0 to 3 Node Injury Scale (NIS) should be used.

## Timing

1. Root damage is greatest when the majority of larvae have completed the 3rd instar (larval stage). Often this is around tasselling and falls in July or August.
2. Digging roots too early can underestimate the amount of damage that will be present.
3. Roots dug after the majority of the adults emerge are more difficult to wash and rate due to root regrowth.
4. Usually there is a 2 to 3 week window that is optimum for digging roots.

## Digging

1. In 3 random locations per treatment, 5 consecutive root balls should be dug.
2. Digging roots from an area with no biotech trait to control rootworm and/or no soil insecticide can help evaluate the overall CRW pressure.
3. If the pressure is light in this 'untreated' area, it is likely that feeding differences will be minimal in the other treatments and further digging may not be warranted.
4. Removing the upper portion of the plant about 1 to 2 feet above the root mass can help make handling (hauling out of the field, soaking, etc) much easier.
5. Label the root masses with the appropriate treatment. Permanent marker on duct tape placed a few inches below where the stalk was cut works fairly well, but there are several other methods.
6. Instead of digging the plants individually, it is often easier to dig in a large oval shape around all five plants. Loosening the soil around the 5 plant area, can help keep the root masses intact and still allow separation of the plants.



**Figure 1.** When digging roots, it is possible to find CRW at all three stages of development: larva (1A), pupa (1B), and adult (1C & 1D). Adult males (1C) emerge about 2 weeks prior to adult females (1D).

## Washing

1. Soaking roots in a tub of water for 30 minutes or more can help remove soil from the roots. In addition, washing roots immediately after digging may remove some of the smaller roots with the soil.
2. If rootworm larvae or pupae (Figure 1) are present in the root ball, they may float to the top of the water while soaking.
3. Roots should be washed carefully using a pressure washer or strong hose. To avoid unwanted injury, the pressure washer should be on low. After washing, roots are ready to be rated.

## Rating

1. While rating, roots should carefully be pulled back at each node to allow for easier inspection of rootworm scarring and root pruning.
2. Three nodes should be evaluated, starting with the uppermost node which has all of the roots at least 1.5 inches into the soil.
3. Later in the season, it is likely that brace roots will be the first one or two nodes that will need to be evaluated. When evaluating brace roots, the 1.5 inch parameter becomes relative to the soil line instead of the crown.
4. To assign a damage rating, assess the root pruning and scarring using the 0 to 3 NIS scale (Table 1 and Figure 2).
5. If regrowth is extensive, consider removing it to help assess damage to original root system more accurately.

## Feeding Damage Can Vary Greatly by Treatment



### Utilizing Root Ratings For Management Decisions

1. Generally under good growing conditions, an NIS rating of 1.0 is when considerable economic damage is likely to occur. Under adverse conditions, especially drought conditions, an NIS rating of 0.25 can cause economic damage.
2. It is important to consider the average NIS rating and consistency when evaluating options for managing CRW.
3. Consistency of protection refers to the percentage of NIS ratings that are less than 0.25, the economic threshold under droughty conditions.
4. Table 2 shows a theoretical example of individual root ratings and how it is common for two treatments to both have average NIS ratings below 0.25, but one to have more consistent protection with fewer root masses having NIS ratings of more than 0.25.
5. Figure 3 represents data collected by Trait Integration within Monsanto. Please note that the average NIS ratings of both Genuity® VT Triple PRO™ and Genuity® SmartStax™ are less than 0.25, but Genuity® SmartStax™ has an overall lower average NIS rating and much better consistency.

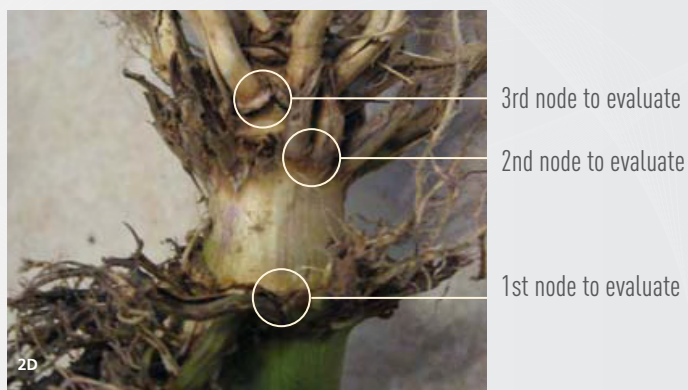
### Examples of NIS Ratings and their Descriptions

NIS Rating	Root Injury Description
0.01	No visible root injury
0.05	Root scarring
0.08	Severe root scarring or root tips pruned beyond 1.5 inches of crown
0.10	10% of a node pruned (often 1 root) within 1.5 inches of crown
0.25	25% of a node pruned within 1.5 inches of crown
0.75	75% of a node pruned within 1.5 inches of crown
1.0	A full node pruned within 1.5 inches of crown
1.5	One full node and 50% of another node pruned within 1.5 inches of crown
2.0	Two full nodes pruned within 1.5 inches of crown
3.0	Three full nodes pruned within 1.5 inches of crown (maximum value)

Table 1. This scale was modified slightly from the one described in the source from James D. Oleson

### Figure 2

- Feeding scars appear as small brown lesions (2A). If the feeding shown in Figure 2A was the extent of the damage on the root mass, it would receive a NIS rating of 0.05.
- Extensive feeding can cause tunneling, which is NOT shown here.
- Figure 2B shows a root tip that has been eaten by CRW. The root is longer than 1.5 inches. If that was the extent of the injury on the root mass, it would receive an NIS rating of 0.08. If this root had been pruned within 1.5 inches of the crown, it would receive an NIS rating of 0.1. Note the characteristic prolific regrowth of roots just above the injury.
- Figure 2C shows the 3 nodes that are used for evaluation. On the 1st node, approximately 75% of the roots were pruned within 1.5 inches of the crown. On the 2nd node, 100% of the roots were pruned within 1.5 inches of the crown. On the 3rd node, 0 roots were pruned. The NIS rating for this root was 1.75.
- Figure 2D shows heavy feeding from CRW. The appearance of this type of feeding is different from the visual effects of mechanical injury that might occur during the digging process.



Theoretical Data to Illustrate How Differences in Average NIS Ratings and Consistency Can be Obtained

Root Mass	Untreated	YieldGard VT Triple®	Genuity® SmartStax™
1	0.5	0.05	0.05
2	1.5	0.1	0.05
3	3.0	0.5	0.05
4	0.5	0.75	0.5
5	0.75	0.01	0.01
6	1.25	0.01	0.05
7	1.0	0.05	0.01
8	2.0	0.05	0.08
9	2.5	0.01	0.05
10	2.75	0.25	0.75
11	1.75	0.75	0.01
12	1.0	0.05	0.05
13	2.0	1	0.01
14	2.5	0.05	0.05
15	2.75	0.01	0.01
<b>Avg NIS Rating</b>	1.72	0.24	0.12
<b>Consistency</b>	0%	66%	87%

Table 2. Gray cells indicate NIS ratings of less than 0.25

Source: James D. Oleson and others. 2005. Node-Injury Scale to Evaluate Root Injury by Corn Rootworms (Coleoptera: Chrysomelidae). Journal of Economic Entomology. 98 (1) 1-8.

Corn Rootworm Damage  
 NIS Ratings and Percent Consistency

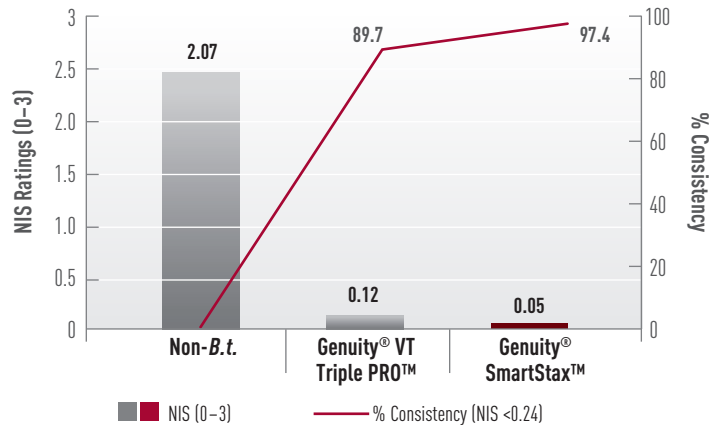


Figure 3. CRW damage ratings from trials conducted in 2009 by the Trait Integration department in Monsanto.



Biotech Rootworm Trait

Soil Insecticide

Untreated Check



**Insect Resistance Management**  
 Planting Refuges, Preserving Technology

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