Corn Insect Management
Francis P. F. Reay-Jones

Grain yield reductions and losses in grain quality due to insect pests are a constant problem in the Southeast. Control options include cultural practices to prevent or avoid injury, transgenic Bt corn, at-planting insecticides (including seed treatments), and foliar insecticides. Because of economic reasons, growers cannot afford to invest a substantial amount of money on foliar insecticides on corn.

Bt corn and insecticide coated seeds are relatively new technologies, and have been evaluated in replicated studies in South Carolina. Insect pressure varies greatly from field to field. Decisions concerning pest management options should therefore be made in careful consideration of the history of insect problems in each field where corn is to be planted. Insecticide recommendations can be found in the Clemson University 2011 Pest Management Handbook for Field Crops and online at http://www.clemson.edu/extension/rowcrops/pest/index.html.

Table 1. Major insect pests of corn in South Carolina.

<table>
<thead>
<tr>
<th>Insect</th>
<th>Description of feeding habit</th>
<th>Methods of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireworms</td>
<td>Feed on planted kernels resulting in poor germination and stunted seedlings</td>
<td>Insecticide, tillage, control of winter weeds</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Girdling of stalk at soil surface</td>
<td>Avoid planting corn on sod or weedy land, selected Bt hybrids, insecticides</td>
</tr>
<tr>
<td>Sugarcane beetles</td>
<td>Burrow into stalk above base of roots</td>
<td>Plant early and do not plant corn after sod</td>
</tr>
<tr>
<td>Billbugs</td>
<td>Chew into stalk and cause bud leaves to wilt and die</td>
<td>Crop rotation, weed removal in and around corn field, insecticides</td>
</tr>
<tr>
<td>Corn earworms</td>
<td>Feed on leaves in whorl and on ear tissue near ear tip</td>
<td>Insecticides, selected Bt hybrids, plant early</td>
</tr>
<tr>
<td>Fall armyworms</td>
<td>May feed on all above ground parts of corn plant</td>
<td>Insecticides, plant and harvest early, control grassy weeds</td>
</tr>
<tr>
<td>European corn borers</td>
<td>Burrow into stalk anywhere on plant, resulting in broken stalks</td>
<td>Crop rotation, plow under old corn residue, selected Bt hybrids and insecticides</td>
</tr>
<tr>
<td>Southern corn rootworms</td>
<td>Larvae feed on roots and leaf bud while adults feed on any plant tissue</td>
<td>Plow under weeds or cover crop early, insecticides</td>
</tr>
<tr>
<td>Southern cornstalk borers</td>
<td>Burrow into base of stalks</td>
<td>Crop rotation, early planting and plow under old corn residue, selected Bt hybrids, insecticides</td>
</tr>
<tr>
<td>Lesser cornstalk borers</td>
<td>Tunnel into corn seedling</td>
<td>Crop rotation and early planting, selected Bt hybrids, insecticides</td>
</tr>
</tbody>
</table>
1. Transgenic corn:

*Bt corn.* Several types of Bt corn are available, each characterized by an ‘event’ (i.e. a successful insertion of the genetic package into a plant) and cry proteins. In a nutshell, there are Bt traits for stalk borers, Bt traits for rootworms and stacked Bt traits for both stalk borers and rootworms. Please refer to table 2 below for efficacy of available products.

*Bt traits for stalk borers.* Available Bt traits for stalk borers are:

- YieldGard Corn Borer (event MON810, cry protein Cry1Ab).
- Herculex I (event TC1507, cry protein Cry1F; glufosinate herbicide tolerance).
- Genuity VT Double Pro (event MON89034, cry proteins Cry1A.105 and Cry2Ab2; glyphosate herbicide tolerance).
- Agrisure CB/LL (event Bt11, cry protein Cry1Ab; glufosinate herbicide tolerance).
- Agrisure Viptera 3110 (events MIR162 and Bt11, vip protein Vip3A and cry protein Cry1Ab; glyphosate and glufosinate herbicide tolerance).

All products provide excellent control of stalk borers (European corn borer, southern cornstalk borer). The activity in seedling and whorl stage is greater in Herculex I than in YieldGard Corn Borer, which provides good early season control of cutworms, lesser corn stalk borer, and fall armyworm. YieldGard Corn Borer and Agrisure CB/LL have greater activity in ears and kernel than Herculex I; corn earworm control is therefore fair in YieldGard Corn Borer and Agrisure CB/LL, and poor in Herculex I. A more recent Bt corn trait is YieldGard VT Pro. This is the first Bt corn to have two genes expressing Bt toxins to control above ground Lepidoptera pests. The major advantage relative to the previously mentioned products is that YieldGard VT Pro provides very good control of both corn earworm and fall armyworm. The new Viptera traits will also provide very good control of corn earworm and fall armyworm, and good control of cutworms. These hybrids may be particularly useful in late planted and no-till corn.

*Bt traits for rootworms.* Available Bt traits for rootworms are:

- Herculex RW (event DAS59122-7, cry protein Cry34/35Ab1; glufosinate herbicide tolerance).
- YieldGard Rootworm (event MON863, cry protein Cry3Bb).
- YieldGard VT Rootworm/RR2 (event MON88017, cry protein Cry3Bb; glyphosate herbicide tolerance).
- Agrisure RW (event MIR604, cry protein mCry3A).

All products provide good to excellent control of western corn rootworms (but no control of grubs and wireworm). Western corn rootworms are not currently widespread pests in South Carolina, and these products should generally not be needed unless planting corn after corn without crop rotation. YieldGard VT Rootworm (MON88017, Cry3Bb) uses a new methodology...
to insert genes into the corn plant, and is more effective in controlling western corn rootworms than the older product YieldGard Rootworm.

**Stacked Bt traits for stalk borers and rootworms.** Available products are:

- **Herculex Xtra** (events TC1507 and DAS59122-7, cry proteins Cry1F and Cry34/35Ab1; glufosinate herbicide tolerance).
- **YieldGard Plus** (events MON810 and MON863, cry proteins Cry1Ab and Cry3Bb).
- **YieldGard VT Triple** (events MON810 and MON88017, cry proteins Cry1Ab and Cry3Bb1; glyphosate herbicide tolerance).
- **Agrisure CB/LL/RW** (events Bt11 and MIR604, cry proteins Cry1Ab and mCry3A; glufosinate herbicide tolerance).
- **Agrisure GT 3000** (events Bt11, and MIR604, cry proteins Cry1Ab and mCry3A; glyphosate and glufosinate herbicide tolerance).
- **Agrisure Viptera 3111** (events MIR162, Bt11 and MIR604, vip protein Vip3A and cry proteins Cry1Ab and mCry3A; glyphosate and glufosinate herbicide tolerance).
- **Genuity VT Triple Pro** (events MON89034 and MON88017, cry proteins Cry1A.105, Cry2Ab2 and Cry3Bb1; glyphosate herbicide tolerance).
- **Genuity SmartStax** (events MON89034, MON88017, TC1507 and DAS59122, cry proteins Cry1A.105, Cry2Ab2, Cry3Bb, cry1F, and Cry34/35Ab1; glyphosate and glufosinate herbicide tolerance).

These products combine the cry proteins (and efficacy) of the stalk borer and rootworm Bt corn traits.

**Refuge requirements for Bt corn for stalk borers** (see dealers for complete refuge requirements)

- For YieldGard Corn Borer, and Agrisure CB/LL, Herculex I: 50% of corn on a farm can be planted as Bt corn.
- **Genuity VT Double Pro**, Agrisure Viptera 3110: 20% of corn on a farm can be planted as Bt corn.
- Blocks can be internal (within Bt field) or external (in separate field within ½ mile of Bt field to maximize random mating; ¼ mile is however preferred.
- In field strips: at least 4 rows wide to reduce effect of larval movement (6 rows preferred)
- Refuge can be sprayed with any insecticide except Bt products

**Refuge requirements for Bt corn for rootworms** (see dealers for complete refuge requirements)

Bt corn for rootworm has specific regulations that differ from stalk borer Bt corn (see [http://www.epa.gov/oppbppd1/biopesticides/pips/bt_corn_refuge_2006.htm](http://www.epa.gov/oppbppd1/biopesticides/pips/bt_corn_refuge_2006.htm) for EPA requirements). The major difference for rootworm Bt corn is that refuges must be either adjacent to or within the Bt field, rather than within ¼ mile of the Bt field for stalk borer Bt corn. This is due to the poor flight ability of corn rootworm adults.
Refuge requirements for stacked Bt corn for stalk borers and rootworms (see dealers for complete refuge requirements)

- For YieldGard Plus, YieldGard VT Triple, Agrisure CB/LL/RW, Agrisure GT 3000, and Herculex Xtra: 50% of corn on a farm can be planted as Bt corn.
- Genuity VT Triple PRO, Genuity SmartStax, Agrisure Viptera 3111: 20% of corn on a farm can be planted as Bt corn.
- 2 options for the refuge:
  o Common rootworm/corn borer refuge
  o Discrete rootworm and corn borer refuges
- For common refuge and discrete rootworm refuge: use adjacent field, block perimeter, or in-field strip.
- For discrete corn borer refuge: separate fields can be used in addition to other refuge options.
- For shared refuge and discrete rootworm refuge: refuges must be adjacent to or within field.
- For discrete corn borer refuge: separate refuges must be within 1/2 mile (but 1/4 mile preferred).
- At least 4 rows (for discrete corn borer refuges, at least 6 rows are recommended).
- Refuge can be sprayed with any insecticide except Bt products.
### Table 2. Relative Efficacy of Various Bt Corn Products
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<table>
<thead>
<tr>
<th>Product Trade</th>
<th>Corn Earworm (ear)</th>
<th>Fall Armyworm (whorl)</th>
<th>Corn borers (stalk)</th>
<th>Western corn rootworm (roots)</th>
<th>Black Cutworm (seedling)</th>
<th>Lesser Corn-stalk Borer</th>
<th>Refuge requirement</th>
<th>Original Target Pests (Bt Protein)</th>
<th>Event(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bt Corn for Controlling Above-Ground Caterpillars (Lepidoptera) and Below-Ground Rootworms (Coleoptera)</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agrisure CB/LL</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair-Good</td>
<td>Good</td>
<td>Good</td>
<td>20%</td>
<td>Corn earworm, western bean cutworm, black cutworm, and fall armyworm control (Vip3A), corn borer protection (Cry1Ab), Liberty (glufosinate) herbicide tolerance and corn rootworm protection (modified Cry3A)</td>
<td>MIR162, Bt11, GA21, MIR604</td>
</tr>
<tr>
<td>Agrisure 3000GT</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair-Good</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab), Corn rootworm protection (modified Cry 3A), glyphosate herbicide tolerance, Liberty (glufosinate) herbicide tolerance</td>
<td>Bt11, MIR604, GA21</td>
</tr>
<tr>
<td>Agrisure CB/LL/RW</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair-Good</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab), Corn rootworm protection (modified Cry3a), Liberty (glufosinate) herbicide tolerance</td>
<td>Bt11, MIR604</td>
</tr>
<tr>
<td>Genuity SmartStax (GENSS) or DowAgroSciences SmartStax (SSX)</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Very Good</td>
<td>20%</td>
<td>Corn borer, fall armyworm, corn earworm, western bean cutworm, black cutworm protection (Cry1A.105, Cry2Ab, Cry1F) Corn rootworm protection (Cry3Bb, Cry34/35Ab1) Roundup (glyphosate) herbicide tolerance Liberty (glufosinate) herbicide tolerance</td>
<td>MON89034, MON88017, TC1507, DAS 59122-7</td>
<td></td>
</tr>
<tr>
<td>Genuity VT Triple PRO (GENVT3P)</td>
<td>Good-Very Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Very Good</td>
<td>20%</td>
<td>Corn borer, fall armyworm, corn earworm protection (Cry1A.105 and Cry2Ab), Corn rootworm protection (Cry3Bb), Roundup (glyphosate) herbicide tolerance</td>
<td>MON89034, MON88017</td>
<td></td>
</tr>
<tr>
<td>Herculex XTRA (HXX)</td>
<td>Poor</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Very Good</td>
<td>50%</td>
<td>Corn borer, western bean cutworm, black cutworm and fall armyworm resistance (Cry1F), Corn rootworm resistance (Cry34/35Ab1), Liberty (glufosinate) herbicide tolerance</td>
<td>TC 1507, DAS 59122-7</td>
<td></td>
</tr>
<tr>
<td>YieldGard Plus (YGPL)</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab), Corn rootworm protection (Cry3Bb)</td>
<td>MON810, MON863</td>
</tr>
<tr>
<td>YieldGard VT Triple (VT3)</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab), Corn rootworm protection (Cry3Bb), Roundup (glyphosate) herbicide tolerance</td>
<td>MON810, MON88017</td>
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</tr>
<tr>
<td><strong>Bt Corn for Controlling Above-Ground Caterpillars (Moths, Lepidoptera)</strong></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Agrisure CB/LL</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>None</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab) Liberty (glufosinate) herbicide tolerance</td>
<td>Bt11</td>
</tr>
<tr>
<td>Product Trade Name (Abbreviation)</td>
<td>Corn Earworm (ear)</td>
<td>Fall Armyworm (whorl)</td>
<td>Corn borers (stalk)</td>
<td>Western corn rootworm (roots)</td>
<td>Black Cutworm (seedling)</td>
<td>Lesser Cornstalk Borer</td>
<td>Refuge requirement*</td>
<td>Original Target Pests (Bt Protein)</td>
<td>Event(s)</td>
</tr>
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</tr>
<tr>
<td>Agrisure Viptera 3110</td>
<td>Excellent</td>
<td>Excellent</td>
<td>None</td>
<td>Good</td>
<td>Good</td>
<td>20%</td>
<td>Corn earworm, western bean cutworm, black cutworm, and fall armyworm control (Vip3A), corn borer protection (Cry1Ab), Liberty (glufosinate) herbicide tolerance, glyphosate herbicide tolerance</td>
<td>MIR162, Bt11, GA21</td>
<td></td>
</tr>
<tr>
<td>Genuity VT Double Pro (GENVT2P)</td>
<td>Good-Very Good</td>
<td>Excellent</td>
<td>None</td>
<td>Poor</td>
<td>Very Good</td>
<td>20%</td>
<td>Corn borer, fall armyworm, corn earworm protection (Cry1A.105 and Cry2Ab), Roundup (glyphosate herbicide tolerance)</td>
<td>MON89034, NK603</td>
<td></td>
</tr>
<tr>
<td>Herculex I</td>
<td>Poor</td>
<td>Very Good</td>
<td>Excellent</td>
<td>None</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer, western bean cutworm, black cutworm and fall armyworm resistance (Cry1F) Liberty (glufosinate) herbicide tolerance</td>
<td>TC 1507</td>
<td></td>
</tr>
<tr>
<td>YieldGard Corn Borer (YGCB)</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
<td>50%</td>
<td>Corn borer protection (Cry1Ab)</td>
<td>MON810</td>
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</tr>
</tbody>
</table>

**Bt Corn for Controlling Below-Ground Rootworms (Beetles, Coleoptera)**

<table>
<thead>
<tr>
<th>Product Trade Name (Abbreviation)</th>
<th>Corn Earworm (ear)</th>
<th>Fall Armyworm (whorl)</th>
<th>Corn borers (stalk)</th>
<th>Western corn rootworm (roots)</th>
<th>Black Cutworm (seedling)</th>
<th>Lesser Cornstalk Borer</th>
<th>Refuge requirement*</th>
<th>Original Target Pests (Bt Protein)</th>
<th>Event(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrisure RW</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Fair-Good</td>
<td>None</td>
<td>None</td>
<td>20%</td>
<td>Corn rootworm protection (modified Cry3A)</td>
<td>MIR604</td>
</tr>
<tr>
<td>Herculex RW (HXRW)</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Excellent</td>
<td>None</td>
<td>None</td>
<td>20%</td>
<td>Corn rootworm resistance (Cry34/35Ab1) Liberty (glyphosate herbicide tolerance)</td>
<td>DAS-59122-7</td>
</tr>
<tr>
<td>YieldGard Rootworm (YGRW)</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Good</td>
<td>None</td>
<td>None</td>
<td>20%</td>
<td>Corn rootworm protection (Cry3Bb1)</td>
<td>MON863</td>
</tr>
<tr>
<td>YieldGard VT Rootworm/RR2 (VTRR2)</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Excellent</td>
<td>None</td>
<td>None</td>
<td>20%</td>
<td>Corn rootworm protection (Cry3Bb) Roundup (glyphosate) herbicide tolerance</td>
<td>MON88017</td>
</tr>
</tbody>
</table>

1. Most of these insect resistant products are marketed as stacks with herbicide resistant products.
2. Southwestern corn borer, European corn borer, and sugarcane borer.
3. There are several species of corn rootworm in the Southeast. Southern corn rootworm is the most prevalent species. These “rootworm” products are not effective against southern corn rootworm. They are effective against western corn rootworm larvae, which occur in areas such as north Alabama and north Georgia.
4. Based on limited data.
5. Lepidopteran Bt traits do not specifically list lesser cornstalk borer as a target pest.
6. See product Insect Resistance Management (IRM) documentation from the seed companies for more details.
7. The meaning of these terms is somewhat arbitrary. Excellent usually means better than 95 percent control. Poor means about 30% control. Rankings are meant to be relative.

2. Insecticides at planting:

Table 3 lists the efficacy of insecticides used at planting in corn in Georgia (Dr. David Buntin, UGA). Granular, liquid and seed treatment insecticides can be used. Seed companies are using more and more seed treatments (Poncho [clothianidrin] and Cruiser [thiamethoxam]), and seeds without such treatments are becoming harder to find. Both provide systemic activity for aphids, thrips and leafhoppers for 2-3 weeks, as well as the control listed in Table 3.

Table 3. Relative efficacy of insecticides for at-planting use in corn in Georgia (reprinted with permission from D. Buntin, University of Georgia).

<table>
<thead>
<tr>
<th>Product</th>
<th>Seed-corn maggot</th>
<th>S. Corn root-worm</th>
<th>Wire-worm</th>
<th>Grubs</th>
<th>Lesser corn-stalk borer</th>
<th>Cutworm</th>
<th>Bill-bug</th>
<th>Sugar-cane beetle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter 15G</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-/+</td>
</tr>
<tr>
<td>Lorsban 15G</td>
<td>++</td>
<td>++</td>
<td>-/+</td>
<td>-/+</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Force 3G</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-/+</td>
</tr>
<tr>
<td>Capture 2EC LQ</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Furadan 4F LQ</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Regent 4SC LQ</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>Poncho 250 ST</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>-/+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-/+</td>
</tr>
<tr>
<td>Cruiser 250 ST</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>-/+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-/+</td>
</tr>
<tr>
<td>Poncho/Cruiser 1250 ST</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</tbody>
</table>

Rating: - indicates poor activity; + indicates fair activity; ++ indicates good activity.
LQ = Products require specialized equipment for liquid injection in-furrow.
ST = seed treatments, applied by seed dealers.

3. Foliar insecticides:

Seedling corn is particularly sensitive to insect damage. Recommendations for UGA state that yield loss occurs when 10% of plants are destroyed or severely damaged. In general, corn beyond the 5-7 leaf stage can withstand a good amount of defoliation before insecticides are required. Insecticides and rates are listed in the corn insecticide recommendations (http://www.clemson.edu/extension/rowcrops/pest/index.html).