Guide to Commercial Cabbage Production

Historical Perspective
Cabbage (Brassica oleracea L. var. capitata) is a member of the Brassicaceae (Mustard) family (Figure 1). This family includes broccoli, brussels sprouts, cauliflower, kale, mustard (greens), and collards. Collectively, these crops are referred to as cole crops or crucifers.

Figure 1. Well-formed head of cabbage

Early Greek and Roman literature refers to the cultivation of cole crops for their perceived medicinal properties as well as a source of food. Belief that these crops relieved such conditions as gout, deafness, and headaches furthered the spread of cole crops from the Mediterranean through the Old World.

Now, cabbage and many of the cole crops are cultivated throughout the world for use fresh and in processed products. Nutritionally, 1 cup of raw cabbage contains 93 percent water and is a good source of dietary fiber as well as vitamins A and C. Worldwide, China is the leading producer and consumer of cabbage. In the United States, 80,000 acres of cabbage valued at almost $280 million was harvested in 1997.

Figure 2. Characteristic symptom of tipburn on exterior (top) cabbage head

Planting Recommendations

Planting Dates, Seeding, and Transplanting

Cabbage is a cool-season crop generally requiring 60 to 100 days from sowing to reach market maturity, depending on the variety. Cabbage can be grown as a spring crop as well as a fall crop in Alabama. Although it can be direct-seeded, most cabbage production relies on the use of transplants. Ideal monthly temperatures for optimal growth and development ranges from 60°F to 65°F.

Temperatures over 75°F can induce “bolting” in cabbage, but varieties differ in their susceptibility to this disorder. Bolting is the process in which the plant switches from vegetative growth (heading) to reproductive growth (formation of flowers and seeds). This switch becomes evident when seed stalks appear, making the heads unmarketable. The presence of a seed stalk is not always apparent from examining the exterior of the cabbage; the head may have to be split to see the seed stalk forming from the base of the plant. Many varieties differ in their tolerance to higher temperatures that induce bolting. More information on variety selection is discussed in the Variety Selection section of this publication.

Direct-seeding of cabbage requires using a precision seeder to place single seeds at the desired plant spacing. Soil temperatures must be above 40°F to ensure germination of the seed; otherwise, seed will be lost to rotting and damping off, resulting in poor, uneven stands. The optimal range for germination is between 45°F and 95°F.

Some growers opt to produce their own transplants in field beds where seed is scattered over a prepared area and then transplants are dug 5 to 7 weeks later. One ounce of cabbage seed will produce about 5,000 transplants.

For a spring crop, transplant in late December through early January in South Alabama or in late January through early February in North Alabama. The fall crop should be field-seeded during the first half of August in South Alabama and during the last half of July in other areas. If using transplants in the fall, plant about 1 month later than if field-seeding.

Prepare the land early by turning the soil so that any crop residue is fully decomposed before transplanting or direct-seeding is done. Space plants 12 to 15 inches apart in 36- to 42-inch rows. This will produce heads that range from 2 to 3 pounds. When larger heads are desired, increase the spacing.
Figure 3. Diamondback moth caterpillar larvae are smaller than other caterpillar pests of cole crops; mature larvae are green, 1/3 to 5/8 inch long, and tapered at both ends.

Figure 4. Mature cabbage looper larvae grow as large as 1 1/2 inches in length and have only three pairs of fleshy prolegs in the rear.

Figure 5. Green larvae of the imported cabbageworm can be distinguished from other caterpillars by the dense coating of fine hairs that give the larvae a velvety appearance.

Figure 6. Cabbage webworm larvae are 3/4 inch long when mature and are gray in color with five dark stripes.

Figure 7. The cross-striped cabbage-worm is easy to identify by the black and white transverse stripes down the back.

Figure 8. Beet armyworm larvae are light green to dark olive green and may have longitudinal stripes on the back or sides of the body.

Figure 9. Cutworms are dark gray-brown in color with a greasy appearance, and they often curl into a C shape at rest or when disturbed.

Figure 10. Seed and root maggots are the immature, or maggot, stages of flies that are attracted to decaying organic matter.

Figure 11. Several aphid species, including cabbage aphids, infest cole crops. Large numbers of aphids may kill small plants, and their feeding can distort leaves of older plants, causing leaf curl.

Figure 12. Closely related to the stinkbug, the harlequin bug is a brightly colored, shield-shaped bug with red and black markings and piercing-sucking mouthparts.

Figure 13. Flea beetle adults are small, dark-colored beetles with enlarged hind legs that enable them to jump great distances.

Figure 14. Vegetable weevil adult
between plants within a row. Another option is to use double rows (two rows of plants within each bed). Using double rows will increase your yields from 30 to 50 percent or more. Plants in double rows compete better with weeds and produce a more uniform crop.

Use Table 1 to determine the number of plants per acre required at the various spacings. To determine the number of plants required per acre for any spacing, divide 43,560 (number of square feet in 1 acre) by the product of the desired spacing between plants and the spacing between the rows. For example, a 12-inch between-plant spacing on 36-inch centers would require 14,520 plants per acre: (12 in. \( \times \) 36 in. or 1 ft. \( \times \) 3 ft. = 3 ft.\(^2\); then divide 43,560 by 3 = 14,520 plants per acre). For double rows, simply double the number of plants required for single-row production.

**Table 1. Number of Plants Required at Various Spacings**

<table>
<thead>
<tr>
<th>Between-row spacing</th>
<th>36 inches</th>
<th>42 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 inches</td>
<td>14,520</td>
<td>12,446</td>
</tr>
<tr>
<td>15 inches</td>
<td>11,616</td>
<td>9,957</td>
</tr>
</tbody>
</table>

**Soil and Fertility**

Cabbage can be grown on a wide range of soil types. A well-drained sandy loam soil with good organic content is preferred. Avoid soils that tend to dry quickly. Adjust soil pH to between 6.0 and 6.5. Plow under cover crops at least 1 month before planting to allow sufficient time for the cover crop to decompose. To avoid potential soil-borne disease and nematode problems, do not plant cabbage in soils that have produced a crop of cabbage, broccoli, collards, or any other cole crop in the past 2 to 3 years. Crop rotation can be an effective means of decreasing disease severity or incidence.

Soil testing is essential for determining the amount of fertilizer and lime required to successfully produce a crop of cabbage. The best strategy is to have a soil test performed yearly. Timely and appropriate applications of fertilizer can make a significant difference in the quality and quantity of cabbage harvested. Collect soil samples from each area that you intend to crop, and have a soil analysis performed on each sample. **Apply recommended lime 2 to 3 months before planting** because it takes time for lime to raise the soil pH. Failure to properly lime your soil can ultimately cause your crop to have a major nutritional problem that is not easily corrected. Often, by the time a nutrient disorder is visible, it is too late to salvage the crop, especially if that disorder has resulted from very low soil pH. Contact your county Extension agent for information about how to collect, submit, and interpret the results of your soil test.

The general recommendation for cabbage is to apply enough fertilizer to furnish 120 pounds each of nitrogen (N), phosphorus (P\(_2\)O\(_5\)), and potassium (K\(_2\)O) per acre. This can be done by applying 800 pounds of 10-10-10 per acre by broadcast or band placement methods before planting. Also apply 10 to 20 pounds of Borax per ton of fertilizer. If boron is not applied with preplant fertilizer, spray 10 pounds of Solubor per acre or 2 quarts of N-Boron per acre directed at the base of young plants. Cole crops have a higher demand for boron than many other vegetable crops do. A boron deficiency can manifest itself as a condition called “hollow heart” in cabbage. With hollow heart, the pith of the head (center) becomes cracked and brown as the cabbage reaches maturity.

Sidedress with 20 to 25 pounds of N per acre 2 weeks after transplanting or 4 to 5 weeks after direct-seeding. Sidedress again with another 20 to 25 pounds N per acre 3 weeks later. Other fertilizer grades (besides 10-10-10) can be used to supply equivalent amounts of nutrients. Fertilizer applied before planting or transplanting should be well mixed into the soil to prevent any chance of plant injury.

**Variety Selection**

Cabbage varieties can differ in terms of head size, density, shape (globe, round, flat round), color (green, red, blue-green), leaf texture (smooth or savoyed), and market maturity as well as tolerance to bolting. Read variety descriptions in seed catalogues, variety trial reports, and other publications to determine whether a particular variety meets all the requirements for your growing area, season of production, and intended market. Most varieties indicate whether they are suited to spring and/or fall production. This is an indication of how susceptible that variety is to bolting. In Alabama, bolting tends to be more problematic in the spring when temperatures commonly fluctuate above 75°F. For a spring crop, choose a cabbage variety that is less sensitive to bolting.

Disease resistance/tolerance is also important. The disease black rot (described in the Controlling Diseases section) can be devastating to cabbage because it can be difficult to control. Use cabbage varieties that are tolerant of the disease, especially for plantings that will be placed into fields that have produced cabbage or any other cole crop in the past 2 to 3 years.

Tolerance to a physiological condition called tipburn is also desirable. Tipburn is related to a calcium deficiency in developing tissue. The condition is favored by excessive or rapid growth due to overfertilization, or it can be caused by low soil pH. High relative humidity also favors the development of tipburn. Symptoms of tipburn are not always detectable on the exteriors of heads (Figure 2). Often, it is not apparent until a head is cut in half and the internal tissue is examined.
Tissue inside the head turns black, especially the tissue that surrounds the growing point of the head. Once tipburn develops, it cannot be reversed, and the head is unmarketable. To prevent or limit the development of tipburn, grow only tolerant varieties and avoid excessive fertilization. Soil test and lime with dolomitic or calcitic lime to a pH of 6.0 to 6.5. Apply calcium if necessary as indicated by the soil test. Sprays containing calcium can also be used to supply extra calcium, especially under stressful growing conditions. These sprays, however, are not a substitute for proper soil pH and an adequate soil calcium level.

Contact your county Extension agent for a copy of the latest edition of the report entitled “Fall Vegetable Variety Trials” from the Alabama Agricultural Experiment Station at Auburn University. In the report, you will find information about the performance of selected cabbages in trials at several locations throughout Alabama. Although there are a large number of commercial varieties available, grow only those that are adapted to Alabama. It is advisable to grow a small trial plot of several varieties each year to determine which varieties are best suited to your specific growing conditions, management practices, and marketing outlets.

Irrigation

Irrigation is an essential element of a successful vegetable production operation and is critical to the consistent production of quality produce. Cabbage is a fast-growing, shallow-rooted crop whose roots penetrate only 12 to 15 inches into the soil. Although cabbage is relatively drought tolerant, adequate soil moisture levels should be maintained to maximize yields. In cabbage, the most critical period for irrigation is following direct-seeding or transplanting and during head development. Any stress related to a lack of water during these periods can lead to small head size (reduced yields), growth cracks, or tipburn. Any of these problems will result in the production of poor-quality heads, reducing their marketability and value.

Production on Plastic Mulch

Using polyethylene (plastic) mulch offers several advantages. Plastic mulch increases soil temperature, which accelerates plant growth and development. It also conserves soil moisture and reduces several problems including compaction and crusting of soil, leaching of fertilizer, drowning of crops, evaporation of soil moisture, and competition from weeds. At harvest, wrapper leaves are cleaner, requiring less washing, which greatly facilitates field packing.

Although using mulch increases production costs, those costs can be offset by earlier and larger yields of high-quality heads. In order to spread increased costs over two seasons, growers can plant another crop (double cropping) into plastic mulch before or after the cabbage. Care must be taken throughout the growing season not to tear or otherwise damage the mulch. Double-cropping will spread your production costs over two crops, decreasing the risk associated with higher preharvest costs. In the fall, growers in Alabama commonly double-crop cabbage following such crops as watermelons and tomatoes or preceding such crops as tomatoes, bell peppers, and watermelons in the spring. On plastic, use double rows of cabbage plants spaced 12 to 14 inches apart between rows within the bed. Contact your county Extension agent for more information about using plastic mulch.

Controlling Weeds, Insects, Diseases, and Other Pests

Contact your county Extension agent or consult Extension publication ANR-500A, Alabama Pest Management Handbook—Volume 1, for current information on strategies to control pests (fungi, bacteria, nematodes, insects, weeds) and for materials used to control these pests in cabbage. Always confirm that what you are applying will control the target pest(s). If you are unsure, contact your county Extension agent.

Since cabbage is related to broccoli, collards, cauliflower, and other cole crops, it is a host for many of the same pests that attack these other cole crops. Planting related crops year after year in the same area will increase pest pressure in that area. Eventually, you might not be able to produce a marketable crop of cabbage. To avoid this, rotate to crops in other plant families (such as the Cucurbit family—cucumbers, watermelons; or the Solanaceous family—tomatoes, bell peppers, eggplant).

The use of cover crops can also be used in a rotation. Crop rotation is one of the most effective pest-management strategies that a grower can use. Locate fields for cabbage production away from areas where any related crops were grown the previous season. The longer the rotation, the more effective the pest control will be (3 to 4 years is ideal).

Controlling Weeds

Weed management in cole crops in Alabama usually begins with some form of tillage before seeding or transplanting to destroy emerged weeds. Nonselective herbicides such as Gramoxone Extra (Zeneca) or Roundup Ultra (Monsanto) can be used in place of tillage to destroy emerged weeds if the crop is planted no-till. Most herbicides registered for use in cole
crops are designed to provide control of annual grasses such as annual bluegrass and crabgrass and small-seeded broadleaf weeds such as chickweed, henbit, lambsquarter, and common purslane.

Avoid locations with heavy weed pressure, especially areas with perennial weeds such as nutsedge. If nutsedge is a problem, consult Extension publication ANR-1073, “Nutsedge Control in Commercial Vegetables.”

Mechanical cultivation between rows is a valuable tool for use in cole crops. Cabbage is a shallow-rooted crop, so cultivation should not extend any deeper than 2 inches into the soil. On small areas, using organic or plastic mulch will help suppress many weeds. The herbicides currently registered for use in cabbage, broccoli, and cauliflower are listed below. These products must be used according to label directions and applied with the proper equipment calibrated to apply correct rates.

Dacthal 75W (ISK Biosciences) at 6 to 14 lb./acre. Dacthal should be applied preplant-incorporated or preemergence to the soil surface after seeding or transplanting. This product requires rainfall or overhead sprinkler irrigation for activation to control annual grasses and small-seeded broadleaf weeds. Dacthal will not control emerged weeds. Crop rotation restriction: 8 months for crops not specified on the label.

Devrinol 50DF (United Phosphorus) at 4 lb./acre. Devrinol should be applied preemergence to soil after seeding or transplanting. This product requires rainfall or overhead sprinkler irrigation for activation to control annual grasses and small-seeded broadleaf weeds. Devrinol will not control emerged weeds. Crop rotation restriction: 12 months for crops not specified on the label.

Goal 2XL (Robm and Haas) at 1 to 2 pt./acre. Goal should be applied to the soil surface before transplanting. Transplanting should be done with the least amount of soil disturbance possible. DO NOT use on direct-seeded crops. Use a low rate on sandy soils. Goal controls small-seeded broadleaf weeds. Use with a grass herbicide to obtain adequate annual grass control. Crop rotation restriction: see label.

Prefar 4E (Gowan) at 5 to 6 qt./acre. Prefar should be applied preplant-incorporated or preemergence to soil after transplanting for control of annual grasses and small-seeded broadleaf weeds. Prefar will not control emerged weeds. Irrigate with overhead sprinklers immediately after preemergence application. Crop rotation restriction: 4 months for crops not specified on the label.

Poast 1.5E (BASF) at 0.5 to 1.5 pt./acre. Poast should be applied over-the-top for control of emerged annual and perennial grasses. Poast will not control broadleaf weeds. Two pints of crop oil concentrate per acre should be added to all Poast treatments. Poast should not be sprayed within 30 days of harvest. Crop rotation restriction: none.

Trifluralin 4E (several manufacturers) at 1 to 1.5 pt./acre. Trifluralin should be applied preplant-incorporated before seeding or transplanting for control of annual grasses and small-seeded broadleaf weeds. Crop rotation restriction: 5 months for crops not specified on the label.

Scouting Fields

The most important tool in pest management is regular (at least weekly) scouting of fields to correctly identify pests and to determine if their numbers and potential for damage warrant treatment. Growers who monitor their fields are able to make treatment decisions based on knowledge of pest conditions, and they can avoid having to make unnecessary pesticide applications. Most insect pests found on cole crops have parasite and predator natural enemies that are often able to keep pests below damaging levels. Because natural enemies are very sensitive to synthetic insecticides, particularly those with a broad target range, it is best to use insecticides only when necessary based on scouting information. When scouting plants, it is important to correctly identify pests because incorrect identification may result in false estimates of the potential for damage or improper selection of pesticides for control.

When scouting, it is helpful to divide each field into four quadrants. Scouting should be done in a zigzag pattern across the field to ensure that all quadrants of the field are covered. Approximately 10 sites should be sampled in the field, with 5 adjacent plants sampled at each site for a total of 50 plants per field. The plants should be selected at random—do not select plants because they are large or look damaged. Sample field edges and areas with poor stands separately; some insect infestations start at and may be limited to these areas. At each plant, count and record caterpillars before sampling for aphids or other pests. Keep written records of pest observations. It is helpful to develop a printed format and make copies to use on each sampling date. Keep separate records for each insect species because many insecticides are not equally effective against all species.
Determining When to Treat for Insect Pests

For pest management purposes, plant growth can be separated into the following three stages: (1) seedling development, or prethinning stage (seed to 6 inches), (2) preheading or precupping stage (from thinning to head formation), and (3) heading or cupping stage (heads forming).

The extent of economic damage caused by insects depends on crop growth stage, so treatment thresholds change as the plants grow. Small seedling plants (stage 1) are very susceptible to insect damage, and large numbers of insects that migrate into fields can destroy plant stands. Plants in stage 2, between thinning and head formation, can tolerate moderate insect populations. Because most leaves and stems grow during this time, spraying may not go to market, moderate damage will not cause economic loss as long as it does not stunt plant growth and delay maturity. Treatment thresholds must be lowered during stage 3 because insect damage or contamination during head formation will reduce the market value of the crop. Therefore, when scouting for insect pests, it is important to consider the plant growth stage in determining whether treatments are necessary. Crop-maturity-based action thresholds for several insect pests have been developed and are listed below.

Applying Insecticides

Adequate spray coverage is critical to successful pest management in cole crops because leaves grow close together and insects seek protected areas underneath and between leaves. Good spray coverage is particularly important when using Bacillus thuringiensis (Bt) insecticides because caterpillars must eat the treated foliage to ingest the toxin. The advantage of Bt insecticides is that they are non-toxic to humans and most insect natural enemies. For best results, all insecticides should be applied using a boom sprayer equipped with swivel-type drop nozzles arranged with one nozzle over each row and adjacent nozzles on drop tubes between plants. This way, the spray is directed over the tops of the plants and also outward and upward into the plants. The top nozzle should be approximately 9 to 12 inches from the top of the plant, and the drop nozzle should be within 3 inches of the ground or bed between rows. One nozzle directly over the row is sufficient during the stage 1 growth phase. For complete coverage, the sprayer should be operated at 150 to 250 pounds per square inch (psi) with 80 to 120 gallons of spray volume per acre. Because cole crops have a waxy layer on the leaf surface, a spreader-sticker product should be included in the spray tank to inhibit the formation of large drops and to ensure even wetting of the spray on the foliage. Refer to Extension publication ANR-500A, Alabama Pest Management Handbook—Volume 1, for a complete listing of recommended insecticides.

Foliage-Feeding Caterpillars

Diamondback Moth Caterpillar
Diamondback moth (DBM) has become a serious worldwide pest of cole crops because it has been able to develop resistance to insecticides. The caterpillar’s name comes from the diamond-shaped markings on the adult moth. DBM caterpillars are most active in spring and early summer, producing as many as ten generations during the growing season. DBM larvae are smaller than the larvae of other caterpillar pests of cole crops. Mature larvae are green, ½ to ¾ inch long, and tapered at both ends (Figure 3). A larva wriggles violently when disturbed and often dangles from a leaf by a silken thread. Larvae feed on the leaf undersides. Small larvae do not chew completely through the leaf, giving the damage a “windowpane” appearance. Large larvae can chew completely through leaves, creating holes. Larvae may also feed on the developing heads, causing head deformation and providing entry for disease. DBM pupae are green and enclosed in netlike cocoons attached to the foliage.

Because DBM populations can increase rapidly at temperatures above 80°F, at least twice-weekly scouting is recommended. Heavy rains may reduce populations dramatically. Bt insecticides are usually effective and should be applied at the first sign of worm activity (see treatment thresholds below). Sprays may need to be applied at 5-day intervals when populations are high. A combination of Bt and pyrethroid insecticides (e.g., Asana, Ambush, Pounce) may be used if increased activity is needed. DBM pupae suffer natural mortality from native parasitoids, and parasitized pupae can be recognized by the presence of a broad white stripe around the pupa. Disking after harvest to destroy crop debris will prevent buildup of DBM and migration to plants in adjacent fields.

Cabbage Looper
The cabbage looper (CL) is most active in early summer and fall. Mature larvae grow as large as 1½ inches in length and have only three pairs of fleshy prolegs in the rear (Figure 4). The larvae loop their bodies when they move and grasp the plants tenaciously when handled. Their green color blends well with the foliage, and their dark frass, or excrement, is often detected before the larvae are seen. CL pupae are green and are attached to the leaf undersides. They are twice as large as DBM pupae. CL larvae chew complete holes in the leaves, and more mature, larger larvae consume great amounts of plant material. Because large larvae are less susceptible to insecticides than young larvae are, sprays should be applied when larvae are still in the
**Early Growth Stages.** *Bt* insecticides are moderately to highly effective and may be combined with pyrethroid insecticides (e.g., Asana, Ambush, Pounce) for increased activity if needed.

**Imported Cabbageworm.** Imported cabbageworm (ICW) moths are white to yellowish-white butterflies with black spots on their wings. Unlike nocturnal CL moths, ICW moths are often seen flying around plants during the day. The green larvae can be distinguished from other caterpillars by the dense coating of fine hairs that give the larvae a velvety appearance (Figure 5). The mature larva has a faint orange stripe down the back. The larvae chew irregular holes in the leaves, bore into heads, and contaminate leaves and heads with fecal material. Damage is similar to that caused by the CL. ICW is effectively controlled with the same insecticides recommended for the DBM and CL.

**Treatment Thresholds for DBM, CL, and ICW.** Because these three worm species cause similar damage, they should be considered together when making treatment decisions. Because different types and sizes of worms cause varying levels of feeding damage, their importance should be weighted according to the following chart. After field scouting is conducted, add the total number of each of the worm species found on all the plant samples, and fill in column 2 of Table 2 below.

**Cabbage Webworm.** Cabbage webworm larvae are 3/4 inch long when mature and gray in color with five dark stripes (Figure 6). The head capsule is black with a distinct white V-shaped mark. Cabbage webworm is an occasional pest of cole crops and feeds in areas around buds. The caterpillars produce webbing that can protect them against insecticide contact. Insecticides for other caterpillars will provide control of webworms as long as the bud areas are adequately covered by spray.

**Cross-Striped Cabbageworm.** The cross-striped cabbageworm (Figure 7) is easy to identify by the black and white transverse stripes down the back. It is controlled with *Bt* and other insecticides recommended for caterpillar control in cole crops.

**Beet Armyworm.** Beet armyworms may infest fall plantings of cabbage and other cole crops. They may move into cole crops in large numbers as other crops die or are harvested, so it is important to monitor late summer/fall plantings carefully and to apply insecticides when infestations are first detected. The moths lay egg masses on the undersides of leaves and cover the eggs with white, fuzzy scales. The larvae are light green to dark olive green and may have longitudinal stripes on the back or sides of the body (Figure 8). There is a black spot above the second pair of true legs just behind the head. Recommended insecticides should be applied if egg masses or larvae are found on 2 to 3 percent of the plants.

**Other Insect Pests**

**Cutworms.** Cutworms are caterpillars that rest beneath the soil during the day and feed at night, causing damage to stems and foliage. They are dark gray-brown in color with a greasy appearance, and they often curl into a C shape at rest or when disturbed (Figure 9). Cutworm larvae overwinter in fields and therefore may be present at the time of planting, particularly in fields with high organic matter from previous crop residue. Cutworms can be detected when land is prepared for planting, and a pre-planting or at-planting soil insecticide can be applied if necessary. If cutworm damage is observed after planting, insecticide sprays directed to the base of the plants may achieve some control.

**Table 2. Chart for Conversion of Caterpillar Counts to Larval Units**

<table>
<thead>
<tr>
<th>Insect and Size</th>
<th>Total Counted</th>
<th>Conversion Factor</th>
<th>Larval Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large CL</td>
<td>x</td>
<td>1</td>
<td>=</td>
</tr>
<tr>
<td>Small CL</td>
<td>x</td>
<td>2/3</td>
<td>=</td>
</tr>
<tr>
<td>Large ICW</td>
<td>x</td>
<td>2/3</td>
<td>=</td>
</tr>
<tr>
<td>Small ICW</td>
<td>x</td>
<td>1/10</td>
<td>=</td>
</tr>
<tr>
<td>DBM Larvae</td>
<td>x</td>
<td>1/10</td>
<td>=</td>
</tr>
</tbody>
</table>

Multiply the numbers in column 2 by the appropriate conversion factor (column 3) to calculate the larval units (column 4). Next, add all the larval units together, and divide the total by the number of plants sampled to get the average number of larval units per plant.

Total larval units = no. plants sampled $	imes$ larval units per plant

Finally, consult Table 3 to determine if treatment is necessary.

**Table 3. Treatment Thresholds for DBM, CL, and ICW**

<table>
<thead>
<tr>
<th>Plant Growth Stage</th>
<th>Treatment Thresholds (avg. larval units/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seedling to 6 inches</td>
<td>0.50</td>
</tr>
<tr>
<td>2. Preheading or precupping</td>
<td>1.30</td>
</tr>
<tr>
<td>3. Early to late head or cup formation</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Thresholds developed by the New York State IPM Program and validated in cabbage trials in Alabama.
Seed and Root Maggots. These are the immature, or maggot, stages of flies that are attracted to decaying organic matter (Figure 10). The maggots feed on young roots and stems and may severely reduce plant stands. Damage usually occurs during cool, wet spring conditions when plants grow slowly. The best approach to preventing maggot damage is to plant seed or transplants when weather conditions are favorable for rapid plant growth. Planting when conditions are cool and wet increases the risk of maggot damage.

Aphids. Several aphid species, including cabbage aphids (Figure 11), may infest cole crops. Cool, dry weather is most favorable for aphid development. Aphids do not usually infest seedlings but may build up after thinning or transplanting have been done. Large numbers of aphids may kill small plants, and their feeding can distort leaves of older plants, causing leaf curl.

Often, the most serious problem associated with aphids is contamination. Aphid colonies in the heads of cabbage, broccoli, and cauliflower are almost impossible to remove before marketing. Natural enemies can provide control of aphids, but they usually do not build up fast enough to keep heavy aphid populations below damaging levels. Use of broad-spectrum insecticides like pyrethroids can increase aphid numbers by eliminating natural enemies; therefore, these insecticides should be used sparingly early in the season and only when necessary to control other insect pests.

Sweetpotato or Silverleaf Whitefly. Adults are tiny, winged insects about 1/16 inch long with white bodies and yellow heads. Although small, they are easy to detect on the undersides of leaves or when they fly off plants when disturbed. They lay eggs on the undersides of the leaves where the immobile nymphs develop. The nymphs are scalelike in appearance. Like aphids, whitefly adults and nymphs suck plant sap with piercing-sucking mouthparts, and they produce sticky honeydew on leaves where they are feeding. Black sooty mold often grows on the excreted honeydew. Insecticides are not highly effective against whiteflies, so prevention is the best approach. Make sure that transplants are free of whiteflies, and plant fields as far as possible from other whitefly-infested crops. Destroy weeds and previous crop residues that may harbor whitefly populations.

Harlequin Bug. This insect is closely related to the common stink bug. It is a brightly colored, shield-shaped bug with red and black markings and piercing-sucking mouthparts (Figure 12). It feeds in the veins of leaves, causing leaves to wilt. Harlequin bug eggs are barrel-shaped and laid in clusters on leaves. The eggs are white, and each has two black bands around the circumference. Treatment thresholds developed in Georgia recommend treatment if one bug per ten plants is found.

Flea Beetle. Flea beetles are most common in the spring and in fields that are weedy or are surrounded by weeds. The adults are small, dark-colored beetles with enlarged hind legs that enable them to jump great distances (Figure 13). They feed on the undersides of leaves, causing numerous small, round, or irregular holes often referred to as “shot-hole damage.” Flea beetles are of most concern during the seedling stage and do not usually cause economic damage to mature plants.

Vegetable Weevil. The vegetable weevil adult is ⅛ to ⅜ inch long with a stout snout (Figure 14). It is brownish gray with two light-colored marks on the wing covers. Larvae are legless grubs. Adults and larvae feed on the foliage and stems of plants and cause the most damage when feeding on seedlings, causing significant stand reductions in young plantings, particularly in early fall and spring plantings. Treatment is recommended if more than 5 percent of the stand exhibits damage.

Controlling Diseases

There are a number of plant diseases that can limit cabbage production in Alabama, including black rot, black leg, Alternaria leaf spot, wirestem, and downy mildew.

Black Rot

Black rot, caused by the bacterium Xanthomonas campestris, is a problem on cole crops worldwide. Black rot is considered to be the most important disease affecting cabbage production in Alabama and the Southeast. It is not uncommon to lose an entire crop to black rot.

Symptoms

Seedling infection first appears as a blackening along the margins of the cotyledons. Cotyledons shrivel and drop off. Infected seedlings are often stunted and yellowed and may eventually wilt and die. Seedling infection can be difficult to diagnose since only a few plants in a lot may be infected.

On older plants, the disease is easily recognized by the presence of yellow V-shaped or U-shaped areas extending inward from the margins of the leaves (Figures 15 and 16). As the disease progresses, the yellow lesions turn brown and the tissue dies (Figure 17). Veins darken and the midrib of leaves turns black within the affected leaf area. This vein discoloration progresses toward the base of the leaf. Eventually, the bacteria spread into the main stem. When infected stems are cut in cross-section, a black vascular ring may be evident where bacteria have moved into the water-conducting vessels. This vascular discoloration extends from the stem to the upper leaves and down into the roots. In later stages of the disease, all central tissues of the main stem turn black. This
Symptom can be confused with Fusarium yellows disease; however, discoloration caused by Fusarium is dark brown rather than black.

Cabbage heads infected with black rot often do not reach full size, and their lower leaves fall off. Frequently, symptoms are more severe on one side of the head. Diseased plants may rot quickly before or after harvest, owing to secondary, soft-rotting bacteria. Soft-rotting bacteria commonly invade heads of black-rot-infected plants and turn them into slimy, foul-smelling masses of tissue (Figure 18). Late infections from black rot may simply result in leaf spots or smaller heads.

Black rot is usually most severe in low, wet areas of fields or along windbreaks where plants remain wet for long periods of time. Black rot can also be seen moving down rows as the bacterium is spread during cultivation. However, distribution of the disease often is quite uniform across production fields.

Transmission and Persistence

The black rot bacterium can be carried over from year to year in or on the seeds of infected cole crop host plants, on overwintering cruciferous weeds, or in partially decayed, infected plant material in the soil. The bacterium can persist in plant residue for 1 to 2 years or as long as the plant debris remains intact. Black rot is spread on seed and seedlings, by movement of contaminated plant material, in irrigation water or splashing rain, by insects, by cultivation equipment, and by field workers. The organism can also survive on numerous weed hosts in the mustard family, including black mustard, field mustard, wild turnip, wild radish, shepherdspurse, and Virginia pepperweed.

In the spring when seedlings emerge, bacteria are typically carried from diseased plant refuse to leaf edges by splashing rain. Bacteria invade young leaves through natural openings or wounds. From the infected leaves, the bacteria move through the water-conducting vessels to the main stem, down into the roots, and up into the leaves. Plant-to-plant infection in the field occurs through the hydathodes at leaf margins. Bacteria can also enter through insect feeding wounds. “Clipping” of oversized transplants with rotary or flail mowers also promotes spread of the disease if the bacterium is present. Root infections can occur through wounds and are most common when infested soil is saturated with water.

The disease develops best under warm, wet conditions. Growth of the bacterium is favored by temperatures of 80°F to 86°F. Free moisture in the form of rain, dew, or fog is required for infection to occur and for the disease to develop.

Control

Purchase and plant certified, disease-free transplants only. Always examine plants thoroughly before purchasing them. Plants that are discolored, have visible lesions, or appear unhealthy should not be purchased. Grow plants in fields that have not held cole crops for at least 3 years. Rotate with plants from other plant families that are not hosts of the disease. Plant only in areas that provide good soil drainage and free air movement. Provide a balanced soil fertility program based on recent soil test information. Control all cruciferous weeds in and around the production field. To avoid spreading the disease, do not work in fields when plants are wet. Control cabbage root maggots, cutworms, cabbage-worms, and other insects, using recommended control practices. When possible, clean up and burn or cleanly plow down all crop debris immediately after harvest. Removing plant residue from the field surface will greatly reduce the bacterium’s ability to survive the winter. A copper-containing product such as Kocide will reduce damage from black rot. Begin applying the material when weather conditions favor disease development. Apply the material at 7- to 10-day intervals. Be aware that copper-containing products may cause plant injury.

Black Leg

Black leg, caused by the fungus Phoma lingam, can cause serious losses in cabbage production. Black leg and black rot are the two most serious diseases of cabbage.

Symptoms

Symptoms of black leg are usually first seen in the field as an oval, sunken, light brown canker, often with a black or purple margin near the base of the stem. The canker enlarges until the stem is girdled and the plant wilts and dies. Foliar symptoms first appear as pale, irregular-shaped spots on leaves. These spots gradually enlarge, becoming circular with gray centers. Small, black, pepperlike spots (pycnidia) can be seen within the leaf spots. These are the spore-producing structures of the fungus, which can also be seen within stem cankers. Severely infected plants are stunted. Infected plants eventually wilt and then turn a dull blue-red color. With black leg, it is not uncommon for plants to suddenly fall over due to the deterioration of the stem (Figure 19).

Transmission and Persistence

The fungus can survive in plant residue for 2 to 3 years. It can also be carried on seed. Plants are often infected in the seedbed, where splashing water spreads the spores of the fungus from one plant to another. Secondary spread of the disease may occur during the transplanting/pulling operation. The fungus can also be spread by splashing rain, by workers, and on equipment in the field. The disease is more severe under wet conditions.
Control

Purchase only transplants certified to be free of black leg. Never grow cabbage in a field where a cole crop was grown in the past 3 years. Remove plant debris following a season when the disease was present. Fungicide seed treatments and soil fumigation or solarization have been shown to be effective in controlling black leg.

Alternaria Leaf Spot

Alternaria leaf spot is caused by the fungus *Alternaria brassicae*. The disease can cause severe damage to cabbage if left uncontrolled.

Symptoms

The initial symptoms are small, circular, dark spots on the surfaces of older leaves. As the spots enlarge, concentric rings develop within the lesions (Figure 20). A lesion is often surrounded by a yellow halo. The tan-colored centers of spots may eventually drop out, producing a shot-hole appearance, or under wet conditions may become covered with a black mass of fungal spores (Figure 21). If left uncontrolled, the disease can defoliate a plant. In storage, spots enlarge and soft-rotting bacteria may enter through these lesions.

Transmission and Persistence

The disease can overwinter on crop debris. Cruciferous weeds may also harbor the fungus. Spores of *Alternaria* can be spread by wind and in water. The disease is most damaging under wet, warm conditions (68°F to 81°F).

Control

Never grow cabbage in a field where a cole crop was grown in the past 3 years. Remove plant debris following a season when the disease was present. Plant disease-free transplants. Begin a fungicide spray program at the first sign of the disease, and continue at 7- to 10-day intervals with a protective-type fungicide (fungicides with the active ingredient chlorothalonil [Bravo] or maneb [Manex, Maneb 80]).

Wirestem

Wirestem, caused by the fungus *Rhizoctonia solani*, can be a problem in transplant beds as well as in the field. Early, fall-planted cabbage is more vulnerable to the disease.

Symptoms

Plants infected with wirestem often have a reddish-brown discoloration to their stem near the soil line; the discolored area often appears severely constricted. Plants may be bent or twisted at this point but do not break, hence the name “wirestem.” Affected plants that survive are weak and produce small heads.

Transmission and Persistence

The fungus is present in all soils but is more common in soil with infected plant debris that has not decomposed. Prolonged, overly moist soil favors development of the disease. The amount of wirestem is greatly influenced by the recent cropping history.

Control

Eradicating cruciferous weeds to eliminate potential overwintering disease inoculum. Do not use overhead irrigation. The fungicides Alliette, Alliette/Maneb 2+2, and Ridomil/Bravo 81 are labeled for use on cabbage for control of downy mildew.

Downy Mildew

Downy mildew is caused by the fungus *Peronospora parasitica*. The disease can enter a field on infected transplants or wind-blown spores. Plants can be infected anytime during the growing season.

Symptoms

In moist weather, a white, fluffy, fungal growth develops mostly on the undersides of infected leaves. With time, yellow to tan spots develop on the corresponding upper leaf surface. Infected leaves on young plants may drop, and plants may die. Infected leaves on older plants usually remain attached. On older leaves, the infected areas turn tan in color and papery in texture. A mass of gray spores can be seen on the undersides of infected leaves. Downy mildew can predispose infected plants to bacterial soft rot.

Transmission and Persistence

The fungus overwinters on seed, in cruciferous weeds, and possibly in the soil. Heavy fogs, light rains, prolonged dews, and night temperatures between 46°F and 61°F with day temperatures below 75°F greatly favor this pathogen. Spores of the fungus float long distances in cool, moist air.

Control

Never grow cabbage in a field where a cole crop was grown in the past 3 years. Remove plant debris following a season when the disease was present. Soil fumigation and careful watering may reduce damage from this disease. The fungicide Terraclor can be used in the transplant water for control of wirestem.
Figure 15. Close-up of lesions on cabbage leaves caused by black rot. Note the V- or U-shaped areas extending inward from the leaf margins.

Figure 16. Production field with cabbage infected by black rot.

Figure 17. Close-up of cabbage leaf with characteristic symptoms of black rot. Lesions have turned brown, and tissue has begun to die.

Figure 18. Area of cabbage field infected with black rot where soft-rotting bacteria have invaded the heads.

Figure 19. Root and stem tissue damage and deterioration caused by black leg infection.

Figure 20. Lesion caused by Alternaria leaf spot. Note the enlarged, concentric rings that develop within the lesions.

Figure 21. Black mass of fungal spores on lesion produced by Alternaria leaf spot.
Harvesting and Storing Cabbage

Yields will vary with the season of production, variety, and production system used. With proper management, cabbage can produce 10 to 12 tons per acre (400 to 500 50-pound crates or bags). Growers in Alabama have produced upwards of 16 to 20 tons per acre. Generally, most markets prefer heads that average 2 to 2 1/2 pounds. Some varieties of cabbage mature uniformly, requiring one to two harvests. Others can require three or more pickings to complete harvesting.

When harvesting, cut stems close to the ground near the base of the head. Be sure that heads are well formed and firm (see Figure 1). Typically, outer wrapper leaves are removed. Once cut, remove cabbage from direct sunlight because cabbage wilts quickly when exposed to sunlight. Wilting results from a loss of water from the head. Cool cabbage to 40°F before shipping it. This will increase shelf life and reduce the development of rot diseases. In cold storage, cabbage can be stored at 32°F with 98 to 100 percent relative humidity for 5 to 6 months.

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Use pesticides only according to the directions on the label. Follow all directions, precautions, and restrictions that are listed. Do not use pesticides on plants that are not listed on the label.

The pesticide rates in this publication are recommended only if they are registered with the Environmental Protection Agency and the Alabama Department of Agriculture and Industries. If a registration is changed or cancelled, the rate listed here is no longer recommended. Before you apply any pesticide, check with your county Extension agent for the latest information.

Trade names are used only to give specific information. The Alabama Cooperative Extension System does not endorse or guarantee any product and does not recommend one product instead of another that might be similar.

For more information, call your county Extension office. Look in your telephone directory under your county’s name to find the number.