CROP PROFILE FOR BROCCOLI IN VIRGINIA

PREPARED: March 2013

GENERAL PRODUCTION INFORMATION

The 2007 National Agricultural Statistics Service Census for Virginia indicated there were 551 acres of broccoli harvested on 75 farms (one processing and 74 fresh market). In 2002, there were just 31 farms producing broccoli on 86 acres. Broccoli is not currently grown on a commercial scale in Virginia, and detailed statistics are not readily available.

PRODUCTION REGIONS

Broccoli is grown on a small scale all over the commonwealth. New field trials are being conducted in western Virginia (Carroll County) to determine which broccoli varieties may be suitable for future large-scale East Coast production.

CULTURAL PRACTICES

Broccoli (Broccoli oleracea) belongs to the Brassicaceae (mustard) family, which includes kale, collard greens, cauliflower, cabbage, brussels sprouts, and kohlrabi, among others. Collectively, members of this family may also be referred to as cole crops or crucifers.

According to the 2013 Vegetable Production Guide for Virginia, recommended broccoli varieties include Castle Dome (heat tolerant), Captain, DeCicco, Major, Everest, Imperial (heat tolerant), Emerald Pride (heat tolerant), Batavia (heat tolerant/powdery mildew resistant), Green Gold, Emerald Crown (heat tolerant), Arcadia (black rot/downy mildew resistant), Gypsy (downy mildew resistant), Green Magic (bolting/powdery...
mildew resistant), Iron Man (hollow stem resistant), Eureka (fall production), Liberty, CMS Liberty, Diplomat (downy mildew resistant), and Windsor (downy mildew resistant).

There are two main types of broccoli grown for commercial production: “heading” and “sprouting” (Italian). Broccoli heads are actually flower buds, and the plants must be harvested before they turn yellow and begin to open. The heading type forms the quintessential large head in the center. Once the central head is removed, lateral branches develop throughout the summer. However, sprouting broccoli produces multiple florets but never forms a condensed central head.

If a fall broccoli crop is being grown from seed, direct field seeding is done in rows 30 to 36 inches apart at a rate of 0.5 to 1.0 lb. per acre so that plants are 12 to 18 inches apart in a row. Broccoli seed is usually sown in successive plantings between June 20 and July 20. However, if broccoli transplants are being used, they are typically planted between July 15 and August 20, depending on location. Transplants are set 12 to 18 inches apart in rows 36 inches apart. In cooler regions of the state, heat-tolerant varieties may be transplanted between April 1 and April 20 to produce a spring crop. If producing bunched broccoli (high-population planting), it is recommended that growers plant two to four rows per bed, with rows 18 to 20 inches apart and plants 9 to 10 inches apart in a row. Seed should be sown between June 25 and July 10; transplants should be planted between July 20 and August 15, depending on location. For fall plasticiculture double cropping, crop debris should be removed and broccoli transplants set 12 to 21 inches apart in double rows 10 to 12 inches apart. If larger heads are desired, increase in-row spacing. Plants should be set in late July through mid-August, depending on location. Broccoli has been successfully grown by transplanting plants into rolled or herbicide-killed cover crops using a no-till transplanter.

Broccoli prefers cool temperatures during the day (65°F to 70°F) and a minimum temperature of 60°F at night. Transplants reach maturity in approximately six to seven weeks. Broccoli plants have a shallow rooting system and should be mulched. The target soil pH for broccoli is 6.0 to 6.5. Lime should be added if the pH is below 6.2. Broccoli is one of the few crops that may need additional boron (growers should add 3 lb. per acre if levels are low, or 1.5 lb. per acre if levels are moderate).

Water is critical when heads are developing, so irrigation must be applied correctly and at the proper time. Brassica crops require a fair amount of water during the growing season – usually 10 to 15 inches. For spring production, precipitation/irrigation is most critical as harvest time approaches. For fall crops, the greatest amount of water is needed at midseason.

The heading type of broccoli is harvested once the heads have reached their maximum diameter but before the flowers have opened. Lateral bud clusters are harvested later as they develop. In Virginia, broccoli is usually harvested from September to November. Broccoli is typically stored on ice (packaged ice or liquid icing) or by using hydrocooling systems. Broccoli should be stored at 32°F and 95% to 100% relative humidity. If stored properly right after harvest, broccoli will keep for 10 to 14 days at these conditions.
WORKER ACTIVITIES

Broccoli can be machine harvested, but harvesting the crop by hand produces greater yields. During the growing season, worker activities in the field include seeding, transplanting (April-June), cultivating, scouting, spraying, occasional hand weeding, and harvesting (August-September for summer plantings and November-December for fall plantings). Strictly following re-entry intervals (REIs) should minimize any risk of exposure to pesticides during these activities. If workers are required to go back in the field before the proper time limit has expired then personal protective equipment (PPE) is worn. Activities that bring workers in direct contact with the plants during the growing season are generally limited to harvest time because the cabbage heads are hand picked by the workers.

SPECIAL USE LABELS

Section 18 Emergency Use Exemption and Special Local Need 24 (c) labels are used to supplement the chemical tools available to producers for pest control. Once the problem or gap in pest control has been identified, specialists submit the proper documentation for the Emergency Use/Special Local Need label. Thus far, Extension specialists have been successful in obtaining these labels. Special Local Need labels in Virginia are granted by the Virginia Department of Agriculture and Consumer Services and are usually only valid for limited time intervals. However, a fee must be paid annually by the registrant to keep the product registered for use in Virginia. Section 18 Emergency Use labels are evaluated and granted by the Environmental Protection Agency and can be renewed annually.

ARTHROPOD PESTS

INSECTS

MAJOR PESTS

Major pests of Virginia broccoli include the cabbage looper (CL), diamondback moth (DBM), and imported cabbageworm (ICW). Together, these caterpillars make up the cabbageworm complex. If the cabbageworm complex causes the most pest problems in the broccoli field, then a threshold of one cabbage looper equivalent per 10 plants can be used to determine when to spray. Regarding defoliation potential, the formula is $1 \text{ CL} = 1.5 \text{ ICW} = 5 \text{ DBM}$. Broad-spectrum pesticides should be avoided because they kill beneficial natural enemies; also, pest caterpillars have developed varying levels of resistance to these chemicals. The bacterial biological control agent *Bacillus thuringiensis* (Bt) is effective against many types of caterpillars, but it must be ingested. Therefore, it is important to apply Bt to the specific parts of the plants fed upon by each species of pest.
**Cabbage Looper, *Trichoplusia ni***

These light-green caterpillars are active from mid-June to late September and cause damage by chewing the underside of leaves of Brassica crops. As their name indicates, they move in a “looping” fashion. The adult moths are grayish brown with a silver “8” on the middle of the wings. They are nocturnal, fly around at plant height, and lay one to seven pale greenish white eggs on the upper surfaces of the outer leaves of plants. There are two or three generations per year. At the end of the growing season, caterpillars attach themselves to plant foliage or debris and overwinter as pupae within a silk cocoon. Cabbage loopers are mostly problematic in Virginia from late July or early August until the first frost. Small caterpillars prefer to feed on lower surfaces of leaves, but as they mature, they chew large holes away from the leaf margin.

**MONITORING:** Scout plant foliage weekly for evidence of loopers, pupae, or feeding damage (holes). Adult moths can be monitored using light traps at night.

**CHEMICAL CONTROL:** Treatment thresholds differ depending on what stage the broccoli plant is in. In a seedbed, chemical control should begin when 10% of plants are infested. For transplants up to the first flower stage, the threshold is 50% infestation; when plants are in the flowering to mature head stage the limit is 10% infestation. See the Chemical Arthropod Control section below for more information.

**BIOLOGICAL CONTROL:** *Bacillus thuringiensis* (Bt) is a good control option. Many natural enemies (e.g., parasitic wasps, predators, fungi, and viruses) also effectively control cabbage loopers.

**CULTURAL CONTROL:** Cabbage loopers can be picked by hand in small plots. Plow under crop debris in spring to bury pupae before adults emerge.

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**Diamondback Moth, *Plutella xylostella***

Diamondback moth caterpillars are very pale with a dark head in early instars. Later, they turn light green with tiny black hairs and a pair of prolegs in the shape of a “V” on their hind end. They are active from mid-April to September, chewing leaves and boring into broccoli flower heads. The larvae attack virtually all crucifers and will eat all plant parts but prefer young plant buds, the undersides of old leaves, and crevices between loose leaves. Young larvae mine the leaves, but older larvae cut windowpane-like holes (top leaf tissue is left intact while underside is eaten) in the foliage. If buds are severely damaged, broccoli heads will fail to develop properly and the crop may be ruined. Plants are also more susceptible to diseases such as black rot. When disturbed, diamondback moth caterpillars will wriggle violently backward and drop from the leaf but remain attached by an anchor thread. There are four to six generations per year in Virginia. The adult moths, also known as cabbage moths, are grayish brown with fringed hind wings and are approximately 1/3 inch long. When at rest, the wings reveal a white or light yellow diamond pattern down the back. Females lay their pale yellow eggs singly or in groups of two to three on the leaves. Mature caterpillar larvae spin a loose cocoon attached to the underside of a leaf within which they pupate. Adult moths overwinter in field debris.
**MONITORING:** Scout plant foliage weekly for evidence of caterpillars, pupae, or feeding damage.

**CHEMICAL CONTROL:** After cupping (early head formation), insecticides can be applied when there is an average of one larvae or hole per 10 plants. There are issues with DBM resistance in certain areas. See the Chemical Arthropod Control section below for more information.

**BIOLOGICAL CONTROL:** *Bacillus thuringiensis* can be used to control early infestations. Natural enemies include ladybird beetles, spiders, lacewing larvae, predatory bugs, and parasitic wasps. The fungus *Beauveria bassiana* may also be used to control caterpillars.

**CULTURAL CONTROL:** Field debris and nearby mustard-type weeds should be removed or plowed under to remove overwintering sites for adult moths. Resistant varieties may also be planted to reduce the pest population.

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**Imported Cabbageworm, Pieris rapae**

Active from mid-April to September, ICW caterpillars chew the underside of leaves and bore into broccoli heads. The larvae are green and velvety with yellow dots on the side and a thin yellow stripe down the middle of the dorsum. The caterpillars are known to camouflage themselves by resting along the leaf vein. However, they produce a copious amount of fecal material that strongly indicates their presence. There are three to six generations per year, and they overwinter as pupae within garden debris. Adult butterflies, known as cabbage whites, are yellowish white with black spots on their wings. The yellow eggs are laid singly on leaves.

**MONITORING:** Scout plant foliage weekly for evidence of cabbageworms, pupae, or feeding damage.

**CHEMICAL CONTROL:** Chemical controls should be applied after cupping (early head formation) and when monitoring indicates there is an average of one or more larva or new hole per 10 plants. Treatment thresholds differ depending on what stage the broccoli plant is in. In a seedbed, chemical control should begin when 10% of plants are infested. For transplants up to the first flower stage, the threshold is 50% infestation; when plants are in the flowering to mature head stage, the limit is 10% infestation. See the Chemical Arthropod Control section below for more information.

**BIOLOGICAL CONTROL:** *Bacillus thuringiensis* can be used to control cabbageworms. Natural controls include parasitic wasps (e.g., *Trichogramma* spp.), predatory insects (e.g., stinkbugs and *Polistes* wasps), viruses, and diseases. Currently, the Braconid wasp, *Apanteles glomeratus*, is the most effective known natural enemy. The fungus *Beauveria bassiana* may also be used to control caterpillars.

**CULTURAL CONTROL:** Handpick caterpillars, practice good postharvest sanitation, and remove all plant debris where ICW has been problematic before.

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**MINOR PESTS**

Usually, minor pests are only sporadic problems in broccoli fields and require no chemical control actions. However, this can vary from year to year and between geographic regions within Virginia.
**Aphids**, Family Aphidae

Aphids are active from June to September and produce multiple generations per year. Infestations are worse in cool, dry weather. Both the adults and nymphs suck plant juices and can carry diseases. They overwinter near, but outside, the garden. There are different species of aphids that infest Brassica vegetables: the cabbage aphid (*Brevicoryne brassicae*), the turnip aphid (*Lipaphis erysimi*), and the green peach aphid (GPA; *Myzus persicae*). Infested plants exhibit curled, crinkled, cupped leaves that may be entirely lined with aphids. Severe infestations cause plants to wilt and die. If plants survive, they will be small, grow slowly, and form dwarfed heads. Aphids can also vector innumerable diseases. In Virginia, the GPA lays yellow or green eggs, which turn black as they mature, in crevices or near buds. Winged female nymphs are pinkish while the wingless adults are greenish yellow. Green peach aphids overwinter on trees in the *Prunus* genus but move to other hosts in summer.

**MONITORING:** Scout plant foliage weekly for evidence of aphids.

**CHEMICAL CONTROL:** Aphids can be difficult to control because of their resistance to broad-spectrum insecticides (e.g., pyrethroids). Chemical control is therefore recommended only if > 50% of leaves are covered. Stickers/spreaders must be added to the mix to help the chemicals reach all the crevices where aphids may hide. Chemicals such as pymetrozine, spirotetramat, and fonicamid are mostly safe for natural enemies, so these work best with an integrated pest management (IPM) program. See the Chemical Arthropod Control section for more information.

**BIOLOGICAL CONTROL:** Natural enemies include parasites and predators, (e.g., ladybird beetles, lacewing larvae, syrphid fly larvae, and plant bugs). Parasitized aphids appear immobile, pale, and swollen. They should be left alone to encourage the emergence of additional beneficial insects. Entomopathogenic fungi (e.g., *Beauveria bassiana*) also kill aphids when humidity is high. Biological controls usually keep aphid populations in check.

**CULTURAL CONTROL:** In small plots, foliage can be sprayed with soapy water, then rinsed, and finally covered with insecticidal soaps. Old plant stalks should be destroyed immediately after harvest to prevent outbreaks. Avoid overfertilizing plants as excess fertilizer can encourage aphid populations. Reflective (metallized) mulch can keep aphids from colonizing new plants. Remove nearby *Prunus* trees to eliminate overwintering spots.

**Beet Armyworm, *Spodoptera exigua***

Beet armyworm (BAW) adults are nocturnal and lay 50 to 150 eggs in a cottony ovisac. Although they overwinter as pupae in other states, BAW migrate into Virginia from warmer regions to the south. For this reason, they do not appear until later in the summer. Feeding damage consists of holes chewed in the leaves. Larvae have longitudinal stripes on their sides, and the dorsal side is usually darker green than the underside. Larvae also possess a unique dark dot on the side of the third body segment.

**MONITORING:** Adult moths can be monitored using light traps at night.
CHEMICAL CONTROL: Chemical control should begin when 10% of the plants are infested. Older larvae are harder to kill, so treatment should target young caterpillars. See the Chemical Arthropod Control section for more information.

BIOLOGICAL CONTROL: Bacillus thuringiensis var. azawai is the only Bt formulation that is currently known to be effective against BAW.

CULTURAL CONTROL: No current recommendations for commercial production.

**Cabbage Root Maggot, Delia radicum**

Cabbage maggots, also known as the cabbage root fly and turnip fly when mature, are white, legless, and active from mid-April to late June. They can often be found in hollowed-out tunnels within the roots. Adult cabbage root flies resemble very small houseflies. There are several generations per year, and they overwinter within garden soil. The first generation causes the most damage when larvae enter roots or feed at the root surface. Infested plants look unhealthy, stunted, and off-color. When heavily infested, plants will wilt in the heat and die.

**MONITORING:** In general, when yellow rocket plants begin to bloom, cabbage root flies will soon begin laying eggs on roots or soil near roots. Herbicide-treated fields should be inspected daily for flies and maggots for several weeks after herbicides have been applied since these pests are attracted to decaying plant tissue.

**CHEMICAL CONTROL:** See the Chemical Arthropod Control section for more information.

**BIOLOGICAL CONTROL:** None are currently recommended.

**CULTURAL CONTROL:** Decaying organic matter in the soil should be reduced or removed to avoid attracting adult flies. Soil should be tilled four to six weeks before planting. Furthermore, floating row covers with the edges buried may prevent infestation. Postemergence herbicides can cause cabbage maggot problems indirectly by killing weeds that later decompose.

**Cabbage Webworm, Hellula rogatalis**

Cabbage webworm (CWW) is a sporadic pest of broccoli and other cruciferous crops in Virginia in late summer and fall. Eggs are small, gray or yellowish green, and are laid singly or in small masses. Larvae are yellowish gray at first but later develop five black longitudinal dorsal stripes, a black head, and long, yellowish brown hairs. Caterpillars produce a large quantity of silk to create protective webs on leaves. Mature larvae or pupae overwinter in webbed cocoons within the soil. The forewings of the nocturnal adult moths are yellowish brown with white bands and a dark, bean-shaped spot while the hind wings are grayish white. Damage can be significant during the fall once population numbers reach a high level. Young larvae mine the undersides of leaves, later folding them over and webbing them together as the larvae mature. The growing tip and buds of plants may be damaged, and if webworms burrow into the main leaf vein, the foliage may die. Although multiple generations occur each year, cabbage webworms do not usually appear in Virginia until late summer.
**MONITORING:** Scout plant foliage weekly for evidence of webworms, pupae, or feeding damage. Webbing is particularly indicative of CWW. Adult moths can be monitored using light traps at night.

**CHEMICAL CONTROL:** Pesticides must be applied when larvae are small and first begin feeding. Cole crops are more easily protected if a sticker/spreader or adjuvant is added to the chemical mix to adequately cover the waxy leaves typical of the Brassica family. See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** There are few natural enemies due to the protective webbing produced by the caterpillars.

**CULTURAL CONTROL:** Plant early-maturing varieties that complete development before webworms reach damaging levels. Some growers have used early mustard as a trap crop to attract this pest and deter it from attacking valuable crops.

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**Corn Earworm, *Helicoverpa zea***

Adult corn earworms (CEW) are nocturnal and females lay eggs singly. They overwinter as pupae, but most migrate in from southern states each summer. Feeding damage consists of holes chewed in the leaves. Corn earworms resemble armyworms but can be multiple colors, including yellow, brown, pink, or green. They have two small dots above the proleg on each body segment.

**MONITORING:** Adult moths can be monitored using light traps at night.

**CHEMICAL CONTROL:** See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** *Bacillus thuringiensis* can be used to control corn earworms.

**CULTURAL CONTROL:** Handpick CEW, if feasible. Most crops harvested before mid-July escape CEW damage.

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**Cross-Striped Cabbageworm, *Evergestis rimosalis***

Cross-striped cabbageworm (CSCW) caterpillars have horizontal black stripes across the bluish gray dorsal side and both black and yellow longitudinal stripes on the sides. They cause damage by chewing small holes in leaves and boring into broccoli heads. As a result, infested plants are more vulnerable to diseases such as black rot. The adult moths lay eggs in clusters of 20 to 30 on the undersides of leaves. There are four generations per year, and the larvae overwinter just below the garden soil surface.

**MONITORING:** Scout plant foliage weekly for evidence of cabbageworms.

**CHEMICAL CONTROL:** Generally, cabbageworms are controlled by chemicals applied to manage other pests. See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** None are currently recommended.

**CULTURAL CONTROL:** Cabbageworms can be picked by hand in small plots.

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**Crucifer Flea Beetle, *Phyllotreta cruciferae***
Crucifer flea beetles are black, shiny, and small (2 mm long) with enlarged jumping hind legs. There are two to three generations per year. They hibernate in soil, leaf litter, hedgerows, windbreaks, and wooded areas near fields. The overwintered beetles resume activity from mid-April to late June. Later generations emerge in the summer and damage fall crops. Flea beetles chew “shot holes” in leaf margins, which can reduce crop yield, delay maturity, and produce unmarketable crops. Heavy damage can also kill seedlings and may lead to dead, dry leaves. This particular species feeds only on Brassica crops.

**MONITORING:** Beetles can be monitored weekly using yellow sticky cards or by gauging feeding damage on newly emerged seedlings.

**CHEMICAL CONTROL:** Chemical control should begin if there is damage to cotyledons or seedlings. In Virginia, it is recommended that treatment begin when the pest population reaches one beetle per transplant or five beetles per 10 plants in the cotyledon stage. See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** None are currently recommended.

**CULTURAL CONTROL:** Spun-bonded row covers work well if secured with soil or bags around all edges right after seeding or transplanting. The covers should be removed and replaced the same day when cultivation is necessary. Rotate spring crops far from the previous season’s fall Brassica crops. Separate early- and late-season Brassica crops. If possible, avoid planting early in order to break the reproductive cycle. Cultivate and till crops immediately after harvest to destroy larvae feeding on roots. Ensure crops are healthy by providing adequate water and nutrients and avoiding soil compaction.

**Cutworms,** Family Noctuidae

Cutworm caterpillars feed on stems and leaves at night, often severing them. They rest in the soil at the base of the plant during the day. Larvae curl up when disturbed and may bite or release a green fluid when threatened. Black cutworm (*Agrotis ipsilon*) moths are dark brown with a light band near the end of each wing. Eggs are deposited in clusters in the soil and are white at first, but later turn brown. Cutworm caterpillars are gray and have a greasy appearance along with dark, coarse lumps on their bodies. Granulate cutworm (*Feltia subterranea*) moths have yellowish brown front wings with mostly white hind wings. The caterpillars are grayish to reddish brown. Adults fly into fields and lay eggs in clusters of up to 30 eggs on leaves, stems, plant stubble, or field debris on the ground.

**MONITORING:** Fields should be scouted within a week of planting or plant emergence to assess potential cutworm damage. Cutworms are not typically seen during the day. If cutworm damage begins to noticeably impact broccoli stands; however, control may be necessary.

**CHEMICAL CONTROL:** See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** No current recommendations for commercial production.

**CULTURAL CONTROL:** Weedy/minimum tillage fields are attractive to egg-laying adult female cutworms, so it is important to control weeds and cultivate soil properly.

**Fall Armyworm,** *Spodoptera frugiperda*
Fall armyworm (FAW) adults are nocturnal, and female moths lay up to 400 eggs in a cottony ovisac. Although they overwinter as pupae in other states, these pests migrate into Virginia from warmer regions to the south. For this reason, they do not appear until later in the summer. Feeding damage consists of holes chewed in the leaves. Fall armyworms resemble beet armyworms, although they lack the black dot and instead have a white inverted “Y” on their head.

**MONITORING:** Adult moths can be monitored using light traps at night.

**CHEMICAL CONTROL:** See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** Natural enemies, including parasitoids, target and help control FAW.

**CULTURAL CONTROL:** No current recommendations for commercial production.

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**Saltmarsh Caterpillar, *Estigmene acrea***

Adult females lay 400 to 1,000 eggs. They overwinter as mature larvae. Feeding damage consists of both skeletonization of the leaf (small caterpillars) and large holes (larger caterpillars). Saltmarsh caterpillars are yellow and very hairy.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** No current recommendations for commercial production.

**CULTURAL CONTROL:** No current recommendations for commercial production.

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**Southern Cabbageworm, *Pontia protodice***

The southern cabbageworm has deep blue and yellow stripes along its body and black spots on each body segment. The adult butterflies are similar to those of the imported cabbageworm but are commonly known as checkered whites.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the *Chemical Arthropod Control* section for more information.

**BIOLOGICAL CONTROL:** No current recommendations for commercial production.

**CULTURAL CONTROL:** No current recommendations for commercial production.

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**Thrips, *Thrips tabaci***

Thrips, tiny brown or yellow winged insects, are a late-season problem in Brassica crops. Active from late June to August, both nymphs and adults rasp plant tissue and suck plant juices. This causes white stipple marks on leaves that later turn yellow and dry. Multiple overlapping generations occur each year in Virginia. Females lay their eggs in cuts made in the plant tissue. Thrips overwinter in garden debris, weeds, and small grains. Infested plants may be less vigorous and exhibit damaged, scarred leaves with reddish orange or yellow spots.

**MONITORING:** Fields should be scouted weekly, particularly along the margins where populations increase early.
CHEMICAL CONTROL: Although treatment thresholds vary, a common recommendation is three thrips per leaf or 30 per plant. See the Chemical Arthropod Control section for more information.

BIOLOGICAL CONTROL: Natural enemies include lacewing larvae, pirate bugs, and predatory thrips.

CULTURAL CONTROL: Broccoli should not be planted near onions (or other Allium family crops), alfalfa, clover, or wheat, all of which may harbor large populations of thrips. Cultural control practices include good sanitation, eliminating volunteer onion plants, using straw mulch, alternating onion rows with carrot rows, avoiding the use of the previous year’s onions, and not using imported transplants.

CHEMICAL ARTHROPOD CONTROL

Always read the label before applying any chemicals, and be sure to follow the rates specified for the crop of interest. For chemical control recommendations specific to broccoli, please refer to the Commercial Vegetable Production Recommendations: Virginia, which is updated and published annually. A current PDF version can be found online at: http://pubs.ext.vt.edu/456/456-420/456-420-pd.pdf. For noncommercial recommendations, please refer to the Virginia Pest Management Guide: Home Grounds and Animals, which is updated and published annually. A current PDF version can be downloaded from the following URL: http://pubs.ext.vt.edu/456/456-018/456-018.html.

DISEASES

Bacterial Head Rot, various species

Bacterial head rot, also known as bacterial soft rot, first becomes apparent when two or three broccoli florets look water soaked or greasy. These infected spots grow larger and begin to rot, becoming sunken within a week when conditions are consistently warm and wet. The smelly, rotten spots will continue to spread even when the crop is properly stored in a cooler.

MONITORING: No specific monitoring protocol is recommended.

CHEMICAL CONTROL: Chemical controls will not work on bacterial head rot. Because surfactants increase the prevalence of bacterial soft rot, it is important to get insect problems under control before rot appears. If insecticide applications are necessary, they should be applied when no precipitation is expected. See the Chemical Disease Control section for more information.

BIOLOGICAL CONTROL: No biological control is currently recommended.

CULTURAL CONTROL: The only way to control bacterial head rot is to plant tolerant varieties. These varieties have tight, dome-shaped heads with small beads (flowers) that allow water to drain adequately. Broccoli should be planted only in fields with good drainage. Irrigation should occur when plants are already wet; for example, at night when dew is present or early in the day when plants are dry and weather conditions will allow rapid drying afterwards. During harvest, cut broccoli stems at an angle to prevent water from pooling on the stumps.
**Blackleg, Phoma lingam**

Blackleg symptoms include gray spots overlaid with small black dots that appear on the leaves and stems. The spots eventually girdle the plants, causing them to wilt and die. Wet conditions favor the development of black leg.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the *Chemical Disease Control* section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Plant resistant varieties. If planting from seed, use heat-treated seed from a reputable supplier: heat treatment kills pathogens within the seed coat as well as outside. Bleach treatments are also used, but they only kill diseases on the outside of the seed. When possible, plant broccoli in fields not previously used to grow cruciferous crops. Rotate broccoli with noncole crops every four years to prevent blackleg.

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**Black Rot, Xanthomonas campestris**

Black rot symptoms can vary with the plant type, age of the plant, and site conditions. In general, yellow “V”-shaped spots appear at the tips of the leaves. Wilted tissue spreads backward toward the base of the leaves. Veins will eventually turn black or brown, and the infection may spread into the stems. When cut open, the stem tissue will often be blackish brown with a sticky, yellow slime. Infected plants become stunted, wilt, and die. Black rot is spread primarily by infected seeds, contaminated equipment, wind, splashing water, workers, and animals (including insects).

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the *Chemical Disease Control* section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Prevent black rot from developing by using resistant varieties and/or certified disease-free seeds and transplants. Heat treatment kills pathogens within the seed coat as well as outside. Bleach treatments may also be used, but this only kills diseases on the outside of the seed. When possible, plant broccoli in fields that are well drained with good air circulation that have not previously been used to grow cruciferous crops. Rotate broccoli with noncole crops every two to three years to prevent disease development. Remove and destroy nearby weeds, volunteer plants, and old plant debris from the garden and surrounding areas. Refrain from handling plants when they are wet.

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**Clubroot, Plasmodiophora brassicae**

Clubroot is a disease caused by a fungal pathogen that affects primarily Brassica crops, but also infects corn poppy, mignonette, ryegrass, and red clover. Broccoli plants are only moderately susceptible to the disease — cabbage, in contrast, is very susceptible. Infected broccoli plants look normal at first. Later, their growth rate may slow, and they will
appear unhealthy, stunted, and wilted on sunny days. The roots of affected plants will develop large galls and become club shaped. These galls can be distinguished from those caused by the root knot nematode, which are smaller and more rounded. Crop production may be limited or nonexistent. In the field, the disease first affects a few plants in scattered clumps, but later it may spread throughout the entire field. Once a field becomes infected, the pathogen may linger and contaminate the field for three to 10 years, making it impossible to plant cruciferous crops until the fungus is gone.

The longevity of clubroot depends on soil conditions: sandy, poorly drained soils low in organic matter are not as hospitable to the clubroot fungus as are acidic, cool, well-drained clay soils. The clubroot pathogen is typically introduced to a field when infected transplants are used. The disease is also spread in part by surface runoff, contaminated irrigation water, dirty equipment, and animals. However, it is not seedborne.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the Chemical Disease Control section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Prevention is key. Plants should not be grown in beds known to harbor the clubroot fungus. Transplant lots containing even one plant with clubroot symptoms should be rejected and destroyed. Certified plants should be used when possible. Do not irrigate plants with water from contaminated or potentially contaminated fields. Clean equipment and shoes after use in fields suspected or known to have the clubroot fungus. Where clubroot has not occurred, plant Brassica crops in rotation with crops outside the same family every three to five years, making sure to eliminate susceptible weeds from surrounding areas. In infested fields, rotate cruciferous crops in every seven to 10 years. Add and incorporate hydrated lime after soil testing has determined the correct amount to use. Improve field drainage and plant on raised beds. If plants must be grown in fields where clubroot is present, lime the soil to 7.0 to 7.2 pH (any higher may reduce quality of crop) at least six weeks before planting.

**Damping-Off, Pythium spp., Rhizoctonia solani**

Damping-off is a disease of seeds and young transplants caused by soilborne fungi. It causes seeds to decay in the soil and young plants to rot at the soil line, collapse, and eventually die.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** If damping-off has been a problem, chemicals can be applied before or at seeding time. See the Chemical Disease Control section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Control methods include planting on raised beds and ensuring the site has good drainage.

**Downy Mildew, Peronospora parasitica**

Downy mildew fungi affect seedlings as well as fully grown plants by attacking the underside of leaves. A gray mold develops on the bottom surface of the foliage while the
upper side of the leaf becomes yellow, then brown and necrotic. This disease is not to be confused with powdery mildew, which affects both sides of the leaf. Damp conditions contribute to the development of mildew.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** See the *Chemical Disease Control* section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Plant resistant varieties. Rotate cole crops with other types of crops. Plant material should be removed immediately after harvest. Spacing between plants should be increased to facilitate drying of the leaves. Water should be applied directly to the soil, not to the foliage.

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**Yellows/Fusarium Wilt,** *Fusarium oxysporum*

The fungus that causes yellows, or fusarium wilt, enters plants at transplanting time through young roots or wounds in older roots. Seedlings may be stunted or die. Older plants initially appear unhealthy and yellowish green; later, leaves may drop and stems become twisted to one side. The symptoms are similar to those of black rot, although discoloration inside the stem is yellowish brown, not black.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** No chemical control is recommended.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** In infected soil, the only method of control is to use resistant varieties and practice long crop rotations. If the site does not harbor the fungus, infected seedlings should be kept out of the soil.

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**CHEMICAL DISEASE CONTROL**

*Always read the label before applying any chemicals, and be sure to follow the rates specified for the crop of interest. For chemical control recommendations specific to broccoli, please refer to the Commercial Vegetable Production Recommendations: Virginia, which is updated and published annually. A current PDF version can be found online at: [http://pubs.ext.vt.edu/456/456-420/456-420-pdf.pdf](http://pubs.ext.vt.edu/456/456-420/456-420-pdf.pdf). For noncommercial recommendations, please refer to the Virginia Pest Management Guide: Home Grounds and Animals, which is updated and published annually. A current PDF version can be downloaded from the following URL: [http://pubs.ext.vt.edu/456/456-018/456-018.html](http://pubs.ext.vt.edu/456/456-018/456-018.html).*

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**WEEDS**

Many different species of annual grasses, perennial grasses, and broadleaf weeds infiltrate cropland in Virginia. If left uncontrolled, weeds can inhibit root quality and reduce harvest yields. Proper weed management is essential to the production of broccoli, as well as other crops. Weeds compete with crops for light, space, nutrients, and water.
Weeds can also serve as a refuge for pests and disease. Additionally, weeds make it difficult to harvest crops.

**MONITORING:** No specific monitoring protocol is recommended.

**CHEMICAL CONTROL:** Herbicides are necessary for adequate control of weeds in commercial production. See the *Chemical Weed Control* section for more information.

**BIOLOGICAL CONTROL:** No biological control is recommended.

**CULTURAL CONTROL:** Fields with a history of severe weed infestations should be avoided. Crop rotation can help prevent domination by any particular weed species from year to year. Mechanical cultivation works well to remove or cover small weeds.

**CHEMICAL WEED CONTROL**

Always read the label before applying any chemicals, and be sure to follow the rates specified for the crop of interest. For chemical control recommendations specific to broccoli, please refer to the Commercial Vegetable Production Recommendations: Virginia, which is updated and published annually. A current PDF version can be found online at: [http://pubs.ext.vt.edu/456/456-420/456-420-pdf.pdf](http://pubs.ext.vt.edu/456/456-420/456-420-pdf.pdf). For noncommercial recommendations, please refer to the Virginia Pest Management Guide: Home Grounds and Animals, which is updated and published annually. A current PDF version can be downloaded from the following URL: [http://pubs.ext.vt.edu/456/456-018/456-018.html](http://pubs.ext.vt.edu/456/456-018/456-018.html).

**ARTHROPOD PEST TIMELINE**

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**Selected Minor Pests**

| Aphids            |      |      |      |      | x   | x    | x    | x    |      |      |      |      |
| Cabbage maggot    |      |      |      |      | x   | x    | x    |      |      |      |      |      |
| Flea beetles      |      |      |      |      | x   | x    | x    |      |      |      |      |      |
| Thrips            |      |      |      |      | x   | x    | x    |      |      |      |      |      |

**ONLINE RESOURCES**


Virginia Cooperative Extension. [www.ext.vt.edu](http://www.ext.vt.edu)
REFERENCES


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