Cole Crop Production
(Broccoli, Cabbage, and Cauliflower)

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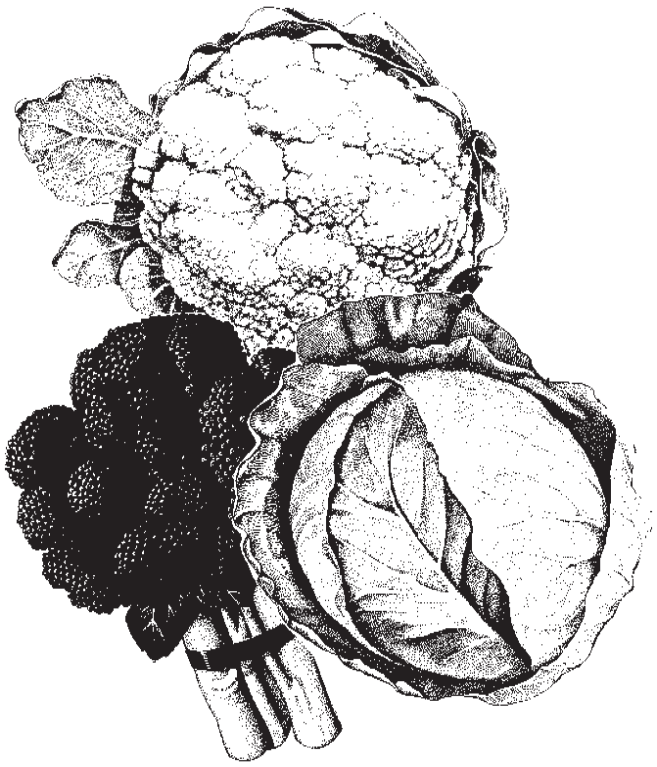

Production Requirements

Broccoli, cabbage, and cauliflower are known as cole crops. Several other vegetables belong to this group, including Brussels sprouts, Chinese cabbage, and kohlrabi, but these are considered minor vegetables. Cole crops are cool season vegetables that grow best at temperatures between 60 F and 68 F. Properly hardened mature plants of cabbage can withstand short durations of temperatures as low as 25 F, while broccoli and cauliflower plants tolerate light frosts. The upper limit for cole crop growth is about 80 F to 85 F. All these crops lose quality when temperatures exceed 80 F. Cabbage is the most heat tolerant, but prolonged high temperatures cause puffy heads with long cores and increased tipburn. High temperatures cause broccoli and cauliflower heads to become loose and branchy and may favor the development of bracts (leaf-like structures) in the heads. Broccoli buds turn yellow and flower rapidly in hot weather, while cauliflower buds develop a fuzzy, "ricy" appearance.

Expected Yield

Good yields under irrigation in Oklahoma and the approximate number of days from field setting of transplants to harvest are as follows:

Broccoli – 5 tons per acre; 55 to 75 days.
Cabbage – 15 tons per acre; 70 to 90 days.
Cauliflower – 6.5 tons per acre; 70 to 85 days.

For direct seeding, allow an additional three to four weeks from field planting to harvest.

Sites and Soils

Cole crops can be grown on a wide range of well-drained sites and soils. Sandy loams are preferable for the early crop, while later crops are likely to give highest yields on silts, silt loams, or clay loams. Soil crusting can be a problem with direct-seeded cole crops on heavier soils.

Varieties

Most cole crops are produced in Oklahoma for the fresh market. Production for processing requires varieties dictated by the processor. Only hybrid cole crop varieties are recommended for production in Oklahoma. Open-pollinated varieties cannot match the hybrids for uniformity and vigor. Also, hybrids dominate the national market in broccoli and cabbage.

The number of days to harvest is the main factor limiting adaptation of cole crop varieties to Oklahoma. Spring crops must be harvested prior to the hot summer, while fall crops are limited by frosts. Do not choose late or full-season varieties. As a general rule, do not choose broccoli varieties that mature later than 'Green Valiant' or cauliflower varieties that mature later than 'Candid Charm' (both take about 75 days from transplanting to harvest). For cabbage, a general guide is to choose varieties which mature in 85 days or less from transplanting; 75 to 78 days is safer. Please refer to HLA-6032 and HLA-6035 for specific variety recommendations.

Soil pH and Fertilizer

Cole crops perform best when soil pH is between 6.0 and 6.8. Apply lime if the pH is too low. Use dolomitic limestone

if soil tests show that magnesium content is relatively low (especially for cauliflower). Proper pH adjustment will help prevent calcium deficiency (tipburn), molybdenum deficiency (whiptail, where broccoli and cauliflower plants in particular have deformed growing points and strap-like leaves that are mostly midrib), and boron deficiency (hollow central stems with internal browning, and a rusty-brown discoloration of broccoli and cauliflower florets). Based on Oklahoma State University's soil test results, the following quantities of phosphorus (P_2O_5) and potassium (K_2O) are recommended:

Phosphorus Per Acre

When test shows	0-19	20-39	40-69	70+
Add lbs. P_2O_5/A	100	75	50	none

Potassium Per Acre

When test shows	0-99	100-199	200-249	250-299	300+
Add lbs. K_2O/A	250	150	100	50	none

Note: For cabbage, decrease added potassium recommendations by 50 lbs. K_2O/ac.

Nitrogen. Cole crops may need 150 to 200 lbs. per acre of total nitrogen (N). Apply 50 lbs./ac N with the recommended P_2O_5 and K_2O fertilizer, as shown in the preceding tables, in a broadcast, preplant-incorporated application. If soil tests indicate a low residual N content, or if soils are very sandy, an additional 50 lbs. per acre N can be applied at planting, either as a side-dress (if transplanting) or in bands four inches deep and three to four inches from the row. Cole crops benefit from a side-dressing with 40 to 50 lbs. per acre N two to three weeks after setting transplants in the field (about five weeks after direct seeding). A second side-dressing with 40 to 50 lbs. per acre N should be given about six weeks after setting transplants in the field, or at about the time when heading begins. Excess N can contribute to ground water pollution and may reduce quality, especially in cabbage where heads may show increased tipburn and possible bursting.

When transplanting, a starter solution high in nitrogen and phosphorus should be applied at a rate of one-half pint of solution per plant. Three pounds of soluble 20-20-20 in 50 gallons of water can be used in making a starter solution.

Transplanting

Cole crops may be direct-seeded or transplanted. Hybrid cole crop seed is expensive. Transplanting can reduce seed costs by wasting fewer seeds and reducing field-related risks compared to direct seeding. See OSU Extension Fact Sheet HLA-6020 for more information on raising transplants.

Buttoning. In young broccoli and cauliflower plants, there is a fine balance between vegetative and reproductive growth. If the balance tips toward reproduction while the plant is young, root and leaf growth are restricted and the developing head becomes exposed on a small plant. The head never reaches marketable size and soon breaks up as the flower stalks elongate. This "premature" head development is called buttoning. Buttoning is most likely to occur when well-developed young plants experience stress, especially cold temperatures. Follow these guidelines to help prevent buttoning.

1. Keep soil temperatures above 60 F and daytime air temperatures above 70 F while growing transplants in the greenhouse. Avoid temperatures below 50 F. Harden by gradually reducing water or withholding nitrogen for the final week before field planting, rather than by lowering temperatures, but do not stress the plants.
2. Set plants in the field when they are about four weeks old. Plants more than five weeks old are especially likely to button. Avoid transplant shock. When the largest leaves are three to four inches wide or wider, exposure to field temperatures below 50 F for more than four days promotes buttoning.
3. Prevent nutrient stress. Apply recommended preplant fertilizers. Use starter solutions when transplanting. Side-dress young plants with nitrogen as needed.
4. Prevent moisture stress. Plants grown in cold, wet soils experience slow growth. As plants develop, irrigation may be required.
5. Prevent stress from weeds, pathogens, and insects.
6. Buttoning is more common in cauliflower than in broccoli. Also, varieties differ in their tendency to button. The earliest maturing varieties are most likely to button.

Bolting. Young plants of biennial vegetables, including cabbage and cauliflower, which are exposed to prolonged temperatures below 50 F to 55 F are likely to show bolting (premature flowering) later in the season. Bolted plants are worthless for market. Set plants in the field when they are about four weeks old. Following the same temperature guidelines shown above for the prevention of buttoning also will minimize bolting.

Direct Seeding

Cole crops may be direct-seeded about 15 to 20 days before the normal transplanting date. The use of a precision seeder followed by thinning to the proper spacing is recommended. Careful seedbed preparation is required and irrigation is needed to ensure good moisture during germination and early seedling growth. Planting depth must be shallow (one-fourth to one-half inch) since seed size is very small. About one-half to one and one-half pounds of seed are needed to field seed one acre, depending on seed size and spacing. Seedlings should be thinned at the three-leaf to four-leaf stage. Disease control is improved by the use of hot water-treated seed that has also been coated with a fungicide.

Suggested spacings for the cole crops and the number of plants required per acre are as follows:

Broccoli. Use double-row beds on 36- to 40-inch centers. Space rows about 14 inches apart on the beds and space plants at nine to 12 inches apart within the rows. This requires 26,136 to 38,720 plants per acre.

Cabbage. Use double-row beds on 36- to 40-inch centers. Space rows about 14 inches apart on the beds and space plants at 10 to 14 inches apart within the rows. This requires 22,402 to 34,848 plants per acre. Cabbage head size tends to respond to spacing. The lower plant populations will give larger individual heads.

Cauliflower. This is the most difficult of the three major cole crops to produce. Use single rows spaced 36 to 40 inches apart and space plants 15 to 20 inches apart

within the rows. This requires 7,841 to 11,616 plants per acre. Experienced growers may try double-row beds on 36- to 40-inch centers; however, cauliflower plants get too tall and elongated if they are crowded.

Time of Planting

There is a limited potential for commercial production of broccoli and cauliflower in the spring in Oklahoma. A spell of high temperatures in May or early June can quickly ruin either crop. Cabbage, in contrast, succeeds in the spring. All of the cole crops give high-quality yields in the fall. However, planting must be early enough to allow harvest before the first expected frost, especially for cauliflower. This means that stand establishment must occur under hot, dry conditions. Fall plantings require careful monitoring and frequent irrigation to get the young plants through the first month of growth. Conditions usually become more favorable as the crops develop.

In general, cole crops should be direct-seeded from March 1 to March 15 for a spring crop, and from August 1 to August 15 for a fall crop. Set transplants in the field from March 15 to March 25 for a spring crop and from August 15 to August 25 for a fall crop.

Irrigation

The cole crops have shallow root systems, penetrating the soil to a depth of 18- to 24-inches. They obtain most of their water from the upper foot of soil. As a general guide, at least one inch of water per week is required for uninterrupted growth. Light, sandy soils may require up to two inches of water per week during hot, dry periods.

Irrigation is especially critical immediately after field planting. The plants then should make continuous, steady growth during the season for highest quality. Moisture stress can check growth and reduce quality. Moisture stress is suspected as the primary cause of tough, fibrous stalks in broccoli, and it is known to increase tipburn of all three crops. All three crops need adequate water prior to head initiation to obtain large heads at harvest time. However, avoid watering cabbage when heads have reached marketable size, as excess moisture may cause heads to split.

Weed Control

Cultivation should be shallow and should only be done on young plants. Consult the most recent revision of OSU Extension Fact Sheet HLA-6008 and the latest edition of Extension circular E-832, *Extension Agents' Handbook for Insect, Plant Disease, and Weed Control* for further information and specific chemical recommendations.

Insects

This section discusses the biology, damage, and management of the major pests of cole crops in Oklahoma. For specific insecticide information, refer to the current edition of Extension circular E-832, *Extension Agents' Handbook for Insect, Plant Disease, and Weed Control*.

Soil and Surface Pests

White Grubs and Wireworms. Soil-dwelling insects such as wireworms and white grubs may cause serious damage to crucifers, particularly when the crop is planted following a grass crop or in a weedy field. Larvae of wireworms are long, cylindrical, and tannish brown. White grubs are the C-shaped, light-colored larvae of May/June beetles. Both pests cause damage when larvae feed on germinating seeds and roots of young plants. Severe stand reduction can result when population density of wireworms or white grubs are high.

Management. A pre-plant insecticide should be applied in fields with a history of white grub or wireworm problems or when the crucifer crop is planted in a field that was weedy the previous season or is planted following a grass crop. Routine treatment of fields is generally not warranted. However, control of soil insects on a "rescue" basis after planting is usually not successful.

Cutworms. Cutworms include several species whose larvae characteristically chew plant stems at the soil surface, cutting them at ground level. Pest species include black cutworm and variegated cutworm. In general, cutworm problems are sporadic but can be severe occasionally.

The dark-colored cutworm moths are active at night and lay eggs on leaves or stems close to the soil surface soon after plants emerge. After hatching, young larvae may feed on leaf surfaces for a short time, but older larvae tunnel into the soil and emerge at night to feed. Cutworm larvae may be distinguished from other larvae by their habit of curling their bodies when disturbed. Cutworm damage is characterized by plant stems severed partially or completely at the soil surface. Plants begin to wilt and usually die soon after damage occurs.

Management. After plant emergence, check for wilted plants with completely or partially severed stems. Once damaged plants are located, look for cutworms by digging around the base of plants and sifting the soil for caterpillars. Typically, cutworms are not found on the soil surface during the day. They can be found at dawn or at night using a flashlight. Damaged plants often occur in a sequence of four or five within a row. Cutworms often recur in the same fields and in the same parts of fields from year to year. Areas that have had a dense stand of weeds often have high populations. Baits are more effective when other food is limited, so check for cutworms and apply bait to the field before the crop emerges, especially where cutworms have caused damage before.

Cultural controls can help prevent cutworm damage. Remove weedy field margins and disc fields at least 10 days before planting to destroy larvae, food sources, and egg-laying sites. Treatment for cutworm before thinning is seldom warranted unless the plant stand is otherwise poor. If chemical control is required, effectiveness is increased by applying a band of insecticide at the base of the plant, preferably at or shortly before dusk.

Primary Lepidopterous Pests

The most important pest complex of crucifers statewide includes several species of foliar-feeding caterpillar pests. In Oklahoma, key pests include cabbage looper, diamondback moth, imported cabbageworm, and occasionally, beet armyworm.

Cabbage looper is generally the most prevalent pest of crucifers in Oklahoma. Adults are robust moths with brownish-gray forewings that have a silver '8'-shaped marking. Hind wings are light colored with dark margins. Eggs are dome

shaped and laid singly, usually on the underside of leaves. Larvae are light green and have three pairs of jointed legs near the head and three pairs of fleshy, abdominal prolegs. These caterpillar pests form a hump or "loop" at their midsection as they crawl on host plants, hence their common name of "looper." Young larvae feed on the lower surface of leaves, creating a windowpane effect. At warm temperatures, development from egg to adult lasts about 18 days to 25 days. Four to five generations occur per year, with peak activity usually in May or June and in late September for fall-planted crops.

Diamondback moths (DBM) are small grayish-brown moths whose wings have a light-colored diamond pattern when folded at rest. Larvae are much smaller than looper larvae (usually less than one-third inch long) and have a distinctive appearance. Prolegs on the last abdominal segment are spread apart, forming a "V" shape. Diamondback moth larvae wriggle abruptly when disturbed, often dropping from the plant. Pupae are light green and covered with a loosely spun, gauze-like cocoon. The life cycle takes about four to six weeks from egg to adult. In recent years, diamondback moth has achieved major pest status in cole crops and has become increasingly difficult to control with insecticides.

Imported cabbageworm (ICW) can be a significant pest of crucifers. Adults are white butterflies with brown- or black-tipped forewings and one or two dark spots on each forewing. Eggs are cigar-shaped, pale yellow, and laid singly on the underside of leaves. The velvet-like larvae are pale green with a faint stripe down the back. The chrysalis or pupa has several sharp angles and may be green, gray, or brown. Cabbageworm eggs hatch in three to seven days and larvae develop through five instars in 10 to 14 days. The entire life cycle takes four to six weeks, depending on temperature. Compared to other caterpillar pests, imported cabbageworm is adapted to cool weather and occurs in mid-April in most years.

Beet armyworm adults are robust, dark-colored moths that somewhat resemble cabbage looper adults. Eggs are laid in clusters and are covered with hair-like scales from the female's body, giving them a cottony appearance. Larvae are light green with a dark spot on the side of the body above the second true leg. The life cycle takes about three to five weeks to complete, depending on temperature. Beet armyworm feeds on many hosts, including other crops such as beets, peppers, tomatoes, beans, and cotton. Some weeds are also good hosts, particularly pigweed and carelessweed (*Amaranthus* spp.).

Damage. Cabbage looper, diamondback moth, imported cabbageworm, and beet armyworm all damage crucifers by chewing on foliage, causing ragged holes in leaves. Occasionally, these caterpillar pests bore into and contaminate heads with their bodies and fecal material. In general, any damage by larvae to cabbage heads, excluding the wrapper leaves, renders the head unmarketable. Each species varies in the quantity and location of feeding on host plants. Cabbage loopers are the most voracious, feeding 10 to 20 times more than diamondback larvae and two to three times more than beet armyworm.

Management. Decisions to apply insecticides should be based primarily on the presence of larvae. Research has shown that the composite action threshold for caterpillars on cabbage is 0.3 larvae per plant (one larva per three plants). This threshold can be used for all species as long as fields are scouted at least twice weekly and the field is sampled sufficiently to gain a representative index of larval activity. Usually 25 to 40 samples are adequate for a field measuring less than 40 acres. Although attention should be paid to field edges and "problem" areas, such as beneath electrical power lines, treatment decisions should be made based on randomly selected plants from all sections of the field. More larvae can be tolerated prior to cupping in cabbage than after cupping (usually up to 0.5 larvae per plant). Also, caterpillar control before thinning direct-seeded crops is not critical unless the plant stand is significantly threatened. Recently, diamondback moth has become more difficult to control with insecticides and high levels of resistance have been observed in several production areas. It is strongly advised to use a Ba*cillus thuringiensis* (B.t.) product in each of the insecticide sprays as a basis for a control program. However, note that B.t. is most effective against small larvae, so treatment should start early in each generation to target young caterpillars.

An important form of cultural control is destruction of crop residue and weeds that serve as alternate hosts for caterpillar pests, thus reducing source populations. Because diamondback moth pupae survive in soil and crop residue, it is important to destroy harborage by shredding, discing, and plowing under residue following harvest. Beet armyworm populations often build up on pigweed at field margins and in fields where weed control is poor. It is important to destroy any pigweed near fields where crucifers are grown several weeks before planting.

Aphids

Aphids are small, soft-bodied insects that remove plant sap through their piercing-sucking mouthparts. Aphids are recognized by their cornicles on their abdomen. These structures resemble exhaust pipes and are visible under light magnification. Several aphid species may be serious pests of cole crops. Aphids live in small, compact colonies formed after the immigration of winged adults. Females reproduce asexually and may produce several nymphs per day. Because generation time is short (less than two weeks), many generations are produced each year, allowing for tremendous reproductive potential. Aphid feeding damage is manifested as stunting, leaf distortion, and potentially reduced head size. In broccoli and cauliflower, aphids may colonize the heads, reducing the marketability of the crop. Removal of aphids from heads can be difficult and cost prohibitive. Finally, aphids produce honeydew, a sticky waste product that coats leaves and serves as a growing medium for black sooty mold.

Management. Biological control of aphids by small parasitic wasps as well as natural mortality from environmental factors (e.g., heavy rain) may reduce aphid populations. Natural enemies (i.e., parasites and predators such as ladybeetles and lacewings) can be effective in maintaining aphid populations below damaging levels, especially during fall production.

Wild mustards serve as hosts for cabbage aphids and may speed the colonization of aphids into cole crops. Aphid problems can be minimized by destroying these weeds before planting and maintaining weed-free field margins. Chemical control can be successful using an array of insecticides, provided care is taken to ensure good coverage. However,

broad-spectrum insecticides can wipe out natural enemies, causing an explosion in populations of aphids and secondary pests that are normally kept under natural regulation by predators and parasites.

Economic thresholds for aphids are not well defined for Oklahoma production areas. However, information from California and field observations in Oklahoma suggest that control should be initiated when one to two percent of crop plants are infested. It is particularly important to keep populations at low levels in broccoli and cauliflower after heading. Care should be taken to get a representative sample from each area of a field because of the clumped distribution of aphids.

Occasional Pests

Thrips (*Thrips tabaci*, *Frankliniella* spp.). Thrips can be a severe pest in some years, especially in cabbage grown in spring. Thrips are tiny insects with narrow, elongated bodies. Adult thrips range in color from a pale yellow to dark brown and have feather-like front and hind wings that can be seen under light magnification. Immature thrips are wingless and usually pale to lemon yellow. Thrips have a broad host range, including many weed species as well as a number of cultivated crops. Often, thrips invade cabbage when adjacent alfalfa is cut for harvest. Thrips damage takes on a "silvering" appearance from the rasping of the leaf tissue with their mouthparts. Small black fecal specks are also usually found. No information is available on the yield loss caused by thrips, but damage to cabbage heads prior to harvest can render the heads unmarketable.

Management. No economic thresholds have been established on cole crops grown for fresh market. However, it is generally understood that control procedures should be initiated soon after infestations are discovered. Control is often difficult to obtain once populations are well established, underscoring the importance of monitoring for thrips. In cabbage, thrips often feed underneath wrapper leaves and cause internal head damage.

Flea Beetles. Flea beetles are tiny beetles varying in color from metallic green to dark brown or black. Flea beetles chew on foliage of cole crops and can cause severe defoliation of plants when present in large numbers. Although larvae can feed on the roots of plants, it is the adult beetle that causes the greatest damage. Flea beetles make small pits in leaves that create a "shothole" appearance in the leaf. Their host range is broad and they sometimes move into crops in large numbers from adjacent weeds.

Management. Many of the current cultivars provide some resistance to flea beetles. It is important to provide good weed control in and around the cole crop field to reduce source plants for the beetles. The use of insecticides becomes necessary when beetles are present in fairly large numbers and a significant amount of defoliation is imminent.

Harlequin Bug. This bug is fairly large, about one-third inch long with orange and black markings on its shield-shaped body. Eggs are distinctive with barrel-shaped, dark-colored bands on the side and top and are laid in two-row clusters. Nymphs resemble adults except they are smaller and lack fully developed wings. Adults and nymphs feed on leaves with their piercing-sucking mouthparts, extracting plant juices. Young plants can become wilted, stunted, and are sometimes killed. Management. Destruction of old crop residue will aid in reducing carry-over populations. Elimination of weed hosts (especially those in the mustard family) adjacent to the field will help reduce the number of bugs overwintering on those plants. No economic thresholds are established for this pest, but control is usually warranted shortly after bugs are found in the field. Repeat insecticide applications may be needed, especially in young plantings.

Spider Mites. Mites are an occasional pest of cole crops; however, when they do infest a field, they can be very destructive. Cole crops are not a preferred host, but mites sometimes migrate from other crops such as cotton, peanuts, or corn. Special attention should be paid to these crops in the fall as they begin to dry down before harvest, especially if they are located adjacent to fall cole crops. These pests are very small, about the size of a pin head, have eight legs in the adult form, and usually have two dark spots on their backs (two-spotted spider mite) or are reddish in color (carmine mite). Many generations per year are possible with the life cycle requiring only five to 20 days, depending on the temperature. Damage by mites results in yellowed patches appearing on leaves, and the damaged areas eventually dry out and turn bronze or white. Once mite colonies are established, the underside of leaves becomes covered with silken webs. Damage by mites can become quite severe, especially under hot, dry conditions. The use of broad-spectrum insecticides may increase severity of mite problems as these chemicals eliminate natural enemies.

Management. No threshold guidelines are available for spider mites, but good coverage with a miticide is essential for achieving control. Maintaining control of mites in adjacent crops will help reduce migration of mites into the cole crop. To enhance efficacy, use high-volume sprays because mites reside underneath leaves and webbing can impede insecticide penetration into the crop.

Field Sampling. A key component of effectively managing pests on cole crops is monitoring. Fields should be monitored regularly in a manner that provides representative information about the pest population and the developmental stage of the crop. Pests should be controlled with insecticides only when necessary using established thresholds. This approach can reduce costs associated with controlling insect pests and minimizes adverse effects of insecticide use. In general, fields should be scouted twice a week by walking through the field in a crisscross pattern. Whole-plant observations should be made while scouting, concentrating on the underside of leaves and inside heads. Samples should be as unbiased as possible, taking care not to focus on damaged plants. Records of the percentage of plants infested throughout the season will help the decision-making process and provide an indication of the effectiveness of insecticide sprays.

Diseases

Black rot is the most common disease of cole crops in Oklahoma, but other diseases may also develop. Seed rot and seedling blight (damping off) are caused by one or more of the fungal pathogens *Fusariuum* spp., *Pythium* spp., and *Rhizoctonia solani*. *R. solani* also causes a lower stem rot (wirestem) on all cole crops and bottom rot on cabbage.

Other root and stem diseases caused by fungi include black leg (*Phoma lingam*), clubroot (*Plasmodiophora brassicae*), Fusarium wilt or yellows (*Fusarium oxysporum* f. sp. *conglutinans*), Phytophthora stem and root rot (*Phytophthora* spp.), Sclerotinia rot or white mold (*Sclerotinia sclerotiorum* and *S. minor*), and Verticillium wilt (*Verticillium dahliae*). Foliar fungal diseases include Alternaria leaf spot (*Alternaria* spp.), downy mildew (*Peronospora parasitica*), and white spot (*Pseudocercosporella capsellae*). Important diseases caused by bacteria are bacterial leaf spot (*Pseudomonas syringae* pv. *maculicola*), black rot (*Xanthomonas campestris* pv. *campestris*), and soft rot (*Erwinia* spp. and *Pseudomonas* spp.). Cauliflower and turnip mosaic viruses occur occasionally, but usually do not cause significant damage. Root-knot nematodes (*Meloidogyne* spp.) also attack cole crops and can cause significant damage where the nematodes reach high levels in the soil.

General disease management strategies for crucifers include cultural practices, use of disease resistant cultivars, and chemical control programs when needed. Cultural practices include the use of high-quality seed tested for the presence of seed-borne pathogens that cause black rot and black leg, and/or the use of healthy transplants produced from such seed. While seed germination may be reduced, seed of unknown health status may be hot-water treated at 122 F for 20 minutes (broccoli and cauliflower) to 25 minutes (cabbage) to control black rot. Timely removal or burial (plowing down) of infested crop debris in which many pathogens survive, and crop rotation with non-crucifer crops for two years reduce pathogen levels and help prevent disease build-up. Rotate with a grass crop such as corn for at least two years where root-knot nematode is a problem. The use of drip irrigation may reduce levels of foliar diseases compared to sprinkler irrigation, but only during dry production seasons. Planting of cabbage varieties with resistance to Fusarium wilt and black rot is encouraged. Broccoli varieties with resistance to downy mildew are also available. Damping-off is reduced and stand establishment is increased by planting seed treated with fungicide. Fungicide and bactericide (coppers) programs may be needed in the production of transplants in the greenhouse and/or in crucifer crop production in the field. It is important to accurately identify disease problems so that effective control practices are used. For example, a fungicide program will not be effective if the problem disease is caused by a bacterium or a virus. Consult your local extension county educator for submitting plant samples for disease diagnosis and soil samples for nematode testing to the OSU Plant Disease and Insect Diagnostic Laboratory. Consult the latest edition of the Extension circular E-832, *Extension Agents' Handbook for Insect, Plant Disease, and Weed Control* for specific disease control recommendations.

Harvesting

Broccoli—Broccoli should be cut when heads are three to six inches in diameter and before the flower buds open to show any yellow. Leave about eight inches of stem when cutting heads. On some varieties, side shoots will develop off of the main stem after the central head is harvested. These also can be harvested.

Cabbage—Harvest cabbage when the head feels firm and solid when pressed with the thumb and fingers. Split heads are a sign of over-maturity. Allow some wrapper leaves to remain on the head to protect it in transit to market.

Cauliflower—Most cauliflower varieties have to be tied to keep sunlight off the curds (heads) in order to maintain a white color. This process of excluding light is called blanching. Some late varieties are termed "self-blanching," meaning that the outer wrapper leaves tightly cover the curds so that no sunlight can penetrate. These varieties sometimes do not fully cover the developing curds, especially under warm temperatures, and most are too late for reliable production in Oklahoma.

When tying cauliflower, check the field every three to four days as maturity approaches. Any plant with a visible white curd of at least one inch in diameter should be tied by gathering the leaves together and placing a colored rubber band or a piece of twine around them. The same color band should be used for all plants tied on the same day. Three or four days later, repeat the process with a different color band. Avoid cracks or spaces between leaves that will allow sunlight to penetrate and discolor the head.

After the heads form, they grow rapidly. Starting four days after tying, check several heads to see if they have attained market size. Time from tying to harvest varies from about four days to two weeks, depending on the temperature and available moisture. Each head should be six to eight inches in diameter and weigh one and one-half to two pounds. Good quality cauliflower is pure white, well domed, tight, solid, and clean. There should be no hollow stem and no insect or disease damage on the head. If 75 percent of the heads are ready for harvest, cut all heads tied the same day as those checked. Although some small heads may be harvested, this process eliminates the need to check every head individually. Before packing, wrapper leaves must be trimmed to about one to two inches above the head. If heads are film-wrapped, the wrapper leaves are trimmed flush with the top of the head.

During damp, humid weather, the curd is very susceptible to rot-causing pathogens. Tying leaves tightly around the curd to exclude light will increase the chances of disease. In such cases, tie the leaves together as high above the curd as possible to allow some air movement.

Post-Harvest Handling and Marketing

Broccoli is packed in half-cartons holding 14 to 18 bunches and weighing 20 to 24 pounds. Cabbage is packed in 50-pound mesh sacks, wooden crates, or waxed fiberboard cartons. Cauliflower usually is marketed in flat or two-layer cartons weighing 18 to 24 pounds and holding nine to 16 trimmed and film-wrapped heads.

Precooling is beneficial to cabbage, but is a slow process. Precooling to 40 F immediately after harvest is essential for maintenance of quality in broccoli and cauliflower. Hydrocooling is the most common method of precooling for cole crops. Broccoli may be liquid-iced, and pressure cooling (forced air) can be used for film-wrapped cauliflower. All three crops tolerate the use of crushed ice to maintain quality in transit, and refrigerated transport is recommended for moving these crops to market.

All three crops are stored at 32 F with a relative humidity of at least 95 percent. Broccoli and cauliflower are stored for only brief periods as needed for orderly marketing. With proper conditions, broccoli has a storage life of 10 to 14 days, while cauliflower will keep for three to four weeks. Storage of cabbage is of commercial importance in the northern United States, but not in Oklahoma. Most cabbage varieties grown

in Oklahoma have storage lives of three to six weeks. Late varieties grown in the northern United States specifically for storage may remain in good condition for five to six months. Avoid storing any of the cole crops with fruits that produce large quantities of ethylene gas.

Small acreages of broccoli may be marketed by pick-your-own methods. Some growers harvest the largest central heads themselves and allow customers to pick the side shoots, which develop later. If this is desired, choose varieties carefully, since not all varieties are vigorous producers of side shoots.

The Oklahoma Cooperative Extension Service
Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

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