

COLE CROPS

BROCCOLI, CABBAGE AND CAULIFLOWER

BY
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Broccoli, cauliflower, and cabbage are closely related vegetables that are often called cole crops. They are cool-weather vegetables, suitable for growing as spring or fall crops in Kansas. Recent increased popularity of fresh vegetables has increased the demand for these crops immensely. In fact, fresh broccoli consumption has grown from 0.3 pounds per person to 1.4 pounds per person in the past 10 years. Consumption of cauliflower and cabbage is also increasing, especially with fresh use in salad bars.

MARKETING

These vegetables are perishable, requiring rapid movement to the market under refrigerated conditions. This is particularly true for broccoli, which must be quickly refrigerated after harvest and sold within a short time. Wholesale or retail growers and produce markets are possible outlets. Check with markets in advance concerning quantities desired, packaging, quality standards, and delivery schedules.

These crops can be used in “pick-your-own” operations. They overlap or are slightly later than the strawberry season and appeal to homemakers for home freezing and canning (or sauerkraut). Excess produce not harvested can be sold later to other outlets. Providing detailed harvesting directions for customers is not as critical with these crops. Little damage is usually done to plants and broccoli can often be multiple-harvested for side shoots following removal of the main head. Pick-

your-own operations usually sell these crops by the pound rather than by volume measures.

SOIL AND LOCATION

Cole crops can be grown on both upland or bottom soils. The crops have a fairly shallow root system (18 to 24 inches) and can grow in a wide variety of soil types. Sandy soils warm up earlier in the spring, resulting in earlier plant growth and harvest. Because of poor water holding capacity, sandy soils require frequent irrigation and more fertilizer (as nitrogen is rapidly leached from the root zone). Usually these crops grow before weeds become serious problems, but growers should avoid areas where infestations exist. Since early planting is necessary, fall tillage may be needed in heavier soils because wet, cold conditions often delay spring tillage.

FERTILIZATION AND SOIL IMPROVEMENT

A soil test will indicate the need for limestone and several fertilizer elements. Soil pH should be adjusted to 6.0 to 6.8, and if pH levels are below 6.0, lime should be added. Normally, lowering of pH levels is not necessary in Kansas soils.

Cole crops are heavy nitrogen consumers, and preplant applications of 18-46-0 or similar fertilizers, at 200 to 250 pounds per acre (lbs / A) (broadcast and incorporated), are suggested. Fertilizer rate can

be reduced by “banding” fertilizer 4 inches deep and 3 to 4 inches from the row before or at planting.

Sidedressing

One of the most critical factors for rapid growth and early harvest is nitrogen sidedressing. Apply 30 to 35 lbs / A of nitrogen (N) 3 weeks after transplanting and make an additional application 2 weeks later. For late cabbage or cauliflower, an additional 30 lbs of N may be required if excess leaching of nitrogen occurs. Of the three crops, cabbage can probably grow with the least nitrogen, followed by broccoli and cauliflower.

Starter Fertilizer

One additional component of a well-balanced fertilization program is the use of starter solution in the transplant water as plants are set in the ground. A high phosphate, soluble fertilizer dissolved in water ensures early root development and quicker growth. This practice is possible in small plantings or where field-grown plants are set out.

TRANSPLANTS

Because of the shortened spring season in Kansas, transplants must be used, especially for broccoli and cauliflower. Cabbage is more reliable as a transplanted crop, as well. Early, direct-seeded cabbage will mature 2 to 3 weeks later than transplanted cabbage. A compact transplant, 4 to 6 weeks old, that has been well “hardened” by exposure to cold before transplanting should be used. Seeds germinate rapidly at temperatures of 70° to 75°F. Grow plants at daytime temperatures of 65° to 70°F and night temperatures of 50° to 60°F. Plants should be exposed to outside temperatures about 10 to 14 days before transplanting. A well-hardened plant can tolerate 26° to 28°F temperatures. (Cauliflower is the least cold tolerant of the cole crops.) About 5,000 transplants can be produced from 1 ounce of seed.

Large, old plants of cauliflower and broccoli are likely to “button” (prematurely produce a small head) if exposed to cold temperatures of 50° to 60°F after planting. Plants that “button” never recover to produce adequate or normal heads. Lack of nitrogen sidedressing also increases the tendency of plants to “button.”

VARIETIES

Cabbage

Choose early to mid-season varieties.

Discovery Solid Blue

Conquest Fortuna

Headstart (early) Bravo

Improved Gold Acre Types

Savoy Ace (Savoy type)

Red

Ruby Red Acre Solid Red

Broccoli

Several excellent, early-maturing varieties are available.

Packman

Green Comet (early, good side shoots)

Baccus (early)

Premium Crop (late)

Dynasty

Numerous new hybrids are being evaluated. Check with K-State for upgraded variety suggestions.

Cauliflower

Several excellent, early hybrid varieties are available.

Early

Snow Crown (early hybrid)

Super Snowball

Early Snowball

(other early snowball types)

Mid- to Late Season

Self blanche

Imperial 10-6

TRANSPLANTING

Spring cole crops should be set in late March to mid-April, with early planting preferred. Broccoli and cabbage are the most cold hardy and can normally be planted with less chance of cold injury than cauliflower. Earlier planting dates can be used in southern Kansas, whereas central or western Kansas should delay planting 2 to 3 weeks—about 2 weeks prior to the average frost date in your area should be a good date to aim for. Spacing and rate of planting are as follows:

Spacing Plants

Crop In row Between rows Required/Acre			
Cabbage	12"	36"	14,500
Broccoli	12"	36"	15,500
Cauliflower	18"	36"	9,699

SPRING CARE

Irrigation during dry periods is critical, since these leafy crops have shallow root systems and rapidly deplete available soil moisture during periods of stress. Water after fertilizer applications, if feasible, to move fertilizer rapidly into the root zone. Sudden rainfall or watering following dry periods can cause cabbage heads to split. Your goal should be to provide an even moisture supply to ensure uniform growth.

Weed control is not as critical a problem with these crops as with other vegetables, since transplants grow rapidly before weeds emerge. Shallow cultivation can deal with many weed problems. If needed, these herbicides can be used.

Dacthal. Effective on some broadleaf and grassy weeds. A light incorporation often improves effectiveness.

Treflan (preplant). Effective on many broadleaf and grassy weeds. Incorporation immediately after application is essential.

Cauliflower needs to be tied (or blanched) by wrapping some outer leaves around the small head when it reaches ½ to 2 inches in diameter. Rubber bands (3½ x ¼ inch size) are often used. A different colored band for each day that heads are tied gives a rapid color code when harvesting. Place a number of rubber bands on the arm and wrist, pull the

leaves together, and pull one band down over the leaves with the other hand. Heads exposed to direct sun will be yellowed and may develop a bitter “off flavor” in warm periods. Self-blanching varieties cannot be counted on to adequately blanch themselves in warm conditions. These varieties still need to be tied in most seasons.

HARVEST

Spring harvest usually begins in early to mid-June for cabbage and broccoli. Cauliflower matures 1 to 2 weeks later. Harvest should be completed when hot temperatures begin to develop in late June to early July. Heads should be cut from the plant, field trimmed, and rapidly moved to refrigerated storage. Cabbage can tolerate slightly more heat and can be harvested longer into hot weather than cauliflower or broccoli.

Harvest cabbage when the heads are firm and solid (judged by the pressure of the thumb on the head). Broccoli should be cut before the flower buds begin to separate or show any tinge of the yellow petals beginning to emerge. Cauliflower is cut before the head begins to loosen and before heads develop a slightly rough feel.

For local markets, a variety of cartons or baskets can be used. Cabbage is usually sold to wholesale or produce companies in mesh bags (50 pounds) or 53-pound cartons. Broccoli is usually packed in bunches (1 to 1½ pounds) in half cartons 20 to 23 pounds. Cauliflower may be packed in two-layer cartons that hold 12 to 16 trimmed heads. Cabbage is usually priced on the market by pound, whereas broccoli and cauliflower may be sold by the head or by the pound.

FALL CROPS

It is certainly possible and feasible to plant a second crop in the fall in Kansas. One difficulty growers can encounter is starting these crops in the hot Kansas summer. Fall crops can be “direct-seeded” July 1 to 15, or transplants can be started in cooler locations for later field setting between July 20 and August 10. Adequate water should be applied until seedlings emerge. Gradually reduce irrigation as the crop is established. Follow a similar pattern for fertilization. However, only two-thirds

to three-fourths the amount of fertilizer used in spring will usually be required, since leaching of fertilizer by heavy rains will not be a problem. Fall harvest will begin in early to mid-October and may continue until mid-November in most years, if desired. Well- “hardened” plants can tolerate temperatures in the mid ’20s, often surviving until temperatures dip into the low ’20s.

INSECTS

Three insects, the imported cabbage worm, the cabbage looper and the diamondback moth, cause severe damage to cole crops and must be controlled annually to ensure marketable crops.

Imported cabbageworm. Overwinters here and appears early. Adults are day-flying white butterflies with black wing spots. When seen near or in fields, egg laying can be expected and crops should be checked regularly for eggs (tiny, green) on topside of leaves or worms (green, tiny to large) on undersides of leaves. Worms are velvety and hard to see when they rest along the leaf veins.

Cabbage looper. Migrates from the south. Appears from May to June, possibly earlier in warm springs. Moths lay eggs at night. Worms are greenish with dark head capsules and move in a looping motion. The cocoons are threadlike and are attached to the leaves. Damaged leaves show holes, the size depending on worm size.

Diamondback moth. Adults are 1 centimeter long, fast-moving moths. The worms are also very small. Damage appears as leaf tunnels and scraped out areas that often show tiny black droppings.

Monitoring. Check plants (especially under leaves) every other day for signs of worms or feeding damage. Damage to leaves before head formation does not require control, but may indicate potential damage later. Treatment schedules may be based on worm counts. For example, 5 or fewer worms per 25 plants does not require control, but more than this may not be acceptable. Samples may be made by walking in a V or X pattern across the field to include a total of at least 25 plants.

Control. The same insecticides are used to control the three worms pests. All worm pests should be controlled when very small; large worms (especially loopers) are difficult to control. Thorough coverage under leaves and inside heads is important for good control.

The bacterial insecticides (*Bacillus thuringiensis* products) are fast-acting, effective, safe-to-use materials. Use a spreader-sticker to ensure thorough coverage. They are most effective at about 75°F.

For all insecticides, be sure to read the label for proper application and safety instructions.

Note: Trade names are used to identify chemicals. No endorsements are intended, nor is any criticism implied of similar products not mentioned.

Chemical Treatment

Bacillus thuringiensis

Dipel, 1 / 2 lb / A

Thuricide, 1-2 qts / A

Bactur-L, 1-2 lbs / A

SOK-BT WP, ¼ - 1 lb / A OR

permethrin

Ambush 2 lb EC, 3-6 oz / A

Pounce 3.2 lb EC, 2-4 oz / A

esfenvalerate

Asana 1.9 EC 1.7–3.4 oz / A

Waiting interval to harvest (days)
Cabbage Broccoli Cauliflower

0	0	0
0	0	0
0	0	0
0	0	0
1	1	1
1	1	1
3	3	3

Chemical Treatment	Waiting Interval to harvest (days)		
	Cabbage	Broccoli	Cauliflower
*methamidophos (Monitor 4 Ec), 2 pts / A OR	35	35	35
fenvalerate (Pydrin 2.4 EC) 5.10, fl oz / A OR	3	3	3
*azinphosmethyl (Guthion 50% W) 1 - 1 ½ lbs / A OR	21	15	15
*mevinphos (Phosdrin 4 EC) 1 pt / A	1	1	3
*endosulfan (Thiodan 50 WP) 2 lbs / A	7	7	14
rotenone 1% dust, 30-35 lbs / A OR	1	1	1
diazinon 48% Ec, 1 pt / A OR	7	5	5
*naled (Dibrom 8 lb EC0) 1 pt / A	1	1	1
*+methomyl (Lannate 90% SP) ½ lb / A	1	3	3

Minor Insect Pests

Aphids, flea beetles, root maggots, cutworms, and armyworms may cause occasional problems.

endosulfan (Thiodan) OR	7	7	14
*naled (Dibrom) OR	1	1	1
*mevinphos (Phosdrin)	1	1	3
(above, same rates as for cabbage worms) OR			
diazinon (50% WP, 1 lb / A)	7	5	5
(48% EC, 1 pt / A) OR	7	5	5
dimethoate (Cygon 4 EC, ½ - 1 pt / A) OR	3	7	7
DeFend 2.67 EC, 3-4 - 1 ½ pts / A	3	7	7
ROOT MAGGOTS: (in transplanted crops)			
(use soil drench after plants are set)			
diazinon 50% WP, 1 lb / A OR	7	5	5
*fonofos (Dyfonate 4 EC, 2 qts / A)	7	5	5

FLEA BEETLES, CUTWORMS, ARMYWORMS:

Many of the same insecticides used against cabbage worms and root maggots are effective against these pests. Be sure to check the labels for registered uses, rates, and safety precautions.

* Highly poisonous. Use **all** safety precautions.

+ Cabbage loopers may show low sensitivity and, in some cases, resistance to methomyl.

DISEASES

Black Rot. Incitant: Bacterium *Xanthomonas campestris*

Symptoms: Black rot is one of the major disease problems of crucifers in the world. Cabbage, cauliflower, Chinese cabbage, turnip, and rutabaga are very susceptible to black rot but the disease also may affect broccoli, Brussels sprouts, radish, kohlrabi, collard, black mustard, Indian mustard, and rape.

Black rot may occur at any stage of the plant's growth. One characteristic early symptom of the disease is the formation of a wedge or V-shaped yellowing extending from the leaf margin inward along the midrib of the leaf. As the disease progresses, the yellow regions turn tan and become dry and papery or brittle in texture. The veins in the affected region appear black when viewed with black lighting. The yellowing and blackening of the veins continues until the leaf eventually falls from the plant. At this point, the pathogen enters the main stem and moves through the vascular system to other parts of the plant. Diseased leaves turn yellow, become stunted, and drop from the plant. Extensive defoliation can occur. Affected stems develop a black discoloration of the vascular system, which can be viewed by slicing crosswise through the stem. The heads of cabbage and cauliflower develop a watery soft rot as they are attacked by secondary organisms. The roots of certain crucifers, such as turnip and rutabaga, may turn black and develop an internal breakdown of tissue.

Black Leg. Incitant: Fungus *Leptosphaeria maculans*, *Phoma lingam*

Symptoms: The fungus can attack cabbage, broccoli, cauliflower, kale, kohlrabi, Brussels sprouts, turnip, rutabaga, and Chinese cabbage. Susceptible plants may be affected at any stage in their growth. The disease may first be noticed in the plant bed a few weeks before transplanting. Irregular to roughly-circular yellow spots develop on the flower leaves. The centers of the lesions quickly turn ashen-gray and bear tiny black fruiting structures (pycnidia) of the fungus. Infected leaves soon wilt and die, but remain attached to the plant (unlike black rot and Fusarium yellows). Elongate or linear lesions, often surrounded by a purple

border, also develop on the stems near the soil line. These lesions may eventually girdle the stem or progress below the soil line, resulting in extensive decay of the fibrous root system. Affected plants may be killed or become stunted and develop a reddish or purplish cast on the younger leaves. Extensive stem and root decay can cause the heads to topple over later in the growing season.

Control: Control measures for black rot and black leg are similar. Both organisms are seedborne, thus, it is extremely important that seed is free of the black rot bacterium and the black leg fungus before it is sown in a seedbed or seedling flats. Generally, seed produced in the western United States is relatively free of the black rot and black leg organisms. Seed grown in Europe or the eastern United States has a higher percentage of infected seeds. If there is any question as to whether the seed was assayed or is contaminated, it should receive a hot water treatment. Seed should be dipped in hot water for 25 minutes at a temperature of 120°F, then removed, and immediately placed in a cool water bath. After cooling, the seed should be spread out to allow for rapid drying. A fungicide seed treatment may be added to prevent damping-off or blackleg. Be sure to check the hot water procedure and the germination percentage on a small sample before treating all the seed.

Sanitation in the seed bed (planting bed) also is important. Avoid using planting beds or seedling trays that previously have been used for cole crop production, unless they have been thoroughly cleaned. Do not use soil from areas where cole crops have been grown; if you are reusing soil, it should be fumigated or steam sterilized. Transplants purchased from another state should be certified free of black rot and black leg. Carefully inspect seedlings for any symptoms of black rot or black leg and immediately remove any "suspicious" looking plants. If black rot is found in the transplant beds, some copper-based fungicides may help reduce the incidence of the disease.

Crop rotations of 3 years are advisable, since these organisms can survive in the soil for 2 years. Keep weeds, especially cruciferous ones, under control during the growing season. Avoid walking through the field when water is still on the leaves. Some copper-based fungicides (labeled for cabbage only) may suppress the development of black rot in

the field, but these chemicals are not completely effective in controlling black rot and should be used only as a last resort. Some cultivars of cabbage and broccoli show resistance or tolerance to black rot, although many of these may not be adapted to Kansas growing conditions.

Fusarium Yellows. Incitant: Fungus *Fusarium oxysporum* f. sp. *conglutinans*

Symptoms: Several different races of the pathogen are known. Race 1 attacks cabbage, kale, Brussels sprouts, cauliflower, broccoli, kohlrabi, rutabaga, turnip, mustard, rape, Chinese cabbage, garden cress, and radish; race 2 is found on radish but also attacks the hosts of race 1 with the exception of cabbage, Brussels sprouts, and cauliflower. Symptoms of Fusarium yellows may be expressed at any growth stage of the plant, but typically they become more apparent when soil temperatures are greater than 70°F. Initially, the lower leaves on the plant turn a dull yellow-green. The yellowing may be uniform, but more often it is restricted to leaves on one side of the plant. Leaf veins and the vascular stem tissue turns dark yellow or brown (similar to black rot). Vascular discoloration may be viewed by cutting crosswise through the stem. Disease plants are stunted and unthrifty. Affected leaves often develop a purplish tinge before they eventually turn brown and drop from the plant. The yellowing and wilting of leaves progresses upward until the plant is finally killed.

Control: Crop rotation may be of little value, since the fungus may persist for many years in the soil. The most practical means of controlling Fusarium yellows is the use of resistant cultivars. Most commercial cabbage cultivars have resistance to the yellows disease. Those that do should be marked YR (yellow resistant) on the package. Consult seed catalogs for resistant varieties of cole crops.

Rhizoctonia Disease (Damping-off, Wirestem, Bottom Rot and Head Rot). Incitant: Fungus *Thanetophorus cucumeris* (*Rhizoctonia solani*)

Symptoms: The fungus is a common soil inhabitant and attacks a wide range of plants. In general, the disease is not a serious problem of crucifers in Kansas, except on emerging seedlings and young transplants (damping-off and wirestem). The pathogen may attack plants in all stages of growth,

and depending on the age of the plant, different symptoms may be expressed. These phases of the disease can be categorized into damping-off, wirestem, bottom rot, and head rot. The damping-off phase occurs when the fungus attacks the germinating seedling, causing a water-soaked, brown to black lesion on the hypocotyl. The constriction and death of the hypocotyl causes the plant to fall over. Older seedlings also may develop black lesions near the soil line, but the constriction of the stem is not complete. These constricted stems turn brown to black, and become tough, and woody (wirestem). Young plants with wirestem may soon wilt and die after transplanting or live but produce very small heads. In cabbage, those plants with wirestem may develop bottom rot. The lower leaves on the plant wilt, but remain attached to the plant. The roots of these plants may be extensively decayed. If these heads are harvested and stored under moist conditions, they may rot entirely (head rot).

Control: Damping-off and wirestem can be controlled effectively in plant beds by sanitation. All soil and flats should be steamed or disinfected with chemicals to eradicate the pathogen. Old seedling trays should be cleaned thoroughly. Drenching of plant beds with pentachloronitrobenzene (Terraclor) also will help eliminate damping-off and wirestem. If wirestem develops on transplants, they should be discarded. Avoid planting crucifers in the same area year after year.

COSTS AND RETURNS

Cole crops offer a rapid return on investments, since harvest is completed early in the season. Also, “double-cropping” offers a chance of two crops for the same parcel of land. Cabbage produced in Kansas fits a natural market “slot,” since the southern producing areas finish marketing and northern areas are not yet into production when our crop reaches maturity.

Cabbage can be expected to yield from 210 to 250 hundred weights per acre (420- to 500-pound sacks). Broccoli should produce from 8,500 to 11,000 pounds / acre. Each head should be from $\frac{3}{4}$ to 1 pound in size. Cauliflower should produce 10,000 to 15,000 pounds / acre with heads averaging $1\frac{1}{4}$ to $1\frac{1}{2}$ pounds in size. Fall cauliflower yields will be slightly greater since later-maturing varieties with slightly larger heads can be used.

COST RETURN PROJECTION FOR COLE CROP PRODUCTION IN KANSAS

<i>Variable Costs Per Acre:</i>	Cabbage	Broccoli	Cauliflower
1. Fertilizer	\$ 90.00	\$ 90.00	\$ 90.00
2. Transplants	350.00	350.00	300.00
3. Herbicides	8.00	12.00	12.00
4. Insecticides 3 applications	30.00	24.30	24.30
5. Fungicides	00.00	00.00	00.00
6. Nematicides	00.00	00.00	00.00
7. Labor	405.00	405.00	450.00
8. Fuel and Oil	33.72	33.72	33.72
9. Repairs	68.75	68.75	68.75
10. Water	8.00	8.00	8.00
11. Utilities	00.00	00.00	00.00
12. Custom hire	00.00	00.00	00.00
13. Supplies Sacks/ Cartons	170.00	350.00	400.00
14. Marketing	00.00	00.00	00.00
15. Other	00.00	00.00	00.00
A. Total Variable Costs	\$1,163.47	\$1,341.77	\$1,386.77
<i>Fixed Costs Per Acre:</i>			
16. Interest on land & buildings	60.00	60.00	60.00
17. Taxes on land & buildings	10.00	10.00	10.00
18. Rent for rented land	00.00	00.00	00.00
19. Depreciation on machinery	75.00	75.00	75.00
20. Interest on machinery	45.00	45.00	45.00
21. Depreciation on buildings	12.50	12.50	12.50
22. Depreciation on irrigations equipment	165.00	165.00	165.00
23. Interest on irrigation equipment	99.00	99.00	99.00
24. Insurance	6.63	6.63	6.63
B. TOTAL FIXED COSTS	\$ 473.13	\$ 473.13	\$ 473.13
C. TOTAL COSTS	\$1,636.60	\$1,814.90	\$1,859.90
D. YIELD PER ACRE (CWT / A)	250.00 CWT	85.00 CWT	120.00 CWT
E. PRICE PER UNIT (\$/CWT)	11.00 6/sack	60.00 .60/lb	65.00 .65/lb
F. RETURNS PER ACRE	\$2,750.00	\$5,100.00	\$7,800.00
G. RETURNS OVER VARIABLE COST	\$1,586.53	\$3,758.23	\$6,413.23
H. RETURNS OVER TOTAL COSTS	\$1,113.40	\$3,285.10	\$5,940.10
I. VARIABLE COSTS PER UNIT	\$ 4.65	\$ 15.79	\$ 11.56
J. TOTAL COSTS PER UNIT	6.55	21.35	15.50

Fuel consumption is estimated at 1.5 gallons per hour of tractor time. Oil and lubrication is estimated at 15% of fuel cost. Repairs are estimated at \$2.25 per hour of tractor time and \$17 per acre for irrigation equipment. Fuel, repairs, and taxes for a truck are not included as costs. Depreciation, interest on investment, and insurance for a truck are included as costs.

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