

CAULIFLOWER

Extension Bulletin E-1591

February 1982

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Climatic Requirements

Temperature: Cauliflower is a cool season crop. Its seed germinates at 40°F. Cauliflower plants can withstand temperatures as low as 20°F for several hours late in the fall without damage to the curd. However, soft, young cauliflower plants are susceptible to freezing injury (See Buttoning, below). Although cauliflower can be grown as an early summer crop, buttoning may be a problem if plants are subjected to low temperatures after transplanting.

Cauliflower grows best at air temperatures of 70°F to 85°F under sunny skies. Growth may be substantially reduced during cloudy periods. If temperatures are above 80°F during curd formation, cauliflower is susceptible to several physiological disorders, including leaves in the head; rough, irregular heads; riciness (over mature florets); purple or green coloration of the curd; and poor wrapper-leaf development. Resistance to these disorders is dependent on variety. In Michigan, cauliflower is usually produced as a fall crop. However, new varieties developed at MSU (Stovepipe and White Empress) can be grown successfully during the summer. The best areas for cauliflower production in Michigan are near the Great Lakes, which modify extremes in temperature during the growing season.

Moisture: Cauliflower roots penetrate the soil to about 18 to 24 inches. With such a shallow root system, it is necessary to add water regularly to maintain active growth. Approximately 1 inch of water per acre should be added weekly from transplanting to maturity. Very light sandy soils may require up to 2 inches of water during hot dry periods. Any

Production: Average yield for Michigan is 4 tons per acre; good yield is 7 tons per acre and excellent yield is 10 tons per acre.

Use: 80% of Michigan cauliflower is packed for fresh market; 20% is processed (brined).

reduction in growth due to moisture stress can result in buttoning.

Too much water also can cause stress in cauliflower. If the roots stand in water-logged soil for 24 to 48 hours, the plants will die. Excess moisture in the air and soil creates a favorable environment for a number of diseases to which cauliflower is susceptible.

Irrigate cauliflower with ½ to 1 inch of water immediately after transplanting into moist soil. Be sure there is no dry soil around the roots. Avoid transplanting at temperatures above 85°F, or many plants will dry out and die before water is applied.

Days to Maturity

Depending on the season and variety, cauliflower matures 50 to 100 days after transplanting. Only early and mid-season varieties should be grown for a summer crop. All types can be used for a fall crop, with early varieties maturing in early September and late varieties maturing in mid- to late-October.

Buttoning

Premature heading, or curd formation, in cauliflower is called buttoning. It is caused by any type of stress to the plant, including moisture stress; cold soil or air temperatures during transplant production; transplant shock; transplanting of root-bound or old plants; fertilizer stress (especially nitrogen); and insect or disease pressure. The plants are especially susceptible up to 2 months after seeding. Early maturing varieties are more susceptible than later varieties, and buttoning is most commonly a problem in summer-crop cauliflower.

In young cauliflower plants, there is a fine balance between vegetative and reproductive growth. Any stress tips the balance toward reproductive growth and curd development. To avoid buttoning, keep plants growing until harvest. The following practices will help prevent buttoning in summer-crop cauliflower:

1. Make sure transplants are not exposed to freezing temperatures.
2. Keep soil temperatures above 60°F and air temperatures above 70°F while growing transplants. Early varieties are more susceptible than late varieties to cold temperature stress.
3. Set plants in the field when they are 4 to 5 inches tall and about 4 weeks old. Avoid use of large, old plants. Avoid exposure to temperatures below 50°F for more than 4 days after transplanting in the field. Avoid transplant shock.
4. Irrigate on a regular basis; be especially careful to avoid moisture stress immediately after transplanting.
5. Plant disease- and insect-free plants; use pesticides to keep them insect- and disease-free.
6. Fertilize and sidedress as needed to avoid nutrient stress.

Growing Transplants

Early Crop: Transplant summer cauliflower about May 25 for production in July and August. Plant seeds about April 25 in a greenhouse, hotbed or cold frame. Plants may be transplanted in April or early May for early summer production, but the incidence of buttoning will probably increase. Plants grown in individual

pots or cells will resist transplant shock better than bare-rooted plants. Each plant should have 2 square inches of growing space, and a root volume of 2 cubic inches. If plants are grown in cells, make sure all plants get sufficient water and do not become root bound.

Cauliflower plants should not be subjected to air temperatures below 60°F. (Short exposure of small, young plants to temperatures as low as 40°F will not cause damage.) Optimum growth will be obtained with soil and air temperatures of 60°F to 70°F. Leaves grow too fast if the air temperature rises above 80°F. High temperatures with close plant spacing result in tall, weak, goosenecked plants.

Plants can be grown in cold frames if the temperature is controlled. A simple cold frame can be modified for cauliflower plant production as follows: Spread a sheet of insulation on the ground inside the cold frame and cover it with a 1-inch layer of sand. Lay electric heating cables at 1-foot intervals and place a ½-inch square mesh screen over them to help distribute the heat. Cover the screen with 4 inches of clean sand. If the same sand is used more than one year, it should be fumigated.

Three days before sowing the seed, turn on the heat, stir the seed bed, and close the sash. When the soil temperature reaches 70°F, soak the soil with water and sow the seed, either in rows or broadcast. After the first true leaves appear, fertilize once per week with ½-strength starter solution (such as 10-52-17, 1.5 lb. in 50 gallons of water). After 2 true leaves have formed, fertilize twice per week. As seedlings emerge, it may be necessary to ventilate the cold frame to lower the air temperature. After 2 true leaves have emerged, turn off the heat and regulate the temperature by opening and closing the sash. This will slow growth and harden the plants in preparation for transplanting. The plants should be ready for transplanting about 4 weeks after seeding.

Fall Crop: Plants for the fall crop are generally grown in plant beds in the field. Plants can be grown in the greenhouse, but it will be more difficult to keep temperatures low during the warm sunny days in June.

Establish plant beds in the field on soil that has not had cruciferous

crops on it before. Soft, loose sand is preferred. If possible, fumigate the soil. Disc in 300 lb. 12-12-12 or comparable fertilizer per acre before sowing.

Sow seeds ¼- to ½-inch deep in early June for transplanting in early July. Sow 3 to 4 seeds per inch of row, with rows at least 12 inches apart. Three to 4 ounces of seed will provide enough plants for 1 acre of field planting. Drench the soil after sowing with an insecticide to avoid maggot damage.

Before pulling, dig plants with a fork, or undercut with a knife, 4 inches below the soil to get as much of the roots as possible with the plants.

If cauliflower harvest is required over an extended period, plant several varieties with different maturity dates. If possible, do not use plants more than 6 weeks old for transplanting. If you use plants more than 6 weeks old, increase the nitrogen level in the starter solution by 50%.

Soil Requirements

Cauliflower can be grown on well-drained sand, loam, muck or clay soils. Root diseases may become a problem if grown on poorly drained soils. (See "Diseases," page 3.)

Fertilization

Add lime to maintain a pH of 6.2 to 6.5 on mineral soils and 5.2 to 5.5 on muck soils. A 7-ton crop of cauliflower requires about 150 lb. nitrogen, 250 lb. phosphate (P₂O₅), and 400 lb. potash (K₂O). Cauliflower is sensitive to boron and molybdenum deficiency. Supplemental fertilizer needs should be determined by a complete soil test.

Cauliflower constantly demands nitrogen throughout the season. Any nitrogen stress can result in buttoning, poor leaf growth, and small heads. In general, the larger the leaves, the larger the heads will be.

Boron deficiency causes hollow stems and darkened heads. Often, it first appears as small light brown spots on the head and spreads until the whole head is discolored. Since the availability of boron is affected by pH, the amount required on deficient soils will vary by soil pH and type.

Generally, 2 to 3 lb. of actual boron (20 to 30 lb. of borax) per acre will overcome any deficiency and will not leave sufficient residual boron to injure sensitive crops the next year. Borax should be mixed thoroughly with the preplant broadcast fertilizer, or spread separately and worked into the soil.

Molybdenum deficiency occurs occasionally on soils with pH's below 6.0 and with high iron content. The early stages look like nitrogen deficiency, with yellow mottling between leaf veins. Leaf margins turn yellow, then brown, curl inward, and eventually wither. In later stages of growth, the leaves do not expand, causing a condition known as whiptail. If molybdenum deficiency is known to exist in a field, use a seed treatment before sowing in the seedbed. Dissolve ½ ounce sodium molybdate in 3 tablespoons of water and mix with the seed to plant 1 acre. If molybdenum deficiency becomes apparent in a growing crop, apply 3 ounces of sodium or ammonium molybdate per acre with an insecticide spray.

To prepare the field for transplanting, plow down the cover crop and old crop trash. Broadcast and disc in 60 lb. nitrogen, 120 lb. P₂O₅, and 120 lb. K₂O per acre (e.g. 600 lb. of 10-20-20). Include 30 lb. borax. Three weeks after transplanting, sidedress with 150 lb. ammonium nitrate per acre (50 lb. N). Apply another 150 lb. ammonium nitrate 3 weeks later. Two to 3 weeks later apply a final sidedressing of 100 lb. urea per acre (45 lb. nitrogen). If heavy rains occur after the last sidedressing, it may be necessary to apply another 100 lb. urea, especially on sandy soils. Be sure to irrigate after each sidedressing.

Spacing and Planting

For field planting, cauliflower rows should be 2½ to 3 feet apart; plants should be 18 to 24 inches apart in the row, depending on variety. Smaller, upright varieties can be planted closer than large, fall varieties. Plant populations will average 7,500 to 10,000 per acre. Generally, 75 to 90% of the plants produce marketable heads, depending on variety. Closer spacings reduce air movement between plants and can cause increas-

ed foliar disease. Also, when plants are too close together, spraying and harvesting become more difficult.

Cauliflower usually is transplanted in Michigan. The summer crop is transplanted about June 1 and fall crop about July 1. Include a high-phosphate starter fertilizer and insecticide for maggot control in the transplant water, or drench the soil at the base of the plants immediately after transplanting.

Cauliflower can be direct-seeded for fall harvest. It is important to get the correct spacing, either by planting to stand or thinning. In either case, a precision seeder is desirable. Singulation and uniform spacing are necessary to obtain a good crop. Plant seed around June 15 for the fall crop.

Harvest and Post-Harvest

Quality Characteristics: Good quality cauliflower is pure white, round, tight and solid, 6 to 8 inches in diameter, 2 to 4 lb. each, clean and free from insect debris; there should be no hollow stem and no insect or disease damage on the head. To maintain quality at harvest, cut the heads with a number of cover leaves intact, transport to a packing shed and trim to the desired number of wrapper leaves. Cool the heads as quickly as possible to avoid wilting. To avoid discoloration of the curd, do not ice the heads.

Tying: Most cauliflower varieties have to be tied to keep sunlight off the curds, which helps maintain white color. Some late varieties are "self-blanching," i.e. wrapper leaves tightly cover the curd so that no sunlight can penetrate. Self-blanching varieties should not be grown during the summer or in low, humid areas where fall fogs are common because the curds will not dry out well and may become discolored.

For varieties that require tying, check the field every 3 to 4 days as maturity approaches. Any plant in which the white curd is visible (1 inch or more in diameter) should be tied by gathering leaves together and placing a colored rubber band or piece of twine around them. The same color band should be used for all plants tied on a particular day. Three or 4 days later, the process should be repeated 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. Usually cauliflower is ready to cut 7 to 10 days after tying, depending on the weather. Starting 7 days after tying, check several heads to see if they have attained market size. If 75% 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 every time you cut.

Some new varieties, called "stove-pipe" types have an upright growth habit which reduces the sunlight reaching the curd. They usually have to be tied, but the upright habit makes tying very easy.

During damp, humid weather, the curd is very susceptible to fungal diseases. Tying leaves tightly around the curd to avoid sunburn will increase the chances of fungal disease. In such cases, tie the leaves together as high above the curd as possible to allow some air movement. Avoid spaces between the leaves through which sunlight can pass.

Cauliflower for fresh market is usually packed 12 or 16 heads to a box. Most Michigan cauliflower is packed with a few wrapper leaves on each head, trimmed even with the top of the curd to protect it. Some cauliflower is stripped of all wrapper leaves and wrapped in cellophane.

Pests

Weeds: Annual grasses and broad-leaves are the major weed pests in cauliflower. Good control should be obtained through use of preplant incorporated, and pre- and postemergence herbicides. Cultivation when sidedressing also helps remove weeds.

Insects: Maggots are a serious pest of young cauliflower plants. An insecticide drench should be applied above the row soon after seeding. An insecticide should be included in the transplant water when setting transplants or applied as a drench after planting. A subsequent drench at the base of the plants may be needed if maggots persist.

Other insects that frequently infest cauliflower are imported cabbage worm, cabbage looper, diamondback moth, aphids, and thrips. Most of

these eat the leaves of the cauliflower, reducing plant vigor and the potential for a good crop. They also may infest the head, making it unsalable. A regular spray schedule will help avoid insect damage.

Diseases

Cauliflower is affected by a number of diseases. In the greenhouse and seedbed, seeds or seedlings are susceptible to pre- and post-emergence rotting (damping off) caused by *Pythium* sp. or *Rhizoctonia solani*. Poor seedling stands generally are due to preemergence damping off.

In young seedlings affected by post-emergence damping off, stems become restricted at the soil line and rot rapidly, causing wilting or toppling over of the seedling. More mature seedlings may survive, but the lower stem of the plant turns black and is severely restricted (wirestem) causing stunted, yellow, and unthrifty plants. Since affected plants usually do not survive to maturity, do not plant diseased seedlings. Arasan 50 Red (thiram) can be used as a pre-plant seed treatment. Arasan 50 Red is formulated for dry treatment at a rate of 1½ teaspoons per lb. of seed.

Black Rot: Black rot, caused by *Xanthomonas campestris*, appears periodically in Michigan cauliflower fields. *X. campestris* is a bacteria that is carried into fields on seeds and transplants. Local dissemination is mainly by wind-blown rain and cultivating equipment. Infection generally occurs through hydathodes (small natural openings on leaf margins) and through wounds caused by insect chewing. Infected areas turn yellow in a V-shaped pattern with the base of the "V" away from the leaf margin. Veins and veinlets in the infected area turn black and are easily visible when the lesion is back-lighted. The bacteria moves into the main stem through the vascular system, causing further blackening of veins and yellowing of plant tissues. Severely infected leaves will dry up and fall off. Infected heads are more subject to invasion by softrotting bacteria.

The severity of black rot depends on environmental conditions. Dissemination of the bacteria to healthy plants is favored by warm, wet weather. When conditions are unfavorable, external symptoms disap-

pear, but the bacteria continue to spread slowly through the plant.

Black rot is difficult to control in the field but may be avoided by the use of hot-water treated seed. Although black rot is not known to overwinter in Michigan, a 3-year rotation to non-cruciferous crops is advisable. Spread of black rot in the field may be reduced by the use of copper fungicides applied at the first sign of lesions and every 5 days thereafter if warm, wet conditions persist. If small pockets of infected plants are visible in a field, they should be rogued out immediately.

Clubroot: Clubroot is a problem when cruciferous crops are grown in the same field over a number of years. The pathogen, *Plasmodiophora brassicae*, is usually introduced in a field on transplants and disseminated locally by drainage water and farm implements. Aboveground symptoms are overall stunting of the plants and wilting of leaves on hot sunny days.

The organism invades the root system, causing infected roots to enlarge and swell to form clubs of various shapes and sizes. In addition to reducing the plant's ability to take up water, the clubbed tissue fails to develop a protective outer layer and thus is subject to invasion by soft rot organisms. As clubbed roots progressively decay, materials toxic to the plant are produced, further inhibiting water uptake. Young root tissue is most susceptible to clubroot infection, but wounded older tissue also can be invaded.

Cauliflower should not be grown in fields known to be infested with clubroot. The clubroot organism can survive in the soil up to 10 years, making crop rotation of little value. High soil moisture favors infection; therefore, disease development is usually more severe in low, poorly drained areas. However, because high soil moisture is important only during the 18- to 24-hour period of initial root infection, well-drained fields can also have high levels of disease.

Clubroot can be minimized on mineral soils by adjusting the pH to 7.2 through liming. On organic soils with

a high buffering capacity, liming is of little value in reducing infection. Control is best achieved by using disease-free plants and transplant water treated with 3 to 6 lb. terraclor per 100 gallons. If a crop affected by clubroot is close to maturity, irrigation may help salvage it because the main effect of clubroot on plants is moisture stress.

Blackleg: Blackleg is caused by *Phoma lingam* and appears occasionally on cauliflower seedlings. Leaf lesions have well-defined margins with ash gray centers containing small, spherical black fruiting structures.

Lesions that form on the stem may be surrounded by a purple border. Below the soil, dark cankers form on the main stem and the fibrous root system is gradually destroyed. Affected stems may topple over as the heads mature.

Phoma lingam survives in the soil for several seasons on plant debris or seed. Spores of the fungus are spread to healthy plants by splashing water.

Although most seed produced in the western U.S. is considered to be *Phoma* free, purchasing hot water treated seed is advisable. A 3-year rotation between cruciferous crops is recommended. No chemicals are registered for blackleg control.

Downy Mildew: The downy mildew fungus *Peronospora parasitica* can be a serious pest on fall cauliflower. Lesions are small, sunken and irregularly shaped with a grayish-purple coloration. Lesions initially appear on the underside of leaves and become covered with a fluffy gray growth of fungal mycelium. Eventually, yellow areas appear opposite the lesions on the tops of the leaves and subsequently the leaves dry out. The disease may move into the main stem and head of cauliflower.

The pathogen overwinters in plant debris or cruciferous weed hosts. Cool (under 70°F) moist conditions favor disease development and the pathogen spreads rapidly from plant to plant with splashing water. Very little damage will occur when the weather is hot and dry. If cool, wet

weather persists, spray with Bravo, Maneb, Zineb, or other registered fungicides.

Alternaria Spot: *Alternaria* spot usually occurs as a secondary problem when plants are weakened by other pathogens, adverse weather, or poor management practices. Generally the leaf spotting stage is unimportant if other stress factors are reduced. However, the head discoloration phase is of economic significance. Disease incidence is greatest under cool, wet conditions as spores are spread by splashing water.

Leaf lesions appear as small discolored areas which enlarge to about 1/2 inch then bleach out. When the relative humidity is high, black spore masses become visible on the surface of the lesion. The spore masses often are arranged in concentric rings, giving the appearance of a target. Lesions on stems and petioles are more elongated but still may have the appearance of a target.

Head spotting generally occurs on mature heads with black masses of spores giving the head a moldy appearance. Although there may be some brown discoloration of the curd under the spore masses, the damage is largely superficial.

Alternaria spot can be reduced by following good growing practices and spraying with Bravo, Maneb, and Zineb.

The head spotting stage is more difficult to control because applying fungicides to tied heads is difficult. Tying heads as high above the curd as possible to reduce moisture condensation and improve air movement will reduce the incidence of *Alternaria* head rot.

A regular spray program is necessary to control cauliflower pests. See the latest editions of MSU Extension Bulletin E-433, "Weed Control Guide for Vegetable Crops," and E-312, "Control of Insects, Diseases and Nematodes on Commercial Vegetables," for current pest control recommendations. Check with your County Extension office for availability and cost.

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Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

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O-13446

1P-3M-2:62-UP-KMF, Price 25 cents. Single copy free to Michigan residents.

FILE: 25.62