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Cole Crops-An Overview

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Cole crops originated from the word caulis (Latin) meaning stem or stalk of a plant. Today cole crops, means the stem brassicas. It is assumed that the cabbage and kales originated in Western Europe and that cauliflower and broccoli came from the Mediterranean region. Cabbages and kales use as food, they were used mainly for medicinal purposes. The sprouting broccoli originated in the Mediterranean area. Cole crops are biennials but are generally grown as annuals. At the seedling stage, these different crops are hard to distinguish. Except for certain strains of cabbage, broccoli and tropical type cauliflower a cold period is necessary for flowering. The brassica family are well adapted to cool season production. These plants are quite cold resistant. Young hardened cabbage plants can withstand -10^{0}C for a short time, older plants are less hardy. The growth rate of cabbage stops at 0^{0}C and is quickest at 15^{0}C to 20^{0}C. Above 25^{0}C growth stops. Cole crops require a regular water supply of 25 mm per week during the growing season. Shortage of water is detrimental for head development. The minimum temperature for seed germination is 5^{0}C with an optimum germination temperature of 27^{0}C, an optimum range of 7 to 27^{0}C and a maximum germination temperature of 37^{0}C. Cauliflower and broccoli will not stand temperatures as high or low as cabbage. High temperatures delay maturity and increase vegetative growth (number of leaves) and cool temperatures hasten maturity and may induce "bolting". Young hardened plants can withstand -5 to -10^{0}C. An optimum growth rate occurs at 15^{0}C to 22^{0}C and growth stops above 30^{0}C. Cole crops require soils that can provide continuous water throughout the season. Well drained, sandy loam soils are suited to early varieties, loamy and clay loam soils are suited to late ones. Late cultivars are somewhat tolerant of poor drainage. Well drained soils can be rotated closely since clubroot is easier to control. Early cabbage is usually transplanted in late April or early May and maturity is usually in early July

Cole Crops include:
Cabbage - *Brassica olerace var Capitata*
Cauliflower - *Brassica oleracea* var *Botrytis*
Broccoli - *Brassica oleracea* var *Italica*
Brussels Sprouts - *Brassica oleracea* var *Gemmifera*
Kale - *Brassica oleracea* var *Acephala*
Kohlrabi - *Brassica oleracea* var *Gongylodes*

Nutrient Content:
Broccoli:
Very good source of Vitamins A and C; rich in potassium, calcium and phosphorus.

250 mL (1 cup) cooked broccoli contains about 45 kilocalories.

Brussels Sprouts:

Very good source of Vitamins A and C; rich in potassium and folate. Contains other nutrients in small amounts. 250 mL (1 cup) serving contains 58 kilocalories.

Cauliflower:

Good source of Vitamin C, folate and potassium. Supplies small amounts of several minerals and vitamins to the diet. 250 mL (1 cup) cauliflower supplies 26 kilocalories.

Cabbage:

Excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet. 250 mL (1 cup) raw cabbage contains 21 kilocalories; cooked 58 kilocalories.

Crop Establishment

Seeding/Planting

For early markets plants must be raised in greenhouses. About 5 to 6 weeks are required to produce transplants. Young plants with 4 or 5 leaves are generally superior to older ones. The temperature should be maintained between 13 and 24^0 C. Slight hardening is beneficial but severe hardening may stunt growth. Large or old plants of cauliflower and broccoli and those grown at low temperatures (10 to 15^0C) are likely to button (bolt) if exposed to a period of cool weather after field setting. Plants may be grown in module trays, in peat blocks or in paper cells. Normally 300 to 350 grams of seed will produce enough plants for 1 hectare.

Crop	Distance Between Rows(cm)	Distance Between Plants (cm)
Cabbage, early	60-75	30-40
Cabbage, late	75-90	30-70
Cauliflower	60-90	35-50
Broccoli	60-90	30-40
Brussels Sprouts	75-90	30-45

Crop Management

Cabbage splitting

It is mainly a problem with early cabbage. A problem can develop when moisture stress is followed by heavy rain. The rapid growth rate associated with rain, high temperatures and high fertility cause the splitting. Proper irrigation may help prevent splitting and there are significant differences between cultivars in their susceptibility to this problem. Splitting may also be partially avoided by deep cultivation to break some of the plant roots.

Cauliflower and Broccoli buttoning

Buttoning is the premature formation of a head and because the head forms early in the plant's life, the leaves are not large enough to nourish the curd to a marketable size. Buttoning may occur shortly after planting in the field, when normal plants of the same age should be growing vegetatively. Losses are usually most severe in the early planted crop during cold, wet seasons, when vegetative growth is checked by: (1) too much hardening of greenhouse plants (2) too little hardening of greenhouse plants (3) low soil nitrogen (4) low soil moisture (5) continued cold weather (4 to 10^0 C for 10 days or more) (6) Other disease, insects, micronutrient deficiency, etc. Some cultivars, particularly early ones, are more susceptible to buttoning than others.

Lack of heads in broccoli and cauliflower

During periods of extremely warm weather (days over 30^0 C and nights 25^0 C) broccoli and cauliflower can remain vegetative (does not head) since they do not receive enough cold for

head formation. This can cause a problem in scheduling the marketing of even volumes of crop.

Tipburn of cauliflower and cabbage

This problem can cause severe economic losses. Tipburn is a breakdown of plant tissue inside the head of cabbage and on the inner wrapper leaves of cauliflower. It is a physiological disorder which is associated with an inadequate supply of calcium in the affected leaves causing a collapse of the tissue and death of the cells. Calcium deficiency may occur where the soil calcium is low or where there is an imbalance of nutrients in the soil along with certain weather conditions. (High humidity, low soil moisture, high potash and high nitrogen aggravate calcium availability). Secondary rot caused by bacteria can follow tipburn and heads of cauliflower can be severely affected. Some cultivars are relatively free of tipburn problems.

Hollow stem in broccoli and cauliflower

This condition starts with gaps that develop in the tissues. These gradually enlarge to create a hollow stem. Ordinarily, there is no discoloration of the surface of these openings at harvest but both discoloration and tissue breakdown may develop soon after harvest. Some cultivars of hybrid cauliflower may have openings from the stem into the head. Both plant spacing and the rate of nitrogen affect the incidence of hollow stem. As the plant spacing increases hollow stem increases. As the rate of nitrogen increases then the rate of hollow stem increases. The incidence of hollow stem can be greatly reduced by increasing the plant population.

Cauliflower blanching

The market demands cauliflower which is pure white or pale cream in colour. Heads exposed to sunlight develop a yellow and/or red pigment. The usual method to exclude light is to tie the outer leaves when the curd is 8 cm in diameter. Leaves may also be broken over the curd to prevent yellowing. In hot weather blanching may take 3 to 4 days, but in cool weather, 8 to 12 days or more may be required. Some cultivars give better natural curd protection by having inner wrapper leaves, (without tieing) especially those cultivars which have been bred in Europe. Cauliflower fields scheduled to mature in cool weather (September and October) that are well supplied with water and planted with "self-blanching" cultivars will not need tieing.

Irrigation

The availability of water can be critical to successful production. Steady even growth of these crops are necessary for high quality and yields. Irrigation may also be used to cool plants during periods of high temperature. Fertilizer could also be applied through an irrigation system. Irrigation at the wrong time can cause problems such as head rot of broccoli and cauliflower.

Nutrition

Cole crops are generally crops that require high amounts of fertility.

Manure

Half or more of the fertilizer can be replaced by 25 to 35 tonne per hectare. Do not use manure from animals that have been fed turnips or rutabagas. Excessive use of manure may contribute to tip burn, hollow stem, internal browning, head rot and other problems.

Lime - Lime should be applied to maintain the soil pH in the range 5.8 to 6.5.

Nitrogen - 150 kg/ha

Phosphorus - 125 kg/ha

Potassium - 100 kg/ha

Diseases

Clubroot (fungus)

Characteristics:

Clubroot is a soil borne disease which affects turnips and rutabagas, as well as cabbage, broccoli, Brussels sprouts, cauliflower and radish. The signs of disease vary from swellings on roots to severe malformation of the root, accompanied in many cases by wilting, and frequently death of the plant. Throughout the Atlantic Provinces, it is a major problem where poor management practices are followed. The fungus (*Plasmodiophora brassicae Wor*.) causing this disease is usually present in areas where rutabagas and cole crops have been grown for many years. Once land becomes infested, it will remain so for at least 7 years. Any producer intending to grow cruciferous plants must appreciate this fact. Infected plants are stunted and usually take on a bluish tinge at first, later turning yellow. (Root maggot infested plants may also show the same signs). Wilting is most common on warm sunny days; plants may show little wilting early in the morning or late at night. Small to large spindle-like or slug-shaped swellings develop on the roots of cabbage and other cole crops, large out-growths and misshapen roots occur on turnip and rutabagas (root rot can occur with a severe infection). The clubroot fungus enters the plant through the many fine hairs on the roots. The extent of the disease is affected by many factors. Moist, cool soils usually produce more diseased plants than dry, warm soil. The disease also thrives best in acid soils; that is, when the pH is below 7.2. When clubbed plants rot and break down in the fall, the fungus spores are released into the soil, where they may live for many years, ready to infect any rutabaga or cole crop subsequently planted. Since the fungus spores are in the soil, movement of the soil by any means (boots, tools, wheels or wind and water, etc.) also spreads the disease.

Control:

1) One of the most important controls is to ISOLATE (if possible) or avoid use of infested fields for crucifer crops for about 7 years. The disease affects only the crucifer crops so any other crop may be planted as long as cruciferous weeds are not present.
2) Cattle fed infected plant material can pass the fungus spores in manure. Therefore, do not apply clubroot infested manure on land to be used to grow crucifers.
3) Practice a rotation. Do not grow a susceptible crop within a 5 to 7 year period to avoid infestation.
4) All equipments used on infested land must be washed down and preferably steam cleaned
5) or disinfected to prevent carrying the disease to clean fields.
6) As clubroot seems to thrive best in moist, acid soils it is advisable to apply lime to raise the pH of the soil to at least pH 7.2. Wet, poorly drained land should be avoided or drainage improved. In Atlantic Canada this means a calcium level of 5000 to 6000 kg per hectare and a magnesium level of over 800 kg per hectare using the current testing method.
7) Use clubroot-free transplants - The only way to ensure clean transplants is to use sterile soil. Clean boxes and equipment with steam. In the early stages of infection, plants may not show any signs of disease, so it is essential to purchase plants from a reliable source or to follow the procedures for producing healthy plants.

Alternaria Leaf Spot (fungus)

Characteristics:

Small to large black spots appear on leaves. It may be involved in discoloration and decay of cabbage heads, Brussels sprouts and cauliflower curds under very wet conditions. The disease organism is seed and soil borne. The first symptom of the disease is the appearance of small greyish-brown to black specks about 1 to 2 mm in diameter. These may appear at any time

during the life of the crop. They usually are most conspicuous on the outer, older leaves. The spots enlarge in storage to sunken and black areas. Alternaria is a secondary fungus; it usually invades the plant after it has been injured by other pests or management practices.

Control:
Use hot-water-treated seed. Practice long rotations between susceptible crops (turnips, cabbage, rape, other crucifers). Apply fungicides at first sign of disease at 7 to 10 day intervals. Cabbage intended for long-term storage should be treated 3 to 4 times ending 7 days prior to harvest. Keep storage temperature at 0C and relative humidity at 92% to 95%. Periodic venting with outside cool air removes excess moisture from cabbage surface and reduces losses from decay in common refrigerated storages.

Downy Mildew (fungus)

Characteristics:
Shows as a white, fuzzy fungus in patches on underside of leaves, stems and heads. It may cause browning and black streaking in stems and black spotting on heads of broccoli and cauliflower.

Control:

Rotate land for at least 2 years. Avoid thick seedings, over-watering and the application of water after 3 p.m. In the seedbed, spray seedlings at germination and repeat twice until transplanted with an appropriate fungicide. In the field apply fungicides on a regular basis as required.

Rhizoctonia (fungus)

Characteristics:

The soil-borne fungus *Rhizoctonia solani* causes several diseases. Preemergence damping-off occurs when seeds are attacked and decay, or they may germinate but the young plants fail to emerge. Postemergence damping-off occurs when the stem of 2 to 5 cm tall plants are attacked. A water-soaked area completely encircles the stem near the soil line and the seedling wilts and topples over. Wirestem results from an extension of the damping-off process but new infections may occur on plants 10-15 cm tall. The stem above and below the soil line darkens, and the outer cortex tissue decays and sloughs off in sharply defined area encircling the stem. The stem is thin and wiry at the lesion but remains erect. The plant may survive but will perform poorly. Some cauliflower cultivars are extremely susceptible to wirestem while others are more hardy. Head rot of cabbage occurs during wet weather when the fungus attacks the bases of wrapper leaves causing them to drop off. The fungus may spread over the entire head and several layers deep. The head remains upright, dark and becomes studded with small, hard, brown fungal structures. The decay is initially firm, but soft-rotting bacteria may invade turning infected tissues soft and odorous.

Control:

For damping-off and wirestem in seedbeds, only sterilized soil or soil that has not previously had crucifers for several years should be used. Seeds should be hot-water treated and also treated with a suitable fungicide. Plant density should permit adequate light and air penetration. Factors such as deep planting, reduced seed vigor and excessively cold, hot, moist or

saline soils that delay seed emergence should be avoided. Deficiencies of calcium, potassium and

nitrogen or excessive nitrogen may promote disease. A field rotation with non-cruciferous crops should be practised for at least three years. Avoid mounding of soil onto lower leaves when cultivating.

Blackleg (fungus) and Black Rot (bacterium)

Characteristics:

Early signs of blackleg appear as small spots on leaves of young plants. On stems the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed although new roots sent out above the lesion may keep the plant alive. Many plants wilt abruptly and die. Black rot lesions first appear at margins of leaves. The tissue turns yellow and the lesion progresses toward the center of the leaf, usually in a V-shaped area with the base of the V toward the midrib. The veins become dark and discoloration frequently extends to the main stem and proceeds upward and downward.

Control:

These organisms are seed borne and are capable of surviving in the soil for long periods

without another cole crop (blackleg 3 years, black rot l year). Use only hot-water-treated seed and seed treated with antibiotic. Practice a 4-year rotation. Destroy cruciferous weeds as they may harbour the black rot organism.

Broccoli Head Rot (bacterium)

Characteristics:

Head rot is caused by the soil borne bacterium *Pseudomonas marginalis*. Symptoms appear after periods of rain when heads remain wet for several days. The bacteria are splashed up from the soil to the head. When heads are colonized by the bacteria some areas appear water-soaked (because a biosurfactant is released by the bacteria) in contrast to unaffected areas where the waxy surface of the florets cause water to form in beads. Small black lesions may develop in these water-soaked florets. During long periods of wetness, decay spreads rapidly, resulting in a sunken area on the head. Head rot develops most rapidly at high temperatures (28^0C).

Control:

Avoid high levels of nitrogen and avoid applying pesticides during head formation as most pesticides contain surfactants which enhance rot during wet periods. For this reason, try to control insects prior to heading. The cultivars 'Shogun' and 'Arcadia' show good head rot resistance but only 'Arcadia' possesses good horticultural traits for the Maritimes. 'Green Valiant' and 'Patriot' possess moderate levels of resistance while 'Paragon', 'Emperor', 'Packman', 'Premium Crop' and 'Green Comet' are susceptible.