Cauliflower

VEGETABLE CROPS PRODUCTION GUIDE FOR NOVA SCOTIA

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Published June, 2007

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1.0 INTRODUCTION

Cauliflower (*Brassica oleracea* var *Botrytis*) is part of a large group of plants known as Cole Crops. Cole crops are a group in the *Brassicaceae* or mustard family (previously *Cruciferae* or crucifers).

Cole crops originated from the word caulis, meaning stem or stalk of a plant. Cole crops are biennials, but are generally grown as annuals. Cauliflower came from the Mediterranean region. The first description of cauliflower appeared in 1544.

The brassica family is quite cold resistant, making them well adapted to cool season production. With most Cole Crops, a cold period is necessary for flowering, however each crop has its own temperature tolerances. Young, hardened cauliflower plants can withstand temperatures of 0^0C for less than 36 hours. The minimum and maximum growing temperatures for cauliflower are 0 and 30^0C, with the optimum growing temperature for this crop between 15 and 22^0C. The minimum, optimum and maximum germination temperatures for cauliflower are 7, 27 and 29 ^{0}C respectfully.

High temperatures during cauliflower production delay maturity and increase vegetative growth and cool temperatures hasten maturity and may induce 'bolting'. Bolting is the premature formation of seed stalks. Fluctuating temperatures may induce some cauliflower cultivars which have begun heading, to revert back to vegetative phase which results in poor quality curds.

Well drained, sandy loam soils are suited to early varieties, whereas loamy and clay loam soils are suited to late ones because they are somewhat tolerant of poor drainage.

Cauliflower is well suited to the climate of Nova Scotia, and is extremely important to fresh market.

2.0 CROP ESTABLISHMENT

2.1 SEED TREATMENT

Cauliflower seed can be sized and/or pelleted for precision seeding of plastic plug trays/ plant cells or direct seeding into the field. With the high cost of hybrid seed, almost every seed must produce a marketable plant.

2.2 SEEDING/PLANTING

For early markets, transplants must be raised in greenhouses. About four to five weeks are required to produce transplants, so for early production seeding in middle of March is recommended. Plants may be grown in plastic plug trays/plant cells, or in peat blocks (e.g. Jiffy pots). Normally 300 grams of seed will produce enough plants for one hectare. Old or large plants of cauliflower and those grown at low temperatures (10 to 15 ^{0}C) are likely to button (premature head formation) and bolt if exposed to a period of cool weather after field setting. Seedlings are ready to be planted outside when they are about 15 cm high with 6-8 true leaves. Slight hardening is beneficial, but severe hardening may stunt growth. Hardening is the process whereby, 2 weeks before planting, transplants are gradually acclimatized to the outdoor environment.

For late markets, transplants may be raised in plastic plug trays/plant cells, a greenhouse seedbed, or direct seeded. When direct seeding, 1 kg of seed is required per hectare, since seed is generally planted at twice the final spacing. Direct seed two to three weeks earlier than transplanting for the same harvest date. Place seeds 12 mm deep and 35-50cm apart, in rows that are 60-90 cm apart. Plant spacing's that are more square (i.e. 50 cm x 60 cm) will aid in providing a more uniform crop, however these spacing's are not common in Nova Scotia.

3.0 CROP MANAGEMENT

With tunnel house production early cauliflower cultivars may produce in late June. Early field production does not start until early July. Availability of cauliflower on the market could be stretched to late November with the use of refrigerated storage.

3.1 CAULIFLOWER BLANCHING

The commercial cauliflower varieties grown in Nova Scotia are self blanching, meaning they have inner wrapper leaves that are large enough to cover the curd and protect it from discolouration caused by the sun. Most varieties produced today have some self blanching capabilities, however the older varieties do not and will have to be put through a process called blanching, which is defined as tieing the outer leaves of cauliflower to protect the curd.

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.

The new orange and purple coloured cauliflower curds generally do not require blanching.

3.2 IRRIGATION

The availability of water can be critical to successful production. If direct seeding, plan to irrigate every three days until seedlings are established. Steady, even growth of cauliflower plants is necessary for high quality and yields. Irrigation may also be used to cool plants during periods of high temperature. Fertilizer could be applied through an irrigation system. Cauliflower requires a regular water supply of 25 mm every 5 to 7 days. The most critical moisture period is during head development. Irrigation at the wrong time can cause problems such as head rot of cauliflower. Sprinkler, big gun, furrow and drip irrigation are used in cauliflower production.

3.3 SOIL FERTILITY

Recommendations for supplemental organic matter, fertilizer, lime or manure should be based on a soil test and a Nutrient management plan. In Nova Scotia, soil tests are preformed by the provincial agriculture labs in Truro. To find out more about how to take a soil test, where to send the sample and fees for the tests, visit www.gov.ns.ca/agri or phone (902) 893-4683. Nutrient management plans balance the crop requirements and nutrient availability, with the aim to optimize crop yield and minimize ground water contamination, while improving soil productivity.

Manure

Cauliflower does well when manure is applied, however it is best not to 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. Uncomposted manure may not be applied directly to the crop prior planting.

Lime

Lime should be applied to maintain the soil pH in the range of 6.5 to 7.0, unless club root control is required (pH of 7.2). If soil pH is below 6.2, apply lime either in the fall of previous year or six weeks before planting.

Nitrogen

130 -170 kg/ha of actual nitrogen is required for successful cauliflower production. If manure is applied or legume sod is plowed down, than the rate of nitrogen fertilizer is adjusted appropriately. About half of recommended nitrogen is broadcasted and worked into soil prior planting. The remainder of nitrogen is applied in two side dress applications. The first side dress application should be 7-10 days after planting and the second 4 -6 weeks later. If the season is very moist, a third side dress application may be used three weeks after the second application. Adequate nitrogen produces a dark green colour in cauliflower leaves. Nitrogen deficient plant leaves are light green, eventually turning yellow and may be shed. Nitrogen is not generally recognized in soil test analysis sheets received from your soil lab.

Phosphorous
A soil test will determine the level of phosphorous requirements. Broadcast or band any needed phosphate before planting and work in. Phosphorous is important for root growth. A shortage of phosphorous stunts plants growth.

Potassium
A soil test will determine the level of potassium requirements. Broadcast apply potash in the fall and work into the soil. Excessive potash may lead to increased tip burn (internal and/or external). Potash competes with calcium for uptake from the soil and this is probably what causes the increased tip burn.

Magnesium
Older leaves are the first to show deficiency signs, which include blotches of interveinal chlorosis. As the chlorosis intensifies, purple blotches may be seen near the leaf margins. Deficiency is fairly common especially on light acid soils where dolomitic limestone has not been applied. To avoid these problems, apply dolomitic limestone or add magnesium to the fertilizer. If the problem occurs during the season spray the foliage with Epsom salts (magnesium sulfate).

Sulfur
Early deficiency symptoms appear as blotches of interveinal chlorosis on the youngest leaves, and the leaves may become reflexed. On sandy soils low in organic matter that has been intensively cropped, soil sulfate levels may be low. Application of gypsum should be considered on these soils. Cauliflower crops have a high need for sulfur and have shown signs of deficiency in many fields.

Micronutrients

Boron
Deficiency may cause hollow stem, stem discolouration, cracking, leaf rolling, deformed buds as well as browning of cauliflower curds. If the soil test indicates low levels of boron, apply 2.5 – 3.0 kg of boron/ha and disk in before planting. Boron should never be banded, however it can be foliar applied.

Molybdenum
Molybdenum deficiency causes whiptail in cauliflower. Whiptail results in a deformed growing point causing no head to develop, as well as leaf blades consisting mostly of midribs. Molybdenum may be supplied as a seed treatment, as a foliar spray to transplants before field setting, in the transplant water or as a foliar spray. Apply 30-45 g of Sodium Molybdate per 100 L of transplant water or 280 g of Sodium molybdate as a spray in 1100 L of water per hectare. (Sodium molybdate is approximately 40 % molybdenum). Excessive molybdenum is toxic to plants and animals – use with care. It will carry over in the soil.

Manganese

Deficiencies may occur on sandy, over limed soils. Manganese deficiency causes yellowing between veins of young leaves. Leaves gradually turn pale-green with darker green next to the veins, petioles and stems. Foliar sprays of manganese sulfate may be necessary to correct a deficiency.

3.4 CROP ROTATION

There are many benefits to crop rotation including the suppression of diseases, insects and weeds. In addition, crop rotation improves soil fertility because it is allowed to replenish naturally and soil structure improves because of the alternating between deep rooted and fibrous rooted crops.

Crops within a family tend to be susceptible to the same pests, therefore rotation of non susceptible crops (or groups) for several years allows all plant material to decompose and pest cycles to become broken. Without the presence of susceptible plant material, the number of disease and insect organisms will begin to diminish.

Crop rotation aids in weed control because the growth habit of each crop differs, which causes a decrease in a weeds ability to compete for space. Also, tillage practices and timing are different for dissimilar crops resulting in a decrease in the weeds ability to permanently establish. Another benefit of crop rotation for weed management purposes is with certain crops, there is a better chance at controlling different weeds. For example, in a broadleaf crop, grass control will be easier because of the use of grass killing herbicides and visa versa.

To create a crop rotation schedule, there are several things to be considered including types of vegetables grown, size of root system, size of planting rows, amount of fertility required for the crop and how much organic matter is left in the soil by the crop. Start designing the crop rotation by making a list of all vegetables to be grown and group them together by botanical relationship (e.g. *brassicaceae, solanaceae, alliaceae*). Each year, change the location of the entire group within the field. This way, the same crop group will not be planted on the same piece of land two years in a row. Secondly consider the size of the root system of the crop to be grown. Deep rooted plants will help to break up the soil, while shallow rooted crops will not. Thirdly, consider the size of the plant rows. Wide rows will allow for more weed seeds to germinate, but on the other hand, tillage equipment may be able to go through them with more ease than in narrow rows. The fourth consideration should be given to whether or not the crop to be planted is a heavy feeder. A heavy feeder will deplete the soil of nutrients quicker than a non heavy feeder. The final consideration for a crop rotation is whether or not the crop will leave a lot of organic matter in the soil. Leaving organic matter behind is beneficial for replenishing the soil of nutrients lost to the crop while it was growing.

A long rotation of more than five years is better than a short rotation of two years. Also, ask yourself the following questions when putting together a rotation: Is the rotation profitable? Are the yields sustainable? Does it make use of nitrogen produced by an earlier crop? Are herbicide residues left?

Due to disease and insect pressures (refer to the pest management section in this guide) it is best to plant cauliflower once in four years. Brassica crops use a lot of nitrogen so it may be beneficial to plant a legume crop before cauliflower. Cauliflower has an intermediate root depth that will aid in improving soil structure and aeration. This crop has small seeds which will require a finely manicured seed bed, therefore previous crop residues will not be tolerated. If transplants are used, the roots can tolerate some plant residue, but too much will negatively affect root growth.

4.0 PESTS AND PEST MANAGEMENT

Effective management of any pest requires the use of multiple pest control techniques. Integrated Pest management (IPM) is a system that integrates Managerial, Cultural, Physical, Biological and Chemical control techniques to manage pests. A key to IPM is understanding what pests are in your crop, through scouting and adjusting production practices to discourage pests from becoming problems. IPM is a proactive approach to pest management, rather than just a reaction to pests as they occur. For more information on IPM techniques, refer to the AgraPoint Guide to Pest Management.

4.1 WEEDS

Perennial weeds should be controlled prior to planting. Herbicides recommended for use on Cole crops will not provide complete control of weeds; therefore it is important to grow Cole crops on soil where the weed seed population is low. The weed seed bank in the soil can be reduced by crop rotation, summer fallow, and stale seedbed technique. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur. Refer to the AgraPoint Guide to Pest Management for a list of herbicides and their methods of application.

4.2 DISEASES

Clubroot

Clubroot (*Plasmodiophora brassicae Wor*.) is a soil borne disease which affects cauliflower. Early infections are difficult to detect as symptoms begin underground. Symptoms include small to large swellings and other malformations of the roots. As a result of these swellings, water and nutrient flow are restricted within the plant, which causes the above ground parts to wilt, turn colour and look stunted. Wilting is most common on warm sunny days; plants may show little wilting early in the morning or late at night. Throughout Nova Scotia, it is a major problem where poor management practices are followed.

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. Once land becomes infested with this disease, it will remain so for several years.

When clubbed plants rot and break down in the fall, the fungus spores are released into the soil, where they may live for 10-20 years, ready to infect any 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 spread the disease.

Control:

There are seven things that can be done to reduce the occurrence of this disease;

1. Isolate (if possible) or avoid the use of infested fields for brassica crops for about seven years. The disease affects only the brassica crops so any other crop may be planted as long as brassica type weeds are not present.
2. Do not apply clubroot infested manure on land to be use to grow brassicas. Cattle fed infected plant material can pass the fungus spores in manure, therefore it is best to put contaminated manure back on the field that contained the infected roots, thus preventing the spread of the disease to other fields. Another possibility would be to place contaminated manure on permanent pasture lands that will not be used for any susceptible crop and where run-off will not carry the disease to clean fields.
3. Rotate crops and fields as a preventative measure before club root occurs. Allow at least three years between growing susceptible crops.
4. Clean and disinfect all equipment used on infested land before using on a non-contaminated field. Washing or steam cleaning will prevent carrying the disease to clean

fields. Live steam delivered at 690 kpa pressure for five minutes is the best method to disinfect equipment.

5. Control susceptible weeds whenever possible. Weeds of the mustard family will maintain or increase the level of infestation of clubroot in a field. Examples of susceptible weeds that occur in Nova Scotia are as follows: wild radish, wild mustard, stinkweed, pepper grass, shepard's purse, false flax, hare's ear mustard, worm seed mustard and yellow rocket
6. Apply lime to raise the pH of the soil to at least 7.2. Clubroot seems to thrive best in moist, acid soils, therefore wet, poorly drained land should be avoided or drainage improved.
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. Make sure you have enough clean plants for the area to be planted. Diseased plants beside healthy ones will result in all plants becoming infected. When growing transplants in the field, it is important to select a well drained area where it is known that clubroot has never occurred. Certain soil fumigants will control the clubroot organism.

Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Grey Leaf Spot and Black Leaf Spot

Alternaria brassicae (grey leaf spot) causes small and light brown or grey lesions and *A. brassicola* (black leaf spot) causes larger and darker lesions. These diseases are seed and soil borne. Small black spots (1 to 2 mm in diameter) appear on leaves, later turning into a tan colour with target-like concentric rings. When the spots dry out, the tissue falls from leaves, resulting in a 'shot-hole' appearance. Cool temperatures, rain and high humidity favour the development of this disease. Spots usually are most conspicuous on the outer, older leaves. The disease causes small brown sunken lesions and decay of cauliflower curds, under very wet conditions. The spots enlarge in storage to sunken, 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 clean, certified seed or a hot water seed treatment if certified seed is not available. Practice long rotations between Cole crops, avoid over head irrigation and make sure to incorporate plant debris. Good air circulation is needed in the field, as well as in storage. Keep storage temperature at 0^0C and relative humidity at 92 % to 95%. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Downey Mildew

This disease is caused by the fungus *Peronospora parasitica*. Once infected, the plant shows white, fuzzy masses in patches on the underside of leaves, stems and heads. The tops of leaves turn purple, than later turn yellow or brown. It may cause browning and black streaking on stems below the curd and black, brown or grey spotting on curds of cauliflower. Infection is favoured by wet, cool weather, especially during prolonged periods of leaf wetness, such as during dew or fog. This fungus over winters in seed and can survive for at least two years. It also over winters on infected plants and can survive in the soil for at least one year.

Control:

Good air and water drainage is critical in controlling this disease, along with avoiding water on the crop in the afternoon and evenings. Crop rotation with non brassica plants and incorporating plant debris will also aid in controlling this disease. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Rhizoctonia
The soil borne fungi *Rhizoctonia* and *Pythium* cause two diseases of cauliflower including Damping –off and Wirestem.

Pre-emergence damping off occurs when seeds are attacked and decay, as well as when plants germinate, but fail to emerge. Post-emergence 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.

Control:
For damping off and wirestem in seedbeds, only sterilized soil or soil that has not previously had brassicas 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 vigour 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-brassica crops should be practiced for at least three years. Avoid mounding of soil onto lower leaves when cultivating. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Blackleg
Blackleg is caused by the fungus *Phoma lingam*. This disease can be seed borne. 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.

Control:
Use clean, certified seed, or seed which has been hot water treated. This organism is capable of surviving in the soil for three years without another Cole crop present. Practice a 4 year crop rotation, destroy brassica weeds and thoroughly incorporate plant debris. Good air and water drainage is critical in controlling this disease, along with avoiding water on the crop in the afternoon and evenings. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Black Rot
Black rot is caused by the bacterium *Xanthomonas campestris* and can live in the soil for one year without another Cole crop present. Humid, rainy conditions favour the disease, which is usually spread by splashing rain or irrigation water. 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 discolouration frequently extends to the main stem and proceeds upward and downward.

Control:
Refer to the Black leg control measures, as they are useful in control of black rot as well.

4.3 INSECTS

Cabbage Maggot

The cabbage maggot or cabbage fly (*Delia redicum*) adults fly close to the ground near brassica plants and lay elliptical white eggs on the stems of crops or in nearby crevices in the soil. The adult is a two-winged, ash grey fly, with black stripes on the mid section. It is half the size of a housefly, but has longer legs. Eggs hatch in three to seven days. Larvae are white, legless maggots that enter the roots and feed by rasping the plant tissue with a pair of hook like mouthparts and tunneling into the roots. Feeding damage by the cabbage maggot causes roots to be misshapen and allows the entry of decay organisms and other species of maggots, resulting in stunted or killed young plants. Maggots mature in three to four weeks and pupate. The pupae are 6 mm long, oval, hard shelled and dark brown. Pupae over winter in the soil near the roots of the host plant. Adult flies emerge in two to three weeks; the first generation usually emerges in late May to early June. The presence of adult flies can be determined by looking for eggs which are laid at the base of plants. Generally, there are two to three generations a year.

Control:
Natural enemies for the cabbage maggot include ground beetle, rove beetle, spiders, harvestmen or daddy longlegs and ants.

Cultural controls include covering young plants with floating row cover to prevent the flies from depositing eggs after plant emergence, and intercropping clovers or other legumes to prevent the flies from finding open ground near a brassica stem.

If using chemical controls, scout plants frequently and treat when damage is first observed. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Caterpillar Pests:
The imported cabbage worm (*Pieris rapae*), cabbage looper (*Trichopulsia ni*), diamondback moth (*Plutella xylostella*) and Purple-backed cabbageworm (*Evergestis pallidata*) are all pests of cauliflower. High levels of feeding damage will cause severe defoliation, resulting in stunted plants. Cauliflower can also become unmarketable if the heads are stained with frass (insect excrement) or if frass is visible.

The adult of the Imported Cabbageworm is a white butterfly, easily seen going from plant to plant laying eggs during the summer. The eggs hatch into velvety-green larvae with one thin yellow stripe down the centre of its back. The cabbageworm larvae do not loop when they walk. They are generally the most prevalent of the caterpillars found on Cole crops.

The cabbage looper gets its name from the way it forms a loop as it walks. It is a smooth green larva with two white stripes along the back and two along the sides. The cabbage looper is capable of causing the most damage to Cole crops. Cabbage loopers do not over winter in this region. Adult moths migrate into the region during the summer. Cabbage looper tends to be more problematic during the late summer.

The Diamondback Moth is much smaller than the previous insects. Three to six generations of 1.1 cm yellow-green larvae may develop each year. The larvae squirm actively when disturbed and produce many small holes on the host plant. This pest can bore into the heads of cabbage. Diamondback moths do not survive the winter in this region. Adult moths migrate in throughout the growing season. There is therefore often an overlap in generations, and all stages may be present at one time.

The Purple-backed cabbageworm is not as commonly seen as the others but will cause serious damage in high numbers. The larvae are purple on the back and pale yellow along the sides. There are one to two generations per year.

Control:
There are many natural enemies that will help control these pests in fields. Ground beetles, spiders, damsel bugs, minute pirate bugs, assassin bugs, big eyed bugs, and lacewing larvae will all attack the caterpillars. There are also some commercially available parasitic wasps that sting and parasitize eggs and larvae of caterpillars; these include *Trichogramma* spp., *Copidosoma* spp., *Apanteles* spp., *Diadegma* spp., and *Hyposoter* spp.

Cultural controls include pheromone emitters to disrupt mating, evening overhead sprinkler irrigation, and placement of floating row covers over young crops to exclude egg-laying females.

If using chemical controls, scout plants frequently and treat when the threshold level has been reached. To determine the threshold level, count the number of plants out of 25 randomly selected plants that have 1 or more caterpillars, than multiply by 4. This will give the percentage of plants infested. For cauliflower, the threshold guidelines are 20-30% before heading and 5-10% after heading. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Cutworms:
Cutworms (*Agrotis ipsilon*) are grayish, fleshy caterpillars up to 5 cm long, which curl up when disturbed. Plants may be chewed off above or below ground level and may be damaged higher up by climbing cutworms. Most of the cutworm damage is to newly set plants in the field, but they are often found attacking seedlings in plant bed and greenhouses. Late infestation of variegated cutworm occasionally occurs.

Control:
Prepare the soil two weeks before planting to cultivate in cover crops and destroy weeds. Check plants frequently and treat when damage is first observed. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Aphids
The cabbage aphid, *Brevicoryne brassicae*, is a major pest of Cole crops world wide. Aphids are small, soft bodied, slow moving insects. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. They are often found in large colonies on the undersurface of leaves; however, aphids will feed on heads, flower stalks as well as leaves, resulting in unmarketable produce. Aphids feed by piercing plants and sucking out plant sap, resulting in distorted plant parts and a slowing of plant growth. The plants may be covered by a sticky substance, called honey dew, which is excreted by the aphids.

Control:
There are many natural enemies that will feed on aphids, thus helping to reduce the populations of this pest in the field. Natural enemies that produce larvae which will feed on aphids include syrphid flies, lacewings and the predaceous midge. Adults and larvae of minute pirate bugs, big eyed bugs, lady beetles, soldier beetles and parasitic wasps like *Diaeretiella rapae* will also consume aphids.

Cultural controls include using high pressure sprinkler irrigation to knock the insects off of plants, as well as using living mulch such as clover interplanted with the crop.

If using chemical controls, check plants frequently and treat when damage is first observed. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Thrips

Thrips (*Thrips tabaci*) are slender, yellow-brown insects about 1 mm long. They feed by puncturing the leaves and sucking up the exuding sap. This causes the appearance of dark warts or blisters on the leaves. They also feed on curds, damaging them and making them unmarketable. They over winter on refuse, weeds, and legume forage crops. Populations increase quickly when the air temperature is over 21 ^{0}C.

Control:
Destroy refuse and control weeds. Heavy migrations of thrips can occur following the cutting of forage, particularly alfalfa or clover. It is critical to control them at early head formation (7.5 cm leaf ball).

If using chemical controls, check plants frequently and treat when damage is first observed. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Flea beetles
Flea beetles (*Phyllotreta* spp.) are small shiny black beetles, about 2 mm in length. They are very active early in the growing season, especially during periods of dry sunny weather. Flea beetles can seriously damage seedlings and transplants, and to a lesser extent larger plants, by chewing small pinholes through the leaves. There is one generation per year. The larvae live in the soil and feed on roots.

Control:
Biological control options for flea beetle include using a braconid wasp that will parasitize and kill adult flea beetles, and using nematodes that attack the larvae.

There are several cultural controls which can be used to combat flea beetles. Trap crops such as Chinese type cabbages, radishes or collards can be used, living mulches or polycultures are other possibilities. Covering young seedlings with floating row cover to prevent the insects from attacking the plants is another option. Using white or yellow sticky traps every 4.5 – 9 m and making sure to destroy plant debris are also good cultural control practices.

If using chemical controls, scout plants frequently and treat when the threshold has been reached. One flea beetle per plant (up to the sixth leaf stage) is the threshold number. After the 6 leaf stage, feeding will not interfere with plant growth. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Tarnished Plant Bug
Adult tarnished plant bugs are light brown to reddish brown in colour and about 5-6 mm in length. They occur throughout the season and are very active and quick moving. They feed on cauliflower curds causing brown blemishes or streaks which reduce the marketability of the head.

Control:
Keep plantings and adjacent areas weed free. Avoid planting next to legumes. Check plants frequently and treat when damage is first observed. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Slugs
Slugs exist in various sizes up to 10 cm. They eat holes in the leaves and leave a trail of mucus, which makes plants unsightly. The control of slug populations has been a continuing problem in the Cole crop industry.

Control:

Slugs prefer areas which are cool, moist and high in organic matter. Sod crops, weedy fence lines and hedgerows fulfill these conditions. Since slugs can over winter fairly easily, cultural practices aimed at controlling them should begin at least one year before the susceptible crop is put in. If possible, sod crops should not be followed by Cole crops. A cultivated strip around the crop has been shown to reduce the number of slugs migrating from weedy field borders. If urea (4 kg/ha) is sprayed on this cultivated strip, slug movement may be further impeded. The salt irritates the slugs as they move over it. Repeated applications are necessary as rainfall washes it into the soil. Slugs are usually more numerous in heavy, moist soils; sandy soils usually have fewer slug problems.

4.4 PHYSIOLOGICAL DISORDERS

Cauliflower crops show various non-parasitic disorders which cause tissues to die off. In some cases, these deviations have been shown to depend mainly on heritable characters; whereas in other cases external factors had a least marked effect.

Lack of Heads in Cauliflower

During periods of extremely warm weather (days over 30 ^{0}C and nights of 25 ^{0}C) 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.

Cauliflower Buttoning

Buttoning is the premature formation of a head 2.5 to 10 cm in diameter. Buttoning can occur anytime between seeding and almost mature plant, but usually occurs shortly after transplanting into the field. Generally foliar growth slows after buttoning resulting in too few nutrients to nourish the curd to marketable size. Losses are usually most severe in the early planted crop during cold, wet seasons, when vegetative growth is affected 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 day or more)
6. Other – disease, insects, micronutrient deficiency, etc.

Some cultivars, particularly early ones, are more susceptible to buttoning than others.

Tip Burn of Cauliflower

This problem can cause severe economic losses. Internal leaves turn brown and fold over developing curds. Eventually secondary rots cause leaves to became mushy and smear over the curds, making them unmarketable. It is a physiological disorder which is associated with an inadequate supply of calcium to the young, actively growing inner leaves. High humidity, low soil moisture, high potash, high nitrogen, or low soil calcium all influence calcium availability. Some cultivars are relatively free of tipburn problems

Hollow Stem in Cauliflower

This condition starts with gaps that develop in the tissues, and gradually they enlarge to create a hollow stem, sometimes from the base of the stalk into the head. Ordinarily, there is no discolouration of the surface of these openings at harvest, but both discolouration and tissue breakdown may develop soon after harvest. Avoid excessive nitrogen after head initiation. Dense plantings will maintain even growth rates and decrease the occurrence of hollow stem.

Riceyness

This disorder causes the curds to become uneven and fuzzy, reducing marketability. Riceyness is caused by low temperatures just after planting, warm temperatures during curd development or a late supply of nitrogen to plants.

Leafy Curd
Small leaves develop and protrude through the head during high temperatures, drastic fluctuations in day and night temperatures or improper nitrogen balance.

5.0 HARVESTING AND HANDLING

Cauliflower harvest season begins in late July and finishes in late October, depending on the weather. Harvest the curds when they are fully developed, compact and before they grow loose or separate and become ricey, generally some days after they have become visible. A good curd must be regular in shape, globular, firm and white, orange or purple in colour, depending on cultivar.

The size of the curds varies widely, depending on the cultivar and growing conditions, the largest curds attaining a diameter of 30 cm or more. Early cauliflower is generally smaller than late cauliflower. Frequently market preference is given to medium sized curds between 15 and 25 cm in diameter, while those under 10 cm are unacceptable.

Cauliflower is generally hand harvested using a knife. To aid in the harvesting processes, mechanical conveyor belts may be used to transport cartons to and from workers in the field.

Curds are sometimes marketed without foliage, but it is better to harvest them with a whorl of leaves still attached for protection. When the cauliflower heads are to be transported in flat crates, the upper part of the foliage is generally removed. As a rule, the heads are packed in a single layer to reduce the risk of damage. When the heads are to be transported loose or in high crates, as little foliage as possible should be cut away. Field wrapping trimmed heads in perforated cellophane or plastic bags prior to cooling and storing minimizes dehydration and protects curds from being soiled. Care must be taken to minimize handling since any physical damage may result in later development of speckling or browning of curds during storage and marketing.

5.1 STORAGE AND CONDITIONING

Cauliflower keeps for 2 to 6 weeks at 0 ^{0}C and 95% relative humidity. Heads should be cooled to 5 ^{0}C or below soon after harvest. Both hydro cooling and vacuum cooling are effective methods to remove field heat. In addition, forced-air cooling can be used. Never use ice on cauliflower. Cauliflower that is destined for storage is preferable cut slightly immature, otherwise the curds may separate. Controlled atmospheres do not extend the storage life of cauliflower and may cause off-odours, softening or discolouration.

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