Lettuce

VEGETABLE CROPS PRODUCTION GUIDE FOR NOVA SCOTIA

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1.0 INTRODUCTION

Lettuce (Lactuca sativa) belongs to the Asteraceae family. It is an annual plant native to the Mediterranean area. Cultivation may have started as early as 4500 BC, perhaps initially for the edible oil extracted from its seeds. Salad lettuce was popular with the Ancient Greeks and Romans. Firm heading forms became well developed in Europe by the 16th Century. Oak leaved and curled-leaf types of various colors were described in the 16th and 17th centuries in Europe. In Nova Scotia, the predominant lettuce types grown are iceberg, romaine and leafy. In recent years, baby salad mixes have become popular.

Lettuce is well adapted to growing in a cool season, with optimum growing temperatures at 13ºC to 18ºC. Lettuce will germinate at temperatures as low as 2ºC, but the optimum germination temperature range is between 16ºC to 23ºC. At soil temperatures over 27ºC germination is poor. Hardened seedlings are tolerant to frost (-5ºC to -7ºC), but mature plants are more sensitive to frost (-1ºC). Light frosts in the fall generally only injury the wrapper leaves. The optimum growing conditions for lettuce are warm days and cool nights. Early flowering and seed formation (bolting) will result if the plant is stressed, which can result from early frost damage, and fertilizer or water deficiencies. Tip burn may also result if night time temperatures and relative humidity are too high, preventing adequate calcium uptake.

Warm sandy soils are preferred for the early harvest, loam to clay loam or peat for late production. Good drainage, good soil moisture holding capacity and high organic matter content are essential for a good quality lettuce crop. High humidity and excess water close to the time of harvest can be destructive to the yield and quality of the crop.

2.0 CROP ESTABLISHMENT

2.1 SEED TREATMENT

Seed companies today are priming, pelletizing or doing both to lettuce seeds. Priming the seed breaks the photo-dormancy inherent in the species, allowing the seed to germinate even though it may be pelleted. Pelleted coatings broaden the temperature range in which the seeds will germinate. Pelleted seed is a mix of powders placed around the seed to form a ball. This makes the seed more uniform in size, weight and shape, allowing for easier handling at planting time. Lettuce seeds may also be treated with a fungicide to aid in the fight against disease problems.

2.2 SEEDING/PLANTING

Lettuce crops can either by direct seeded or transplanted, however on Nova Scotia commercial lettuce operations, this crop is established by transplanting. Transplants are raised in greenhouses, and for early plantings, they must be started in mid to late March. Plants may be grown in plastic plug trays/plant cells or in peat blocks. For proper crop growth, use a commercial greenhouse seeding mix. Approximately 275 g of seed will provide transplants for one hectare. Slight hardening is beneficial, but severe hardening may stunt growth. Hardening is the process whereby 7 days before planting, transplants are gradually acclimatized to the outdoor environment. Lettuce can be transplanted up to early August, depending on the variety and the market, therefore continue to seed transplants thru to July. Thoroughly soak the soil in the flats with starter solution before transplanting. Keep as much soil as possible on the roots. When transplanting to the field, transplants should not be planted too deep, otherwise small pointed heads may result. Due to possible moisture excess, lettuce is best grown in double rows with raised beds. Raised beds are preferred as they allow for better air and water drainage and prevent damage from compaction. Rows are usually spaced 40 – 50 cm apart, depending on width of the bed.

For a smaller operation that may choose to direct seed, begin as soon as the land can be worked, usually in late April or early May. A succession of seedings is necessary for continuous cropping.

Space rows 30 cm or more apart as determined by machinery. Lettuce should be seeded at a depth of 0.6 cm or less. Plants should be spaced 25 to 36 cm apart for head lettuce, and 20 to 30 cm apart for leaf and Bibb lettuce. Remember to seed sparsely to reduce thinning. Thin when 2 or 3 true leaves have formed. Direct seeding requires 1 to 2 kg per hectare unless precision seeded. Weed control is usually more of a problem with direct seeded fields.

3.0 CROP MANAGEMENT

Crop harvest in Nova Scotia begins in mid June and continues until the end of September. Succession plantings through the spring and summer allow for regular harvests thus providing a continuous supply to the market.

3.1 IRRIGATION

Lettuce has a high demand for a steady supply of moisture. Irrigation must be monitored, along with the weather especially when the crop is approaching maturity, since excessive moisture may ruin the crop. Irrigation can be used to cool a late summer crop that will be harvested in the early fall. Generally lettuce requires 25 mm of water every seven days, either through irrigation or from rainfall. The most critical time for water is during head expansion. Sprinkler irrigation is used in Nova Scotia to aid in lettuce production.

3.2 SEASON EXTENSION

Lettuce production can be extended with the use of floating row covers. Floating row covers have been used successfully in Nova Scotia for season extension in the spring.

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 performed 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 http://www.gov.ns.ca/agri/qe/labserv/index.shtml#analytical or phone (902) 893-7444. 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

Manure is generally not recommended for a lettuce crop because Canadian Horticulture Council guidelines state manure cannot be applied within three months (90 days) of harvest. However composted manure or compost is recommended.

Lime

Lime should be applied to maintain a mineral soil at a pH in the range 6.5 to 6.8. On peat soils, the pH for optimum crop performance is 5.5 to 6.0.

Nitrogen

110 kg/ha of actual nitrogen is required for lettuce production. If compost or composted manure is applied, than there is a need for a reduction in the amount of total nitrogen applied to the field. Apply 50 % of the required Nitrogen before planting by broadcasting and working into the soil. The remaining nitrogen is applied in one side dress application 2-4 weeks later. Lettuce has a limited root system, and is considered to be a poor feeder. Nitrogen deficient plants appear light green in color and stems are short and stunted. Excess nitrogen can result in rapid growth and tipburn.

Phosphorus
A soil test will determine the level of phosphorus requirements. Broadcast or band any needed phosphorus before planting and work in. If using transplants use a plant starter high in phosphorus. Phosphorous is important for root growth. Deficiency symptoms include slow stunted growth, purplish leaves and delayed maturity.

Potassium
A soil test will determine potassium requirements. Apply potassium in the fall by broadcasting and working into the soil. Lettuce is quite tolerant of salt damage so small amounts of potash may also be banded. Deficiency symptoms include tip and marginal burn on older leaves and slow growth.

Sulphur
Sandy soils low in organic matter, which are being intensively cropped will benefit from a sulphur application. Deficiency symptoms include pale green or yellow young leaves and small stunted plants.

Calcium
Calcium (Ca) deficiencies usually occur when the plant is under stress or when insufficient water is available. The problem arises because of poor Ca movement through the plant, resulting in tipburn or blackheart. Cultural practices that can be implemented to reduce the occurrence of Ca deficiency include limiting nitrogen applications to prevent excessive growth, proper soil management techniques to allow for good root growth and nutrient uptake and regular water application to prevent calcium shortages in the plant. Under hot conditions, lettuce may benefit from foliar calcium sprays to prevent tipburn or blackheart symptoms. Refer to the table below for calcium fertilizer sources and rates.

Calcium Application Rates

			Foliar Applied		Soil Applied	
Nutrient	**Source**	**% Composition**	**Nutrient kg/ 1, 000 L**	**Product kg/1,000L**	**Nutrient kg/ha**	**Product kg/ha**
Calcium $(Ca)^2$	calcium nitrate	19% Ca	1.9	10.0	N/A	N/A
	calcium chloride	36% Ca	1.9	5.0	N/A	N/A

Micronutrients

Boron
Boron applications may be required in organic or peat soils, and sometimes on mineral soils. If soil tests indicate low levels, soil apply or foliar apply some Boron. In romaine lettuce and head lettuce, Boron levels below 30 ppm and 15 ppm respectfully, warrant additional boron. Refer to the micronutrient application table below for a list of fertilizer sources and rates. Boron deficient plants may develop yellow leaves with cracking on the roots. Boron toxicity symptoms include spot-like, striped or blotchy yellowing on the leaves. Eventually, leaf tissues will die.

Copper
Copper deficiency often appears in organic or peat soils, resulting in an application of copper mixed with the fertilizer. Foliar sprays of copper can easily injure plants, so extra caution is advised during the spray. Refer to the micronutrient application table below for a list of fertilizer sources and rates. Lettuce leaves with copper deficiency become 'rabbit-eared', generally the leaves lose their firmness and the plants become whitened on the stems and leaf margins.

Manganese
Manganese deficiencies may occur on sandy, over limed, high pH 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 can be applied after thinning or transplanting. Refer to the micronutrient table below for a list fertilizer sources and rates.

Molybdenum
Molybdenum applications may be required in organic or peat soils and sometimes on mineral soils. If soil tests indicate low levels, foliar application of molybdenum is necessary. Refer to the micronutrient table below for a list of fertilizer sources and rates. Molybdenum deficiency causes plants to become stunted and lack vigor. Leaves may turn brown along the edges.

Micronutrient Application Rates

			Foliar Applied		Soil Applied	
Nutrient	**Source**	**% Composition**	**Nutrient kg/ 1, 000 L**	**Product kg/1,000L**	**Nutrient kg/ha**	**Product kg/ha**
Boron (B)	sodium borate	12-21% B	0.1-0.3	N/A	1.0-3.0	N/A
Copper (Cu)	copper chelates	5-13% Cu	0.5 – 1.5	N/A	N/A	N/A
	copper sulphate	13 – 25% Cu	0.5 – 1.5	2 - 6	7.0 – 14.5	28 - 60
Manganese (Mn)[3]	manganese chelates	5-12 % Mn	0.5 – 1.0	N/A	N/A	N/A
	manganese sulphate	28 % Mn	0.5 – 1.0	1.8 – 3.6	N/A	N/A
Molybdenum (Mo)	sodium molybdate	39% Mo	0.1 – 0.25	0.25 – 0.6	N/A	N/A

3.4 CROP ROTATION
A general guideline to follow concerning crop rotation is that a crop should never follow itself. Continuous cropping of any crop will result in an increase of disease and insect pressure and possibly a reduction in yields.

A proper rotation will include growing different botanical families on the same piece of land, in sequential seasons. The table below outlines some of the common botanical families vegetables belong to.

Botanical Family	**Vegetable Crops**
Asteraceae	Lettuce, Endive, Artichoke, Radicchio
Alliaceae	Leeks, Garlic, Onion
Chenopodiaceae	Spinach, Swiss Chard, Beets
Brassicaceae	Broccoli, Cauliflower, Brussels Sprouts, Cabbage, Kale, Turnip, Kohl Rabi, Radish
Cucurbitaceae	Winter Squash, Summer Squash, Watermelons, Muskmelons, Cucumbers, Pumpkins
Poaceae	Sweet Corn
Fabaceae	Beans, Peas, Peanuts
Solanaceae	Tomato, Eggplant, Peppers, Potatoes
Apiaceae	Carrots, Parsley, Parsnip, Fennel

By rotating crops that leave a high amount of residue in the soil, soil fertility can be enhanced naturally. Crop rotation can also improve soil structure by alternating deep-rooted and shallow-rooted plants.

Crop rotation plays a key role in an IPM program by aiding in the suppression of diseases, insects and weeds. Crops within the same plant family tend to be susceptible to the same pests therefore rotation of non susceptible crops 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. Tillage practices and timings are different for each crop group resulting in a decrease in a weeds ability to permanently establish.

Due to disease pressure (refer to the pest management section of this guide) it is best not to plant lettuce more often than once every three years. This crop has shallow roots that will not help to improve soil structure or aeration. Lettuce seeds require a finely manicured seed bed; therefore previous crop residues would severely hinder crop establishment. Lettuce transplants have a root system that 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.

4.1 WEEDS

Herbicides are available to use in a lettuce crop. Rates and methods of application can be found on the product label. A number of shallow cultivations are an essential part of a weed control program. Good weed control requires integration of cultural and chemical methods. Lettuce should be planted to land free of perennial weeds, where the annual weed seed population has been reduced by cultural practices such as crop rotation, stale seedbed or hoeing.

Crop rotation is discussed in great detail in the section above, but essentially involves growing different groups of crops on the same piece of land in successive years. Due to the limited availability of herbicides, stale seedbed is used frequently in lettuce production. Stale seedbed is a technique whereby the planting bed is made early, under dry conditions, water may be applied, and weeds are allowed to germinate and grow. After the first flush of weeds germinates, they are controlled with a total herbicide (glyphosate) or by a flame weeder. For weeds that escape and grow close to the crop, hoeing can be used as a control option. Between row cultivation is an important method of cultivation. This can be done on a regular basis.

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 Lettuce for a listing of herbicides and their application methods.

4.2 DISEASES

Gray Mould

Gray mould (Botrytis cinerea) is a fungus that can affect plants at all stages of growth, although initial infection is often on seedlings in the greenhouse. Seedlings are usually attacked by the

damping off fungus before the gray mould disease occurs. Affected seedlings usually fail to produce a marketable head. Symptoms on field plants begin by rotting at the stem or on lower leaves in contact with soil, and eventually a slimy rot will spread upwards into the head, causing the plant to collapse. A dense fuzzy white to gray mould appears on infected areas and dark, hard sclerotia may also develop. This disease is capable of overwintering in the soil or on plant debris. Damp, moist, humid weather with temperatures of 180C to 230C promote rapid development of fungal growth.

Control:
Seed treated with fungicides, sterile flats and good plant spacing will assist in controlling this disease in a greenhouse. Out in the field, it is best to grow the crop on raised seed beds to increase air movement and reduce disease pressures. If possible, orientate rows in the direction of prevailing winds to assist with adequate air movement. Follow a crop rotation of 3 or 4 years out of susceptible crops and plough down crop refuse promptly after harvest. At first sign of the disease, apply appropriate fungicide. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of fungicides and their application methods.

Lettuce drop
Lettuce drop (White mould or Sclerotinia drop) is caused by the fungus Sclerotinia sclerotiorum. Fields low in disease must be selected, as this has been the most serious production problem in the development of head lettuce as a major crop. One of the most obvious symptoms is the plant appearing wilted and the outer leaves dropping to the ground, while remaining attached to the plant. Symptoms begin on the stem near the soil surface. A severe wet rot develops rapidly and spreads downward to roots and upward through the head. Once the base of the leaf is rotted the leaf wilts, withers and dies. Symptoms successively develop from outer to inner leaves. The head becomes a wet, slimy mass due to the presence of secondary bacterial rots. During wet conditions, a white cottony mould develops on rotted plant parts, especially on the underside of lower leaves. Hard, irregular black sclerotia (pea sized bodies) may occur in the white mould. Wet conditions, during cool weather will promote this disease. The sclerotia overwinter in the soil and on plant debris and are capable of surviving for many years.

Control:
Use row and plant spacing's to encourage good air movement and water drainage or plant on raised beds. Practice a 3 year rotation with non-susceptible crops (grasses, corn, cereals, onions or beets), as sclerotia can persist for many years in the soil. After harvest, disc the field promptly to destroy production of sclerotinia. Overhead irrigation should be avoided where drop is a problem. Monitor the crop on a regular basis to look for the presence or absence of weak, stunted or yellowed plants. If the disease is discovered, apply a fungicide. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of fungicides and their application methods.

Damping Off
Damping Off and other root rots are caused by several fungi, including Pythium, Phytophthora, Rhizoctonia, Fusarium and Penicillium. These diseases are frequent problems in the greenhouse and the field. Seedling emergence may be poor and there may be a sudden collapse and death of seedlings. Damping Off occurs in cool, wet springs when seed emergence is delayed. Soilless mixes can contain high levels of pythium unless properly treated before use. Root rots occur during periods of warm, wet weather and can affect the plant at any growth stage.

Control:
For greenhouse transplants, use treated seed, sterilized flats and soil and maintain good growing conditions. In the field, use raised beds or well drained soils for early seeding or transplanting. Avoid seeding or transplanting into cold, wet soils. At first sign of disease, apply appropriate

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

Downy Mildew

Downy Mildew (Bremia lactucae Regel) is a fungus that is usually only a problem in cool, wet weather. Seedlings or mature plants can be affected with symptoms that first appear on oldest leaves and slowly move toward younger leaves. Yellowish or light-green blotchy areas appear on the upper sides of leaves. A white, downy mould then appears on the undersides of the leaf spots; finally, the affected areas die. The fungus overwinters in crop residue and spores are spread by wind or splashing rain. The optimum temperature for infection is 15ºC – 20ºC and moisture must be on the leaf surface for spore germination to take place. The time from infection to the production of new spores varies from 5-18 days.

Control:

Choose cultivars that are resistant to the disease and follow a 2 to 3 year rotation. Soil inoculums can be reduced by deeply ploughing under infected residue. Soils with a history of downy mildew or are prone to poor air and water drainage, should not be used for early or late lettuce crops. Monitor the crop on a regular basis and look for the presence or absence of yellowish areas on the upper surface and velvet like spores on the undersides of leaves. If disease is discovered, apply a fungicide. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of fungicides and their application methods.

Rhizoctonia Bottom Rot

Rhizoctonia Bottom Rot is caused by the fungus Rhizoctonia solani and is usually seen on mineral soils. Symptoms begin on the lower leaves that are in direct contact with the soil and eventually progress up the head. Rust colored sunken lesions appear on the midrib of the lower leaves, eventually causing a dark brown, slimy decay, if the conditions are warm, moist and humid. Later the head may dry out leaving a dry, mummified plant. Under dry conditions, the lesions enlarge slowly and it may be possible to salvage the crop by removing the outer leaves at harvest. This fungus is capable of living indefinitely in the soil.

Control:

Crop rotation with legumes, cereals or grasses will assist in control of this disease. Grow lettuce on 8 to 15 cm high raised beds for adequate air and water drainage. Plough down crop residue immediately after harvest and avoid planting lettuce on fields with a history of this disease. Monitor the crop on a regular basis and look for the presence or absence of weak, stunted or yellowed plants and rust colored lesions. If the disease is discovered, apply a fungicide. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of fungicides and their application methods.

Aster yellows

Aster yellows (a mycoplasma-like organism) are vectored by the aster leafhopper and symptoms include yellowing and curling on the youngest leaves (the centre leaves). A pink to brown substance will be exuded when the leaves are forcefully straightened. This brown substance may also be seen on the underside of the midribs. At heading, head leaves are dwarfed and curled and heads remain soft. Secondary bacterial rots often follow aster yellows. The pathogen can overwinter in susceptible grains, perennial weeds and ornamentals.

Control:

Use disease free seed when possible. Eliminate weed hosts in field headlands and ditch banks. Do not plant lettuce adjacent to earlier lettuce plantings that contain infected plants. Grain, grass, carrot or celery crops should not be planted close to lettuce, if they are; spray an appropriate insecticide on the crop before disturbing it. Monitor fields for the presence of aster leafhoppers

(Refer to the aster leafhoppers section for more information). Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides to control aster leafhoppers.

Slime
This is a physiological disease of hot, humid weather, often aided by bacteria. The greatest single danger to mature lettuce, it produces a wet, slimy decay on lettuce in the field, in transit or in the market. Usually the large, internal leaves are affected first.

Control:
Aim for a sequence of harvests at optimal maturity by successive sowings. Do not overcrowd plants and avoid overwatering. Harvest as soon as mature, pre-cool heads to 1ºC and keep them cool.

Pink Rib (non pathogenic disorder)
It first appears as a pink discoloration at the base of the mid veins of the lettuce leaves. This discoloration extends throughout the veins of the outer leaves and then extends into the younger leaves. The cause is unknown but high temperatures may be involved since it shows up most during the summer and much less in June, September and October harvests.

Control:
Crisp head lettuce is most affected during hot weather. Avoid July to mid August harvest schedules. Romaine lettuce and leaf lettuce seem to be much less prone to this disorder. Avoid bruising, tight packing and high storage temperatures.

4.3 INSECTS

Aphids
Lettuce aphids (Nasonovia ribisnigri) are small, soft-bodied, slow- moving insects. A colony consists of winged and wingless adults and various sizes of nymphs. Lettuce aphids may be green or pinkish, 2 -3 mm in length and feed on the inner leaves and within the developing heads. The feeding causes cosmetic damage and makes the head unmarketable. Other aphids (black, yellow, pink or green in color) feed on the undersides of leaves and curl or stunt them.

Lettuce root aphids will also feed on the roots thereby stunting the plants especially under dry conditions.

Control:
There are many natural enemies that commonly occur in the field that will feed on aphids, thus helping to reduce the populations of the 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 avoiding a second crop of lettuce in the same field. Destroy and plough under crop residues after harvest, and remove all Ribes plants around the lettuce fields.

Monitor lettuce crops beginning three weeks after seeding. Check the insides of four lettuce heads at 20 pace intervals and treat when one aphid is found. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides and their application methods.

Tarnished Plant Bug
Tarnished plant bugs are small 5 - 6 mm long insects, oval in shape. They are mottled white and yellow with some black marking on the wings. They fly in from nearby hay fields or weedy areas along the margins of fields. Feeding symptoms occur along the main veins of the leaf and appear

as browning along the lesions. Small holes with brown margins are produced, making the heads unmarketable.

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 Lettuce for a listing of insecticides and their application methods.

Cutworms
There are several species of cutworms which may cause occasional problems in lettuce in Nova Scotia, most commonly the variegated cutworm (Peridroma saucia), the black cutworm (Agrotis ipsilon) and the stripped cutworm (Euxoa tessellate). Cutworms have four life stages, adult moth, eggs, larva and pupa. Moths of the variegated cutworm appear in mid July and peak populations occur in early August, while some of the other species occur earlier in the season. Eggs are laid on the foliage and hatch within 5-10 days. The larvae are soft and fat and they curl up when disturbed; this characteristic is a useful aid to use when trying to identify this pest. Variegated cutworm larvae are larger than the other species. Cutworm larvae live in the top 2.5 cm of soil during the day and feed at night. The most damaging stage of the cutworm is the larva and they will eat (or cut) plants off above or below ground level. Most of the cutworm damage is to newly set plants in the field, but they are often found attacking seedlings in beds and greenhouses. Feeding damage is accompanied by large, brown or black droppings on the soil surface.

Control:
Cultural control methods include fall ploughing of sod or early spring ploughing with delayed planting. Field borders should remain weed free and crop rotation is recommended.

Field monitoring is very important with this pest. Cutworms can be monitored with pheromone traps or black-light beginning early in the season. Monitoring will aid in determining the appropriate time to apply biological or chemical control.

Biological control methods include the use of biocontrol agents and microbial insecticides. Biocontrol agents include natural predators, pathogens and parasites, such as the parasitic nematode. The microbial pesticide Bt var. kurstaki, can also be used, but it needs to be ingested by the insect to be effective.

If using chemical control, scout plants frequently and spray at first sign of insect. Scouting is best done when the insects are feeding in the evening. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides and their application methods.

Aster (six-spotted) leafhopper
Aster leafhoppers (Macrosteles quadrilineatus) can carry aster yellows from plant to plant as they feed. They are small (4 mm long), slender, wedge-shaped insects. They are greenish-yellow in color. Once a leafhopper feeds on an infected plant, it will have the pathogen for the rest of its life, and it will spread aster yellows to all the other plants it feeds on. Eight hours of feeding time on an infected plant is required for the insect to acquire the pathogen. After three weeks, they are able to infect other plants. Direct feeding injury of this insect on lettuce is usually of little or no economic importance. This insect can overwinter in the egg stage, but if the winter is harsh with little snow cover, chances of egg survival are low. Aster leafhoppers may also blow in to the area on warm air currents from the USA. Three generations per year are possible in Nova Scotia.

Control:
Use resistant cultivars when possible and plough down crop residues immediately after harvest. Monitor crops on a regular basis by using a sweep net. A threshold number has been developed in Ontario and should be comparative to our growing conditions in Nova Scotia. To determine the

thresholds, multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leaf hoppers carrying aster yellows in your area (4-5% is currently recommended in Ontario). A number of 20-25 for head lettuce and 30-35 for romaine will require prompt treatment from an insecticide. Pest resistance can develop to insecticides so alternate pesticide groups. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides and their application methods.

Cabbage Looper

The cabbage looper (Trichopulsia ni) 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 significant damage to lettuce by chewing holes in the leaves. Cabbage loopers do not overwinter in this region. Adult moths migrate into the region during the summer. Cabbage looper tends to be more problematic during late summer.

Control:

There are many natural enemies that will help control this pest in fields. Ground beetles, spiders, damsel bugs, minute pirate bugs, assassin bugs, big eyed bugs and lacewing larvae will attack 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 of 5% infestation has been reached. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides and their application methods.

Slugs

Slugs exist in various sizes up to 10 cm in length. They eat holes in the leaves of the crop and leave a trail of mucus which makes the plants unsightly.

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 a lettuce crop. 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.

Wireworms

There are several wireworm (Agriotes) species in Canada, but in Nova Scotia, three species are prevalent; A. lineatus, A. obscurus, and A. sputator.

Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about a week and, depending on the species, will live for 1 to 5 years in the ground feeding on roots and seeds. Wireworms require 3 or more years to complete their life cycle. Wireworms of all sizes and ages are present in the soil throughout the year as there is always an overlapping of generations. The wireworms, or larvae, are orange to tan in color. Fully developed larvae may be 1.2 to 4 cm long and have a hard, smooth surface. When a larva is mature, it pupates in the fall. It then becomes an adult beetle and waits until spring to emerge. Wireworms

are often numerous in lands that have been in sod for several years. They are also more abundant in heavy poorly drained soil.

Wireworms are sometimes confused with millipedes. Millipedes have numerous pairs of legs and coil up when disturbed, while wireworms have three pairs of legs near the front of the body and do not coil up.

Control:
Plant treated seed and avoid planting crops highly susceptible to wireworms in a field that has been recently in sod. Wireworm activity can be monitored in the fall or early spring with the use of bait traps. Place whole carrots 7.5 cm deep in the soil at 10 marked locations in the field for 2-3 days. A count of 0.5-1 wireworm per station indicates a potential problem. Prepare fields at least 1 year ahead of planting by using insecticides and cultivation to reduce wireworm numbers. Refer to the AgraPoint Guide to Pest Management for Lettuce for a listing of insecticides and their application methods. It should be noted that chemical control products may not work on all wireworm species.

5.0 HARVESTING AND HANDLING

Harvest lettuce from mid June through to the end of September, in the morning, if possible. Lettuce plants mature at different times, resulting in a harvest every two to three days, depending on moisture and temperature.

Maturity for crisphead or iceberg lettuce is based on head compactness and firmness. A head that can be compressed with moderate hand pressure is ideal. Head lettuce is harvested when heads are well formed and solid. Generally, head lettuce is ready for harvesting 60-70 days after transplanting.

Maturity for romaine or cos lettuce is based on the number of leaves and head development. 30-35 leaves are needed for a mature head.

Harvest leaf lettuce as soon as the plants are large enough. Leaf lettuce is generally ready 30-45 days after transplanting.

Lettuce is handpicked using a sharp knife, the outer layer of leaves is removed and the marketable head is packed into cardboard boxes in the field. When removing leaves, it is important to keep two to three wrapper leaves. Lettuce can also be put into plastic sleeves or wrapped in cellophane before being placed into the box; however this practice is not very common in Nova Scotia. The boxes are then transported to a location for vacuum cooling, where the product is cooled to 10C.

Rapidly removing field heat from lettuce is important as the quality of harvested heads declines at warm temperatures. Without the aid of a vacuum cooler, a commercial lettuce operation will not be successful. Wilting can be reduced by using individual polyethylene head wraps or open-topped bags in the case of leaf lettuce. Wraps should have ventilation holes to prevent the development of injurious atmospheres or water vapor inside the package.

5.1 STORAGE AND CONDITIONING

Rapidly cooled romaine and iceberg lettuce can be stored for 2 to 3 weeks (21 days) at a temperature of 0ºC, and a relative humidity of 98 – 100%, however, quality will start to fade. At 50C, a shelf life of 14 days can be expected, as long as no ethylene is in the environment. Leaf and butterhead types can be kept for 1 to 2 weeks (14 days) in cold storage, but quality will start to fade. A relative humidity of 95% will prevent dehydration during short term storage and shipping. Lettuce is easily damaged by freezing so be sure to keep all parts of the storage room

at or above 00C. Freeze damage appears as dark water-soaked areas that will turn slimy and deteriorate upon thawing.

Avoid storing lettuce with apples, pears, tomatoes or other products that produce ethylene. Lettuce is sensitive to ethylene and damage will result in the form of discolored brown spots (russet spotting) on the midrib.

Controlled atmosphere storage of 1-3% oxygen at 0-50C can benefit romaine lettuce. Dense heads will incur injury if CO2 levels are greater than 5%.

6.0 FOOD SAFETY: A PREREQUISITE TO QUALITY

(Kendra Heffel, Food Safety & Quality Systems Specialist / Auditor, AgraPoint International)

In order to produce high quality lettuce, food safety issues must be addressed; retailers and end consumers demand it. There are several important and simple steps to be taken to ensure the safety of the lettuce crop:

Premises and Production Sites

Ensure that contamination hazards have been addressed such as flooding, past pesticide usage, environmental pollution (soil, air or water) and animal access is restricted as much as possible. A field history should be maintained for each production site, as well as soil test results. Buildings that house product should be clean, have adequate drainage, and have no entry points (i.e. holes, crevices, cracks) for pests. Either a self-managed or third party serviced pest control program may be used, with documentation maintained of pest activity and any chemicals or bait used. Regular inspections must be conducted and documented to prove due diligence and ensure no additional hazards have arose.

Crop Production Materials

If applicable to the crop, ensure, via testing and/or certification letters, that seed is approved and is not contaminated by pathogens. All crop production materials must be purchased and received from approved suppliers. Pesticides must be applied by, or under the supervision of, a licensed operator. Detailed application records must be maintained for all fertilizer, pesticide, compost, mulch and all other soil amendments. Pre-harvest intervals must be met for all pesticide applications. A copy of pesticide labels should be maintained on file for cross-reference with application records. All materials should be stored in a controlled-access location, separate from product and packaging materials, and kept covered, clean and dry. Pesticide containers must be triple rinsed after use, and not used for any other purpose.

Water

Agricultural water is defined as water used for irrigation and the application of pesticides and fertilizers. Agricultural water does not have to be tested, however potential hazards must be identified and addressed (i.e. animal access, upstream contamination, runoff and spills, condition of well). Preventive measures such as buffer zones, level ground, fences and ditches, must be implemented to aid in contamination avoidance.

Water that is used for fluming product, cleaning equipment, and in hygiene facilities, if sourced from a private well, must be tested twice annually (at beginning of season and midway) for total coliforms and E.coli. Producers using municipal water must receive notice if the water source becomes contaminated. If wash water is treated (eg. chlorine), treatment records must be maintained.

Equipment, Cleaning and Maintenance

Calibration procedures and records for equipment such as sprayers, irrigation equipment and spreaders must be maintained. Sprayers should be calibrated at the beginning of each season,

midway through, and anytime maintenance is performed (eg. nozzle replacement). All food contact equipment must be easy to clean, made of non-porous materials and inspected for damaged or loose parts. Cleaning solutions and maintenance materials (eg. lubricants, greases) that may come into contact with product or food-contact surfaces must be food-grade, and stored in designated areas.

Employee Hygiene and Training

Even smaller operations need to ensure their employees receive the proper training and that training is documented. Refresher training in food handling and hygiene practices must be provided at least annually, at the beginning of the production season. Hygiene facilities must be provided for employees and hand-washing signs posted as visual reminders. A visitor policy must also be established that details restricted access areas of buildings.

Sorting, Storing and Traceability

All new and reusable packaging materials must be clean and free of debris and stored separate from product or pesticides. Market ready packaging materials must be food-grade. While sorting, foreign objects must be removed, as well as rotten product and crop debris. Careful attention must be paid, while sorting and storing product, to maintain traceability documentation from the field, row, plot, etc. Product that requires temperature control must be stored in predetermined and monitored environment. Prior to transporting product, vehicles must be inspected for condition and possible hazards to the product. All information about the product leaving the premises must be documented.

Further information is available within select commodity manuals provided by the Canadian Horticultural Council (hgale@hortcouncil.ca) and may be obtained from provincial associations or direct from CHC. Following the guidelines within these manuals will ensure that all possible hazards to the product have been evaluated and assessed. By going one step further, and participating in a third party audit of your On-Farm Food Safety (OFFS) programs, you can provide your customers with the confidence they seek from your operation and products.

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