PEST MANAGEMENT

Integrated Pest Management

Integrated Pest Management (IPM) is the widely accepted system of crop production that effectively manages pests using a combination of tools – cultural, biological or chemical – in ways that are economically and environmentally sound.

IPM programs consider both plant health and pest management while minimizing harmful impacts on the environment. They aim to create conditions that are optimal for the crop and less favourable for pest development. Strong and healthy plants usually have the best chance to resist pests.
IPM programs develop over time. Researchers and extension specialists work to increase knowledge about how pests, plants and the environment affect one another. Farmers and pest management consultants help to create effective IPM programs for specific fields, with good observations and careful record keeping.

Steps in an IPM program are:

1. identifying and understanding the pests and diseases;
2. regular monitoring of crops and weather conditions;
3. deciding when to control pests or apply preventive measures;
4. choosing control methods;
5. evaluating the effectiveness of the program.

Identifying and Understanding the Pests and Diseases

The first step is to properly identify the pest. Use information on how the pest, crop and environment affect one another to help develop a control strategy. Find out what the pest needs to survive, what conditions promote its development and population increase, and if there are any organisms that eat or parasitize the pest.

Understand the pest's life cycle. Most pests and diseases have a developmental stage when control measures are most effective. Try to time control measures with the appropriate susceptible stage. This production guide gives information on the most common pests found on vegetable crops in B.C.

Regular Monitoring

Scout or monitor the crop regularly to check for potential pest problems. This is the best way to know when to apply control measures. If necessary, specimens can be submitted for identification.

The following information should be provided:

- the pests and numbers present, and their stage of development;

- the beneficials present and their numbers;
- the growth stage and vigour of the crop;
- an assessment of crop damage (i.e. % of field affected,random or localized pattern);
- weather and other environmental conditions affecting the crop and pests;
- soil type, irrigation practices; and
- pesticide use history.

Each field should be checked as conditions vary between fields. Monitoring must be done regularly. Start monitoring fields at least once per week early in the growing season. Increase monitoring to twice weekly when pests are more active. Most monitoring for insect and mite pests is done by counting the pests. A 10X hand lens helps to count small pests like mites. Keep good records – this is essential for making the best control decisions and evaluating their effectiveness.

Monitoring can be done by the grower, by an employee or by a hired pest management consultant. In the Fraser Valley, most potato fields are monitored to detect insect pests and diseases.
In general, growers have reduced the number of pesticide applications per season without increased losses due to pest damage. Pest management monitoring services are available for most vegetable crops on a fee basis to Fraser Valley and Vancouver Island growers.

Table 1 Insect pests and damage for crop monitoring.

INSECTS AND DAMAGE	Aphids	Caterpillars	Root Maggots	Leafhoppers	Lygus bugs	Spider Mites	Leafminers	Cutworms	Flea/Leaf Beetles	Thrips	Weevils	Slugs & Snails	Wireworms
Insects on undersides of leaves	✓	✓				✓				✓			
Speckled damage on leaves				✓		✓				✓			
Insects move about in flowers when blown upon					✓					✓			
Insects will fall into a pan when flower stems are tapped					✓					✓			
Damaged flower buds and growing points	✓	✓			✓	✓		✓		✓			
Dark fecal spots on leaves		✓						✓		✓		✓	
Transparent skins on leaves	✓			✓									
Honeydew and sooty mould	✓			✓									
Insects clustered on stems	✓												
Notched leaves		✓							✓		✓	✓	
Holes in leaves		✓						✓	✓			✓	
Slime trails												✓	
Skeltonized leaves		✓										✓	
Webbing		✓				✓							
Tunnels in leaves							✓						
Hiding under boards and plant debris								✓	✓		✓	✓	
Eggs on undersides of leaves		✓				✓		✓					
Holes in roots and tubers			✓					✓	✓		✓		✓
Adults on sticky cards	✓		✓	✓	✓		✓			✓			

Source: BCMAL.

Deciding When to Control

Decide to control pests using the information collected from monitoring combined with the experience of previous years and the prevailing weather conditions. Also consider the crop stage and susceptibility, pesticide restrictions and personal field knowledge. IPM scouts covering a large

number of farms in the same area can also base their advice on the presence or absence of pests or diseases on nearby farms.

Finally, compare the cost of controlling a pest with the economic losses if the pest is not controlled. Ideally, pests are controlled just before they reach a level that causes unacceptable economic damage (economic threshold). However, these thresholds are often site-specific and/or have not been determined for all pests attacking vegetable crops. In these situations, use IPM information and past experiences to make control decisions. For example, simply controlling aphids before they cause significant direct damage to potato crops is not adequate. One must also realize that aphids spread viruses such as potato leaf roll from crop to crop.

Leaf roll severely damages some varieties of potatoes. High levels of aphids and leaf roll in an area also make it impossible to grow certified seed potatoes.

Choosing Control Methods

The different types of control methods used in an IPM system are cultural, biological and chemical. Good cultural and biological methods promote strong plants and provide unsuitable environments for pests. Sometimes pesticides are needed to keep crop losses low.

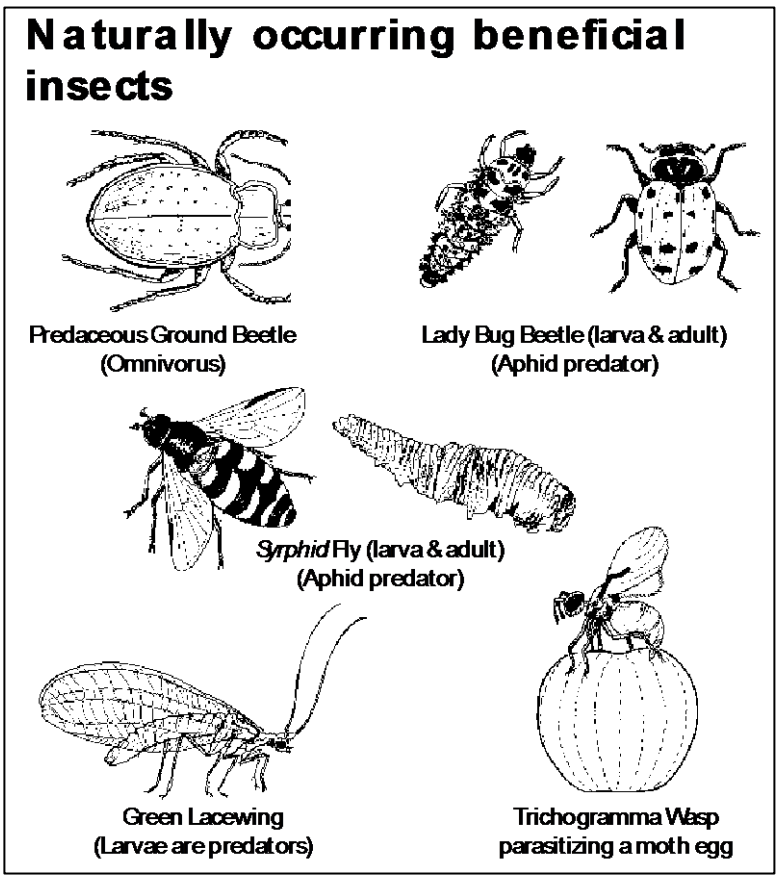
Cultural Control

These methods prevent pests from establishing. They include avoiding sites that are good for pests; selecting varieties resistant to pests; planting cover crops that shelter beneficial insects and compete with weeds and using disease-free seed and/or transplants. Cultural methods such as sanitation, tillage, hand weeding, burning, mowing, turning under crop residue and burying cull piles reduce the incidence and overwintering of pests.

Biological Control

Biological control uses natural enemies to control pests. Natural enemies of insect pests are predators and parasites. These are also called ―beneficials‖.

Predators eat insect pests. Important beneficial predators include ladybeetle adults and larvae, lacewing larvae, syrphid fly larvae, ground beetles and midge larvae.



Parasites live in or on a pest. They weaken and finally kill the pest. Parasites are often very small, but are extremely important in keeping pest populations down. Important pest parasites include Ichneumonid wasps which parasitize caterpillars, and Braconid wasps which parasitize aphids and other pests.

Some microorganisms, such as bacteria and fungi, are important in reducing populations of disease-causing organisms. Healthy soils often have strong populations of ―good‖ microorganisms. Researchers are learning to grow and use the ―good‖ bacteria and fungi for disease management. There are now a few microbial fungicides and insecticides available in Canada.

Monitoring and managing beneficials is an important part of an IPM program. Beneficial insect populations can be enhanced by:

- Releasing beneficials when natural populations are low. For example, ladybeetles and parasitic wasps can be purchased and released to control aphids.
- Providing shelters that attract beneficial insects. For example, building nesting sites for wild pollinators and syrphid flies.
- Applying pesticides only when needed. For example, spraying for carrot rust fly or onion maggot when sticky-trap monitoring indicates their presence rather than on a rigid calendar spray schedule. In general, pesticides will harm beneficials, either by decreasing their food supply, or by killing them outright. The beneficials then take a longer time to build up.
- Timing pesticide applications to have the least impact on beneficial insects. When high populations of beneficials are present, insecticide sprays may not be necessary.

- Choosing pesticides that have the least effect on beneficials and still give pest control. See Table 2 Pesticide Toxicity to Non-Target Organisms.

Chemical Control

This includes the use of pesticides and pheromones. Pesticides should be used as needed in an IPM program rather than on a calendar date. Consider the following when using pesticides:

- **Economics.** Compare the economic benefit expected from the pesticide application with the costs of control. To estimate the benefit of control, predict the crop loss if no pesticide is used. This can be difficult to determine, especially where weather conditions will affect the growth of the pest. The direct costs of a pesticide application include the pesticide; sprayer wear; and labour costs for application and clean-up.
- **Registration.** Make sure the crop and pest are listed on the pesticide label. Use the rate on the pesticide label. Field tests were done to determine the best rate. If you are in doubt about anything you see on the label, contact your local agricultural office or call the manufacturer's 1-800 number on the label for clarification.
- **Effectiveness and pest resistance.** Choose the most effective pesticide. Do not always use the same pesticide. To help prevent pest resistance, alternate pesticides with different group numbers. Use pesticides with different modes of action and only use them when needed. Make sure the rate used kills the pest. Avoid using pesticides that persist in the environment.
- **Impact on the environment.** Pesticides can contaminate surface or groundwater. The risk of leaching is greater with pesticides that are highly soluble in water (above 30 ppm) and with pesticides that break down slowly in the soil.
- **Impact on non-target organisms.** Protect non-target organisms. Use insecticides with low toxicity. When natural enemies of pests are present, do not use broad spectrum insecticides unless there are no alternatives. Some fungicides are also a threat to beneficial insects. See Table 2 for pesticide toxicity to beneficials.
- **Timing pesticide applications.** For the most effective control, base application timing on crop or host plant development, susceptible pest stage, ratio of beneficials to pests, environmental conditions, established threshold levels and required days to harvest interval.
- **Application methods.** Know where the pest is and aim the pesticide application in that area. For example, insecticides applied for control of root maggots should be applied in a high volume at low pressure (drench) to the base of the plants, while fungicides applied for protection against foliar blights should be applied in a lower volume but at higher pressure in order to lightly coat both sides of the leaves. Select and arrange spray nozzles to apply the pesticide at the correct volume and pressure to do the job.

Table 2 Pesticide Toxicity to Non-Target Organisms

INSECTICIDES					
active ingredient	Trade name	predatory mites	predatory insects (beetles & bugs)	parasitic insects (wasps)	bees*
abamectin	Agri-mek	high	moderate-high	high	high
acephate	Orthene	high	high	high	high
Bacillus thuringiensis var. kurstaki	DiPel, Bioprotec, Thuricide	low	low	low	low
carbaryl	Sevin	high	high	high	high
chlorantraniliprole	Coragen	low	low	low	low
chlorpyrifos	Lorsban, Pyrinex, Pyrifos	high	high	high	high
cypermethrin	Mako, UP-Cyde	high	high	high	high
cyromazine	Citation	low	low-high	low	low
deltamethrin	Decis	high	high	high	high
dimethoate	Lagon	high	high	high	high
imidacloprid	Admire, Alias	moderate	high	high	high
kaolin clay	Surround	low	low	low	low
lambda-cyhalothrin	Matador, Silencer	high	high	high	high
malathion	Malathion	moderate-high	high	high	high
methomyl	Lannate	high	high	high	high
naled	Dibrom	high	high	high	high
permethrin	Perm-UP, Pounce	high	high	high	high
potassium salts of fatty acid	Insecticidal soap	moderate-high	moderate-high	moderate-high	low
pymetrozine	Fulfill	low	low	low-moderate	low
spinatoram	Delegate	low-high	low-high	moderate	moderate-high
spinosad	Entrust, Success	moderate	moderate	moderate	moderate
spiromesifen	Oberon	moderate	moderate	low	low
spirotetramat	Movento	moderate	moderate	moderate	moderate
thiamethoxam	Actara	low-moderate	moderate-high	moderate	high

FUNGICIDES					
active ingredient	Trade name	predatory mites	predatory insects	parasitic insects	bees*
azoxystrobin	Quadris	low	low	low	low
Bacillus subtillus	Serenade Max	low	low	low	low
boscalid	Lance, Cantus	low	low	low	low
boscalid+ pyraclostrobin	Pristine	low	low	low	low
Captan	Captan, Maestro	low	low	low	low
chlorothalanil	Bravo, Echo	low	low	low	low
copper sprays	copper sprays	low	low	low	low
cyazofamid	Ranman	low-high	low	low	low
cyprodinil + fludioxonil	Switch	low	moderate	low	moderate
dimethomorph	Forum	low	moderate	no info	low

L = low hazard
M = moderate hazard
H = High hazard
no info = No information found

*Precautions for Bees:
H= do not apply to flowering crops and weeds
M= apply only during late evening or early morning
L = can be used with few precautions with minimum injury to bees

***Note:** Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during reasonably warm weather. High temperatures in the early morning or late evening may extend active foraging by bees and adversly affect bees on treated crops.*

Reference: BCMAL, 2009

Evaluating the Effectiveness of the Program

Keep good records. They help to evaluate IPM programs. Records should include the regular monitoring records plus information gathered on pest control methods, weather, cropping practices and yields. Once the cropping season is over, review this information to decide how to improve the IPM program for the next year.

Weed Management

- Prevent the introduction of new weeds. Use clean certified seed for green manure crops.
- Use only well rotted manure.
- Prevent weeds from setting seed. Many common weeds produce more than 20,000 seeds per plant. Practice total farm weed control by controlling weeds on fence lines, irrigation ditches, farm roads, around yards and buildings and equipment storage areas.
- Practice crop rotation to discourage build-up of specific weeds. Repeated planting of the same crop favours development of insects and diseases. This leads to weak or patchy stands that are easily invaded by weeds.
- Learn to identify weeds, particularly at the seedling stage. Some of the major problem weeds in vegetable crops are illustrated on the next four pages. Know which weeds will and which will not be controlled by various herbicides. For example: hairy nightshade is not controlled by **Sencor**; shepherd's-purse is not controlled by **Bonanza**.
- Apply herbicides at the recommended stage of crop or weed development:

  i) Pre-plant – before seeding.
  ii) Pre-emergence – after planting but before crop or weed emergence.
  iii) Post-emergence – after the crop or weed has emerged.

Herbicides are often more effective on young, rapidly growing weeds. Learn to identify leaf stages. For example: **Poast Ultra** must be applied at the 2-5 leaf stage of barnyard grass for the best control.

- Apply herbicides at moderate temperatures for best results.
- Use the higher label rate on muck (organic) soils when using soil active herbicides (for example: **Lorox L** for carrots).
- Rotate herbicides used on a given crop from year to year, if possible. This will prevent the build-up of weeds that can become tolerant to one chemical.

Crop Injury From Herbicide Residues

Plan your crop rotation. A number of herbicides may remain in the soil and may affect crops in the year following use. Others may be retained and affect crops planted later in the same year. Atrazine and simazine residues following corn or strawberries may be damaging to other crops in the year following use. **Sencor** has injured onions on muck soils planted the year following its use. Check the herbicide label and the crop section of this production guide for such residue injury possibilities.

Spreaders/Wetting Agents

Spreaders (wetting agents, surfactants) are spray adjuvants that are meant to aid in the distribution, coverage and effectiveness of sprays on the plant. Waxy or hairy plant surfaces are difficult to wet with sprays. It is on plants like this that spreaders are of particular benefit. Use the spreader or adjuvant recommended on the label.

Preplant Burndown of Annual Weeds

Aim EC can be used to control labeled annual weeds up to 10 cm tall. It can be used in peas, beans, corn, transplanted fruiting vegetables (eggplant, peppers, tomatoes), transplanted cucurbit vegetables

and potatoes. It must be used with **Agral 90**, **Ag-Surf** or **Merge** adjuvants. See label for directions.

Preplow Cleanup of Perennial Weeds

Clean up of quackgrass, Canada thistle, curled dock and other persistent perennial weeds prior to planting of most crops is recommended. Cultivation the previous season during late summer and fall can be effective in dry weather. Herbicides may also be used. See Table 3, Glyphosate Products for Pre-plow Cleanup of Perennial Weeds.

Table 3 Glyphosate Products for Pre-plow Cleanup of Perennial Weeds

Product	Rate	Weeds Controlled	Comments
Registered **pre-plow** prior to all crops			
Touchdown Total (glyphosate)	1.8 to 5.0 L/ha (0.7 to 2.0 L/acre)	• Canada thistle • Perennial sow thistle (bud stage) • Quackgrass (at least 5 to 5 green leaves and actively growing).	• Is inactivated by soil contact, so is not residual. • Very effective on many perennial weeds. • Excess water will result in run-off and reduced control. • Allow 7 to 10 days before cultivating • See label for weeds, growth stages, rates and amounts of water
	5.0 to 8.6 L/ha (2.0 to 3.5 L/acre)	• Field bindweed & dock species	
Credit 45 (glyphosate)	2.0 to 5.6 L/ha (0.8 to 2.3 L/acre)	• Canada thistle • Perennial sow thistle (bud stage) • Quackgrass (at least 5 to 5 green leaves and actively growing).	
	5.6 to 9.6 L/ha (2.3 to 3.9 L/acre)	• Field Bindweed and dock species	
Weedmaster Glyphosate 41 (glyphosate)	2.5 to 7.0 L/ha (1.0 to 2.8 L/acre)	• Canada thistle • Perennial sow thistle (bud stage) • Quackgrass (at least 5 to 5 green leaves and actively growing).	
	7 to 12 L/ha (2.8 to 4.8 L/acre)	• Field Bindweed and dock species	
Roundup WeatherMAX (glyphosate)	1.67 to 4.67 L/ha (0.68 to 1.89 L/acre)	• Canada thistle • Perennial sow thistle (bud stage) • Quackgrass (at least 5 to 5 green leaves and actively growing).	
	4.67 to 8 L/ha (1.89 to 3.2 L/acre)	• Field Bindweed and dock species	

Stale Seed-Bed Technique

Method – Prepare a smooth, uniform, seedbed. Leave 4 to 7 days so that weeds germinate well before the crop. Seed without further cultivation, and prior to crop emergence use:

Apply **Beloukha (500 g/L)** as a burndown for seedbed preparation at least 3 days before the crop emerges. See label for application details. **Beloukha** leaves no harmful residue in the soil. For control of common amaranath, shepherd's purse, common lambsquarters, small flower galinsoga, wild chamomile, plantain, common purslane, common groundsel, black nightshade, common chickweed. Provides suppression for field bindweed, Canada horseweed and dandelion. Registered for Crop group 8-09 Fruiting vegetables (except cucurbits); Crop group 9 Cucurbit vegetables; Crop Group 1 Root and tuber vegetables; Crop group 6 Legume vegetables (succulent).

Or **Ignite I5SN** at 2.7 to 5.0 L/ha (1.1 to 2.0 L/acre) in 110 to 330 L/ha (44 to 132 L/acre) of water for control of lamb's-quarters, stinkweed, wild mustard, green foxtail, chickweed and redroot pigweed. Use prior to seeding asparagus, carrots, lettuce and onions or prior to ground crack in potatoes. Use the 4.0 L/ha (1.6 L/acre) rate for pigweed. Apply at a higher rate of 4.0 to 5.0 L/ha (1.6 to 2.0 L/acre) for dandelion, oak-leaved goosefoot and wild buckwheat.

Prior to planting: See Table 4, Glyphosate Products for Annual Weed Control Prior to Planting.

Table 4 Glyphosate Products for Annual Weed Control Prior to Planting

Product	Rate	Comments
Touchdown Total (glyphosate)	0.50 to 2.5 L/ha (0.20 to 1.0 L/acre)	• Use low rate for annual broadleaf and grassy weeds under 8 cm high • Increase rate for grassy weeds up to 15 cm high or for difficult to control broadleaf weeds such as shepherd's purse or annual sow thistle. • See label for weeds, growth stages, rates and amounts of water
Credit 45 (glyphosate)	0.6 to 2.8 L/ha (0.2 to 1.1 L/acre)	
Weedmaster Glyphosate 41 (glyphosate)	0.75 to 3.5 L/ha (0.30 to 1.4 L/acre)	
Roundup WeatherMAX (glyphosate)	0.5 to 2.33 L/ha (0.2 to 0.94 L/acre)	

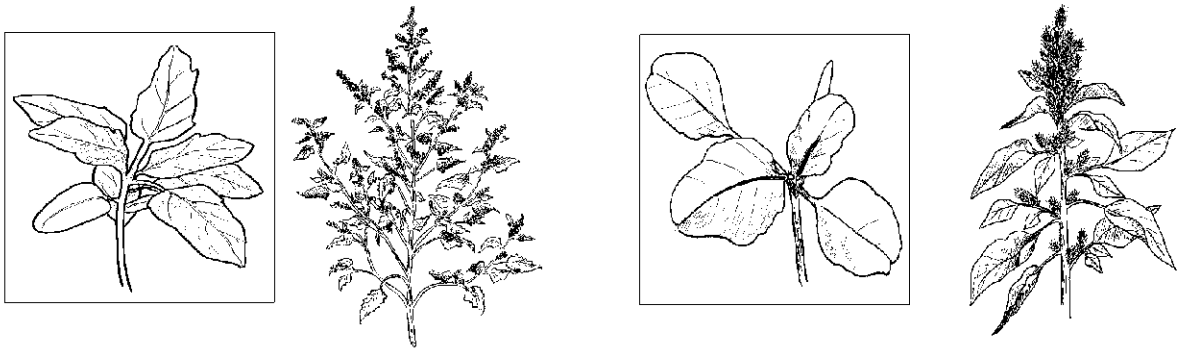
Preplant Soil Incorporation of Herbicides

Some herbicides must be incorporated in the soil to be effective. Thorough incorporation is essential for good weed control but this incorporation must distribute spray drops or granules evenly. If ground is hard and lumpy it should first be cultivated to form an even, clod-free surface before treatment. With most herbicides it is best to incorporate them shortly after application. Soils should be trash free for best results.

Rotovators, if used, should be rotated at speeds high enough to thoroughly mix the soil. Disc type implements, especially tandem discs provide the deepest incorporation. Set at 10 to 15 cm they incorporate 7 to 10 cm; set at 7 to 10 cm they incorporate 5 to 7 cm. Discs should operate at a forward speed of 9 to 11 km/h to mix soil properly. Incorporation is more thorough if discs are run over the field twice (the second pass at right angles to the first).

Tine type implements do not give deep incorporation but will mix the surface layer evenly. Spike tooth harrows give even incorporation at shallow depths in trash free soil but should be run over the field twice (the second pass at right angles) for best results.

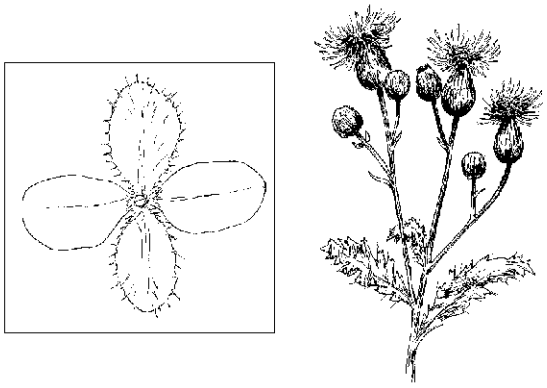
Some Common Weeds in Vegetable Crops



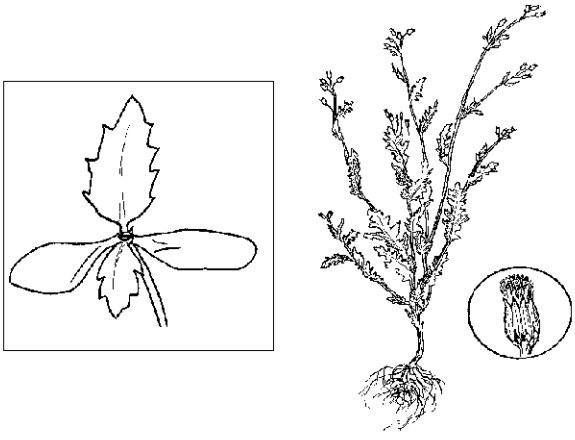
Lamb's-Quarters

Redroot Pigweed

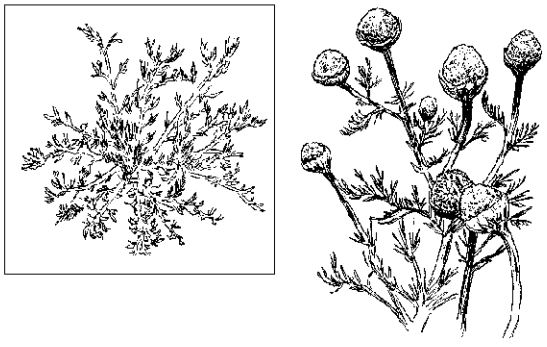
Sheep Sorrel



Canada Thistle

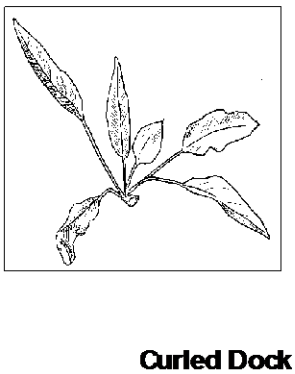


Common Groundsel

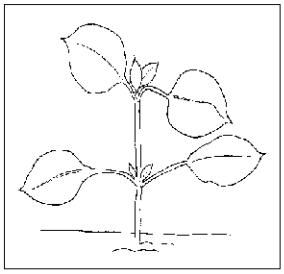


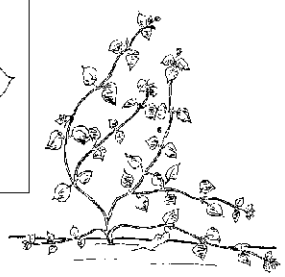
Pineappleweed

Some Common Weeds (cont'd)

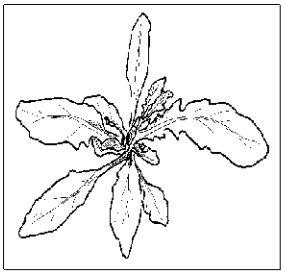


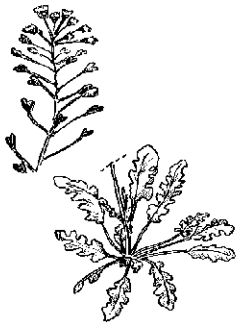
Curled Dock



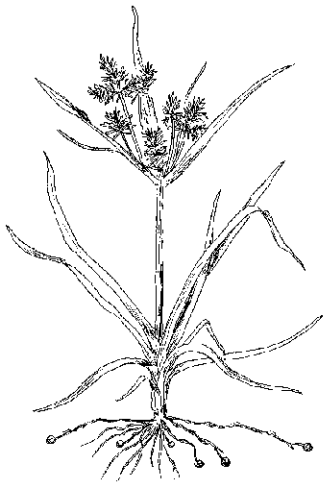


Chickweed

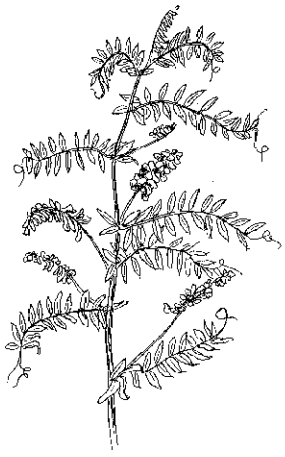




Shepherd's-Purse

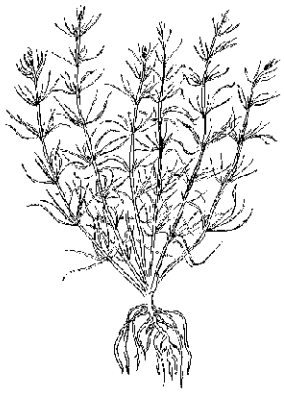


Yellow Nutsedge



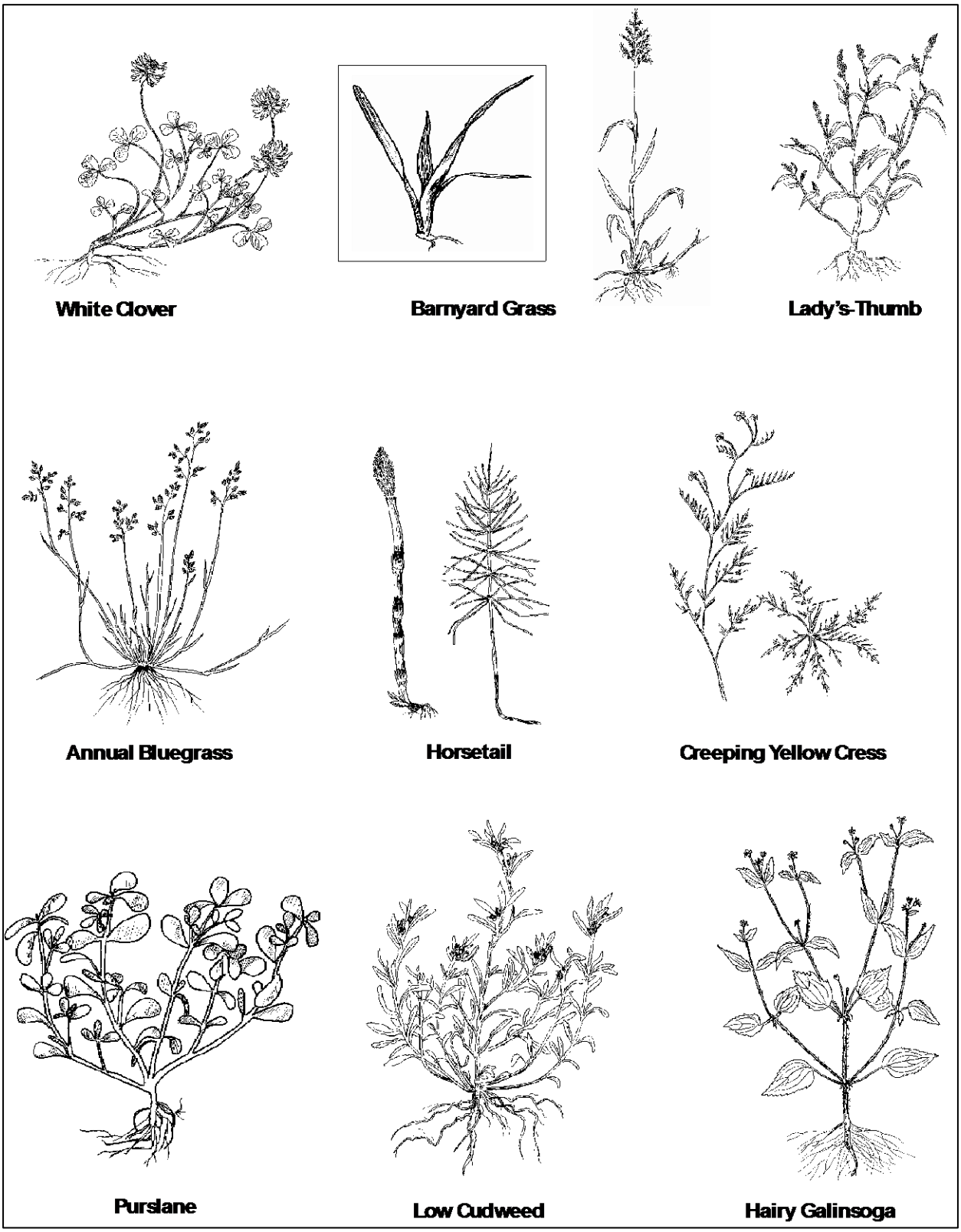
Vetch

Hairy Nightshade



Corn Spurry

Some Common Weeds (cont'd)



Bee Poisoning

Pollinating insects, including honeybees and a variety of wild bees are essential for the production of cucumbers, marrow, melons, pumpkins and squash. Without their presence, cross-pollination does not take place, resulting in low seed and fruit set. Crops grown for seed production depend even more on the abundance of pollinating insects. It is in the grower's interest to protect beneficial insects, including pollinators.

The outbreak of an insect pest may require the use of insecticides. Some of these insecticides may harm the pollinator population. Honeybee poisoning occurs when foraging bees contact contaminated blossoms. Bees may also be killed when collecting water from contaminated sources or when flying through pesticide mists during applications. Growers can take simple management steps to reduce the risk of bee poisoning. Of most concern is the application of insecticides to sweet corn for the prevention of earworm and the application of insecticide to broccoli when a portion of the field is in bloom, thus attracting foraging bees.

The effect an insecticide has on pollinators depends on the type of insecticide used, its formulation, time of application, weather conditions and the percentage of crop bloom available to the bees. The following are a few points to consider in the prevention of bee poisoning.

- Do not spray any flowering crop on which bees are foraging. If insecticides must be applied, spray in the evening, at night or early morning when bees are not foraging. Bees usually do not forage at temperatures under 13°C.
- ***Note:*** *Even newer, lower toxicity pesticides can be harmful to bees if they are sprayed directly.*
- When it is necessary to apply an insecticide during blooming season, notify neighbouring beekeepers before the insecticide is applied.
- Do not apply insecticides on windy days. A lot of the insecticide is wasted when carried away by the wind, and the drift may cause poisoning of nearby colonies.
- Ground applications are generally less hazardous than aircraft applications.
- Where there is a choice of product, choose the formulation least hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.

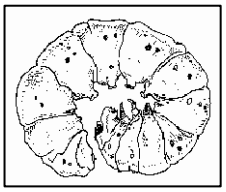
Note: *Most organophosphate and carbamate insecticides are highly toxic to bees. Please read labels before use. Insecticides registered for use in vegetable production and toxic to bees are listed in Table 5, Relative Toxicity of Insecticides to Honeybees.*

Table 5 Relative Toxicity of Insecticides to Honeybees

Group 1 Very toxic. Do not apply to flowering crops or weeds.	
Pounce	permethrin
Dibrom	naled
Lagon	dimethoate
Lannate	methomyl
Lorsban, Pyrinex	chlorpyrifos
Malathion	malathion
Mako	cypermethrin
Sevin	carbaryl
Group 2 Toxic. Apply only during late evening or early morning. See note below.	
Decis	deltamethrin
Matador	cyhalothrin-lambda

Note: *Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during reasonably warm weather. High temperatures in the early morning or late evening may extend active foraging by bees and adversely affect bees on treated crops.*

General Pests



Cutworms

Host

A broad range of vegetable crops.

Damage

Infestations are spotty in the field. Damage is generally not detected until larvae are partially grown. Plants may be chewed off above or below ground and may be damaged higher up by climbing cutworms. Complete defoliation can occur.

Identification

If cutworm damage is suspected, but no caterpillars are visible on the plant; brush the soil surface at the base of the plant to expose cutworms.

Adult. The adult moth is thick-bodied, dull coloured about 2 cm long. In the resting position, the wings are folded horizontally and the moth appears somewhat triangular. Moths fly at dusk or on dull days and feed on plant nectar.

Larvae. Cutworms are dull coloured, (blackish, gray, or brown), and fleshy with shiny heads. When mature, the caterpillars are up to 5 cm long, and curl up when disturbed. Cutworms usually feed at night and spend the daylight hours in the soil at the base of the plant.

Life History

There may be one or two generations a year. Cutworms overwinter as eggs, pupae, or partly grown larvae. Pupation occurs in the soil.

Monitoring

Traps, baited with pheromone, are available. The traps attract and capture male cutworm moths. Trap catches indicate the presence of moths, and from those catches the presence of cutworms can be anticipated. No threshold numbers have been established.

Control

Treat infested areas when damage is first noticed to discourage infestations from spreading. Apply insecticides on a warm evening, so that night feeding larvae are exposed to freshly treated foliage when they are more active. Larvae remain in the soil when not feeding.

In fields where cutworms are known to be a problem use:

Lorsban 4E or **Lorsban NT** or **Pyrinex 480 EC** at 2.4 L/ha (1.0 L/acre) as a preplant soil treatment (check label for registered crops). May be used at 4.8 L/ha (1.9 L/acre) for bulb onions and carrots if the top 1 cm of the soil is dry. Apply 3 to 7 days before transplanting/ planting. Do not incorporate. Application should also be made to a 15 m strip into nearby fence rows. Check the label for days to harvest intervals for specific crops.

If a cutworm infestation develops after planting, use:

Lorsban 4E or **Lorsban NT** or **Pyrinex 480 EC** at 1.2 to 2.4 L/ha (0.5 to 1.0 L/acre) or in 200 to 400 L/ha (81 to 162 L/acre) of water at the seedling (2 to 5 leaf) stage when damage first appears (check label for registered crops). Best results are obtained when the application is made during the afternoon or early evening. Check the label for days to harvest intervals for specific crops.

Or **Pounce EC** at 180 to 390 mL/ha (70 to 160 mL/acre) depending on size of cutworms. (Check label for registered crops.)

Or **Mako** at 175 mL/ha (70 mL/acre). Check label for registered crops and days to harvest interval.

Or **Sevin XLR**. Consult product label for rates on specific crops. Sevin has generally been less effective than **Lorsban** or **Pounce** in controlling cutworms. Use enough water to wet the soil around the base of each plant. Spray on a warm evening.

Note: *Before using one of the above insecticides on a particular vegetable crop, make sure that it is registered for use on that crop and allow the required number of days between last application and harvest.*

Grasshoppers (Interior)

Hosts

A broad range of vegetable crops.

Damage

Chewed-off foliage has ragged edges. Holes are apparent in exposed upper leaves. Vegetables may be attacked by young wingless grasshoppers in May or June. Winged grasshoppers feed from mid-summer until fall.

Identification

Adults. Grasshoppers are up to 6.5 cm long, hard-bodied, winged, and with a pair of long well-developed jumping legs.

Nymphs. The immature stages resemble adults, but are wingless.

Life History

There is one generation a year. In some areas of Central and Northern B.C. there is one generation every two years. The most important species overwinter as eggs in soil. Eggs are laid in pods, up to 100 eggs are glued together with foam which hardens into a protective cover. Some species lay egg pods at random, others lay in concentrated areas called beds. Eggs hatch in May or early June. Nymphs molt five times and reach the adult stage in July or August. Dry weather in the early fall favours egg laying.

Monitoring

The known habitats where grasshoppers hatch should be watched closely in the spring to determine when nymphs appear.

Control

Insecticides are most effective when the bulk of the grasshopper population is at the 3 to 4 instar stage. Species hatched from beds should be controlled before they migrate. Eggs and active stages are attacked by parasites and predators. In some years diseases markedly reduce populations of nymphs and adults.

Sevin XLR at 1.25 to 2.5 L/ha (0.5 to 1.0 L/acre). Spray when grasshoppers are small for best results. See label for water volume directions.

Nolo Bait is also registered for suppression of grasshoppers, and is approved for use in organics.

Lagon 480 is registered for other vegetable pests, and may also control grasshoppers.

Leafminers

Most leafminers seen in vegetables are flies (*Diptera*).

Hosts

Beets, chard, spinach, and certain weeds including lamb's quarters, chickweed and nightshade. In the Cloverdale area, leafminers have also infested onion and celery leaves.

Damage

Colourless blotches with a silvery overcast and tunnels are formed by the larvae mining between the surfaces of the leaves. This makes leaf crops unmarketable. Heavy infestations stunt growth.

Identification

Adults. A gray/black fly, 4 mm long, with a yellow triangular spot on its back. They are frequently seen hovering over the host plants.

Larvae. The small green or white maggots (up to 3.5 mm) feed inside the leaves, forming tunnels and blotches.

Life History

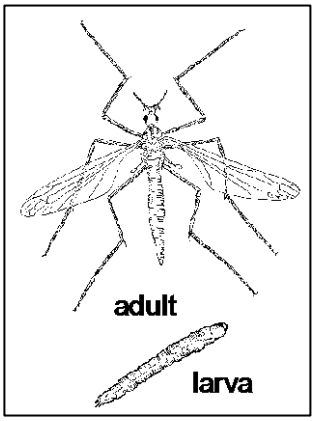
There are several generations a year. Pupae overwinter in the soil. Flies lay eggs on the undersides of the leaves. Larvae enter the leaves, feed until mature, then drop to the ground, pupate, and emerge as flies.

Monitoring

The flies are attracted to the yellow sticky traps used in carrot fields to monitor carrot rust flies.

Control

Early in the season infestations may be suppressed by destroying infested crop residues and weeds. Control measures are not likely needed in crops such as dry bulb onions and topped beets where the leaves are not marketed. This pest should be controlled in celery and lettuce to avoid mines in leaves that will be on the marketable part of the plant. If an onion field is next to a celery field, it may be necessary to spray a strip of the onions next to the celery to avoid pest migration into the celery crop. In fields where the leafminer occurred the previous year, it will be present early in the growing season, as it overwinters in the soil. Products recommended for control of aphids or onion maggots will also control leafminers.



Leatherjackets (Coastal Area)

Hosts

Strawberry, grasses, most vegetables.

Damage

Larvae feed on the roots, crown and leaves of plants. In new plantings, transplants can be cut at soil level as occurs with cutworms. Damage is most severe in March, April and May. Populations are highest in damp or heavy soils. Leatherjackets prefer feeding on grass, so they are normally only a problem in new fields which were in grass the previous September.

Identification

Larvae. Leatherjackets are the larvae of crane flies. The larvae have a tough, grey skin. They are about 3 cm long when mature.

Pupae. Elongate and brown with rows of spines along the top and bottom surfaces. The back end is pointed. Empty pupal cases can be seen at the surface of the soil after crane fly emergence.

Adult. A large, slender, long-legged, brown fly (crane fly) about 2 cm long.

Life History

The European marsh crane fly, the main pest species, lays eggs during September. Larvae (about 3 mm long) hatch from these eggs within two weeks. The leatherjackets are present until the next year in June, growing to 2.5 to 3 cm long.

Monitoring

The presence of leatherjackets in a field can be determined by treating grassy or weedy areas with a soap solution as a drench to the soil. Use about 250 mL of this solution for each 30 cm x 30 cm test area. This irritates the leatherjackets causing them to wriggle to the surface where they can be counted. Ten to 15 sites in a field should be sampled.

Management

Cultural control

Control weeds especially in fall, winter and early spring.

Lygus bugs (Tarnished Plant Bug)

Hosts

Strawberry, raspberry, weeds, clover and vegetable crops.

Damage

Adults and nymphs feed by sucking sap from the growing tips of plants causing tiny seedlings to die. Feeding can cause young plants such as cabbage to go blind (no heads formed), and blemishes to form on developing fruit. Blemishes are often described as —cat-facing‖ or —monkey-facing‖.

Identification

Nymphs. Look like large, green aphids. Unlike aphids, they are very fast moving.

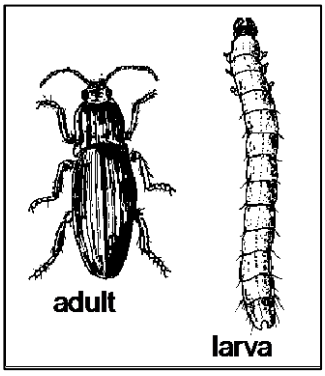
Adults. Shield-shaped, flattened bugs about 6 mm in length. They are a mottled brownish colour with a characteristic white V-shaped pattern on their back. They quickly run or fly when disturbed.

Monitoring

Start monitoring in the spring. To monitor fields, walk slowly through the field and randomly select plants to inspect for lygus. At each plant, look for adults and nymphs on the leaves. Be especially alert monitoring fields located beside hay fields. When the hay is cut and begins to wilt; lygus bugs are forced to find new feeding areas, and will often move into vegetable fields. Yellow sticky cards will catch lygus bugs and support visual monitoring. Flower/foliage tapping onto a white page will dislodge lygus nymphs and adults.

Management

Good weed control within and adjacent to crops will help keep lygus bugs at a low level. Be sure to destroy weeds when lygus are still in the nymph stage and cannot fly. Spray seedlings when lygus bugs are first detected. Other insecticides applied for root maggots, loopers and flea beetles will also control lygus bugs.



Wireworms

Hosts

Grasses and cereal crops are preferred hosts, but will feed on most vegetable, small fruit, tree fruit or ornamental crops.

Damage

Wireworms generally build up to high levels in pasture or fields with longstanding established grass or sod. When these areas are plowed, wireworm larvae, which live for 3 to 4 years, stay in the soil and attack the newly planted crop. They bore into seeds or underground stems of seedlings and transplants, causing the tops to show stunting and abnormal growth or shriveling. Tops remain attached to their roots. In heavy infestations, they will greatly reduce the yield and render root crops and potatoes unmarketable. Wireworm damage can continue for years depending on the crops and rotational practices in the field.

Identification

Larvae. Wireworms are yellowish-brown, shiny, slender, hard-bodied worms 3 to 25 mm long, which bore into seeds and seedlings and destroy them. In the Lower Fraser Valley, most of the damage is caused by two species of introduced European wireworms. They have two dark spots (like eyes) at the pointed (head) end of the body. Other species occur in other parts of British Columbia, but the life cycle and damage is similar.

Adults. Adults are click beetles. They are about 1 cm long and a dark brown or black colour. They are called click beetles because of the clicking sound made when flipping over from their back to their feet.

Life History

The European wireworm life cycle begins with overwintered adult click beetles, which emerge from the soil in March or April, and lay eggs for up to 3 months. Eggs are deposited in the soil, normally near a preferred host such as sod or cereal crops. Within about 6 weeks, the eggs hatch into small larvae. After 3 or 4 years, these larvae become pupae and then adults, usually in August. These adults remain in the soil over the winter and emerge to deposit eggs in the following spring.

Monitoring

It is very difficult to control wireworms once they are feeding on the roots. It is important to determine the presence of wireworms and plan to manage them before planting a susceptible crop. Before planting, use baits of whole wheat flour to find out if wireworms are present. To do this, place 30 g of flour at a depth of 10 cm in the soil using a hand corn planter or a shovel. Mark the location of each bait with a stake. Bury 30 –50 baits per hectare (12 to 20 baits per acre) for an accurate reading. Four days later, dig and examine the baits for wireworms. An average of one or more wireworms per bait can cause severe damage to susceptible crops such as corn or potatoes.

Alternatively, dig a 12 cm diameter hole about 2.5 cm deep and evenly spread about 100 seeds of wheat, oats, barley or fall rye in the hole and cover with soil. A 12 cm diameter open coffee can pushed into the ground can be used to remove soil for planting. Locations can be marked with a flagged wire in the centre. After about one week, a 15 cm diameter coffee can can be centered over the planted area and 5-8 cm of soil removed and sorted for wireworms. If the seed has not germinated, it is too cool to obtain an accurate sample. Use 30 to 50 bait stations per hectare (12 to 20 per acre). An average of one or more wireworms per bait can cause severe damage.

The best time to bait in the Fraser Valley is in April and May. This is when most wireworms are near the soil surface. After May, wireworms are deeper in the soil and baits become less effective. As a result, wireworm numbers may be higher than the bait results show. In the Interior, wireworms can descend to a depth of 60 cm in the fall and not return to near the surface until the soil warms up

sometime in May. Wait until this time to bait as earlier attempts may indicate a lower population than actually exists.

Management

Wireworms take 3 to 4 years to mature, so infested fields can remain a problem for several years. Fields adjoining an infested field should be checked before planting. The natural habitat of wireworms is sod, and populations increase under these conditions.

Biological Control

When fields are ploughed or disced, wireworms are often brought to the surface and eaten by birds such as crows, and seagulls. However, this does not give adequate control.

Nematodes

Hosts

A wide range of crops.

Damage

Their feeding on the roots greatly reduces plant stand and vigour. In the case of root crops such as carrots, they decrease yields and downgrade the quality of the produce.

Identification

Nematodes are microscopic worms invisible without magnification. Because they cannot be seen, poor plant vigour caused by high nematode levels is frequently blamed on other causes such as poor soil fertility, drought, insects or diseases.

Monitoring

Always sample areas for nematodes where susceptible crops are to be planted. Nematodes tend to be very spotty in their distribution in a field, making it very difficult to collect a representative soil sample. For this reason, careful sampling is of extreme importance if harmful nematodes are to be detected. Contact the laboratory that will be processing the samples prior to collecting them for instructions on sampling techniques.

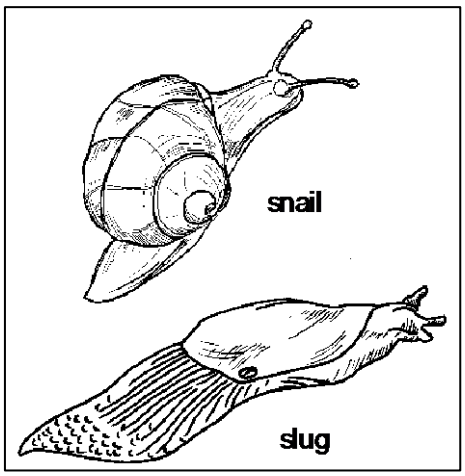
Management

Nematodes are usually spread by planting contaminated stock or by moving contaminated equipment (with adhering soil) from an infested field to a clean one. Practice good weed control to help prevent nematodes from building up in established plantings.

Most nematodes are most efficiently controlled by soil fumigation. Treatment is best done in late August or early September. Soils should be loose and friable to a 20 cm depth, and free of clods,

lumps and crop debris. Avoid treating extremely wet or dry soils. Temperatures should not be lower than 10°C at depth of injection. Nematicides are normally injected by a chisel applicator at a 20 cm depth with chisels set 20 to 25 cm apart. The soil must be sealed immediately after fumigation to prevent rapid escape of the gas. Sealing can be done either by packing the soil with a cultipacker, roller, float, or by sprinkling the surface with 1 cm of water.

See Planting section of this guide (Soil Fumigation) for product information.



Slugs and Snails

Hosts

Most vegetable crops.

Damage

Slugs are usually only a problem in wet seasons. Occasionally they climb up into the plants and feed on leaves. They eat holes in leaves and leave a trail of mucus, which makes the plants unsightly. Snails tend to be less of a problem.

Identification

Slugs are slow-moving, soft-bodied, slimy, legless creatures. They are black, grey, brown or olive green in colour, and do not have a shell. Slugs are 3 to 4 mm when hatched, and grow up to 10 cm in length, depending on species. Snails have shells.

Life History

Slugs overwinter in protected places in all life stages — eggs, immatures and matures. Immatures and matures can freeze to death in severely cold winters. They become active in early spring. Slugs are usually active only at night and on rainy days. During warm sunny days they hide in cool, shady places such as cracks in the soil, and among dead leaves on the ground.

Monitoring

Watch for activity to begin in spring — usually in April or May. To find out when activity starts, mark 10 to 20 plants or weed patches and put 1 tablespoonful of **metaldehyde** slug bait on the

ground. Slime trails and dead or dying slugs and snails will be seen in 1 to 4 days if they are present and active.

Management

Control weeds and keep cover crops mowed as tall grasses and weeds provide protection and may attract these pests.

Where slugs may be a problem, treatment should be applied before planting or while plants are in the seedling stage. When conditions are dry, apply in the evening or at the base of plants or to the headlands, metaldehyde (**Deadline M-PS**) or ferric phosphate (**Sluggo Professional**, **Ferramol** or **Slug & Snail Bait II**) at labeled rates. Avoid direct application to plants. Rain, irrigation or excessive dew will cause the bait to mold and the active ingredient to leach out. It may be necessary to make several applications of the bait to control these pests.

Field mice (voles)

Hosts

Potatoes, carrots and other roots crops.

Damage

Field mice numbers can fluctuate widely, but when numerous they can cause severe damage. Mice injury is usually associated with high grass and weed growth within or beside field plantings. In addition to damaging root crops, they can also damage above-ground plant parts.

Identification

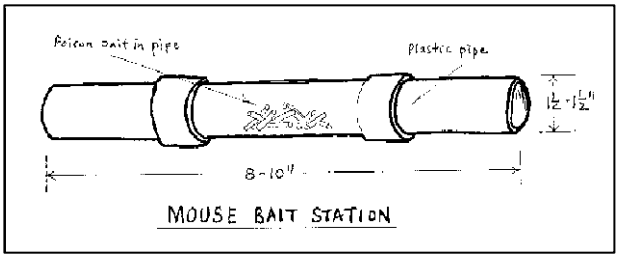
Field mice, also known as voles, are small rodents (about 13 to 23 cm long) with small, furry ears, blunt snouts, and relatively short tails. Do not confuse field mice or voles with moles. Moles are not rodents but are burrowing mammals that eat mainly insects and earth worms, not plants. Mole activity can be recognized by the earth mounds left in lawns and pastures.

Monitoring

Watch for holes in the soil near plants. These are signs of field mouse activity.

Management

A combination of cultural control methods and poison baits may be needed to achieve satisfactory control.



Cultural Control Methods – Remove tall weeds and grasses, brush piles and other trash from around plants, from ditches, fields, along fence rows, around buildings and other places where mice congregate. These provide protection from predators and are breeding sites for mice. Removing this material helps keep mice out of the area and prevents their numbers from increasing.
Herbicide and/or frequent close mowing does as much or more to keep mice under control as poison baits. Therefore, preventive control is the primary method of control.
Trapping of field mice is seldom effective.

Poison Baits – If preventive control measures alone are not adequate, poison baits (rodenticides) may be necessary. Use covered bait stations to both protect the bait from the weather and to prevent accidental poisoning of other animals. Bait stations can easily be built (from pieces of plastic pipe or wood, etc.) or may be purchased commercially. Place bait stations in areas where mice are likely to be found, e.g. near bushes, fences, brush piles and high grass.

For further information regarding best management practices regarding rodent control consult — Agriculture - IPM Practices for Rodents (gov.bc.ca)

Moles (Coast and Lower Mainland)

Identification

Moles are small dark grayish mammals up to 20 cm long. They burrow underground and leave hills and ridges of soil. Their main food is earthworms and a few other insect grubs. Although they do not eat plant roots, their burrowing can do considerable damage to underground plant structures, particularly when infestations are heavy.

Management

Trapping with English scissor traps is the best control method. Trapping is best done from November to March but can be done throughout the year. Trap only in runways that are in use. To find out if runways are in use, stamp down on the mounds and runways and check if they are re-established.

Pocket gophers (Interior)

Identification

Pocket gophers are burrowing rodents and can cause severe damage by feeding on roots. They live in underground burrows. Excavated earth is pushed to the surface in small mounds.

Management

Use a hand-probe when infestation is light or as a clean-up operation between burrow-builder treatments. Probe opposite and about 30 cm from the V-shaped indentation on the side of a mound. The probe will drop about 10 to 20 cm when a burrow has been located.

Alternatively, use a burrow builder machine and form a burrow at a depth of 20 – 40 cm.

Apply:

> zinc phosphide 2% (**ZP Rodent Bait, Rodent Pellets**) at 15 g per probe hole, or **Burrow Oat Bait** at 3.3 kg/ha (1.3 kg/acre).

Traps

Use pocket gopher traps (Victor wire or California Pocket Gopher Traps) where infestations are light or in areas where poisons cannot be used.

See publications —Rodent Control on Agricultural Land in British Columbia: Central and Southern Interior‖ and —The Design and Use of a Home-Made Hand Probe.‖

Damping-off

This disease takes several forms. Seeds rot in the soil, the seedling dies before it comes up or the seedling topples over after emerging from the soil. Stem tissues at the soil-line become water-soaked and brown or black with shriveling of affected tissues following. Wirestem of cabbage is a form of damping-off, but seedlings do not fall over in this case.

Control

- Fumigate soil with **Vapam** (see Soil Fumigation, Planting section of this guide), or use captan thoroughly mixed in the soil according to the label recommendations.
- Use treated seed. See Planting section of this guide.
- Provide good ventilation.
- Water in the morning.
- Don't sow seeds too thickly.
- Keep humidity low.

If damping-off appears and captan was not already incorporated in the seed-bed, it may be applied as a drench to the surface. Use approximately 1/5 of the quantity recommended on the label for incorporation per m^2 of seed-bed. In the case of celery seed-beds, **Thiram 75 WP** may also be used in this way.

Tomato Spotted Wilt (TSWV), **and Impatiens Necrotic Spot Virus** (INSV)

These two related viruses often infect greenhouse crops in B.C. Thrips can spread these viruses to a wide range of plants including field-grown vegetables such as beans, cauliflower, celery, eggplant, endive, lettuce, pea, pepper, potato, radish, spinach, and tomato. Symptoms include stunting, twisting, leaf yellowing, brown leaf and stem lesions, and ringspots on leaves or fruit. Infected crops produce lower yields and quality may be reduced. They are not believed to be seed-borne. Infected greenhouse flower crops may be sources of the virus which thrips may spread to transplants or nearby field vegetables. Certain weeds (chickweed, bull thistle, black medic and clover) are also potential sources of the virus.

Control

There is no cure for TSWV or INSV. Use the following preventive measures:

- Buy healthy transplants from a reputable source.
- Do not produce vegetable transplants near flower crops.
- Control weeds and thrips.

Contact your district agriculture office for further information. Submit suspicious samples to the BCAGRI Plant Diagnostic Laboratory at Abbotsford.

Finding Pesticide Labels on the Internet

Pesticide labels provide important information on the crops and pests that the pesticide can be used on, the amount of pesticide that can be used, how to best use the pesticide, safety precautions for applicators and workers, as well as special environmental protection actions. Pesticide applicators are required, by law, to follow directions on the pesticide label.

The labels of all pesticides registered for use in Canada are on Health Canada's Pest Management Regulatory Agency (PMRA) website at the link shown below. The complete text of the labels, including the pamphlets attached to the labels, can be read at this site.

PMRA Label Site

http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

Sometimes it can be challenging to find the pesticide label you want to read on the web site. If you need instructions to find a specific pesticide label look at the top right side of the computer screen and click on —How to search product information‖. The computer will describe 3 ways to search for the label you want.

When searching for pesticide labels on the web, the computer will ask for certain information. This can include:

CAS Number is the Chemical Abstracts Service Registry Number. This number is used by

scientists. You do not need this number to search for a pesticide label.

Active ingredient is the common name of the chemical that affects the pest. It is only one of the components of a pesticide product. The name of the active ingredient is found beside the word —guarantee‖ on the pesticide label. For example, the guarantee on the Roundup Original Liquid Herbicide label is glyphosate, 356 grams acid equivalent per litre present as isopropylamine salt. Thus the active ingredient is glyphosate.

Product Name is the name the manufacturer or registrant gives the pesticide. The product name is the most prominent part of the pesticide label. For example, Roundup Original Liquid Herbicide, Laredo Liquid Herbicide, Rustler Liquid Herbicide, Touchdown 480 Herbicide Liquid, and Vantage Plus Herbicide Solution are all different Product or Trade Names that registrants have called products that contain glyphosate (active ingredient).

Registrant Name is the name of the company that asked for the pesticide to be registered. This is usually the name of the company that produces or formulates the pesticide. It is located on the front panel of the pesticide label. Examples of registrant names include: Syngenta Crop Protection Canada Inc., Monsanto Canada Inc., Dow Agrosciences Canada Inc., Cheminova Canada Inc.

Registration Number is the number Health Canada assigns the pesticide product when it is registered for use in Canada. Each pesticide has its own unique number. All pesticides used in Canada must have a registration or PCP Act number. PCP stands for Pest Control Products Act. The registration number is on the front panel of the pesticide label beside the words "Registration No."

Registration Status tells you whether the pesticide is currently registered, is exempt from registration or was registered before (historical). If you want to find a label that is no longer registered, mark " Historical".

Marketing Type is assigned to each pesticide product when it is registered. Marketing types include:

- "Domestic": which are designed for use around the home and garden,
- "Commercial" (or "Agricultural"): which are designed for use by businesses such as farms, forestry, or pest control operators,
- "Manufacturing Concentrate": which is designed for use by registrants,
- "Technical Active": which is designed for use by registrants,
- "Restricted": which is designed for use by professionals with training, or
- "Historical": and is not specified. Most pesticides used in agriculture are classed Commercial, Agricultural or Restricted. Anyone purchasing or using a Restricted pesticide in BC must have a valid pesticide applicator certificate issued by the Ministry of Environment and Climate Change Strategy. The marketing type is located on the front panel of the pesticide label.