UNDERSTANDING THE BASICS

Horticultural crop growers share many of the same management concerns of other producers. Although horticultural crops vary substantially, they all require skilled management to produce a high quality product. These crops rely on intensive management of soil, water, nutrient resources and pest populations.

Soil erosion can be particularly destructive to horticultural soils: removing crop inputs, soil and organic matter and damaging or stressing the crop.

SOIL MANAGEMENT

Soil is vital to all crop production, whether sod, vegetables or fruit. Healthy and productive soil helps crops develop good root systems and reduces crop stress caused by drought or excess rainfall. Intensive production of horticultural crops creates some unique challenges in soil management.

Soil erosion is a concern in many horticultural crops. Highly productive land is valuable and the supply is limited. Water and wind erosion can remove nutrients, other crop inputs, soil and organic matter. The crops, themselves, may also be damaged or stressed by erosion, increasing the possibility of disease. The following table shows a number of practices available to reduce or stop erosion.

Erosion control structures, such as berms and terraces, are covered in the Field Crop Production booklet.

EROSION TYPE	EROSION CONTROL STRUCTURES	COVER CROPS	TILLAGE & RESIDUE MANAGEMENT	WINDBREAKS & WIND BARRIERS	STRIP CROPPING
WATER	X	X	X	–	X
WIND	–	X	X	X	X

X = Effective Control Possible

The impact of wind erosion is often underestimated. If soil is visibly moving, more than 11 tonnes/hectare of soil is being moved.

Most horticultural crops leave soil exposed. Even relatively small amounts of residue can reduce wind and water erosion.

Tillage and residue management involves leaving some crop residues to protect the soil. Residue acts in two ways:

- ▸It protects the soil from the impact of raindrops and the resulting movement of soil particles and crusting.
- ▸It acts as small dams or windbreaks slowing the movement of wind and water across a field and reducing their ability to carry soil.

To protect soils, at least 20% residue cover should be left-but any amount will help. See the Field Crop Production booklet for a more detailed discussion of reduced tillage and equipment modifications.

Cover crops are planted to protect the soil surface and to maintain soil structure. They also help tie up excess nutrients, add organic matter to soil and control pests. There is a variety of cover crops available. Some are suited for specific uses. You must know what you want from a cover crop when making the selection. Ask yourself the following questions:

- ▸What kind of growth habit is needed? Do I need vigorous early fall growth as provided by oats, or vigorous spring growth as provided by rye? Is deep-rooting an important consideration? Or, am I looking for lots of top growth in mid-summer?
- ▸Should the cover crop survive the winter or die out?
- ▸Can it become a weed problem? What are the control measures?
- ▸What is the cost, availability of seeds, planting method?
- ▸Does it produce nitrogen (e.g. clover) or take up leftover nitrogen (e.g. rye)?
- ▸Are there benefits to soil structure?
- ▸Is the cover crop related to other crops in the rotation?
- ▸Will pest problems increase or decrease as a result of using the cover crop? For example, certain plant parasitic nematode populations often increase under red clover while they decrease with alfalfa.

A rye cover crop after processing tomatoes adds organic matter, holds some excess nutrients and protects the soil over winter.

COVER CROP SUGGESTIONS

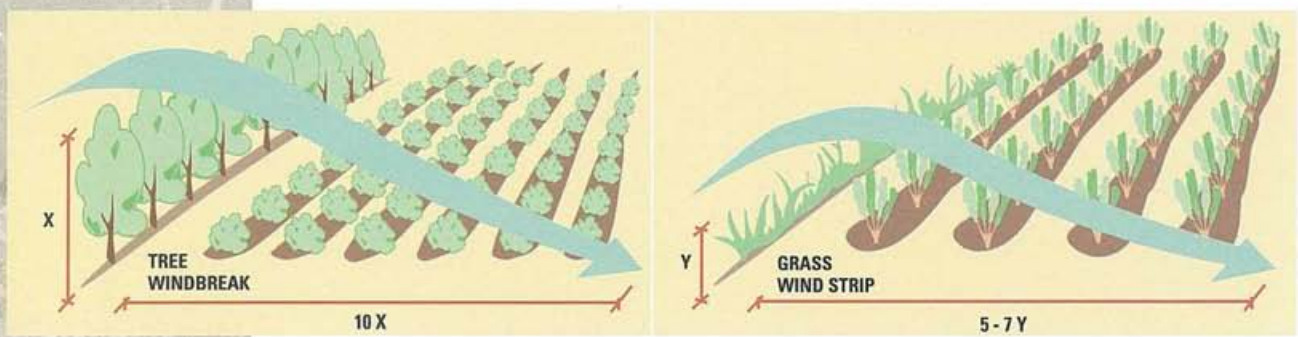
COVER CROP	SEEDING WINDOW	CROP CHARACTERISTICS							
		FAST GROWING	*DEEP TAP ROOT*	*FIXES NITROGEN*	*FROST TOLERANT*	*KILLED OVER WINTER*	*VOLUNTEER SEED POTENTIAL WEED PROBLEM*	*SUPPORTS NEMATODES**	
								Lesion	*Root-knot*
GRASSES									
Winter Rye	LS, EF, LF	X	–	–	X	–	–	+**	Δ
Winter Wheat	LS, EF	–	–	–	X	–	–	+	Δ
Barley	S, LS, EF	–	–	–	X	X	–	+	Δ
Oats	S, LS, EF	–	–	–	X	X	–	+	Δ
Ryegrass	LS, EF	–	–	–	X	–	–	Δ	Δ
Italian Ryegrass	ES, EF	X	–	–	–	X	–	Δ	Δ
Fescues	ES, EF	–	–	–	X	–	–	Δ	Δ
Corn	S, MS, LS	X	–	–	–	X	–	++	Δ
Sorghum-Sudan	ES, MS, LS	X	–	–	–	X	–	0	Δ
LEGUMES									
Red Clover	S	–	–	X	X	–	–	++	+++
Ladino Clover	S, EF	X	–	X	X	–	–	++	+++
Sweet Clover	S	–	X	X	X	–	–	Δ	Δ
Alfalfa	S, LS	–	X	X	X	–	–	Δ	+
Hairy Vetch	S, ES, MS, LS	–	–	X	X	–	–	++	+
Austrian Winter Peas	S, LS	–	–	X	X	?	–	+	+
Field Peas	S, ES, MS, LS	–	–	X	X	X	–	+	+
Soybeans	S, ES, MS, LS	X	–	X	–	X	–	+	+
BRASSICAS									
Spring Canola	S, LS	X	X	–	X	X	X	0	0
Winter Canola	LS	X	X	–	X	?	X	0	0
Tame Mustard	S, LS	X	X	–	X	X	X	0	0
Oil Radish	S, LS	X	X	–	X	X	X	0	0
OTHER									
Buckwheat	S, ES, MS	X	–	–	–	X	X	+++	0

NOTE: Seeding success dependent upon weather, particularly summer seedings.
*** Varietal difference in cover crop species may affect nematode reaction.**
**** Rye–whole season rating would be higher (+++).**

S = Spring **MS = Mid Summer** **EF = Early Fall** **X = Exhibits this characteristic usually**
ES = Early Summer **LS = Late Summer** **LF = Late Fall** **? = Inconsistent in some locations**
– = Not applicable

NEMATODE RATING CODES
Δ = Poor or non-host **+ = Ability to host** **0 = Some cultivars are non-hosts**

Windbreaks and wind barriers are covered in detail in the booklet on Farm Forestry and Wildlife Habitat Management. Wind barriers include a variety of possibilities, from short-term grain interseedings in muck crops to grass strips and fence-like materials to protect vegetables. Barriers reduce the speed of wind and lower its ability to carry soil. The area protected by a tree windbreak is about 10 times its height. The amount of protection provided by other types of barriers varies depending on height and the flexibility of the material.



Wind barriers reduce the speed and soil carrying ability of the wind. Tree windbreaks protect an area about ten times their height. Grass wind barriers are more flexible and can be pushed down by high winds, reducing the protected distance to five to seven times the barrier height.

Strip cropping involves planting strips or sections of a field with crops having different growth habits. For example, growers may alternate strips of early vegetables with later-seeded vegetables. Although management may increase, the soil surface is better protected.

SOIL STRUCTURE

Maintaining good **soil structure** is also a challenge for growers of intensively managed crops. Soil structure refers to how well soil particles are organized and held together as soil crumbs or clods. Structure influences the general health of the crop in the following ways:

- ►Water movement in and through the soil.
- ►The resistance of soil to erosion, crusting and compaction.
- ►A plant's ability to grow a good root system and take up nutrients.
- ►Aeration.

A good root system is essential to production, allowing the plant to exploit soil water and nutrients.

Soil Compaction

Tillage and cultivation tend to break down soil clods and organic matter. Organic matter is the glue that holds soil particles together. Production of high-quality horticultural crops requires timely operations. Sometimes, this means tilling, spraying or harvesting on soils

that are too wet. In addition, to be cost-effective, many of these operations have become highly mechanized. Running heavy equipment in wet conditions may cause soil compaction. Compaction means that the soil has become packed and pore spaces are reduced which decreases the soil's ability to hold both air and water.

Reducing Compaction

- ▸Avoid working on wet soils.
- ▸Reduce the number of trips over a field.
- ▸Keep the weight on an individual axle to below five tonnes. Use trailers with tandem axles.
- ▸Choose radial tires where extra traction is needed. They have up to 27% more surface contact than bias ply tires of similar size.
- ▸Four-wheel drive tractors have better weight distribution between axles.
- ▸Use good crop rotations that include deep-rooted crops or cover crops.
- ▸Limit traffic to certain areas or rows. If possible, use the same travel lanes each year.

Tillage and crop roots usually break up shallow or surface compaction. However, deep compaction or plow pans can be more difficult to deal with. Deep-rooted crops and frost action may help. Research shows that frost takes at least three winters to reduce compaction, assuming that no further compaction has taken place. Deep tillage or subsoiling is a prescription treatment for the worst areas.

It is important to subsoil properly or compaction is just moved deeper:

- ▸Know the depth of the problem.
- ▸Work on soils that are dry to the level of tillage.
- ▸Plant a deep-rooted cover crop to keep the soil open.
- ▸Make changes in your practices to avoid future problems.

Subsoiling is only a temporary solution and does not remove what caused compaction in the first place.

Scheduled harvest of perishable crops sometimes forces working on wet soils. Try to avoid compaction using other measures and plan to rotate away from the problem crops.

Given the soil conditions, this deep tillage implement is where it should be – parked. Subsoiling must be done properly, or problems can be made worse.

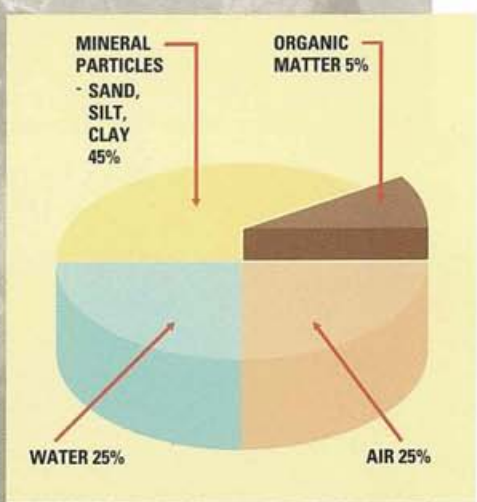
Reducing tillage where possible will help to retain soil productivity by reducing soil compaction and erosion losses of soil and organic matter.

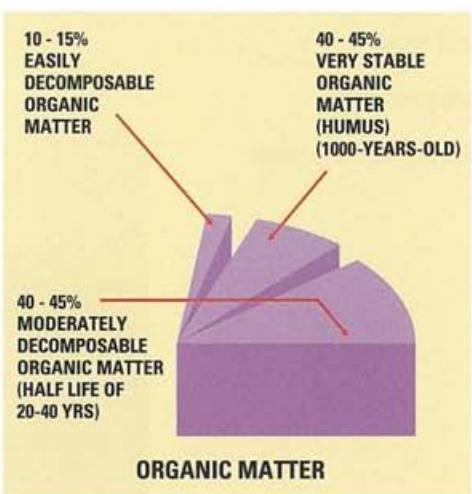
Soil Organic Matter

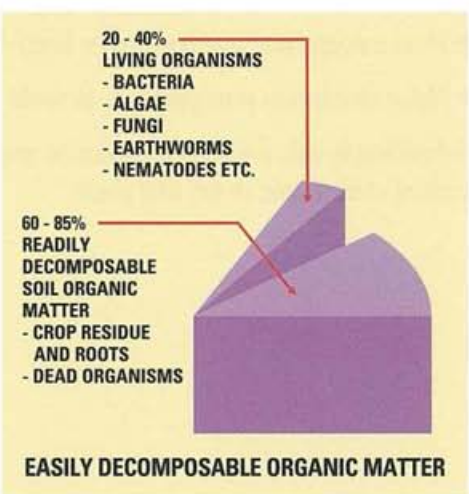
Soil organic matter is a very small part of the soil with a large role to play. Many soils used in horticultural production have soil organic matter levels between 2 and 4%. About 40 to 45% of the soil organic matter is very stable and resists decomposition. Another 40 to 45% is moderately stable. This portion is protected or held within soil clods and on clay particles and is very important to soil fertility, accounting for 40 to 50% of nutrients released each year. The remaining 10 to 15% is composed of living and dead organisms and decomposes easily.

Growers can directly affect the organic content of their soils. Excessive tillage, soil erosion and poor crop rotation will speed loss of organic matter. On the other hand, there are a number of practices that maintain and improve organic matter:

- ►Good crop rotations that return a variety of residues to the soil.
- ►Use of cover and green manure crops that add plant material to soil.
- ►Reducing tillage where possible.
- ►Adding organic matter such as manure, compost and other wastes. It is important to know what is in the material, though, first. (Any field application of organic off-farm waste, e.g. food processing waste, requires a permit from Ministry of the Environment.)
- ►Reducing erosion losses of soil and organic matter.
- ►Keeping tillage shallow to prevent dilution of organic matter.







Organic matter is only a small portion of the soil, but it is very important to soil fertility and good soil structure. Maintaining adequate soil organic matter levels is crucial to consistent production of horticultural crops.

WATER MANAGEMENT

Good quality water is needed for spraying, irrigation and household use. Horticultural crops tend to be very sensitive to moisture levels. Often, it seems there are only two levels — too much moisture and not enough. Irrigation and drainage are best management practices for many horticultural crops. Adequate moisture reduces plant stress and helps prevent disease.

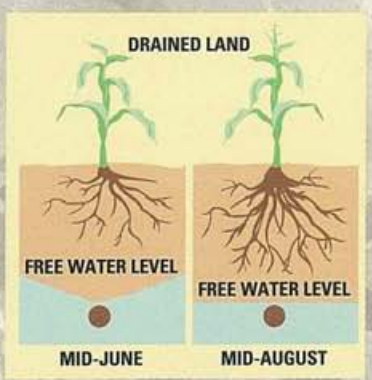
IRRIGATION

Irrigation must be applied properly to be cost-effective and to prevent harm to the environment. When irrigating:

- ►Know your soil type and its capacity to hold water.
- ►Know when moisture is critical to your crop.
- ►Use a scheduling method such as a tensiometer or the evapotranspiration model.
- ►Be aware of the weather forecast.
- ►Monitor the system when it is operating. Breakdowns cost money and waste crop inputs.
- ►Reduce losses from evaporation. When applying water, avoid the heat of the day. Apply on cloudy days and when wind speed is low.
- ►Keep good field records.
- ►Monitor for disease.
- ►If removing more than 50,000 litres (10,000 gallons) a day from a water source, get a permit from the Ministry of the Environment.

A rain gauge is an important tool in water management. Keeping accurate rainfall records will help in scheduling irrigation.

Reduce water loss when using overhead irrigation – avoid the heat of day, apply on cloudy days and when wind speed is low.



Good drainage is critical to the production of horticultural crops. Poor drainage does not encourage deep root growth, making the plants more prone to drought stress.

Soil testing is important. Make sure the sample represents the field.

When properly used, irrigation is an effective management tool. There are a number of publications available that can provide you with more detail on equipment and scheduling.

DRAINAGE

Drainage is critical to production of horticultural crops. Poor drainage adds stress to plants and makes them more prone to pests.

- ▸Ensure drainage is adequate. Repair or replace tiles that do not work.
- ▸Protect tile outlets to prevent damage to ditchbanks (see the booklet on Field Crop Production for details).
- ▸Use a header tile to reduce the number of outlets entering a ditch, where possible. This will help prevent ditch damage and reduce loss of field areas to slumping.

NUTRIENT MANAGEMENT

Good use of nutrient management will improve both your production and the environment. Cost-effective application will produce the best yield potential while minimizing costs. In turn, this helps reduce nutrients lost to the soil through leaching and water erosion.

Soil testing is an important first step. Soil test results will give you a base on which to analyze soil needs. Also do tissue tests, if available for your crop. This shows what plant nutrient levels are at that point in time, as opposed to what is available in the soil. This is particularly important for perennial crops.

Record keeping of soil and tissue tests will help track trends. Include observations on crop growth, yield, quality and weather conditions during the growing season.

Application of nutrients varies from crop to crop. For more details, check the sections on specific crops in the following section and the OMAF publications listed at the back. A few general best management practices include:

- ▸If possible, use split applications of nitrogen to reduce the possibility of loss by leaching. This will also increase management and application costs and may not be suited to all crops.
- ▸Keep soil healthy so that root systems will be most effective in using nutrients.
- ▸If nutrients are left after a crop harvest, use cover crops to hold them for the next crop.

To be competitive, horticultural crop growers have to produce high quality products efficiently. To be sustainable, soil and water resources must be protected and conserved. Best management practices need to be chosen and adapted to suit each farm operation.

PEST MANAGEMENT

Pesticides are often used to control pests in horticultural crops. However, they are often viewed as environmental hazards by the public. Integrated Pest Management (IPM) promotes the responsible and reasonable use of pesticides in combination with non-chemical controls. Relying only on pesticides for control has several disadvantages:

- ▸Insects, diseases and weeds can become resistant to pesticides.
- ▸Resurgence of the pest when the pesticide application kills a high proportion of its natural enemies. The pest population increases rapidly because natural enemies no longer provide control.
- ▸Secondary pests are created when pesticides kill the natural enemies of a non-target pest. Without natural enemies, the pest population increases to where it becomes a problem.
- ▸Possible environmental contamination (e.g. pesticides in well water).
- ▸Input costs for growers.
- ▸Potential health hazards.
- ▸Negative public attitude towards pesticides.

IPM SYSTEMS

There are four components to an IPM system:

- ▸Pest identification.
- ▸Monitoring.
- ▸Control guidelines.
- ▸Methods of prevention and control.

IPM can reduce pesticide use and yet, maintains quality standards by treating pests as part of the total management system. Components of the system include the physical and biological environment of the crop and pest. Pest management practices are combined with production practices to achieve economical, long-term solutions.

Development of a secondary pest.

Weather conditions can be monitored by systems such as this TOM-CAST station. The information can then be used to predict some diseases.

Pest Identification

Identifying the pest properly helps decide which method of control is best. Nutrient deficiencies or physical damage can cause symptoms similar to those caused by pests. Also, the presence of pests does not always cause economic damage. Factsheets on pests are available from the Ontario Ministry of Agriculture and Food to help in identification.

Monitoring

Monitoring allows you to forecast and evaluate potential pest problems. It identifies the pests present, estimates numbers and examines conditions favourable to pests. Monitoring allows accurate timing of pesticide applications which may reduce pesticide use. Each field should be watched separately because conditions vary. Monitor at least once per week and preferably twice per week when the pest is usually most active. Scouts may be hired to monitor the crop.

Good record keeping is essential. Complete written records help decision-making by supplying information on previous problems and applications. It is useful to record:

- ►Crop health.
- ►Pest species present.
- ►Weather and other environmental conditions.
- ►Population level of pests and beneficials.
- ►Sprays and other controls applied.

Methods of Monitoring

There are several ways to monitor pests.

Pheromone traps contain a chemical that attracts only the species of pest being monitored. This makes pest identification easier.

Physical traps are visually attractive to many types of insects. This can make pest identification time consuming.

Direct counts check the number of insects or the amount of disease on a set number of plants. Weed counts across the field will aid in herbicide selection.

Weather monitoring calculates when insects will first emerge in the spring or when a disease is most likely to occur (e.g. BOTCAST predicts when Botrytis leaf blight infection takes place in onions so fungicides can be applied at the best time).

Control Guidelines

Control guidelines, or thresholds, indicate when pesticides need to be applied to prevent economic losses. Timing of control measures is critical. Guidelines for insects are based on an economic threshold where the cost of not applying a control will be higher than applying a control. Guidelines for diseases, weeds, nematodes and vertebrates may be based on weather, history of the field or region, stage of the crop and other field observations.

Control Methods

There are three types of controls used in IPM systems: cultural, biological and chemical (pesticides). Cultural and biological controls are used wherever possible. When these are inadequate, pesticides are usually used. The most economical and reliable way to deal with pest problems is to avoid them when possible.

Cultural Control

Many cultural practices reduce pest damage. They prevent problems and are effective and economical. Examples are:

Site selection - choose sites that are less favourable to pests.

Cultivar selection - choose varieties that are resistant, when possible.

Crop rotation - rotate away from crops of the same family (e.g. turnip, cole crops and canola) to prevent some pests and help control weeds.

Inter cropping - planting a mixture of crops may reduce insect damage (e.g. underseeding brussels sprouts with clover). However, competition may reduce yields in some cases.

Cover crops - can provide shelter for beneficials.

Trap crops - plant crops to attract the pest away from the main crop. Pests can be killed with a localized spray. For example, in tomatoes, trap crops of potatoes and eggplant can be used for Colorado Potato Beetle (CPB).

Tillage - provides weed control and may kill some insects and pathogens.

Time and method of planting - may help to avoid a generation of the pest.

Sanitation - remove pest habitat such as cull piles, dropped fruit or other plants. For example, potato cull piles provide a place for potato blight to overwinter.

Pruning - removes a food source or a point for infection. For example, removal of pear suckers helps to keep psylla numbers down.

Clean seed and transplants - avoid introducing pests. Use seed that has been certified disease-free.

Eggplants are currently being used as a trap crop in tomatoes. Colorado Potato Beetles appear to prefer eggplant and potatoes over tomatoes.

Removing pear suckers will reduce psylla numbers.

Use of clean, disease-free plants such as these pepper transplants will help to prevent disease problems.

IPM systems take advantage of natural enemies such as this parasitic wasp which is emerging from an aphid exoskeleton.

Another example of a natural predator feeding on an aphid in a greenhouse operation.

Plant health - healthy plants are less prone to infection.

Irrigation - use good timing/scheduling to prevent disease.

Biological Control

Biological control uses a pest's natural enemies to control the population of the pest. Natural enemies include predators, parasites and diseases. The term, "beneficials", refers to predators and parasites of insect pests. IPM systems take maximum advantage of control by natural enemies.

There are two ways in which biological control is managed:

Encouraging natural enemies - provide shelters or food sources for natural enemies. For example, a sod or weedy cover in an apple orchard provides an overwintering site for predatory mites. These mites control European red mite and two-spotted spider mite.

- ►Select pesticides that have minimal effect on beneficials. For example, *Bacillus thuringiensis* (Bt) is specific to certain types of caterpillars.
- ►Time or schedule pesticide applications to have least effect on beneficials.
- ►Apply pesticides only when needed.

Adding natural enemies to provide control - adding natural enemies is not usually economical in the field. However, in greenhouse operations, it is often possible. For example, whitefly can be controlled with *Encarsia formosa* (a parasitic wasp). At present, work to develop pest diseases is continuing. In the future, more of these products may come on the market.

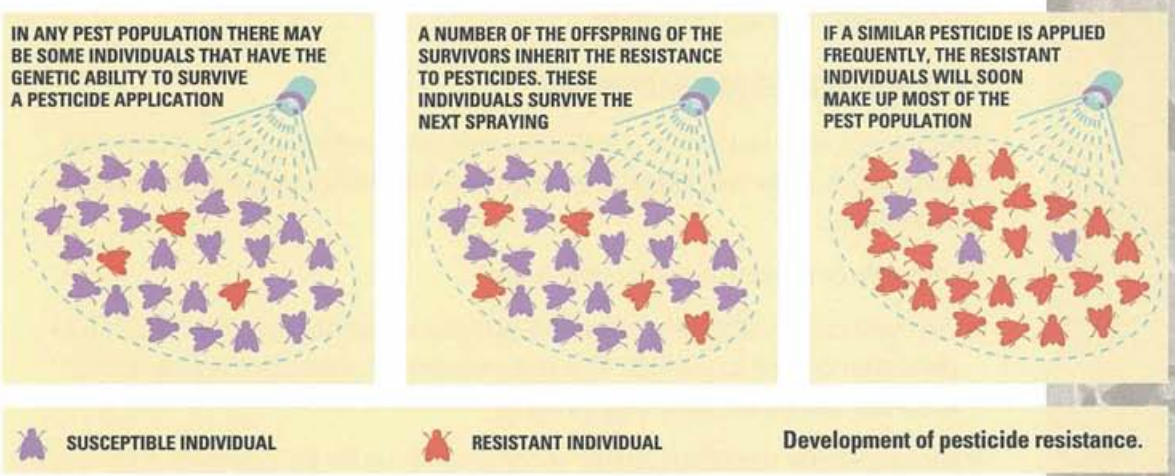
Resistance

Refers to the developed ability of a pest to survive applications of pesticides at rates that once killed most of that species. This ability is passed from generation to generation making the pesticide useless. Colorado Potato Beetle resistance, for example, is a major problem. With fewer new pesticides coming onto the market, resistance could become a more widespread problem. Resistance is most likely when pesticides are applied at lower-than-recommended rates and when either the same pesticide or pesticides with the same mode of action are repeatedly used.

Resistance Management

- ►*Use pesticides only when needed.*
- ►*Avoid pesticide residues.*
- ►*Alternate pesticides with different modes of action.*

- ▶ *Use recommended rates of pesticide.*
- ▶ *Use other controls where possible e.g. rotary hoe for weeds.*
- ▶ *Time pesticide sprays for the most vulnerable stage. For example, spray for the larvae of Colorado Potato Beetle rather than the adult.*



Development of pesticide resistance.

CHEMICAL FAMILIES AND THEIR COMMON NAMES

CHEMICAL FAMILY	COMMON NAMES
BIOLOGICAL CONTROL (BACILLUS THURINGIENSIS)	Dipel, Thuricide, Trident, M-One
SYNTHETIC PYRETHROIDS	Ambush, Cymbush, Ripcord, Pounce, Decis, Belmark
CARBAMATES	Pirimor, Lannate, Furadan, Sevin, Temik, Vydate
ORGANOPHOSPHATES	Guthion, Orthene, Metasystox, Parathion, Malathion, Cygon, Monitor, Lorsban, Diazinon
ORGANOCHLORINES	Thiodan, Methoxychlor

Summary

IPM systems can be effective and economical for horticultural crops. While the level of damage may be higher than when using chemical controls, long-term effectiveness is better. To be successful, IPM requires time and careful attention to pest identification and monitoring, control guidelines and methods of prevention and control.