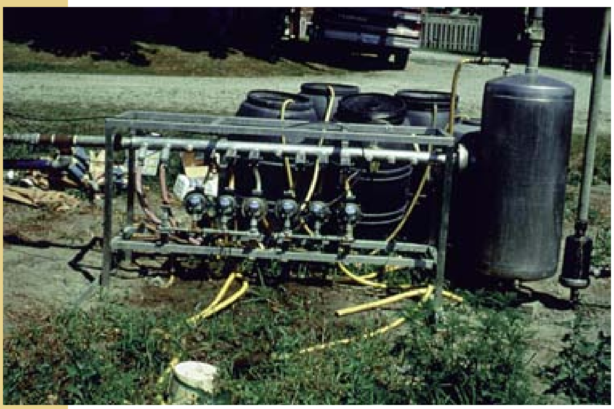
SPECIAL APPLICATIONS

Supplying water for crop use is not the only useful function of an irrigation system. It can also be used to apply crop protection materials to high-value crops. Frosts, sand-blasting and excessive heat can be controlled in some situations. Also, in selected crops, productivity can be increased and quality improved by applying crop nutrients with irrigation water through "fertigation". Fertigation is normally done using drip (also known as micro-irrigation or trickle) systems.

This chapter presents best management practices for special applications of irrigation. These include fertigation, chemigation, evaporative cooling, wind erosion control and frost protection. All of them require careful management to ensure effectiveness, water efficiency and protection of the environment.

FERTIGATION OF FIELD VEGETABLES AND TREE FRUIT

Drip irrigation and fertigation are relatively new practices for fruit and vegetable growers in Ontario. They provide a very efficient method of applying irrigation water and nutrients, and can be used to increase yield and quality of certain fruit and vegetable crops.



Drip irrigation and fertigation can be used to increase yield and quality of horticultural crops.

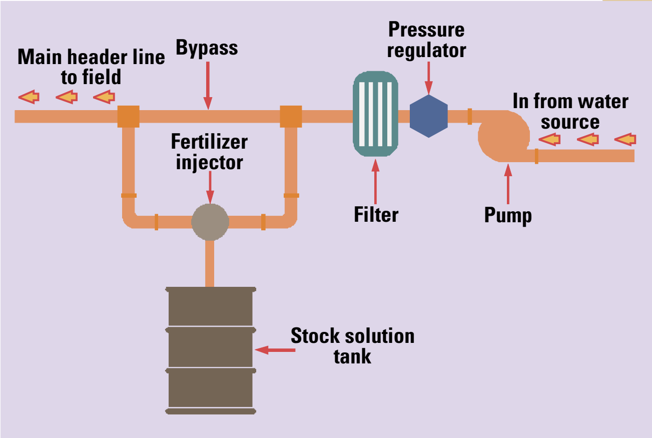
SPECIAL APPLICATIONS

FERTIGATION SYSTEM DESIGN

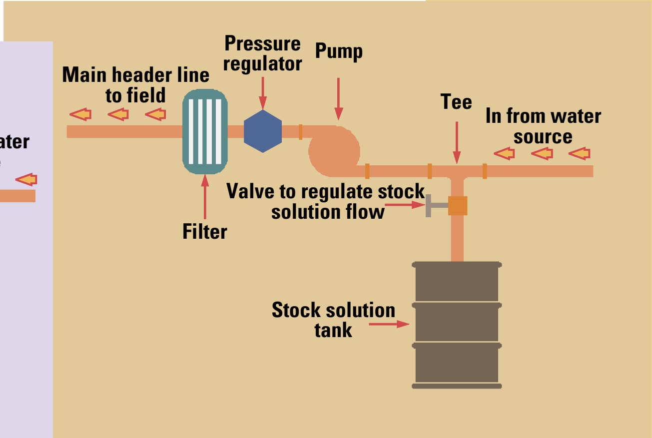
There are many systems available to inject fertilizer solutions into irrigation water. The most accurate is a fertilizer injector (e.g., Anderson, Dosatron, Amiad etc.) that injects the stock fertilizer solution into the irrigation water at a pre-set ratio.

An alternative method is to **install a tee** on the suction side of the irrigation pump, with a hose leading to the fertilizer stock tank. The flow of fertilizer solution into the system is regulated with a tap or gate-valve. This setup isn't as accurate as a fertilizer injector, but is less expensive and should be accurate enough for most field situations.

An anti-backflow device such as a check valve prevents contaminated water from being drawn back into your water source.



The fertilizer injector is the most accurate of fertigation systems. With the main filter before the fertilizer injector, this system requires extra filters at the inlet of each zone or group of zones.



Installing a tee is less expensive, and is usually on the suction side of the irrigation pump. It functions in a fashion similar to a fertilizer injector.

FERTILIZER STOCK SOLUTIONS

Stock solutions are the concentrated fertilizer solutions that are injected into the drip irrigation system. To prepare the fertilizer stock solution:

- calibrate the system to determine how much stock solution is injected over the desired injection period – in most cases an injection period of approximately 1 hour is sufficient

The required amount of fertilizer must be totally dissolved in the volume of water in the stock solution tank before injection.

SPECIAL APPLICATIONS

A solubility ratio of 1:1 means 1 kg of fertilizer will dissolve in 1 L of water (1 L water = 1 kg).

TRY THE JAR TEST

When mixing fertilizer products, it's a good idea to try the "jar test" to make sure that there is no incompatibility between the fertilizers. (An incompatibility means that precipitates may form and emitter plugging may occur.) To do a jar test, put some of the fertilizer solution into a jar of irrigation water. If there's a potential incompatibility between your fertilizer choices, a precipitate or milkiness will occur within one or two hours. If there's cloudiness, emitter plugging may occur. Be sure to wear protective clothing and eye protection when performing any jar test.

- determine how much fertilizer material must be added to the stock solution to deliver the desired rates of nutrients on the land area to be fertigated – see the table on page 101 for suggested fertigation rates for vegetable crops

  (The required amount of fertilizer must be soluble in the volume of stock solution to be injected. Solubility ratios, i.e., weight of fertilizer that can be dissolved in a given weight of water, are given in the table below. If the fertilizer required cannot be dissolved in the water volume, more water must be added, and the solution must be injected over a longer period of time.)

- use only 100% water-soluble dry fertilizers when using dry fertilizer sources
- fertilizer materials may be mixed together in one stock solution tank, or separate solutions may be prepared for each fertilizer material and injected with a multi-head fertilizer injector. Soluble fertilizers 20–5–20 or similar analyses may be used, but are considerably more expensive. DO NOT mix fertilizer solutions containing calcium with solutions containing phosphates or sulphates, as these can precipitate out and plug emitters.

FERTILIZER MATERIALS RECOMMENDED FOR PREPARATION OF STOCK SOLUTIONS FOR INJECTION THROUGH DRIP IRRIGATION

FERTILIZER MATERIAL	% ACTUAL NITROGEN	% POTASH (K_2O)	SOLUBILITY RATIO OF SOLUTE:WATER
AMMONIUM NITRATE	34	0	1:1
CALCIUM NITRATE	15	0	1:1
POTASSIUM NITRATE	13	44	1:4
POTASSIUM SULPHATE	0	50	1:15

SPECIAL APPLICATIONS

FERTILIZER REQUIREMENTS FOR VEGETABLES

Usually part of the nutrient requirement of the crop is soil-applied prior to planting, and the remainder is injected through the drip system. Scheduling of nutrient injection is done according to crop demand. Low rates of nutrients are applied when the crop is small, and increasing rates are applied during the period of rapid growth and fruit development.

Soil testing should be used to determine phosphate and potash requirements. All the phosphate should be applied prior to planting.

Approximately 30–50% of the nitrogen and potash requirement is broadcast prior to planting, and the remainder is injected through the drip irrigation system, according to the schedules in the table below.

RECOMMENDED FERTIGATION RATES FOR VEGETABLE CROPS GROWN ON SAND TO SANDY-LOAM SOIL TYPES

RATES OF ACTUAL N AND K_2O (kg/ha/week)			
GROWTH STAGE	**TOMATOES**	**PEPPERS**	**CUCUMBERS & OTHER VINE CROPS**
VEGETATIVE GROWTH TO BLOSSOM	2.5*	3 – 5	3 – 5
FRUIT SET TO FRUIT SIZING	5.0	7 – 10	7 – 10
HARVEST	2.5	3 – 5	3 – 5

*** 2.5 kg/ha/week of each of N and K_2O**
To convert to lbs/ac, multiply kg/ha by 0.9.

FERTILIZER REQUIREMENTS FOR TREE FRUIT

General recommendations for fertilizing tree fruits are given in Ontario Ministry of Agriculture and Food Publication 360, *Fruit Production Recommendations.*

With fertigation, instead of applying the required amount of N as a single banded application around the drip line of each tree or in the herbicide strip, one-third of the nitrogen requirement per tree is injected as a single dose in early April before the trees leaf out. This is done to stimulate early vegetative growth in the spring. Active root growth starts before any obvious bud movement in the tree canopy.

SPECIAL APPLICATIONS

Total recommended rates of nitrogen and potassium applied as dry fertilizer can be reduced by about 50% with fertigation. This method of feeding orchard trees should be carefully monitored by leaf analysis.

The remaining two-thirds of the nitrogen requirement is applied in equal amounts with each irrigation in May and mid-June. Apply nitrogen after mid-June to slow vegetative growth and promote hardening-off for winter.

When applying potassium (K) using fertigation, instead of applying the total requirement per tree as a single banded application in the spring, K is injected in equal amounts with each irrigation in July and August. The delayed application of K relative to N is to enhance fruit colour, winter hardiness, tree growth and disease resistance during the latter half of the growing season.

Phosphorous (P) is not applied in the irrigation water because Ontario orchards normally don't show a demonstrated need for fertilization with P. Magnesium (Mg) and calcium (Ca) are best applied as foliar sprays if needed, rather than through trickle irrigation. Micronutrients (e.g., boron, manganese, iron, zinc) for tree fruits only need to be applied when deficiency is confirmed by leaf analysis or visible symptoms. Foliar sprays for the element or elements that are deficient is the best way of correcting a deficiency in micronutrients. Micronutrients are not applied via fertigation.

Shown here is a fertigation system with pump, filters and nurse tank. Fertigation systems may be used with trickle irrigation systems to more effectively apply fertilizers to crops. However, for apple and peach crops, evidence to date indicates fertigation offers no significant nutritional advantage over dry granular fertilizers applied in the spring at bud break.

CAUTION

Soil acidification may occur below the emitters where an ammonium nitrogen source is used. Soil acidification does not occur with nitrate–nitrogen sources. This is therefore a preferred nitrogen source for fertigation of tree fruits. At lower soil pH (pH less than 4), manganese and aluminum can be absorbed and become phytotoxic. This results in stunted growth, and reduced fruit yields and quality.

FERTIGATION SCHEDULING FOR VEGETABLES AND TREE FRUIT

The timing of fertigation in relation to tree growth and crop development was described for application of N and K in the previous section. Each fertigation application should be part of a normally scheduled irrigation, and is best conducted near the end of each irrigation cycle to avoid leaching of nutrients below the main rooting zone. The lines must be flushed immediately after each fertigation to prevent plugging of the emitters.

SPECIAL APPLICATIONS

Remember:

- proper irrigation scheduling is important with fertigation to prevent fertilizer leaching
- tensiometers may be used to indicate when drip irrigation is required – for more information on tensiometers, see page 30
  - frequencies of fertigation can vary – low rates of fertilizer may be injected every 2–3 days, or higher rates every 7–14 days
- frequent injections (every 2–3 days) are recommended on sandy soils that don't retain moisture and nutrients well
- drip irrigation systems need to be thoroughly checked for leaks and to be sure all emitters are working before fertigation
- the system should have enough capacity to apply the required amount of fertilizer in a relatively short period of time
  - this is important during rainy periods when irrigation isn't required but fertilizer is still needed
  - after fertilizer injection is completed, it's important to run the drip system for a while to flush the fertilizer out of the emitters – otherwise, plugging of the emitters may result

CHEMIGATION

Chemigation – the application of chemicals using irrigation technology – can be useful for cranberries and greenhouse vegetables. Only approved products (as stated on chemical label) should be used for chemigation.

Applying herbicides and pesticides in minute concentrations can save you time and money. **However, it must be done with skill and caution, in compliance with laws and only with chemicals that are registered for this use.** The main environmental concern is contaminated water entering a water source or ground water in the event of a spill or equipment malfunction.

Chemigation can be useful if you have a solid-set low-volume sprinkler irrigation system.

HARDWARE

- spring-loaded check valve on pressure-side of pump to prevent backflow if pump stops
- foot valve to prevent backflow of water once it has entered pickup line from pond
- water source must be a pond that doesn't have any outflow, and does not operate directly from a municipal water supply system, water well, river or stream
- anti-backflow device should also be used
- only solid-set, low-volume sprinkler-type setups using $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{12}$ inch nozzles, applying water in a uniform, even pattern over a field, are eligible for chemigation

SPECIAL APPLICATIONS

CALIBRATION

Before applying chemicals, you must calibrate the irrigation system.

The goal of the following procedure is to calculate (E), which is the total elapsed time.

1. Turn on pump and charge the system so that all sprinklers are operating correctly, and fix all leaks.
2. Fill the chemical tank with predetermined volume of water, e.g., 40 Imp gal (200 L).
3. Mix in a marker dye.
4. Mark the time (a) and open the suction line valve to allow chemical pickup.
5. Watch the first nozzle to see when dye appears; mark time (b).
6. Continue to operate, observe when last nozzle shows dye; mark time (c) .
7. Continue to siphon chemical until it's all gone.
8. Watch first sprinkler and see when water is clear (free of dye); mark time (d).
9. Observe when last nozzle is free of dye; mark time (e).
10. Note the time for one full revolution of the sprinkler (f).
11. Take note of pressure setting at pump (p).

Total elapsed time (early-season application of insecticide & fungicide): E = e – a

Total elapsed time (insecticide and fungicide applied from bloom to harvest and herbicide applied at any time): E = f – a

Pressure: p

APPLYING CHEMICALS

Remember to calibrate your system before using chemicals (see previous procedure).

1. Use the same pressure (p) that was used during the calibration for all chemical applications.
2. Use preset volume of water in chemical tank (same volume as used for calibration, 40 Imp. gal [200 L]).
3. Know how much area is to be covered (# acres = A).
4. Check rate (r) of chemical from label (mass / acre).
5. Multiply the area by the rate, (A) x (r) to get amount of chemical required for whole patch. This will vary for each pesticide used, e.g., 12 acres at 3 pounds per acre = 12 ac x 3 lb/ac = 36 lb (6 hectares at 2 kilograms per hectare = 6 ha x 2 kg/ha = 12 kg).
6. Always dissolve pesticide in chemical tank thoroughly and keep it stirred up to prevent settling out.
7. Wear all appropriate safety equipment such as gloves, coveralls, mask, etc. when handling products.

SPECIAL APPLICATIONS

8. Turn on system and check that all nozzles are working correctly.
9. Turn on suction line valve to start chemical uptake. Mark time carefully.
10. Continue to chemigate for a total elapsed time E.
    - For early-season sprays of insecticide and fungicide: stop the system at E = e – a.
    - Insecticide and fungicide applied from bloom to harvest and herbicide applied at any time: stop the system at E = f – a (one extra sprinkler rotation is needed to "wash" pesticide down into the canopy).
11. If a blowout or other problem develops during chemigation, turn off suction-line valve to chemical tank, then shut down the pump – use appropriate safety gear if repairs are required in treated area, or on pipes containing chemical product.

SAFETY

- pick a low-wind "perfect" spraying time for chemigation – often early morning is appropriate
- don't allow anyone nearby or in the field while chemigating
- follow re-entry requirements and days to harvest as stated on the chemical label

If irrigation is to be carried out, do the chemigation at the end of the cycle.

Best management practices such as grass wind strips, cover crops, residue management, and windbreaks are your best bets for effective control of wind erosion.

WIND EROSION CONTROL

Many highly productive horticultural soils are prone to wind erosion. Dry loose soil is easily moved by wind.

Irrigation can provide some short-term emergency wind erosion control – or the final piece in an erosion control system. Water applied in advance of the wind event will help to hold soil. The success of this practice depends on:

- soil type
- amount of water applied (before and during windstorm)
- drying ability of the wind (relative humidity)
- duration of the wind event.

This practice is best used in combination with other measures, such as residue management, grass wind strips or windbreaks.

Irrigation for wind erosion control is considered an emergency response only. To be effective, it must be started before the wind event occurs.

SPECIAL APPLICATIONS

If left unchecked, frost can eliminate the early bloom in strawberry. Early blossoms are capable of producing the largest berries in the field.

Dew point affects how quickly the temperature drops. Frost injury can occur before frost forms on the surface if the dewpoint is below freezing. Cloudy ice means that not enough water is being applied. Ice should be clear, not cloudy.

FROST PROTECTION OF BERRY CROPS

REQUIREMENTS

- solid-set sprinkler irrigation system that gives total, even coverage
- nozzles that apply enough water for frost protection but do not flood the field. Usual size is from 1⁄8 to 5⁄32 inch (4 mm) at wind speeds of 0–1.25 km/hr. A rate of .15 inches (4 mm) of water per hour is adequate to carry protection down to -6.7° C (20° F). Recommended rates of application vary .10–.15 inches per hour (2.5–4 mm).
- adequate supply of water
- properly calibrated thermometers that are placed in the coldest spots in the field. An ideal system would involve the use of underground cables connected to thermistors in the field, joined to frost monitoring units with an alarm system set up to the house.

TIMING

Open strawberry blossoms will freeze at around -0.5° C (31° F) over a period of several hours. Unopen blossoms (balloon bud) will freeze at -2.2° C (28° F) over a period of several hours. Unprotected blossoms can withstand colder temperatures but only for a short time. Buds that are tight can take -5.5° C (22° F).

The alarm system should be set at somewhere around 1.1° C (34° F) to allow time for starting up the pump and getting the system going. It's important when temperatures are below freezing to watch that the sprinkler heads do not freeze and stop rotating.

The irrigation system, once it's running for frost protection, should continue to be run until the ice begins to melt. Some growers feel safer with the ice encapsulation method if the ice is completely melted before shutting down. However, this isn't necessary unless there is some fruit ripening.

PROBLEMS

- if winds are above 10 mph (16 km/hr), then poor coverage can result in some buds being frozen
- the higher the wind speed, the more water required per hour because of evaporation and potential freezing damage from the effects of evaporative cooling
- at a wind speed of 16 km/hr, to get protection down to -6.7° C (20° F), the required rate of water application/hr is 20 mm (.78 inch)
- using irrigation for frost protection leads to wet soils, which may favour the development of red stele and other root rots

SPECIAL APPLICATIONS

WARNING: ORCHARD CROPS AND OTHER FRUIT CROPS
(ice encapsulation method of frost control)

Do not apply overhead low-volume sprinkler irrigation (.10" per hour [2.5 mm/hr]) in an attempt to protect from frost injury with wind velocities > 5 mph (8 km/hr). The effect of evaporative cooling resulting from air moving over a thin layer of moisture on leaf or floral parts is enough to cause severe freezing damage at temperatures around the freezing mark. Most sprinkler irrigation systems set up for frost protection may not deliver sufficient water volume to overcome this potential problem. Make sure that adequate volumes of water are stored for a worst-case scenario of several nights' usage. With wind velocities of < 5 mph (8 km/hr), a rate of water application of .15 inch (4 mm) per hour is considered to be adequate to carry protection down to -6.7° C (20° F).

EVAPORATIVE COOLING

Hot dry weather can reduce fruit set and potential size of the fruit (e.g., strawberries). When water evaporates from the plant surface, it cools and can help to overcome these two problems. Water used for evaporative cooling should be of high quality, since the produce will be harvested soon afterwards.

The principle of evaporative cooling involves the use of a thin layer of water on the surface of the tissue. As the water evaporates from the surface of leaf or fruit tissues, it carries heat away from the plant.

Used properly, this process can:

- reduce plant temperature – important in leaf growth and runnering
- reduce the soil temperature
- reduce the fruit temperature
  - reduce ripening rate
  - help increase shelf life of fruit.

For evaporative cooling, use low application rates, i.e., 2 mm/hr. Evaporative cooling should be done in such a way that the plants will dry off before nightfall, thereby reducing the chance of increased disease development.

Evaporative cooling should be used when air temperatures are above 29° C (84° F) with low humidity and with some wind. It's not as effective if relative humidities are high or it is calm. Under ideal conditions, evaporative cooling can reduce temperatures by as much as 9° C (16° F).

Honeybees improve the seed number in developing fruit, and have a positive influence on yield. They won't work during an irrigation cycle.

SPECIAL APPLICATIONS

REQUIREMENTS

- solid-set irrigation system is desirable
- colder water will have an advantage over warmer water in reducing the effect of heat in the planting
- nozzle size
  - $1/8$ – $1/4$ inch
  - smaller size may be desirable for evaporative cooling of entire area at one time because application rates are lower
  - the smaller sizes are also useful for frost protection, but require that the irrigation system run longer for irrigation purposes
- proper timing
  - should be applied once the temperatures reach 29° C (84° F) as measured by a sheltered thermometer in the field
  - the irrigation should be run approximately 15 minutes and shut down
  - this can be repeated if the temperatures should again reach 29° C (84° F)
  - don't apply water past 3:00 pm to allow the foliage to dry before nightfall

PROBLEMS

- increased costs
- possible pollination problems – bees don't like to work during irrigation
- possible increase in disease problems (Botrytis fruit rot, leather rot, black root rot, verticillium and red steele) – see Ontario Ministry of Agriculture and Food Publication 360, *Fruit Production Recommendations* for further details
- evaporative cooling must be done with low application rates (i.e., 2 mm/hr) to avoid nutrient leaching
  - with high application rates and prolonged usage, nutrient leaching is enhanced