APPLICATION

This chapter includes:

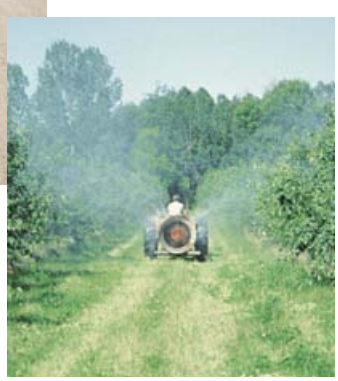
- **a brief overview of integrated pest management (IPM)**
- **the basics of how environmental and management factors can make the difference between coverage and drift**
- **best management practices for application**
- **best management practices for measuring, calibrating, and monitoring.**

It takes a working knowledge of the principles of sprayer technology, plus a toolbox of best management practices, to make pesticide applications work best – whether for horticultural crops, field crops, or livestock.

Determine your target. Know your product. Adjust for conditions. Hit your target. These are the keys to effective pesticide application. Follow these principles and you'll:

- ▶ save money
  - ▷ properly timed applications seldom have to be repeated
  - ▷ properly applied pesticides minimize waste – before and after application
  - ▷ maintain high quality, safe production at lower costs
  - ▷ effective applications help to maintain yields by controlling pests
  - ▷ successful pesticide use helps ensure timely harvests of quality produce
- ▶ protect the environment and wildlife
  - ▷ effective application reduces off-site impact to surface water and wildlife habitat
  - ▷ careful monitoring can help reduce direct exposure of wildlife to pesticides
- ▶ protect people, pets, and livestock.

Poorly timed application of pesticides to livestock can result in herd loss or product quality problems.



Best management practices for application are a good fit with your IPM program. Hitting the right pest at the right time with the right product will help you get the quality you're looking for.

If you think attention to sprayer technology isn't worth your time, count the cost of spraying your crop again.

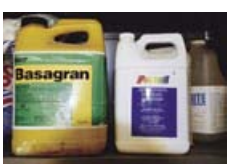
APPLICATION

EFFECTIVE PEST CONTROL

Applying a pesticide may successfully control a pest. But it is likely that the pest will return unless more is done. Effective pest control takes knowledge, skills and careful planning to reduce the probability of pest resurgence. Learning and using the principles of integrated pest management (IPM) provides the opportunity to reduce pesticide application and increase effectiveness.

IPM is a process. And the following steps should be considered before applying pesticides.

Spraying by the calendar is not an effective means of pest control.

IPM STEP	MANAGEMENT CONSIDERATIONS
1. Diagnose the problem. 	• what is the pest? • where is the pest? • is it an economic pest problem? • when is the pest most susceptible? • what are the conditions that favour the pest?
2. Monitor the problem. 	• can the pest problem be predicted? • what monitoring techniques are suited to the pest? • what are the economic thresholds for the pest? **For a general overview of IPM, see the Best Management Practices booklet, *Integrated Pest Management.***
3. Control the problem.  **Consider pest resistance potential and choose products from different families.**	• what control measures work, and under what conditions? • which combinations work best? • which are practical and cost-effective? • what should be known about pest control products? • are there alternatives to pesticides available? • how should the products be applied? • how much do you need? • how many days to harvest? • what is the re-entry interval?
4. Monitor the results. 	• did the treatments work, and is followup necessary? • is there any crop/livestock damage? • is there any off-site damage? • how will you measure or observe this? • is there any impact on beneficial insects, plants, fish, and wildlife?

APPLICATION

The goal of application is to hit the target with the right product at the right time.

Reaching this goal requires an understanding of the principles affecting application: pest characteristics, crop or livestock development, product qualities, environmental conditions, and application technology.

TIMING

Timing is everything, or nearly everything. Timing relates to pest growth stage, pest pressure, the growth stage of the target crop, application of the pesticide product, and weather conditions.

FACTOR	WHY TIMING IS IMPORTANT
FARM PRODUCT	• some **crops** are susceptible to damage at certain growth stages, e.g., some herbicides must be applied before crop emergence • because of **crop** or **foliage growth patterns** over the season, application techniques should be timed appropriately • to protect **beneficial** and **pollinating insects**, no insecticides should be applied during flowering • due to potential **residue problems**, no pesticide should be applied to the crop closer than the days-to-harvest interval • some livestock insecticides should not be used on **young stock** or on **lactating animals**

PEST CHARACTERISTICS	• for **insects**, know when pest is most susceptible
	  ◦ if damage is already done during susceptible stages, it may be wasteful and futile to apply pesticides at this time
	  ◦ also, make sure that you know when it will pay to spray
	• for **diseases**, protectant applications and preventative cultural methods are usually best
	• for **weeds**, know which growth stage of the target weed species is most susceptible to control
	• for some **livestock pests** (e.g., warble fly), susceptibility to control depends on life cycle stage and accessibility for treatment

Spraying too close to harvest could lead to illegal residues.

Most insecticides for Colorado Potato Beetle are designed to provide control of the insect at the larval stage. The cost of an improperly timed application can be excessive ($25/acre and up) when you consider the cost of the first application, the crop damage incurred, and the cost of reapplication.

Different growth stages of target weed species have varying levels of susceptibility to control measures.

APPLICATION

FACTOR	WHY TIMING IS IMPORTANT
PESTICIDE PRODUCT (KNOW YOUR PRODUCT)	• continued use of the same pesticide family can lead to **pesticide resistance** • contact pesticides require adequate **coverage**, so hitting the target is essential ◦ pesticide droplets may be required on both upper and lower leaf surfaces • **durability** – due to the chemical nature of some products, washing off, photodecomposition, and microbial decomposition will reduce durability • **additives** – some additives such as adjuvants may improve the ability of the products to spread and stick to target • **mode (of action)** – how a pesticide is intended to work will dictate time of application, e.g., protectant fungicides must have thorough coverage prior to the infection period for good control
WEATHER (ADJUST FOR CONDITIONS)	• contact and systemic pesticides with minimal residual qualities may wash off if it **rains** immediately after application • **temperature** can affect the breakdown of pesticides • apply at **time of day** when there is less interference by temperature • **high temperatures** and **low relative humidity** will evaporate spray droplets in their travels • **high winds** and fine sprays will result in drift to off-site areas • residual activity may be reduced by **photodecomposition** (intense sunlight)

Consider the relative toxicity of pesticide products to non-target species such as songbirds.

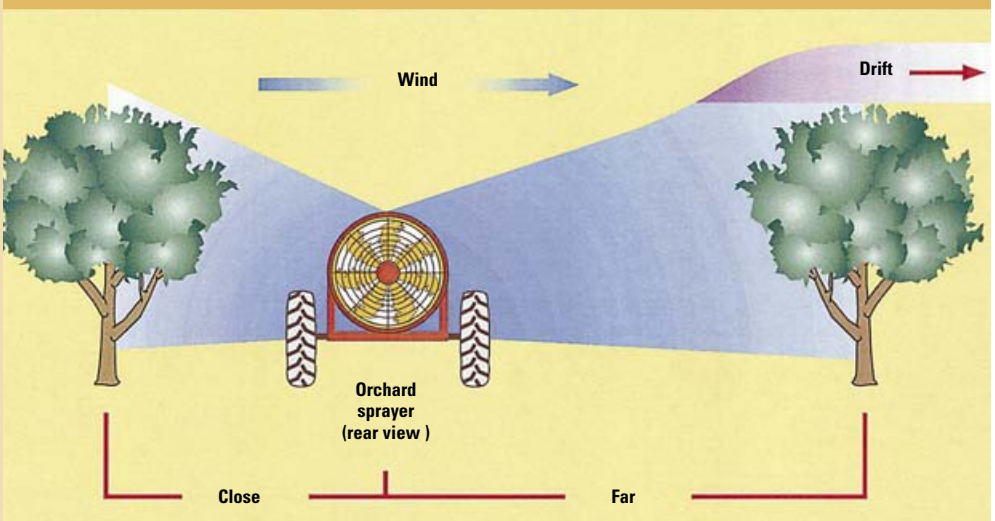
Some pesticides are not useful at high temperatures. Spray in evening or morning.

APPLICATION

COVERAGE VERSUS DRIFT

Maximize coverage and minimize drift. Do this and you'll have effective application. In most cases, factors that improve coverage will reduce drift.

FACTORS AFFECTING COVERAGE AND DRIFT



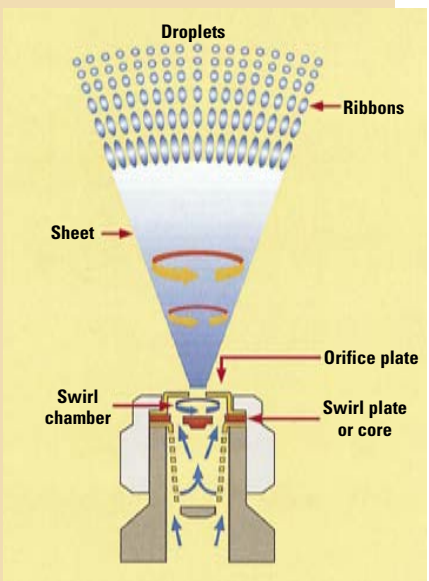
APPLICATION TECHNOLOGY FACTORS

- Water volume
- Pressure
- Droplet size
- Nozzle type
- Distance to target
- Travel speed
- Product selected

CONDITIONS DURING APPLICATION

- Canopy
- Wind
- Temperature
- Humidity
- Light

Generally the risk of drift is greater when a combination of the following factors coincide: low volumes, high pressures, small droplets, fast ground speeds, nozzles with small orifices, volatile chemicals, dense canopies, high winds and temperatures, and low humidity. Generally, coverage is greater when the reverse conditions exist.



A pesticide spray is a pressurized application of a liquid solution or suspension of pesticide product. Sprays are actually atomized solutions consisting of a range of droplet sizes.

Droplets are formed by forcing the solution through a nozzle orifice or by shearing it with a blast of high-speed air.

The solution leaves the nozzle as an unstable sheet or stream of liquid. This becomes thinner as it moves from the nozzle, and eventually breaks into droplets.

Drift can cause off-site damage.

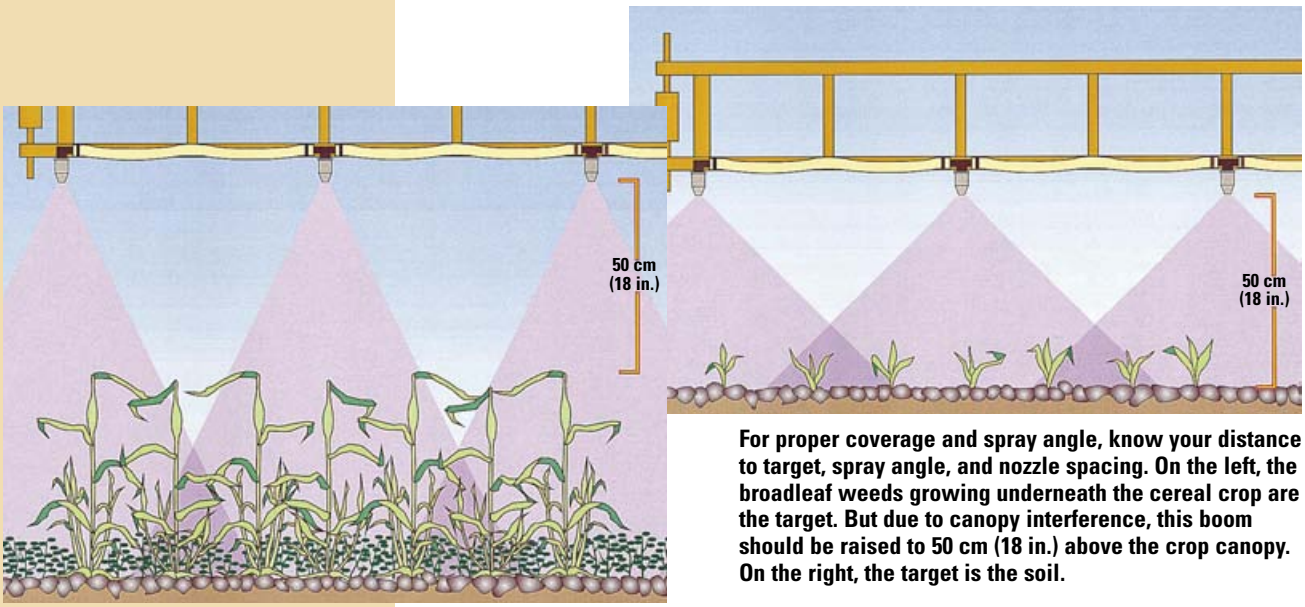
APPLICATION

COVERAGE VERSUS DRIFT – APPLICATION TECHNOLOGY FACTORS

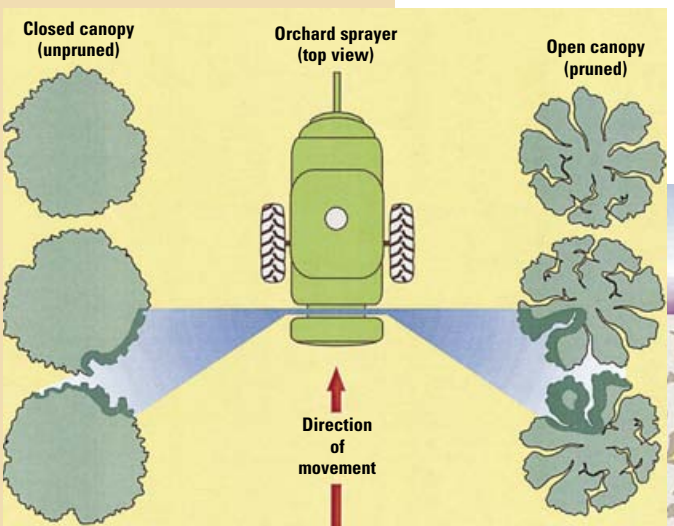
FACTOR	COVERAGE	DRIFT
VOLUME		
• HIGH	• increased coverage (can also cause runoff)	• less drift
• LOW	• less coverage	• increased drift
PRESSURE		
• HIGH	• will improve coverage if the droplets reach the target	• increased drift because of force and reduced droplet size
• LOW	• use lowest pressure that still ensures proper coverage • lowest pressure to maintain spray angle	• reduced drift
DROPLET SIZE		
• LARGE DROPS (large nozzle orifice)	• fair coverage ◦ may shatter ◦ may bounce off ◦ less penetration, less evaporation ◦ fewer droplets ◦ may run off	• high falling velocity • less drift hazard
• SMALL DROPS (small nozzle orifice)	• good coverage ◦ better penetration ◦ more droplets ◦ more evaporation	• higher drift hazard • low falling velocity
NOZZLE TYPE		
• FULL CONE	• moderate coverage	• moderate drift
• HOLLOW CONE	• good coverage	• more drift
• FLAT FAN	• moderate coverage	• moderate drift
• FLOOD	• fair coverage	• less drift
DISTANCE TO TARGET	• closer distances provide better coverage	• greater distances ➔ higher drift
TRAVEL SPEED		
• FAST	• poor coverage – but more acres/hour	• increased drift risk
• SLOW	• better coverage – but fewer acres/hour	• decreased drift risk
PRODUCT SELECTED		
• HIGH VOLATILITY ADJUVANTS	• may compromise coverage • may improve coverage • may alter droplet size • may alter spray pattern	• more vapour drift • reduce drift

This chart is a generalization only. A desirable compromise is reached when the adjustment of application equipment and practices integrates more than one factor.

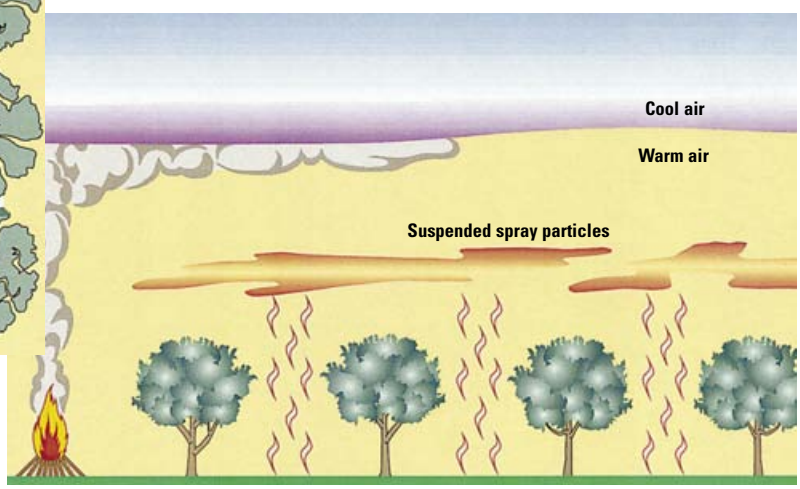
APPLICATION



For proper coverage and spray angle, know your distance to target, spray angle, and nozzle spacing. On the left, the broadleaf weeds growing underneath the cereal crop are the target. But due to canopy interference, this boom should be raised to 50 cm (18 in.) above the crop canopy. On the right, the target is the soil.



Coverage increases when canopies allow for better penetration. Pruning helps.



Temperature inversions occur when warm air is trapped near the surface by cold air, as evidenced by the unique pathway of smoke from the burning of pruned material. Avoid spraying during temperature inversions – when conditions cause smoke to behave as shown, small droplets will drift off-site.

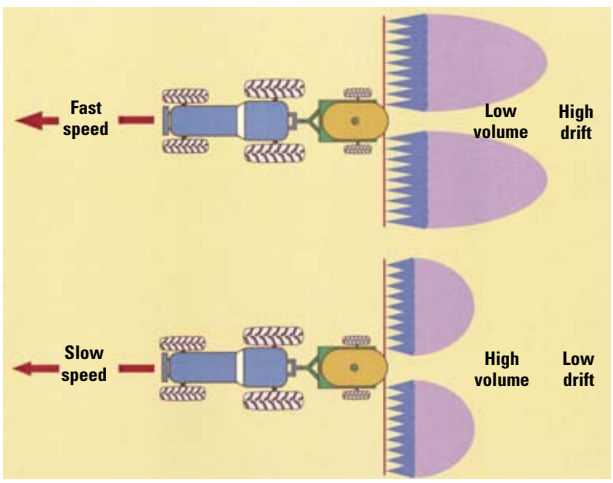
APPLICATION

DISTANCE TO TARGET

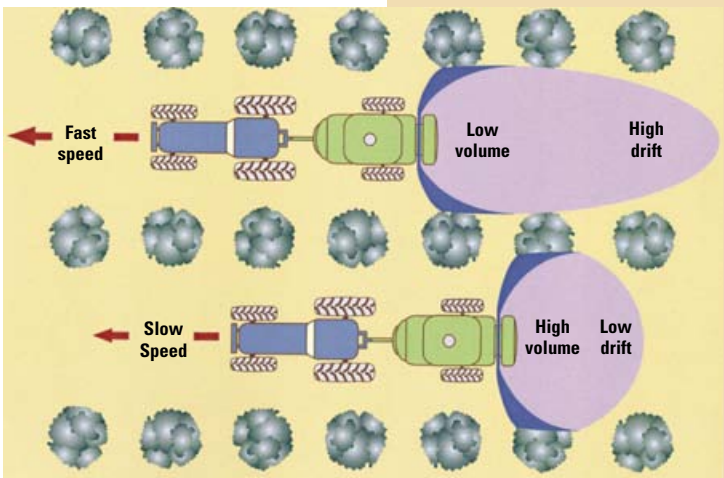
The greater the distance from nozzle to target, the poorer the coverage and the greater the risk of drift. When small droplets have greater distances to travel:

- **the increased time increases risk of off-target deposition**
- **wind and air movement increase with heights.**

VOLUME AND TRAVEL SPEED

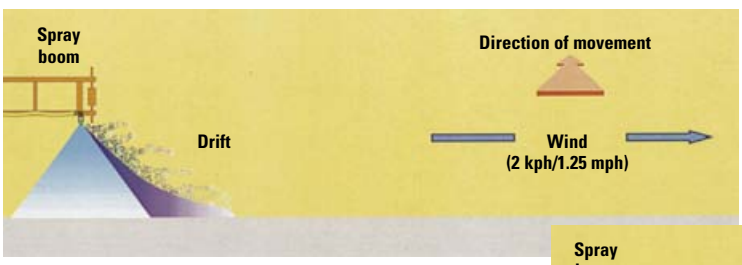


At a given pressure, there is a greater risk of drift with low volumes and fast ground speeds.



At the same pressure, coverage is improved and drift is reduced with higher sprayer volumes and reduced speeds.

DROPLET DIAMETER, WIND SPEED, AND DRIFT



Mist-size and coarse droplets do not drift far from target when winds are at very low speeds.

Under moderately windy conditions, mist-size (100 microns) droplets can move considerable distances downwind from the source. Coarse droplets will only move slightly off-target.

APPLICATION

BEST MANAGEMENT PRACTICES

To do the job right, you need the right tool, and you have to keep that tool in proper working condition. Nothing could be more true for pesticide application equipment. It takes know-how to choose the right sprayer, nozzle, and accessories. And it takes prudence and a few tips to keep the equipment calibrated and working properly.

It pays to routinely maintain and calibrate your sprayer.

Properly selected and functioning application equipment will help you:

- ▶ know your precise rate of spray application (L/ha)
- ▶ hit the pest with the prescribed dose
- ▶ know you have the right output from the nozzle to do the job
- ▶ reduce product waste or leftovers (calibration)
- ▶ ensure that you get the droplet size to do the best possible job
- ▶ avoid off-target and off-site damage
- ▶ save time and money – fewer reapplications keep costs down!

EQUIPMENT TYPES

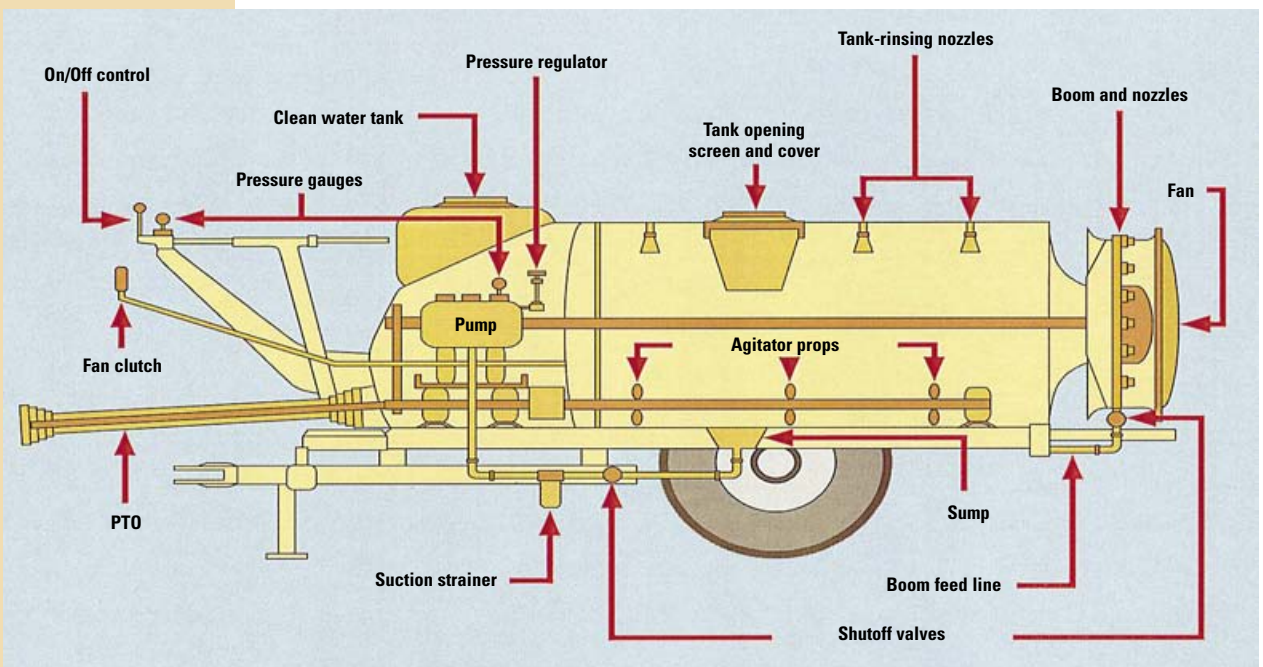
TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
HAND-OPERATED SPRAYERS 	• hand pumping compresses air, forcing the liquid mixture through the wand	• spot spraying small quantities (e.g., around trees) or spraying small areas • pressure regulators are now available to preset pressure + portable and convenient – pressures and outputs fluctuate – insufficient agitation of powders – need to stop and re-pressurize sprayer – physically demanding
HOSE-END SPRAYERS 	• vacuum from running water draws a fixed rate from a small spray bottle	• spot spraying lawns and gardens + may deliver 50 L of output before refilling – dirt in nozzle makes rates unreliable – accuracy is only fair at best – moderate to high risk for personal contamination – requires high water volume

APPLICATION

TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
BACKPACK SPRAYERS 	• operate under pressure provided by small manual pump fitted into top or bottom of spray tank • hand-operated pump forces liquid out of the tank through hose and nozzle at pressures between 100-600 kPa (15-90 psi) • work better when pressure regulators are used – pressure regulators maintain uniform output	• hand-held (4-10 L capacity) or backpack (25 L capacity) • used for spot or limited area application (small orchard, nursery, rough areas) +preset inline pressure regulator available +no trampling of crop –pressure is variable –can drip –hard on shoulders –risk of personal contamination –hard to get into harness alone
MOTORIZED SPRAYERS 	• a power-driven pump is used to provide pressure in the hose rather than the tank • could be boom, single-gun wands with 2-4 nozzles • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• mounted on tractors, trucks, trailers, aircraft • can be low- or high-pressure types • small-scale lawn and garden, hobby farmers, nursery and custom applications +portability –motor is dedicated to single use
BOOM SPRAYERS 	• pump: centrifugal, piston, roller, diaphragm • PTO-driven • partial vacuum is created (except with centrifugal) in the suction line, which fills with spray from the tank • spray is forced through to the sprayer booms and nozzles • tanks are fitted with agitators to keep pesticide in suspension • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• used for row-crop pesticides +distributes pesticides uniformly over large areas +versatile – useful for many crops, pests and application techniques –nozzle-to-target distances will change with hills and valleys in fields
ULTRA-LOW-VOLUME SPRAYERS (ULV) 	• apply concentrates with very little or no water carrier • droplets contained by structure • smaller but more numerous droplets • rates: < 10 L/ha (< 1 gal./ac.)	• protected environment uses, e.g., greenhouse, cold storage +can be controlled remotely after hours +better coverage in protected environment –applicator at greater risk –few pesticides are registered for ULV –prone to drift

APPLICATION

TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
ORCHARD SPRAYERS 	• air and liquid pressure used to deliver mix to target • pesticides pumped through nozzles into a blast of air from high-speed fan • fine droplets are carried to target • rates: 340-1000 L/ha (30-100 gal./ac.) • nozzles: ◦ various types are available ◦ flipover nozzles are available • pressure range: 500-2000 kPa (80-300 psi)	• used with tree fruit, cane fruit, and vineyard +high or low volume, range of pressures –mixture requires mechanical agitation –prone to drift problems
AIR-ASSIST BOOM SPRAYERS 	• similar to boom sprayers with addition of fan and manifold to deliver downward-moving air curtain • air is used to entrain small droplets and direct them towards target • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• used for row-crop pesticides +will reduce off-field deposition +may increase canopy penetration but dependent on crop and stage of growth +direction of air curtain may be adjustable –high initial cost –air speed/volume infinitely variable (there can be problems determining air speed setting, especially with certain horticultural crops) –dust stirred up by forced air may affect pesticide efficacy



Orchard sprayers project fine droplets to a target by pumping pesticide mixture through nozzles into a blast of air from a high-speed fan.

APPLICATION

SPRAYER SELECTION

Choosing the best sprayer for the job takes careful planning. The following considerations should help you choose the most suitable equipment.

Crop types and acreage

- ▶ are you spraying row crops, vineyards, or orchards – or a combination?
- ▶ will you change your operation dramatically over the next 10 years, e.g., size of operation?
- ▶ will the sprayer work in all crop canopy stages, throughout the growing season?
- ▶ which types of materials are sprayed (herbicides, insecticides, fungicides)?
- ▶ how many different crops are planted?
- ▶ how often do you use the sprayer per season (e.g., each area once, 50% of the area 10 times)?
- ▶ are you matching sprayer capacity to acreage and available spray window?

Sprayer capacity

- ▶ how rapidly can products be applied in case of emergency, e.g., severe crop loss due to insects or disease?
- ▶ how many tanks does it take to apply product to the most vulnerable crop?
- ▶ how much water per hectare is needed now and will be in the future?

Performance in adverse conditions

- ▶ does the sprayer or related accessories allow spraying in higher winds without excessive drift (e.g., hooded booms, guide vanes, air-assist, etc.)?

Warranties and service

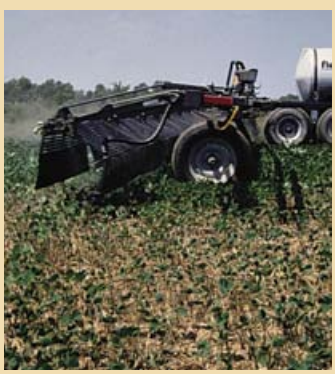
- ▶ are maintenance and repair easy?
- ▶ is expert assistance locally and readily available?
- ▶ are parts available and is the local dealer the only source?

Adaptability to other crops

- ▶ how adaptable is the sprayer (with or without accessories) to spray all crops?
  - ▷ advantages of having a second sprayer are less risk of injury and fewer rinsings per crop, e.g., herbicidal and insecticide sprayer

Choose a sprayer that's best suited and sized to the range of tasks in your operation.

Will the sprayer work in all crop canopy stages, throughout the growing season?



In cases of emergency, sprayers have to be able to work effectively in both ideal and adverse conditions.

Sprayers should be easy to maintain and repair.

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All pumps should deliver the necessary flow rate required at the boom at the desired pressure, and have adequate flow to provide adequate agitation.

SPRAYER EQUIPMENT COMPONENTS

PUMPS

TYPE	FUNCTION	ADVANTAGES	DISADVANTAGES
ROLLER 	• small field/tractor-mounted sprayers • best for emulsifiable concentrates • soluble powders • up to 2000 kPa (300 psi) operating pressure	• low cost • self-priming • compact • easily rebuilt • wide range of sizes available	• mostly low volumes at low to moderate pressures • will wear quickly if wettable powders used • require regular maintenance • pulsation damper required • can be damaged by malfunctioning relief valve
CENTRIFUGAL 	• centrifugal force moves liquids from impeller to outlet; operating pressure up to 500 kPa (75 psi) ◦ multi-staged impellers can deliver higher operating pressures 1400 kPa (200 psi)	• durable, easy to repair, inexpensive • able to handle abrasive materials • only one moving part • high output • for constant pressure output, use pressure/regulator valve	• not self-priming • high-pressure centrifugal pumps are expensive to replace • sensitive to restrictions to inlet or to back pressure
PISTON 	• adaptable to many uses • operating pressure up to 3000 kPa (450 psi) • low to medium volumes/low to high pressures	• reliable, replaceable parts • output is a direct function of pump shaft speed • okay for abrasive materials	• most expensive • require surge chamber to reduce pulsations • large and heavy
DIAPHRAGM 	• high pressure • maximum operating pressure 3000 kPa (450 psi)	• will pump abrasive solutions • self-priming • diaphragms and check valves can be replaced • moving parts do not contact spray mixture	• require surge chamber to reduce pulsations • cost • replace all diaphragms at same time • bypass flow required when boom is shut off • large and heavy

APPLICATION

TANKS AND FITTINGS

TYPE	ADVANTAGES	DISADVANTAGES
MILD STEEL 	• low cost • easy to repair	• corrode and rust • short life • rust scale plugs equipment • right angle joints cause dead agitation areas in tank
STAINLESS-STEEL 	• little damage from spray mixtures • long life • surfaces are easier to clean	• costs more than steel • repair costs more than steel • right-angle joints cause dead agitation areas in tank • different grades of stainless-steel – some are susceptible to corrosion
PLASTICS 	• less damage from spray mixtures • rounded corners are easier to agitate • low weight • no scale/corrosion	• require more support from frame • cannot be field repaired

AGITATORS

Mechanical agitators have a central shaft with paddles to stir the spray suspension.

+ pump sized only for boom requirements

– agitator can't be shut off to prevent foaming

– shaft seal requires regular adjustment to prevent leakage

Hydraulic agitators have a series of nozzles or jets that force liquid inside the tank to stir and mix.

+ adjustable rate of agitation

– requires larger pump

+ = advantage
– = disadvantage

APPLICATION

NOZZLES

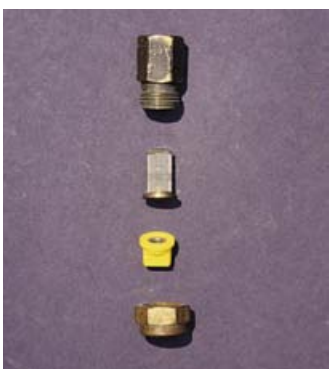
Pesticide efficacy partially depends on good application.

Spray nozzle and tip selection is an important decision, as nozzle type will affect three critical aspects of application:

- ▶ spray volume
- ▶ spray distribution on target
- ▶ droplet size.

The following screens are necessary to protect components and reduce plugging: tank-fill, suction, in-line (optional), and nozzle.

Note: Nozzle screens should be sized according to manufacturer's recommendations.



Most nozzles have four parts: body, screen, tip, and cap. Cone nozzles also have a swirl plate and orifice disc to regulate droplet size and meter the flow.

Note: Tips can be interchanged on a body made by the same manufacturer.

Spray nozzles come in four main families.

Solid-stream nozzles project a cylindrical stream over long distances. They're used for application of liquid fertilizer on crops.

Air-shear nozzles project a sheet of liquid into high-speed air, shearing the sheet. They're used mostly with air-blast sprayers.

Cone or swirl nozzles are primarily for high-pressure application of insecticides, fungicides, and some multi-nozzle directed sprays.

Flat fans are used for low-pressure application of pesticides with boom sprayers.

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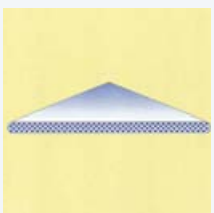
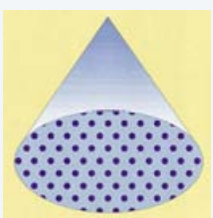
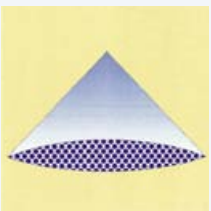
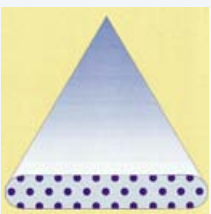
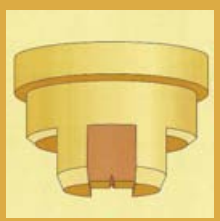
TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
SOLID-STREAM (PIN) 	• handguns – livestock, cylindrical stream • trees, nursery • liquid fertilizer • systemic pre-plant insecticides • roadside vegetation control	• round hole makes a stream that breaks into large droplets	• 140-1400 kPa (20-200 psi)	• mostly large 
AIR-SHEAR 	• air-blast orchard • horticultural crop spraying used on air-blast orchard sprayers	• high-speed air shears liquid sheet • finest droplets if sprayed into air stream	• 140 kPa (20 psi)	• variable – dependent on direction of air stream intersecting nozzle 
HOLLOW CONE 	• horticultural crop spraying used with air-blast sprayers and on row crops • where canopy penetration is required • crop spraying of wettable powders, flowables, and suspensions	• round hole plus 1-4 hole swirl plate produces hollow cone spray • 60-100° spray angle	• 275-2070 kPa (40-300 psi)	• finer, more uniform droplet size than solid cone nozzles 
FULL CONE 	• horticultural crop spraying used on row crop and air-blast sprayers to apply fungicides and insecticides • better crop penetration	• centre hole in swirl plate fills cone	• 275-2070 kPa (40-300 psi)	• larger droplet size than hollow cone 

APPLICATION

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
FLAT FAN (TAPERED) 	• broadcast herbicide and insecticide with booms • 30-100% overlap	• lens-shaped hole (with no swirl plate) • makes elliptical-shaped pattern tapered ends • pattern affected by spacing, height and angle • if lower pressure than recommended is used, spray patterns collapse – reducing spray angle and affecting distribution	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
EVEN FLAT FAN 	• banding of herbicides or insecticides in row crops	• oval hole makes rectangular pattern with sharp cutoff • available in variety of spray angles • boom height and nozzle spray angle will influence width of spray swath	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
FLOOD 	• broadcast spraying of pre-plant herbicides • wind-tolerant spray pattern • large self-propelled sprayers	• wide flat sprays 135° • tapered edge, flat fan pattern • wide spacing capability • older designs had heavy outer edges; improved versions eliminated these	• low pressures • 100-400 kPa (15-60 psi)	• large droplets 

APPLICATION

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
OFF-CENTRE NOZZLES 	• short booms for non-crop areas • extend boom width ends to spray field edge or fence rows • spraying under crop canopy for inter-row coverage of soil surface	• wide, flat spray off to one side	• 100-400 kPa (15-60 psi) • same as flat fan	• majority of droplets fall in middle of a range from fine to coarse 

CHOOSING THE RIGHT NOZZLE FOR THE JOB

Choosing the right nozzle for the job takes careful consideration of:

- ▶ the target
- ▶ the product
- ▶ the nature of the nozzle
- ▶ environmental factors
- ▶ droplet size.

Product formulation (e.g., wettable powder) and mixtures may dictate nozzle type.

Pesticide product efficacy is based in part on timing and coverage.

Mode of action is important. For example, systemic pesticides may not require the same extent of coverage as contact pesticides. However, locally systemic products do require better coverage for effective control.

Look at product labels for recommended volumes, pressures, nozzle types, angles, and spacing.

NOZZLE CONFIGURATION. Hitting the target may mean changing the configuration of nozzles (e.g., drop nozzle in ginseng for foliar disease control).

For dense canopy, solid cone nozzles (rather than hollow) may have to be used to compensate for denser canopy.

ROW CROPS. For pre-plant operation, the target is the soil surface. Use the nozzle that produces low pressure and large droplets. (Floods or flat fans would work.)

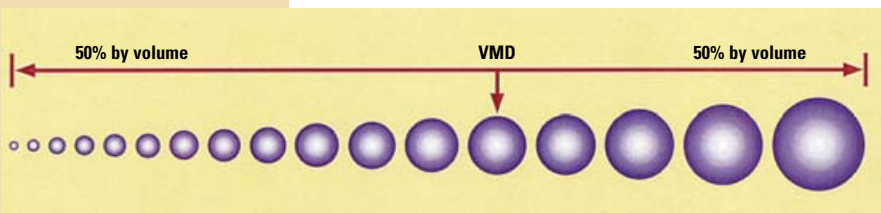
For post-emergence operations, the target is young weeds – some under the canopy or escapes. Use flat fan.

APPLICATION

The best source of help for **nozzle selection** is manufacturers' catalogues. See previous section for description of nozzle types.

NOZZLE MATERIAL	RELATIVE WEAR
• ceramic	• slow
• hardened stainless-steel • plastic • stainless-steel	• moderate
• nylon • steel • brass	• rapid

VOLUME MEAN DIAMETER (VMD)



The droplet spectrum is defined by the term Volume Mean Diameter. This is the diameter in the droplet spectrum in which half the volume is contained in smaller droplets and half in larger droplets.

Choose the nozzle that produces droplets that will hit the target, minimize drift, and produce the droplet size distribution to allow the product to do the job.

ENVIRONMENTAL FACTOR	BEST MANAGEMENT PRACTICE
WIND, HIGH TEMPERATURE, AND LOW RELATIVE HUMIDITY	• use drop nozzle sprays to reduce evaporation • use larger orifices at lower pressures • use wide angle at low boom heights • use high carrier volumes • use drift-reducing tips • minimize nozzle to target distance • don't spray if too windy or near sensitive crops, natural areas, or residential areas • delay application of volatile chemicals to when temperatures are cooler

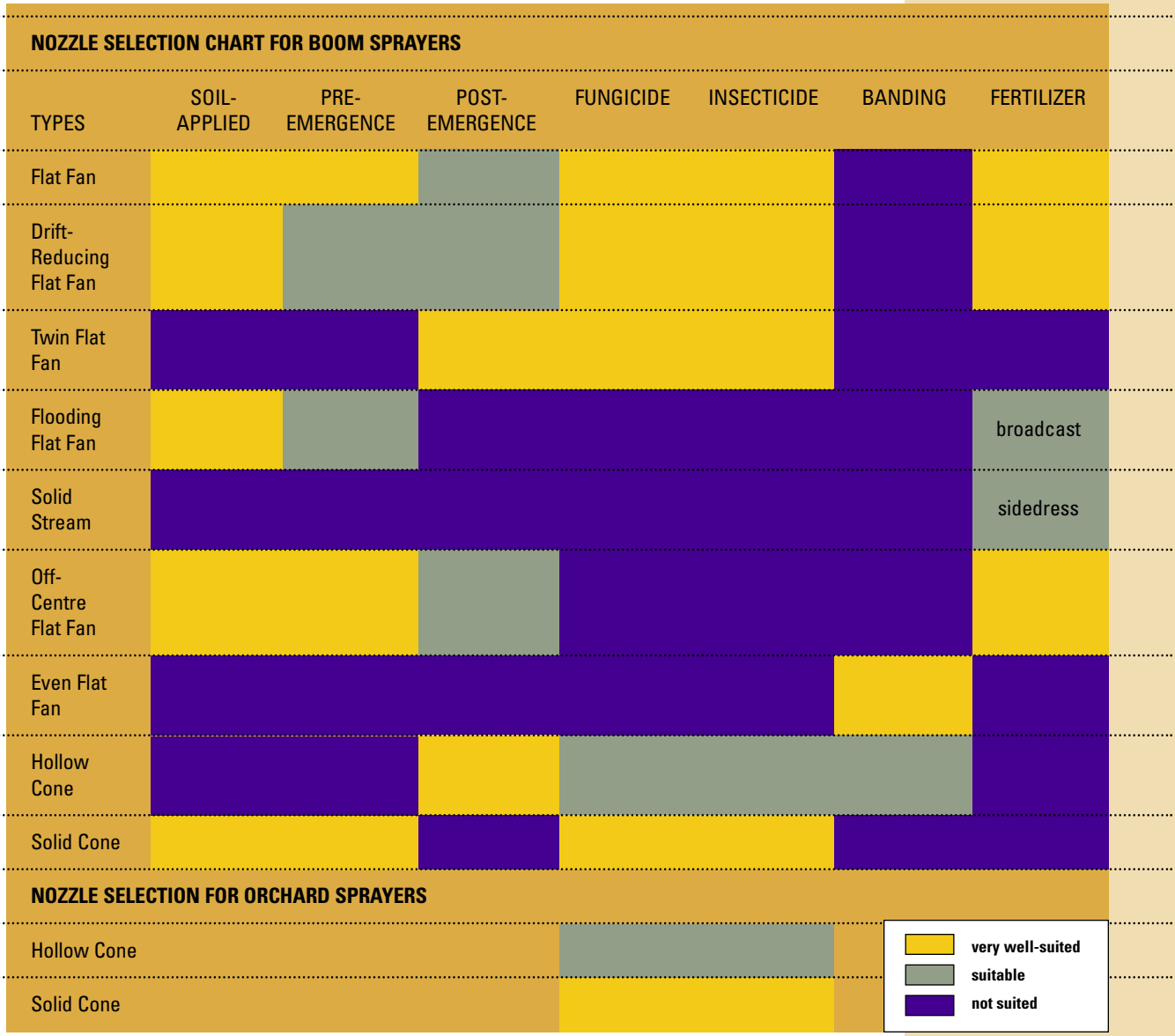
APPLICATION

'Tips' for Tips

A farmer decides to buy a new sprayer. The dealer has told the farmer that they will outfit the sprayer with one set of nozzles of the farmer's choice. The farmer would like to pick the best nozzle that will be capable of doing all spray jobs.

The reality is that one set of tips, and only one set of tips, will not do the best spraying job, when you take into account factors such as: water volumes, weather conditions, whether the product is a contact or systemic material, stage of development of the crop, plant structure, etc. As you delve deeper into nozzle selection, you will find that regardless of the nozzle type selected, it is always a compromise. A nozzle that produces droplets to give you adequate coverage may be very drift-prone.

In choosing a nozzle you have to determine the priority. Is it coverage, penetration, deposition, drift, or distribution pattern?



APPLICATION

SPRAYER ACCESSORIES

Recent developments in sprayer accessories have resulted in more accurate application of pesticides to the target area, reduced the incidence of off-target contamination, and led to safer conditions for the pesticide applicator.

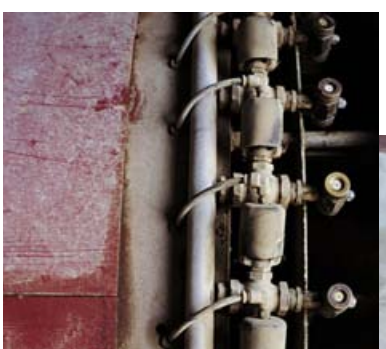
The photos below and on the next page depict some of the recent technology that's now available.

Self-regulating booms are used to keep a uniform distance between the nozzle and the target, even though the terrain undulates beneath the sprayer.

Nowadays, hydraulic wings can be individually raised and lowered according to the terrain. Previously, growers sometimes kept their booms too high to avoid getting too close to obstacles.

These swing booms have a mechanism for keeping the boom at an even height, even though the height of the tank may vary with a rough ride.

Rate controllers have become more popular in recent years. Used to show pressure and flow rate, and monitor spray volume, they can greatly improve sprayer accuracy.



Sonic orchard sprayers will shut on and off, depending on presence or absence of a tree.

Hooded sprayers and spray shields are available to reduce drift and provide selective placement.

APPLICATION

Global Positioning Systems (GPS) are finding their way into uses for pesticide applications, after proving their merit in applying fertilizer and mapping yields. By providing accurate field maps for weed infestation, growers can apply herbicides only where needed. This targets herbicide use to specific problem areas.

Air curtain sprayers have compartments of nozzles and hydraulic arms to reduce nozzle-to-target distances and attain better canopy penetration.

Recycling sprayers reduce drift and increase sprayer effectiveness by using walls and troughs to recycle spray mixture.

Air induction tips add air to reduce pressure and increase droplet size. They help reduce drift and increase coverage.

Vegetation-detecting sprayers are also available. Infra-red detectors can sense the presence of weeds. Nozzles turn on and off to spray sensed weeds.

This tree-sensing sprayer uses reflected light to sense orchard tree presence as it proceeds through the orchard.

APPLICATION

OTHER APPLICATION EQUIPMENT

When using granular insecticides, ensure you:

- ▶ incorporate them into the soil to minimize exposure to birds
- ▶ clean up granule spills at the end of rows and in rough terrain
- ▶ use less toxic granular insecticides to reduce risk to birds.

Granular applicators are often used for field and vegetable crop application of insecticides. Multiple gravity-fed outlets and disc openers place product near seed. Proper applicators agitate the material and stop dispensing when forward motion stops. Poor application rates and broadcasting of granular pesticides pose direct health risks to beneficial wildlife – especially birds. Incorporation or banding granular is a best management practice.

Low-pressure fumigators are used to apply liquid, volatile soil fumigants. Water or soil is used to keep fumigants from vaporizing. Soil injection equipment places the fumigant 15-20 centimetres (6-8 in.) into the soil.

Special precautions are necessary to prevent volatile fumigants from escaping following application.

Birds often ingest soil materials to aid digestion. Granular insectides can be easily mistaken for soil materials. Therefore, choose those products that are less toxic to birds.

APPLICATION

MAINTENANCE

Many problems encountered with the use of sprayer equipment can be prevented with planned, routine and seasonal maintenance. Here are some best management practices for maintaining field and orchard sprayers.

PUMP MAINTENANCE

WHAT TO DO	HOW TO DO IT
• flush the pump daily	• make sure tank is empty of pesticide mix • use clean water to rinse tank, booms, and nozzles daily • empty rinsate onto spray pad, or if mostly clean, use field
• lubricate pump	• follow manufacturer's guidelines • do it daily if grease or oil fittings provided • if oil pan/bath, check levels weekly • use recommended grades of oil/grease
• for a piston pump ◦ inspect check valves, valve seats, o-rings, seals, plunger cups, and cylinders	• inspect annually and replace if necessary • leading edge of cup should be sharp or mix will be trapped between cup and cylinder wall • operate pump with water and ensure no liquid is bypassing cups – do this for new cups or first time in spring
• for a diaphragm pump ◦ if pressure has dropped or reduction in flow evident, investigate	• disassemble pump • inspect all check valves and replace as necessary • annually check machine screws holding the diaphragm in place • replace all diaphragms – replace diaphragms annually as a preventative measure • reassemble
• for a centrifugal pump ◦ check for leaks ◦ check operating pressure ◦ never let pumps run dry ◦ drain all pumps before freeze-up or frost	• for leaks, replace shaft seals • replace seal – or if older model, tighten compression unit • prevent spray mixture from contacting shaft bearings – adjust slinger ring so that it's tight enough to rotate with shaft • drain tank, flush system with water – winterize pump with antifreeze

Flush the pump daily.

Drain all pumps before freeze-up or frost.

APPLICATION

Periodically disassemble pressure regulator to check internal components. Replace parts that show wear, e.g., plunger.

PRESSURE REGULATOR MAINTENANCE

WHAT TO DO	HOW TO DO IT

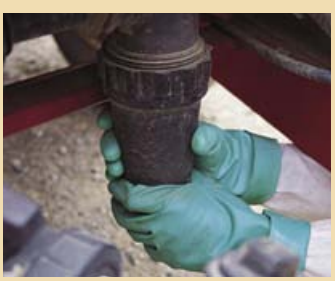
• lubricate
• adjust packing
	• follow manufacturer's recommendation
	• tighten or loosen to prevent malfunction
	  ○ too tight – may allow dangerous pressure levels
	  ○ too loose – leakage or chattering

• if you are not sure of the pressure for which the regulator is set	• slacken pressure before starting pump, then gradually readjust pressure

If gauge needle is bouncing, compare with a known working gauge. Check to see if your pulsation dampener is malfunctioning.

PRESSURE GAUGE MAINTENANCE

WHAT TO DO	HOW TO DO IT
• if the gauge is not functioning	• release in-line pressure • check for plugging from line to gauge • compare with a known working gauge • install a gauge isolator or replace with oil-filled gauge
• if you suspect that the gauge is inaccurate	• connect a new gauge in parallel • compare readings – replace if necessary



Inspect and clean the strainer early in season to ensure free flow of the pump.

STRAINER MAINTENANCE

WHAT TO DO	HOW TO DO IT
• check for tank scale • prevent buildup • clean screen	• inspect and clean early in season to ensure free flow to the pump • at the end of each growing season, rinse tank out thoroughly to flush out particulates • always put water and materials through screen to keep out debris, leaves and other contaminants • if butter-like deposit builds up, follow manufacturer's directions for suitable solvents
• if excessive deposits build up	• check with dealer to discuss chemical compatibility
• if strainer cracked or fits poorly	• replace it
• check nozzle strainer	• nozzle strainer should have a mesh finer than nozzle orifice • check manufacturer's catalogue

APPLICATION

NOZZLE MAINTENANCE

WHAT TO DO	HOW TO DO IT
• clean nozzle tips • replace worn tips	• use a soft-bristled (nozzle tip) brush • check nozzle output per minute to determine wear • use manufacturer's catalogue to match tips to proper nozzle body
• for swirl/cone nozzles	• check swirl plate and orifice disk
• check nozzle tips	• if caps are too tight, spray pattern is altered and may leak • replace washer if leaky

Use a soft-bristled brush to clean nozzle tips.

TANK MAINTENANCE

WHAT TO DO	HOW TO DO IT
• drain tank after use	• drain tank discharge line and sediment chamber, and NEVER LEAVE A TANK PARTLY FULL WITHOUT AGITATION • add clean water to the tank, circulate thoroughly, and spray out in treated field • leave hatch open to permit rapid drying

Drain tank after use.

AGITATOR MAINTENANCE

WHAT TO DO	HOW TO DO IT
• inspect mechanical agitator	• ensure paddles are secure on shaft • check lubricant of shaft bearing • check seals to prevent leakage • check integrity of agitator paddles and shaft • check drive belt, replace as necessary
• inspect hydraulic agitator	• check to see agitators are complete and providing visible liquid movement in tank • ensure pump capacity is sufficient for total nozzle output, plus flow to agitator and some overflow to maintain pressure • check orientation of agitators: they should spray diagonally into corners

Check agitator paddles and shafts for breakage and wear.

APPLICATION

Prevent overheating by cleaning radiator.

Inspect belts regularly.

Keep fan blades clean.

MAINTENANCE FOR	WHAT TO DO	HOW TO DO IT
ENGINE	• prevent overheating	• clean radiator • lubricate, change oil and oil filter
BELTS	• inspect belts	• look for broken, separated, missing or worn belts • look for pulley wear • check belt tension • check idler operation
BLOWER UNIT	• keep fan blades clean	• wash or scrape off deposits – even a small buildup can cause problems
UNDERCARRIAGE	• check frame for cracks or broken welds • check bolts • inspect wheel spindles	• reweld • tighten to recommended specifications • look for signs of wear or fatigue

SPRAYER WINTERIZING CHECKLIST

☑ Fill sprayer tank with clean water and operate pump until only clear water is being discharged through the nozzle. This should be done on spray pad or other suitable containment system. See Handling section.

☑ Open the tank drain valve. Remove and clean suction strainer.

☑ Remove drain plugs from pump and tank. Lubricate pump as outlined by manufacturer. Fill pump with environmentally friendly antifreeze.

☑ Run sprayer for a few seconds to dislodge any water in valves and in lines.

☑ Drain the crankcase. Refill with new oil to prevent corrosion of bearing parts during storage. Check lubrication in speed reducer.

☑ Lubricate spray guns or spraying attachments.

☑ Check all hose connections and replace clamps, etc.

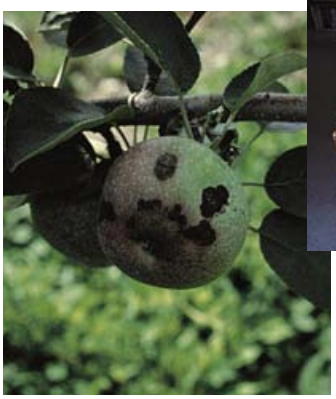
☑ Remove all dirt or corrosion and repaint if needed.

☑ Keep entire sprayer in building, under cover.

APPLICATION

SPRAYER CALIBRATION

Most problems with pesticide application can be prevented if sprayers are properly calibrated. Poorly calibrated sprayers can be the cause of several problems.



PEST ESCAPES. Uneven application or improper dosage can miss a sufficient number of pests at key stages.

PESTICIDE RESIDUES. Inconsistent application rates may leave excessive residue levels on fruit and vegetable products.

POOR RETURNS. Expensive reapplication of pesticides together with losses in yield and quality can lower expected returns on high value crops.

CROP DAMAGE. Uneven nozzle output will deposit too much product on sensitive crops.

The **goals** of sprayer calibration are to:

- ▶ verify that all equipment components are functioning properly
- ▶ ensure that sprayer output and volume applied give you the recommended dosage
- ▶ accurately predict the number of tanks, trips, and total time of the application, but most importantly determine the amount of pesticide per tankful
  - ▷ 'recipe cards' – with all particulars (such as acres/tankful, acres to spray, product/ tankful) should be done in advance, then posted in pesticide storage building.

APPLICATION

BOOM SPRAYER

1. **Clean all components**.

2. **Fill sprayer one-half full of water only**.

3. **Record time for equipment to travel 50 metres:**
   - ► set up two stakes in the field to be sprayed
   - ► set throttle at desired application speed
   - ► do three runs of the 50 m course
   - ► average the time in seconds for the equipment to travel 50 m.

APPLICATION

4. Calibrate nozzles

- ▸ park sprayer
- ▸ use beaker or other graduated container to capture and measure the volume from each nozzle for the same time calculated in Step 3
- ▸ record volume collected on sprayer calibration sheet (see next page)
- ▸ divide the total output from all nozzles by the number of nozzles to determine average flow of one nozzle
- ▸ replace any nozzles that deviate more than 5% from average output or more than 10% from manufacturer's specifications

5. Calculate sprayer application rate (L/ha)

- ▸ measure the distances between nozzles (m)
- ▸ multiply the average nozzle output by factor 0.2 and divide by the nozzle spacing in metres (see sprayer calibration sheet).

$$\text{Sprayer Application Rate (L/ha)} = \frac{\text{Average Output (ml)} \times 0.2}{\text{Nozzle Spacing (m)}}$$

6. Determine the number of tanks to spray field

- ▸ note sprayer capacity in litres
- ▸ measure the length and width of your field
- ▸ multiply length by width to calculate area of field
- ▸ the application rate calculated is based on L/ha – you'll need to determine hectares
- ▸ multiply area by application rate to determine total volume (L) for the field
- ▸ divide total volume (L) by sprayer capacity (L) to determine number of tanks required to spray field

APPLICATION

SPRAYER CALIBRATION SHEET

Tractor: _____

Gear: _____

Engine RPM: _____

Nozzles: Type: _____

Pump Type: _____ Age: _____

Model: _____ Spacing (m): _____

Tank Size: _____ litres Height (m): _____

Time Over 50 Metres: _____ seconds Pressure: _____

Average Time: _____ seconds

Nozzle No. and Volume Collected for Each Nozzle (ml)

1 _____	11 _____	21 _____	31 _____	41 _____
2 _____	12 _____	22 _____	32 _____	42 _____
3 _____	13 _____	23 _____	33 _____	43 _____
4 _____	14 _____	24 _____	34 _____	44 _____
5 _____	15 _____	25 _____	35 _____	45 _____
6 _____	16 _____	26 _____	36 _____	46 _____
7 _____	17 _____	27 _____	37 _____	47 _____
8 _____	18 _____	28 _____	38 _____	48 _____
9 _____	19 _____	29 _____	39 _____	49 _____
10 _____	20 _____	30 _____	40 _____	50 _____

Total All Nozzles: _____ ml

Average Per Nozzle: _____ ml

Application Rate (L/ha) $= \frac{\text{Average Output Per Nozzle (ml)}}{\text{Nozzle Spacing (m)}} \times 0.2$

$= \frac{\text{\_\_\_\_\_ (ml)}}{\text{(m)}} \times 0.2$

= _____ L/ha

Number of Tanks Required to Spray Field $= \frac{\text{Application Rate (L/ha) x Area (ha)}}{\text{Sprayer Capacity (L/tank)}}$

N.B. If you wish to convert to units other than L/ha, use conversion factors in margin after you've completed calibration sheet.

Conversion Factors

L/ha x 0.09 = Imperial gallons/acre

L/ha x 0.11 = U.S. gallons/acre

U.S. gallons x 3.785 = litres

Imperial gallons x 4.54 = litres

APPLICATION

HOW TO CALIBRATE YOUR ORCHARD SPRAYER

1. Calculate tree row volume (TRV)

- ▸ unlike fields, you have to spray a series of rectangular-shaped rows to maximize coverage of orchard trees and minimize wasted spray on alleys between rows
- ▸ TRV is an estimate of the volume of tree foliage in an orchard
- ▸ to determine TRV you need to know:
  - ▷ tree height in metres
  - ▷ tree width in metres (drip line)
  - ▷ spacing between rows in metres
- ▸ calculate TRV
  - ▷ TRV (m^3/ha) = $\frac{\text{Tree Height (m) x Tree Width (m) x 10,000 } (m^2/ha)}{\text{Spacing Between Rows (m)}}$

TRV (m^3/ha) = $\frac{\_\_(m) \times \_\_(m) \times 10{,}000\ (m^2/ha)}{\_\_(m)}$

= _____ m^3/ha

2. Calculate the spray volume per hectare needed to effectively apply a pesticide to your site

- ▸ spray volume required (L/ha) = TRV (m^3/ha) [from Step 1] x 0.028 (L/m^3) [a constant]

= _____ (m^3/ha) x 0.028 (L/m^3)

= _____ (L/ha)

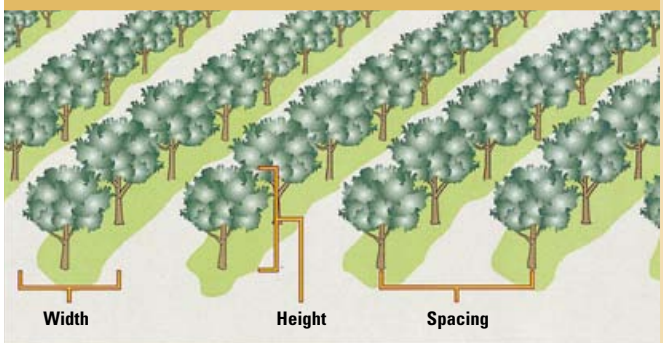
3. Determine the spray volume rate/side (L/min./side)

- ▸ note your target travel speed
- ▸ put your spray volume rate required (Step 2), spacing between rows, and travel speed into the following formula:

L/min./side = $\frac{\text{L/ha x Spacing Between Row (m) x Travel Speed (km/h)}}{\text{1200 (a constant)}}$

L/min./side = $\frac{\_\_(L/ha) \times \_\_(m) \times \_\_(km/h)}{1200}$

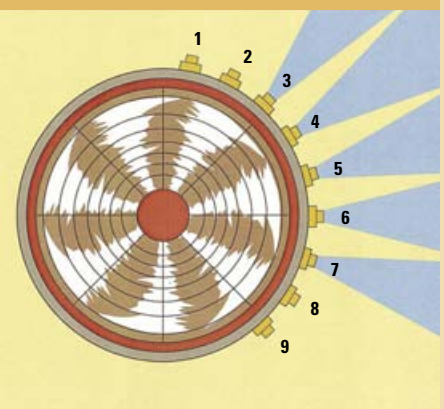
TREE ROW VOLUME (TRV)



Unlike fields, you have to spray a series of rectangular-shaped rows to maximize coverage of orchard trees and minimize wasted spray on alleys between rows.

APPLICATION

NOZZLE CONFIGURATION



This illustration explains the worksheet example on the right. Nozzle positions 1-2 and 8-9 are not used (OFF) so that the orchard sprayer output will be be better directed at the target tree canopy.

Output from the remaining nozzle positions 3-7 should have a distribution as shown in the illustration on page 89, where most of the distribution comes from the central nozzle positions (3-5).

In this example, this distribution is best approximated if the nozzle locations have the following proportion of the ouput:

Nozzle position 3 – 15% of total

Nozzle position 4 – 20% of total

Nozzle position 5 – 30% of total

Nozzle position 6 – 20% of total

Nozzle position 7 – 15% of total.

To achieve this distribution, refer to Step 4.

4. Select and set up nozzles (top to bottom) for the spray volume rate per side determined in Step 3

- ▶ determine the number of nozzles per side
  - ▷ for small trees, block off the nozzles that miss the target
- ▶ determine average output per nozzle by dividing output per side by total number of nozzles to be used

$$\text{Avg. Output/Nozzle} = \frac{\text{Spray Volume Rate/side}}{\text{No. of Nozzles}} = \text{L/min.}$$

- ▶ use a sprayer nozzle output chart that comes with the sprayer to choose nozzles at each position at a selected pressure (e.g., 175 psi)
- ▶ adjust the nozzle selection so that a larger portion of the output is emitted from the centre nozzles of the sprayer (e.g., nozzle positions 4-6), and choose nozzles with progressively smaller outputs as you move away from the centre position to the top and bottom of the nozzle bank (e.g., nozzle positions 3 and 7)
- ▶ total all nozzles to compare output with what you calculate your need to be (compare with Step 3)
- ▶ you still need to run the machine for a period of time and then refill to see if it is putting out what it was set up for.

TRV WORKSHEET EXAMPLE for Spray Volume Rate of 17.5 L/min./side using Spraying Systems Nozzles

NOZZLE POSITION	DISC NO.	SWIRL NO.	L/MIN
1 OFF	D _____	– _____	_____
2 OFF	D _____	– _____	_____
3	D 4	– 45	2.77
4	D 5	– 45	3.50
5	D 6	– 45	4.71
6	D 5	– 45	3.50
7	D 4	– 45	2.77
8 OFF	D _____	– _____	_____
9 OFF	D _____	– _____	_____

TOTAL = 17.25 L/min./side @ 175 psi

APPLICATION

5. Calculate the Tree Row Volume (TRV) chemical rate required per hectare

a) calculate TRV percentage based on a standard orchard (estimated at 35,191 m^3/ha)

$$\text{TRV \%} = \frac{\text{Your TRV } m^3\text{/ha [Step 1] x 100}}{35{,}191\ m^3\text{/ha}}$$

$$= \frac{m^3\text{/ha x 100}}{35{,}191\ m^3\text{/ha}}$$

b) now, calculate TRV chemical rate required per hectare

$$\text{TRV chemical rate/ha} = \frac{\text{__ Label Rate/ha x __ TRV\% (Step 5a)}}{100}$$

$$= \text{_____ Chemical Rate/ha}$$

6. Number of hectares per tank

$$\text{Hectares/tank} = \frac{\text{Spray Tank Volume}}{\text{TRV Spray Volume Required [from Step 2]}}$$

$$= \frac{\text{_____ L/tank}}{\text{L/ha}}$$

$$= \text{_____ha/tank}$$

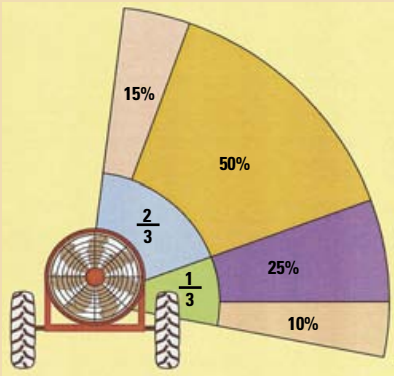
7. Calculate amount of chemical per tank

Chemical/tank = Hectares/tank [Step 6] x Chemical Rate/ha [Step 5b]

= _____ ha/tank x _____ Chemical Rate/ha

= _____ Chemical Rate/tank (e.g., L or kg)

- ▶ agricultural chemical suppliers cannot be held liable for failure due to the use of rates below those recommended on their labels
  - ▷ do not use TRV considerations if a label indicates doing so is inappropriate
- ▶ water volumes of less than 300 L/ha are considered inadequate if there is fruit to protect
  - ▷ the lower the volume of spray, the more critical the accuracy of rates become
- ▶ remember, TRV serves as a guide for calibration
  - ▷ recognize that as the trees grow in height or width and the canopy density increases throughout the season, the amount of water and pesticide required will need to be adjusted
- ▶ higher volume sprays can be important to control some pests
  - ▷ increased pest pressure and past experiences may also influence the actual amount applied
- ▶ accurate calculation of TRV will not compensate for poor coverage, timing, chemical choice, or weather conditions



Adjust the nozzle selection so that a larger portion of the output is emitted from the centre nozzles of the sprayer. Choose nozzles with progressively smaller outputs as you move away from the centre position to the top and bottom of the nozzle bank.

APPLICATION

Prevent resistance – employ IPM practices.

Spray when temperatures range from 15°-25°C.

Explore new technologies to increase application efficiency and effectiveness.

CHECKLIST FOR APPLICATION BEST MANAGEMENT PRACTICES

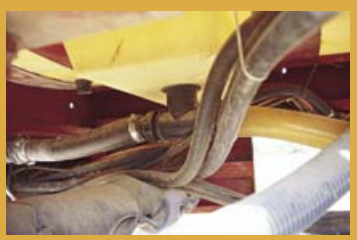
- ☑ Employ integrated pest management (IPM) principles before selecting pest control methods: identify, monitor, and determine critical pest and economic thresholds.
- ☑ Read the label before making application.
- ☑ Avoid pest resistance by practising IPM and pest product rotation.
- ☑ Leave at least 15-metre buffer strips between your treatment and sensitive areas.
- ☑ Use proper water volume rates to ensure coverage and reduced drift. Check the pH of your water – extremely high or low pH can be a problem for some pesticides.
- ☑ Use adjuvants where stated on the label.
- ☑ Select nozzles to attain the droplet size spectrum that will bring about proper coverage and drift reduction.
- ☑ Verify nozzle output. Clean plugged nozzles. Replace worn and damaged nozzles.
- ☑ Adjust nozzle to target distance to minimize drift and maximize coverage.
- ☑ Maintain and adjust your sprayer regularly.
- ☑ Calibrate your application equipment before using it, and throughout the season.
- ☑ Weather: consider wind, humidity, temperature and rainfall events before application. Adjust application practices accordingly.
- ☑ Spray when temperatures range between 15-25°C and favour pest susceptibility. Avoid temperature extremes. Do not spray heat- or drought-stressed crops.
- ☑ Consider nozzles that have coarse droplet spectrums during periods of low humidity.
- ☑ Generally, don't spray insecticides or fungicides if rain is predicted and when drying conditions are poor. Washed off pesticides can cause off-site damage. Reapplication is expensive.
- ☑ Don't spray with conventional equipment during wind speeds greater than 10 km/hr if you select a fine mist spray output. It may be tolerable to spray in winds up to 20 km/hr if the spray droplets are mostly large, and if there are adequate buffer zones around sensitive and residential areas to prevent off-site damage, and if best management practices are used to reduce drift.
- ☑ Track your spray distribution. Use techniques such as water-sensitive paper near sensitive areas or visual evaluation of off-target areas. Know the fate of your spray – for personal safety, crop safety, and environmental protection. Keep accurate and detailed spray records for future reference.
- ☑ Explore new technologies to increase application efficiency and effectiveness.

APPLICATION

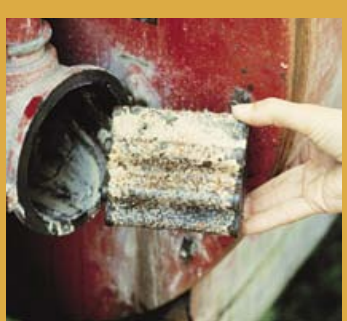
TROUBLESHOOTING KEY

PROBLEM	CAUSE	SOLUTION
MECHANICAL MAINTENANCE AND FAILURE		
SPRAY TANK EMPTIES ON ITS OWN	• sprayer contents backflow into water source • drain valve open, missing or damaged	• install anti-backflow device • replace drain valve
CANNOT PUMP OUT LAST 200 L IN TANK	• flow restrictor missing • pressure relief allowing bypass into tank	• install correct size orifice in agitator line • adjust flow to agitator nozzles
SPRAY SOLUTION LEFT OVER IN TANK	• travel speed too fast • wrong gear • wrong field dimensions • wrong set of tips • plugged nozzles • plugged line • dirty screens/filters	• slow down/recalibrate • check gear recommendations • check field dimensions • calibrate • clean nozzle tips • flush lines • check and inspect filters
PUMP GEARBOXES DAMAGED	• turning PTO off/on to turn sprayer off/on	• turn sprayer off using sprayer controls
BREAKAGE OF BOOMS	• self-regulating boom pinned solid • excessive travel speed • boom too low	• remove pin on self-regulating boom – unless only one side of boom is used • reduce travel speed • consider boom suspension system
FOAMING IN TANK	• agitation nozzles are above level of liquid • mechanical agitation too aggressive • product formulation • agitation inducing air into solution • low pH water	• reduce or shut off flow to agitators • investigate shutting off or reducing speed of agitators • read product label • investigate other product options or use of anti-foaming adjuvants • reduce or turn off agitation • buffer pH
SPILL ON ROADSIDE	• drain valve missing • pump left on • lid not secure • bottom valve not fully closed • broken fitting • tank perforated	• use personal safety procedures • contain spill • restrict source • replace drain valve, turn off pump, secure lid, close bottom valve, fix broken fitting • report spill • clean up spill

APPLICATION

PROBLEM	CAUSE	SOLUTION
MECHANICAL MAINTENANCE AND FAILURE (cont'd.)		
LOSS OF PRESSURE  **Hoses and fittings must be corrosion-resistant and able to withstand pressures or collapse.**	• pressure regulator improperly adjusted or stuck open • suction screen plugged • cracked, collapsed, or porous suction hose • worn pump • agitator nozzles blown off • worn nozzle tips • faulty gauge • pump starving	• clean and adjust pressure regulator • thoroughly clean screen • replace hose • replace or recondition pump according to manufacturer's instructions • ensure agitation nozzles in place • replace nozzle tips • replace gauge • check for collapsed suction hose, plugged filter, main control valve too small or wrong type • check to see that anti-vortex fitting is in place in tank bottom
EXCESSIVE PRESSURE	• pressure regulator improperly set or stuck • pressure line plugged or constricted • bypass hose plugged or too small • faulty gauge	• adjust pressure regulator • unplug the hose or replace it • replace gauge
NOZZLES AND OUTPUT		
DURING CALIBRATION, OUTER BOOM NOZZLES HAVE 10% LESS OUTPUT  **The wrong nozzles for the task at hand can reduce output.**	• incorrrect nozzles • flow restriction • partially plugged lines • partially plugged line filter	• calibrate or replace • check matching fittings both sides of sprayer • use drill to increase internal diameter of fitting • check boom line for blockage • flush out lines • clean line filters

APPLICATION

PROBLEM	CAUSE	SOLUTION
NOZZLES AND OUTPUT (cont'd.)		
SLUDGE IN TANK	• poor agitation • overagitation • poor tank cleaning practices • incompatible mixture	• check to see that agitator nozzles are working • read the label
UNEVEN SPRAY PATTERN  **This uneven spray pattern was caused by improper boom height. Adjust boom height to attain proper overlap.**	• nozzle screen plugged • nozzle tip damaged • pressure too low • nozzles too small, worn or damaged • mismatched nozzles in boom • boom too low • uneven terrain	• clean or replace screen • replace tip with new one • check pressure on boom end with a gauge ◦ pressure should be within 10 to 16 kPa of main gauge – if not, check size of fittings and hoses for restrictions • replace nozzles • raise boom or rotate ahead or back slightly • slow down, install boom wheel, readjust directional vanes (orchard air-blast)
PULSING SPRAY OUTPUT	• waterlogged pressure accumulator • diaphragm ruptured in pulsation dampener	• drain pressure accumulator or fix leak • replace diaphragm
SPRAY NOT REACHING TARGET	• spray too fine • boom set too high (row crops) • carrier airstream improperly directed • too windy • canopy interference	• reduce spray pressure, use larger nozzles • lower boom and angle forward or back • readjust directional fans • quit spraying • change nozzle type or nozzle placements
NO OUTPUT  **No output can be caused by plugged main filter screens. Clean or maintain routinely.**	• frogs (or other wildlife) trapped in suction strainer • plugged lines • suction line shutoff valve is closed • suction intake in tank plugged • cracked suction lines • collapsed suction line to pump • pump malfunction • tank is empty	• flush lines • unplug • check tank and screens • replace with crush-proof pesticide compatible line • check pump intake • improper winterizing – check for cracks • check calculations • calibrate and check field dimensions

APPLICATION

PROBLEM	CAUSE	SOLUTION
MONITORING		
CROP DAMAGE INCREASES AS YOU PROCEED DOWN THE FIELD	• ineffective agitation • soluble package dissolves too slowly	• check agitation equipment; don't use bypass line for agitation • review product mixing instructions
PHYTOTOXICITY	• improper product selection • dosage too high • improper tank mixes • timing of application • temperature, humidity, sunlight • equipment malfunction • crop development	• follow label directions • follow label directions and calibrate • follow label directions • spray in morning or evening – follow label products • follow label directions for conditions • check pump, pressure, nozzle output • read label and follow instructions
CROP INJURY IN STRIPS PARALLEL TO SPRAYER TRAVEL	• excessive overlapping • oversized nozzle tip(s) • excessive nozzle wear • nozzle to target distance	• use tram lines • replace and calibrate nozzles as required • check and follow manufacturer's recommended nozzle-to-target distances
WEED ESCAPES IN CORNERS	• underapplication of pesticides	• don't spray around the corner • back into corner, then start spraying
LACK OF CONTROL	• excessive travel speed • poor mixing • improper pesticide choice • pesticide resistance • excessive operating pressure • blocked screen • wrong stage of development	• calibrate and reduce speed • ensure adequate uniform agitation • check label • rotate chemical family • check label, re-evaluate nozzle choice and operating pressure • check screen and clean • diagnose pest problems more accurately
OFF-TARGET PROBLEMS	• high winds • small droplets • excessive spray	• nozzle selection • calibration • if windy, refrain from spraying • hooded sprayers

APPLICATION

PROBLEM	CAUSE	SOLUTION
MONITORING (cont'd.)		
PEST ESCAPES IN TOP INSIDE OF FRUIT TREES	• improper dosage • excessive canopy growth obstructs deposition • water volume too low • improper nozzle configuration • poor timing	• follow label directions • prune for better penetration • increase water volume, monitor prior to application • re-nozzle or reconfigure nozzles • monitor prior to application
NO WEED CONTROL IN WHEEL TRACKS	• spray not adhering to weeds • settling dust is deactivating spray	• use recommended adjuvant • don't spray when soil is pulverized
WEED ESCAPES IN STRIPS PARALLEL TO SPRAYER TRAVEL  **Unharvested strips in this field are evidence that the producer didn't get full coverage of this field when applying herbicides.**	• plugged nozzles • worn or broken nozzles • travel too wide between swaths • nozzle-to-target distance (improper nozzle overlap) • sprayer not calibrated • canopy deflects spray	• replace worn or broken nozzles • use proper foam markers • use boom width as multiple of planter width • use tramlines • check manufacturer's recommendations • investigate front-mounted booms
RANDOM PATTERNS OF ESCAPES	• rate controller malfunctions • pressure too low • uneven terrain • product not fully dissolved	• investigate, repair as required • check pressure at boom end with gauge • re-evaluate travel speed • consider gauge wheels to improve boom heights • ensure good mixing
PLANTED CROP DOES NOT GERMINATE	• carryover from previous crop • poor sprayer cleanout	• keep accurate records • study product labels • check cleanout recommendations on label
EXCESSIVE RESIDUES IN HORTICULTURAL CROPS	• excessive dosage • interval to harvest too short • crop structure influences spray deposition	• read label – follow recommended rates • increase interval to harvest • reconfigure nozzle arrangement and volume • monitor deposition patterns

APPLICATION

Backsiphoning

In an effort to fill his sprayer more quickly, a farmer decides to use a PTO-driven roller pump, in addition to the garden hose. With just the garden hose, the fill time is 45 minutes. With the addition of the roller pump powered by the second tractor, this time is reduced to 20 minutes. The garden hose is supplied from the house pressure system sourced from a deep drilled well. The roller pump is drawing from a dug well. The farmer fills the sprayer just before lunch. He decides to have lunch before he heads to the field. When he finishes lunch, he goes out and finds the sprayer empty. There's no water on the ground. The line from the roller pump is still in the tank.

The water in the sprayer has siphoned back into the well because no anti-backsiphoning device was installed. Luckily there was only water in the sprayer.

DETERMINING PESTICIDE EFFECTIVENESS

HOW TO MONITOR IN-FIELD PERFORMANCE

To monitor is to look, identify, and record.

Monitoring is part of effective crop management. You can measure product effectiveness, reduce costs, and help reduce environmental impacts by monitoring before and after application.

If you have recently applied a pesticide to your orchard, vegetable or field crop, take the time to see how well it worked.

If it's an **insecticide**,

- ▶ scout the field or orchard, or if you prefer have a trained scout do it – it's one good way to see if you obtained your money's worth from the treatment.

For **herbicides,**

- ▶ monitoring the weed control effectiveness will help you this year (perhaps you need to re-spray) and next year (knowing your weed escapes).

To **monitor:**

- ▶ brush up on your weed and weed seedling identification skills
- ▶ take a random walk through a field
- ▶ look at all areas for a particular weed problem
- ▶ record what you see
- ▶ take representative samples to determine current levels of pests.

It's important to sample correctly and regularly to get an accurate picture of the problem. You may conduct visual counts or use traps. Refer to the Best Management Practices book on *Integrated Pest Management* for specific monitoring details.

APPLICATION

MONITORING AND MINIMIZING IMPACTS ON NON-TARGET ORGANISMS AND HABITATS

Perhaps the best way to reduce impacts off-target is by using best management practices for pesticide application so the product hits the target pest.

It's a good management idea to make notes on the product used, the location of pest/weed infestations, application rates, weather conditions at time of and after application, effectiveness of application, and environmental effects. This will help you determine whether the product is staying on the crop, or if it's moving off target.

Environmental effects of pesticide applications outside the crop can provide clues to improper equipment calibration or poor application conditions.

PRE-APPLICATION MONITORING

If your pest problems are not known, survey your crop to determine the extent and location of various pests. There is no point to spraying if the problems don't exist.

Also, note the proximity of potential environmental hazards – ponds, streams and other habitats that may be affected by your application. Look into product alternatives that have fewer off-target risks and lower toxicity.

Survey before spraying – know the type and location of pests prior to application.

POST-APPLICATION MONITORING

How to monitor:

- ▶ survey fields two or three days after application while observing re-entry restrictions
- ▶ look for pest/weed/disease infestation levels, and the degree of control
- ▶ look for crop damage – this will depend greatly on the product used
- ▶ look for visible pesticide residues such as granules left on the soil surface and at end of rows.

Two or three days after application, check fields to verify that control targets were met.

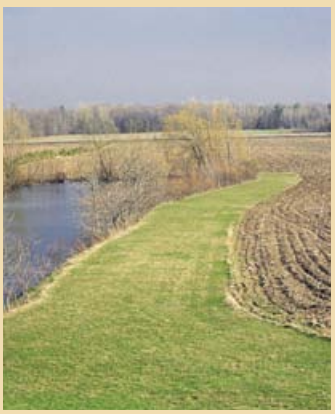
APPLICATION

Is the product moving off the target crop? After spraying, is there any chance it moved towards:

- ▶ your family and domestic animals?
- ▶ bystanders following application?
- ▶ your neighbours' crops, livestock, or homestead area?
- ▶ wild pollinators and other beneficial insects?
- ▶ surface water or source of drinking water?
- ▶ fish, wildlife, or native plants?

How to monitor:

- ▶ when surveying fields, look outside the crop area for damage to wild plants such as white or brown spots on the leaves, or large areas of recently dead or dying plants a week to 10 days post-spray – these signs are an indication that the product has moved off the crop
- ▶ survey fields for dead or dying animals or birds 12-24 hours after organophosphate or carbamate insecticide applications – the Canadian Cooperative Wildlife Health Centre maintains a number to call for reporting disease and mortality in wildlife
- ▶ examine ponds and the shorelines of streams for dead fish or frogs.



Near surface waters, avoid using pesticides that are acutely toxic to aquatic life.

As discussed earlier, surface broadcasting of granular formulations can be mistaken for grit by birds that use it for digestion.

The product label gives information about hazards to surface water.

APPLICATION

CHECKLIST FOR REDUCING THE EFFECTS OF PESTICIDES ON WILDLIFE

☑ Application techniques that reduce wildlife exposure to pesticides are the same as those used to reduce human exposure, environmental damage, crop damage, and waste of expensive chemicals through over-application.

☑ When purchasing products, read the label, and watch for warning statements about environmental hazards.

Statements to look for include:

- ▶ "This product is toxic to birds and other wildlife."
- ▶ "This product is toxic to fish."
- ▶ "This product is highly toxic to bees."

Choose alternatives if possible.

☑ Never wash spray equipment near lakes, ponds, or rivers.

☑ To avoid pesticide drift into non-target areas, use the pesticide formulation and application equipment that keeps the application on target.

☑ Avoid spraying on windy days; early morning and late afternoon are usually the least windy. If you must spray when windy, make some changes to nozzles, water volumes or droplet size.

☑ Don't apply pesticides if there's a potential for heavy rainfall soon after application. Heavy rains can cause pesticide runoff into bodies of water and excessive leaching of chemicals into soil and groundwater.

☑ If you are applying pesticides near water, leave at least a 15-metre buffer strip between the pesticide treatment area and the body of water to avoid contaminating the water and aquatic organisms.

☑ Be extremely cautious when applying granular insecticides. Many of the insecticides that are most toxic to birds are also attractive to birds, who probably mistake them for food or grit. Careful soil incorporation of granular insecticides is required to reduce this wildlife hazard. Clean up spills that may occur at the end of rows or in rough terrain.

If there is a choice, select pesticides that are less toxic to fish and wildlife.

APPLICATION

KEEPING RECORDS

Farmers should monitor and keep records on the type and prevalence of pests in a crop. At application, growers should record:

- ▶ pest stage
- ▶ crop stage
- ▶ wind speed and direction, temperature, soil temperature, relative humidity at time of spraying
- ▶ date, time of day, field location
- ▶ product and rate applied (including adjuvants)
- ▶ water rate (volume)
- ▶ level of control achieved
- ▶ weather conditions for two or three days following application.

This information is invaluable should you have a product performance complaint. Sometimes the number of pests is not large enough to need control, or the pests may become established in the crop when they can no longer do it any harm. The cost of a pesticide application may be more expensive than the damage that could be done by the pests.

Records will prove useful later when trying to decide on:

- ▶ re-entry
- ▶ harvest dates
- ▶ time of next application
- ▶ equipment settings
- ▶ application rates
- ▶ trouble areas.

Keep records of pesticides applied and conditions that existed during application.

Records of pesticide use will help to protect you and your investment by providing documentation if a question or problem arises from an application. Just as important is the task of observing any effects on nearby plants, animals, and natural environments.

Pesticide application records will help you to:

- ▶ evaluate your results
- ▶ improve your pest management practices and efficiency
- ▶ avoid pesticide misuse
- ▶ purchase only what you need
- ▶ establish proper use in case of a residue or crop damage question
- ▶ solve application problems
- ▶ document your use of pesticides in case of lawsuits
- ▶ plan your pesticide needs for the next season, e.g., rotation of pesticides for resistance management.

WHEN APPLYING PESTICIDES, BE PROFESSIONAL

It's simple to make positive changes to your pesticide application system, and the benefits far outweigh the small investment of time and effort. A safe and effective pesticide application system includes structures, equipment, devices and record-keeping for each job, as well as sound management practices. Following the best management practices in this book will help you to produce crops safely and economically while protecting the environment.

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The following acronyms will appear throughout the list of contributors:

AAFC = Agriculture and Agri-Food Canada
DOE, CWS = Department of the Environment (Canada), Canadian Wildlife Service
CPIC = Crop Protection Institute of Canada
MOE = Ministry of the Environment (Ontario)
OFA = Ontario Federation of Agriculture
OFEC = Ontario Farm Environmental Coalition
OMAFRA = Ontario Ministry of Agriculture, Food and Rural Affairs
TFIO = The Fertilizer Institute of Ontario

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References

BEST MANAGEMENT PRACTICES SERIES

Field Crop Production
Horticultural Crops
Integrated Pest Management

FROM THE ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Appli-Tech, 1992, Conference Proceedings, Helmut Spieser, tel: 519-674-1618

Compendium of Veterinary Products (red book)

Corn Rootworms, 1989, AGDEX 111/622, Order No. 89-174

Disposal of Farm Wastes That Cannot Be Composted, 1994, AGDEX 700, Order No. 94-041

Field Sprayer Calibration, AGDEX Order No. 88-129

Field Spraying Application Technology, Course Binder, Helmut Spieser, tel: 519-674-1618

Flat-Fan Nozzletips for Field Weed Sprayers, Order No. 89-110

Fly and Louse Control on Beef Cattle, 1986, AGDEX 420/653, Order No. 86-009

Fly and Louse Control on Dairy Cattle, 1987, AGDEX 410/653, Order No. 87-050

Fly Control in Barns and Stables, 1983, AGDEX 419/653, Order No. 83-019

Fruit Production Recommendations, Publication 360, 1996/1997

Guide to Handling and Applying Herbicide to Protect Water Supplies and Reduce Personal Exposure, 1987, AGDEX 607, Order No. 87-044

Guide to Weed Control, Publication 75

Honeybees for Pollination of Crops, Publication 616, 1989, Order No. 89-117

Land Preparation: a Key to Successful Soil Fumigation, AGDEX 200/628, 1989, Order No. 89-177

Livestock Medicines Manual

Management of Pesticides on the Farm, 1988, AGDEX 607, Order No. 88-083

Metrics for Agriculture, Livestock Pesticides, 1982, AGDEX 400/601, Order No. 82-058

Pest Management Recommendations for Ontario Greenhouse Crops, Publication 365, 1996

Pesticide Application Technology, Conference Proceedings, Mike Crutchley, tel: 519-674-1626

Pesticide Container Rinsing, 1987, AGDEX 607, Order No. 87-057

Pesticide Handling Facility, AGDEX 607, Order No. 90-037

Production Recommendations for Nursery and Landscape Plants, Publication 383, 1994

Recommendations for Turf Management, Publication 384, 1994

Reducing Pesticide Drift and Crop Damage, 1988, AGDEX 607, Order No. 88-118

Rodent Control in Livestock Facilities, 1986, AGDEX 680, Order No. 86-036

Transportation of Pesticides in Ontario, Video V6572

Vegetable Production Recommendations, Publication 363, 1996/1997

War on Warbles, 1982, AGDEX 400/601, Order No. 82-058

Weather-Timed Sprays for Carrot Blight Control, 1979, AGDEX 258/635, Order No. 79-035

OTHER SOURCES

Bees Act, Government of Ontario, 1993

Environmental Impact of Ontario's Pesticide Reduction Program, Food Systems 2002, Dr. G.A. Surgeoner, Department of Environmental Biology, University of Guelph, 1996

Grower Pesticide Safety Course Manual, University of Guelph, 1999

Spray Smarter and Safer, Course Binder, Tom Sawyer, tel: 519-622-4011

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