USE OF PLANT PROTECTION PRODUCTS

1 INTRODUCTION

1.1 Act 36 of 1947

Many of the plant protection products used on citrus are synthetic organic materials. In general they are characterised by their ability to cause mortality by contact and penetration through the insect cuticle. In most cases death is caused by interference with the nervous system.

All plant protection products used on agricultural crops need to be registered in terms of Act 36 of 1947. Law prohibits the use of an Agricultural Remedy for a purpose, or in a manner, other than that specified on the label. Registration requires detailed work on both efficacy and safety aspects. Down the years, CRI entomologists have worked closely with the chemical industry to identify useful roles for particular products and determine their possible impact on key natural enemies.

Only registered usages are listed in these recommendations but these may change with time. Ensure that the product is still registered and consult residue restrictions on export fruit (see below). In some cases, products no longer offer the degree of control originally achieved as a result of pest resistance to treatments. The red scale and organophosphates (OPs) are the prime example in this regard. In the case of citrus thrips there is also evidence for developing resistance to the same insecticide group in addition to other groups. Indeed, with the long exposure to synthetic materials that has occurred, it would not be surprising if most insect species on citrus have developed some degree of tolerance or resistance to these materials.

1.2 The container label

In terms of the registration procedure, all relevant, practical information relating to the product must be described on the label attached to its container. It is most important that labels be thoroughly studied before materials are used. In particular, labels should be checked for any warnings relating to mixing, phytotoxicity, effect on bees, compatibility with other spray materials, and antidotes in case of over-exposure to the material.

1.3 Handling and employee training

All plant protection products should be regarded as hazardous to mammals. This point should be impressed on all operators dealing with them. In particular, operators involved with the measuring and mixing of concentrates should be adequately trained to deal with the hazards involved. Familiarity should not be allowed to breed contempt of the hazards.

Spray operators should be well trained in "spray hygiene" based on the following major points:

- Use of respirators during spray operations.
- Washing of hands before eating or smoking.
- At least daily use of clean spray clothes.
- Avoidance of spray drift.
- Maintenance of daily personal hygiene during spray operations.
- Understanding of toxicity symptoms.

1.4 Disposal of containers

A most important aspect of product usage is the safe disposal of empty containers. Paper containers should be burned. Metal and plastic containers should be rinsed three times with water, then punctured, crushed and buried or recycled. Under no circumstances should they be used for water or food storage. Similarly they should not be washed in dams or streams.

1.5 Compatibility and phytotoxicity of plant protection products

The compounds registered for the control of citrus pests contain complex active ingredients. In each case during the formulation process the active ingredient is mixed with solvents and adjuvants to facilitate the preparation of the mixtures suitable for spray purposes.

Most registered treatments are compatible with a wide range, if not all, citrus cultivars. Cultivars

unable to tolerate a particular treatment usually become apparent during the development work that precedes registration, in which case restrictions relating to that usage will be stated on the label. All labels and especially those pertaining to treatments being used for the first time on a planting or cultivar should be studied for comments on usage restrictions and possible hazards related to the treatment.

Many types of plant protection products can be mixed without danger. However, in general, the preparation of mixes not specifically noted on the label should be avoided. This applies particularly to mixes or so-called "cocktails" comprising insecticides, fungicides and trace elements.

At the research level it is not possible to examine the safety of all the mixture permutations on the complete range of citrus cultivars in the districts in which they are grown. As a result it is also not possible to provide a comprehensive list of compatibilities. However, due to the current lack of compatibility charts, some information derived from observations made by growers and extension officers has been provided in Table 1. Growers who, through force of circumstances, may wish to use treatment mixtures of which they have no experience and which do not appear in Table 1, should apply such mixtures on a trial basis to a small number of trees of the cultivar concerned at least two weeks before the main application is due. This may allow enough time for major incompatibilities resulting in phytotoxicity to become apparent. In these circumstances growers should also seek guidance from local consultants and companies dealing in the treatments.

Apart from the specific information provided in Table 1, the following information on various incompatibilities or phytotoxic complications associated with the use of treatments needs to be emphasised:

- Most products listed are variably susceptible to breakdown when exposed to alkaline conditions. Such exposure is most likely to affect the residual toxicity of treatments. Arising from this all treatments should be applied as soon as they are mixed. Certain labels specify the pH level at which the treatment must be mixed.

- High concentrations of horticultural oil can pose a threat to yield, fruit colour and internal quality at certain times of the year. The major precautions required when using oil are described in Chapter 3 under RED SCALE.

- Oil and sulphur formulations such as lime sulphur and wettable sulphur should not be mixed because such mixtures will be phytotoxic to foliage and fruit of all cultivars. A six week period between oil and sulphur-containing treatments is needed to avoid phytotoxic reactions and this period may need to be longer where citrus is grown under net.

- A six week interval is also required between an oil treatment and some chemicals with sulphur radicals.

- Fruitlets of grapefruit and mandarins are readily damaged by a wide range of mixtures comprising emulsifiable concentrate (EC) formulations plus concentrations of oil. Avoid mixing two or more EC formulations together, especially if the mixture is going to take several hours to dry, (e.g. abamectin plus pyriproxyfen plus oil)

- The protein attractants registered for fruit fly control should not be used on fruit with copper residues. The protein/copper interaction can result in severe blemishing. This can happen even if the copper residues are several months old.

- Organophosphate trunk applications can be incompatible with certain cultivars grown on Volckameriana (VA) rootstocks.

Table 1. Compatibilities and incompatibilities observed by growers and others

Chemical	Compatible with:	Incompatible when:	Comments
Acarol	most products including; Applaud, oil, Nomolt		Residues limit usage.
Agrimec	oil, Phosdrin, Dithane, Lannate.		
Alsystin	Applaud, Acarol.		
Applaud	oils, Acarol, Benlate, Dithane, Topsin Flo, Nomolt, Alsystin, Cypermethrin, Morestan (if no oil).	mixed with oil and agitated vigorously - produces a slurry which blocks the filter.	Slurry problem can be solved with Latron B 10 ml/hl.
Azodrin (no longer registered in RSA)		applied to stems recently treated with Confidor or Mospilan.	Azodrin and Monostem SL are the only OP formulations to be used for stem treatments.
Benlate	Applaud, oils, Dithane, Lannate.	mixed with other EC products. mixed with zinc.	Fruit burn is possible with other ECs. Avoid extremes in pH.
Copper (oxychloride)	ZnO, Bo, Mn.	mixed with tartar emetic, $MgNO_3$, oil, protein fruit fly bait, acidifiers or Aliette.	Darkens blemishes on green fruit. Can cause stippling on fruit.
Cypermethrin	Applaud, Curacron, oil.		Optimal pH 4,5-5,0.
Dipel 2X, Thuricide	most products when mixed in the tank shortly before spraying.		
Dithane M45	most fungicides, trace elements, oil, Agrimec, Nemesis, Ultracide.	mixed with calcium arsenate or nitrates.	Can be phytotoxic if sprayed with oil soon after petal fall and left wet all night.
Dursban	oil, and Zn, Mn, Mg and urea in the absence of oil.	mixed with boron and copper.	EC causes fruit ridging if sprayed within 2 weeks of budburst.
Elsan	Meothrin		
Endosulfan WP (no longer registered in RSA)	copper oxide, zinc oxide, boron, tartar emetic.	applied within 6 weeks of oil or mixed with other trace elements or micronutrients.	The SC is phytotoxic to most citrus. Endosulfan has been phytotoxic on mandarins, Minneolas,

Chemical	Compatible with:	Incompatible when:	Comments
			and oranges.
Envidor		Mixed with Flint	Causes fruit burn.
Fastac		applied undiluted to the stem.	Only for use on ant barrier.
Folimat	oil, Ultracide.		
Lannate	oil, tartar emetic, sugar, trace elements, Solubor, zinc nitrate, zinc oxide.	mixed with tetradifon - phytotoxic.	Breaks down at high pH.
Malathion	sugar, oil or protein bait.		Breaks down at high pH.
Meothrin	Elsan		
Mesurol		mixed with nutritional sprays or oil.	
Mitac		when acidified.	Breaks down at low pH.
Mevinphos	Tartar emetic and sugar, Agrimec, oil.	mixed with trace elements.	
Nemesis	Dithane.		Can burn fruit in mixtures with other ECs and oil.
Nomolt	Applaud, Acarol.		
Oil	most OPs except Ultracide. Lannate, IGRs, 2,4-D.	used within 6 weeks of sulphur-containing compounds, Omite, endosulfan, or magnesium sulphate. Do not mix with calcium arsenate or copper.	Do not apply trace elements within 2 weeks of an oil spray. High oil conc. + WP + EC may cause burn.
Parathion	oil, and Zn, Mn, Mg and urea in the absence of oil.	mixed with boron and copper.	
Protein hydrolysate	Dipterex, Malathion, sugar.	used within 8 weeks of a copper spray.	Must not be mixed with other products.
Rogor	oil and all OPs.	Hyvar X is applied to the ground within 4-6 weeks of a Rogor soil treatment.	Rogor has a poor shelf life. Fruit burn and leaf drop has occurred on lemons and navels.
Selecron	Cypermethrin.	sprayed on grapefruit fruitlets - causes burn. Also incompatible with copper or sulphur.	Can cause leaf drop in grapefruit, especially after a winter oil spray.

Chemical	Compatible with:	Incompatible when:	Comments
Sulphur		used within 6 weeks of an oil spray or spray containing oil.	
Suprathion	Folimat, dimethoate, Dithane, and Zn, Mn, Mg and urea in the absence of oil.	mixed with zinc oxide, calcium arsenate, Benlate + oil, boron, copper and sometimes oil.	Ultracide EC sometimes forms crystals when mixed with oil which block the filter. Ultracide, Nemesis plus oil may burn fruit.
Tartar emetic	sugar, molasses, Lannate, mevinphos, endosulfan.	mixed with oil, calcium arsenate, nutritional sprays or trace elements.	Allow 5-6 weeks between copper sprays and tartar emetic to avoid burn.
Tetradifon		mixed with Lannate	

2 RESTRICTIONS ON THE USE OF PLANT PROTECTION PRODUCTS ON EXPORT FRUIT

The directions on container labels are based on current local registrations. However, overseas markets' residue tolerances may differ from local requirements and change at short notice. This has meant that further usage restrictions are required to ensure compliance with export requirements. These restrictions require periodic assessment and the current requirements can be obtained from the CRI website by registered members (www.cri.co.za). All exporters must ensure that they are familiar with these requirements to ensure continued compliance with export residue requirements. **Treatment options provided in these guidelines may not be suitable for certain markets or at certain times of the year. It is the producer's responsibility to check these details before the product is applied.**

3 APPLICATION OF PLANT PROTECTION PRODUCTS

Obtaining export quality citrus in southern Africa is currently not possible without having to apply at least one plant protection product or foliar feed per annum. As spray contractors are not freely available, this generally means that each grower requires access to at least one spray machine. Up to about 1970 all sprays for citrus pest control were applied manually using hydraulic machines. After 1970 there was a dramatic shift to automatic airblast machinery which allowed for more rapid and efficient applications. During the last 40 years, the latter type of machine has evolved considerably in southern Africa and many different machines are now available.

This section provides an overview of the fundamental requirements for efficient spraying and defines different types of coverage and degrees of wetting.

3.1 Identifying the target

The distribution of the pest target within the tree must be identified before an appropriate application technique can be selected. Some pests may overwinter on the trunk and main framework of the tree and require full cover sprays to reach these plant parts. Other pests may develop best on the fruit or leaves in the shade and need to be controlled with medium cover sprays which penetrate half-way into the tree canopy. For foliar feeds and pests which occur on the outer canopy only, such as citrus thrips, there is no need for the spray to penetrate the tree canopy and outside cover sprays are adequate.

3.2 Use appropriate machinery and spray technique

Very often the orchard geography, planting arrangement or irrigation method will determine whether an automatic machine can be used or

not because it must be driven at constant speed. High density trees planted in tramlines cannot be sprayed effectively with an automatic machine because the nearest tree prevents the tree behind it from being covered adequately. The tops of extremely tall trees may need to be sprayed by hand from a tower. Very often the latter technique is used in conjunction with an automatic machine spraying the lower parts of the trees. However, it is important that these sprays are applied almost simultaneously with the tower rig following the automatic machine. This will allow the operator/s on the tower to see how much of the tree crown requires spraying and reduce the risks associated with over-application.

3.2.1 Coverage

Inadequate spray coverage is the most common reason for treatment failures. Traditionally, spray coverage of citrus trees has been related to that achieved with high pressure hand guns which produce large droplets. The terms "full", "medium" and "light" cover sprays were introduced to indicate the proportion of the tree covered to the point of run-off, i.e., film-wetting. **Full cover** implies that all above ground tree parts are covered and **medium cover** means that most tree parts, with the exception of the trunk and main scaffold branches, are covered. Due to confusion surrounding the use of the term light cover this has been replaced with **Outside cover**. **Outside cover** sprays only cover the outer canopy (Table 2). With the increased usage of mistblowers capable of producing smaller droplets, which are carried into the trees by wind, many sprays do not have to be applied as films (to run-off) but evenly-distributed, diffuse droplets on the plant surfaces are often adequate for mobile insects. It is therefore proposed that the terms "film" and "diffuse" be added to the terms "outside", "medium" and "full" in order to describe both the degree of wetting and the type of coverage, respectively. Details on these requirements for different pest groups are supplied in Table 2.

3.2.2 Spray volumes

As a guideline, diffuse sprays require approximately 25% less volume than film sprays. However, citrus thrips bait sprays are an exception and require only 40-50% of the volume needed for outside cover film sprays, but these treatments are often applied at double the film spray concentration (i.e., 2X). Guidelines for determining spray volumes required for different coverage requirements for different canopy densities are given in Table 3. The canopy height is the tree height less the height of the skirt. The figures in the table refer to the total litres of spray mix required per metre height of the canopy and per metre length of the row (both sides of the tree). Tree width is therefore ignored and a figure is calculated for the length of the row.

The variable factors are therefore tree height, density and number of rows per block. For density, unpruned trees, grapefruit and Clementines would be considered dense, as well as orange trees in late summer. Pruned orange trees in spring, lemons, and Satsuma mandarins would be considered thin. For example, navel orange trees in March with 2.5 m high canopies and rows 7 m apart requiring a full cover film spray would require: 3.33 x 2.5 ℓ/m = 8.33 ℓ/m or 833 ℓ/100 m. The number of rows in 100 m would be 100/7 = 14.3. Volume per hectare = 14.3 x 833 = 11 912 ℓ. If a volume per tree is required this would be obtained by multiplying 8.33 ℓ/m by the width of the tree canopy in metres.

3.2.3 Spray machines without wind assistance

Practically all hand-operated spray machines used in citrus in southern Africa have high pressure pumps driven by tractor PTOs (at 540 rpm). These units can be converted to boom sprayers which are adequate for application of thrips bait sprays, but if increased coverage or film wetting is required these booms will require an oscillation mechanism in order to prevent spray shadows (unsprayed areas). With true oscillating boom spray machines the nozzles move in circles to create turbulence; not just side to side.

3.2.4 Mistblowers

The most common automatic spray machines used in citrus orchards in southern Africa are wind-assisted mistblowers that use nozzles to form the spray droplets. The wind from the fan

either passes directly from the fan over the nozzles into the tree (radial flow), or it is channelled via tower ducting to pass transversely over the nozzles and into the tree (transverse flow). Mistblowers generally fall into three size categories. **Low profile machines** are basic, double sided, radial flow mistblowers without any tower or deflector. **Medium profile machines** are either raised, radial flow mistblowers with or without a single-sided deflector, e.g. Jacto Arbus, or transverse flow mistblowers with short towers. **High profile machines** have tall towers to distribute the spray material transversely into the tree and may have the fan in the centre of the tower. Some high profile machines have multiple fans on each side rather than using a tower that needs to be pressurised by a single fan.

The higher the wind volume and velocity produced by the mistblower, the better the penetration of the spray material into the tree canopy and the more even the deposition of residue (although a lot of wind turbulence soon after petal fall may increase wind scarring). Unfortunately, most manufacturers use theoretical wind volumes in their specifications which, depending on the number of obstructions and the type of ducting used between the fan and the nozzles, may be much higher than the actual wind volumes passing the nozzles. Some machines have two fan speeds and a neutral position so that the fan speed can be reduced or turned off for outside cover sprays, or turned off when hand guns are used. This is important for IPM because natural enemies inside the tree can survive when outside cover sprays are applied to the outer canopy.

Table 2. Types of coverage and wetting and examples of target pests

Tree coverage	Type of wetting	Target pests
Outside (outer canopy only)	Baits	Thrips (bait sprays)
	Diffuse	Thrips (Dicarzol + sugar); aphids; bollworm, leafroller, orange dog.
	Film	Thrips; psylla; leafminer; red spider, red, oriental and grey mites; foliar nutrients.
Medium (outside canopy & branches up to 75 mm diameter)	Diffuse	Looper; leafhoppers; stink bugs.
	Film	Bud, flat, rust and silver mites; soft, waxy, and powdery scales; FCM; fungal diseases.
Full (all plant parts above ground)	Diffuse	Red scale (Nemesis).
	Film	Australian bug, mealybugs; mussel, purple & red scale (Movento, oil sprays, OPs and Applaud).

Table 3. Total volume of spray mixture in litres required on both sides per metre of row length and per metre of canopy height

Canopy density	Full coverage		Medium coverage		Outside coverage		
	Film wet	Diffuse	Film wet	Diffuse	Film wet	Diffuse	Thrips bait
Dense (late summer)	3.33	2.50	2.20	1.65	1.11	0.83	0.56
Thin (spring)	2.67	2.00	1.80	1.35	0.89	0.67	0.45

An oscillation mechanism to increase wind turbulence improves spray penetration of the canopy, especially during summer and autumn when fruit are large and weigh the branches down.

High pressure pumps are not essential to form suitable droplets because nozzles such as the Albuz range can be used to produce the required droplets at a fraction of the pressure required for conventional nozzles.

All regionally-distributed mistblowers capable of applying full cover **film** sprays must do so by directing all the air out of one side of the machine. Many mistblowers are capable of applying outside and medium cover sprays from both sides and the medium or high profile machines may be able to apply a full cover **diffuse** spray from both sides, if the inter-row spacing is close and the tree foliage is not dense. The medium or high profile models are essential for full cover sprays of large trees.

3.2.5 Atomizers

The other category of automatic spray machines used in southern Africa are atomizers, e.g., Cima. With these machines the spray droplets are formed and carried by high velocity wind and the pump only requires sufficient pressure to deliver the spray material to the spray heads. The droplet size is generally smaller than the average droplet produced by high pressure nozzles and there is less range in droplet size. These machines may not have enough wind output to apply a full cover film spray to large trees.

3.2.6 Nozzles and spray technique

Where wind is not being used to carry the droplets into the tree, the combination of pressure and spray cone width will determine the degree of foliage penetration. With hand guns, a handle is used to vary the width of the spray cone whereas with fixed nozzles on a boom or mistblower, the core or whirler determines the width of the spray cone. With the commonly used Spraying Systems nozzles, size 25 cores have a broad spray cone and should only be used for thrips baits. Size 45 cores should be used for outside and medium cover sprays. Both these cores produce hollow cones of spray because there is no central hole in the plate. Sizes 35 and 56 cores do have central holes and therefore produce a full or solid cone of spray. Size 56 is preferred for full cover film wetting of dense trees, especially where the wind from a mistblower is inadequate for penetration. The spray volume is determined by the nozzle disk orifice. Disk numbers 4 or 5 may be required for full cover sprays while a number 3 disk could be used for medium cover sprays. A combination of reduced pressure and number 2 nozzle disks could be used for the application of outside cover sprays.

Although mistblowers use wind to carry droplets through the tree, a high pressure at the nozzle can help in obtaining full cover film wetting when the wind volume is inadequate for penetration. With high pressure nozzles a pressure of 15 bar at the nozzle (approximately 20 bar at the pump) is optimal for full coverage. The oscillation mechanism used in most medium or high profile mistblowers must also be adjusted to suit the ground speed, otherwise spray efficiency is reduced. An optimal rate is 70-75 oscillations per minute. The tractor driver should try to maintain a distance of 300-500 mm between the nozzles and the tree for optimal coverage.

Droplets should generally be in the range of 100-275 μm in diameter. Droplets smaller than 150 μm in diameter are beneficial because they tend to settle on the backs of leaves and fruit. However, droplets smaller than 100 μm are very susceptible to drift and evaporation. Droplets larger than 275 μm in diameter will give film wetting at high volume but can be used for thrips bait sprays at lower volumes and with reduced pressure.

Mistblowers and atomizers which use air to carry the spray material into the tree are particularly susceptible to wind in the orchard. Too much wind will prevent effective coverage of the upper parts of the trees which are most exposed to the wind. A general practice with low profile, radial flow mistblowers is to direct two-thirds of the spray volume at the upper half of the tree by using larger orifice nozzles and higher number cores at the top of the machine. This will reduce drift (because the droplets are larger) and improve the coverage at the tree top. However, spraying should be stopped if the wind speed exceeds 12 km/h. In regions where wind is common, growers should try spraying at night after the wind has died down. However, night spraying requires good lighting and supervision to ensure effective results. There is also more chance of chemical burn on fruit when mixtures of two or more products are sprayed at night

because the droplets take a long time to dry. With oscillating booms the tractor speed must be adjusted to prevent overlap of the spray (too slow) or unsprayed gaps (too fast). When spraying large trees by hand the inside of the tree should be sprayed first before the outside is sprayed from the top to the bottom.

3.2.7 Low volume or concentrate sprays

Before the onset of OP resistance in red scale (*Aonidiella aurantii*), concentrated sprays of OPs were sometimes used for the control of this and other pests. However, with the development of OP resistance in red scale and implementation of IPM, the use of concentrate sprays on citrus beyond 2X ended. Besides their detrimental effect on natural enemies, concentrate sprays are more hazardous to operators and may result in unacceptable post-harvest residues because withholding periods are based on dilute sprays. Although some plant protection products may be suitable for concentrated sprays in the future, most spray machinery used in citrus in southern Africa is currently intended for dilute sprays.

3.2.8 Tank agitation

Modern spray machines use a variety of techniques for agitation of the spray mixture. These include mechanical, hydraulic, pneumatic and electrical agitation. If oils are to be sprayed a mechanical agitator is the most effective.

3.2.9 Tractors

The kilowatt rating of the tractor required for the spray machine will depend on the power required by the pump and fan and the weight of the full tank. All tractors must have functional rev. counters so that PTOs are driven at the correct speed (540 rpm). If a slower PTO speed is used for a particular reason the gearing on any oscillation mechanism will have to be modified to produce the correct number of oscillations per minute (>65).

Ensure that the tractor to be used for spraying can go as slow as 2 km/h. Some tractors cannot go slower than 2.4 km/h which is too fast for most full cover sprays. Speeds slower than 2 km/h allow for full coverage sprays at lower volumes when using smaller nozzle discs, but progress is slow.

3.2.10 Safety

All pesticides should be considered to be poisonous. Their degree of toxicity is indicated by the coloured band on the label and the poison group to which they belong. Some simple precautions to be observed when handling pesticides are given at www.agri-intel.com and elsewhere. Some of these precautions are repeated here.

- Wear rubber gloves when pouring or measuring a concentrate before dilution.
- Immediately wash off any spillage with soap and water.
- Wear overalls or other old clothing that will cover most of the body. Wash these regularly.
- When applying, always keep out of the spray drift.
- Never smoke, eat or drink during application. Wash at least the hands and face before doing so.
- Take a bath or shower after completing the application and change into clean clothes.
- In the case of highly poisonous pesticides (Group 1) it is imperative that additional precautions be taken. Special protective clothing, rubber gloves and boots, headgear, goggles and mask or respirator must be worn.

3.3 Choosing a spray machine

There is a wide variety of spray machines available in South Africa. In choosing a machine, the following factors need to be considered:

- What size are the trees that require spraying and what coverage is required for the target pest?
- Will the machine be required for other crops?
- Will hand guns be required?
- What spray products are to be applied (e.g.,

oils)

- What maintenance will be required and are spares readily available?

- Is the machine good value for money?

Some thoughts to consider are that high pressure spray machines will probably require more maintenance (especially the pump) than low pressure machines. Transverse flow designs (e.g., high profile machines) are preferred for Integrated Production because they cause less drift than radial flow types. However, mistblowers with tall steel towers can be unstable on slopes or rough ground. Some machines are specifically designed for easy maintenance.

Whether a machine is chosen for its ability to cope with any pest on any tree size or whether it is selected with a specific target pest in mind, it is essential that the machine is calibrated correctly, fitted with unworn nozzles and driven at the correct speed in order to apply plant protection products most effectively. Keep detailed records of volumes, nozzle arrangements, oscillator speed, pressure and fan gearbox settings for each spray that is applied so that they can be referred to if pest control was inadequate.

4 TRUNK APPLICATION PROCEDURE

Trunk application of at least one of the following undiluted systemic treatments (monocrotophos [not in RSA], Citrimet, Confidor SL or Mospilan SL) is registered as an option for the control of the following pests: red scale, mealybug, triozids, aphids, leafminer, orange dog, various mites and thrips on foliage of young trees.

4.1 Method of application

The following two methods can be used to apply systemic treatments to tree trunks but the brush technique is not recommended for products with high mammalian toxicity (Group 1).

4.1.1 Paint brush application

On trees between one and three years old, treatments of monocrotophos and Citrimet can be applied with a paint brush. This method is impractical on older trees and inaccurate for use with Mospilan. All precautions must be taken to prevent poisoning of the operator through splashing or inhalation.

The following method is recommended to determine the correct dosage of monocrotophos or Citrimet per tree:

- Establish the diameter of the tree trunk directly below the first framework branch, which is usually the thinnest part of the trunk.

- Apply the treatment around the tree trunk in a band equal in height to the diameter of the trunk. If sufficient material has been applied, the run-off will form a band approximately double the width of the original after a few minutes.

4.1.2 Spray applicator

Application of systemic treatments with a manually operated, mechanical spray applicator (e.g., Calibra) reduces the risk of human contact with the insecticide. It is therefore safer for the operator and is preferable to the brush application.

In practice it is not always possible to apply the treatment as an unbroken ring around the trunk with a mechanical applicator. Fortunately, experience has shown that a complete ring is not required. However, it is essential to have a number of treatment impact points on the trunk. In Table 4 the minimum number of nozzles required for different sized trunks to ensure sufficient absorption and distribution of material, is indicated.

Table 4. Number of applicator nozzles required for different sized tree trunks

Trunk circumference (mm)	Minimum no. of nozzles
Nursery trees – 100	1
100 – 200	2
200 – 300	4
300 – 500	5

4.2 Insecticide dosages

A major hazard when applying insecticides is overdosing which can result in phytotoxicity. Conversely, applying too little material may be ineffective. The correct dosages for monocrotophos and Citrimet that should be applied to various sized trees are indicated in Table 5. Mospilan and Confidor should be applied according to the rates on the label. Mospilan should not be applied to green wood (i.e., trees in the nursery or in the first year after planting out) and Confidor should only be used as a trunk treatment on bearing trees.

4.3 The effect of water on Monostem and Citrimet trunk applications

Freshly applied monocrotophos and Citrimet can be washed off by rain and irrigation water as the compounds are highly water soluble. The time taken for sufficient material to penetrate the tree trunk to control pests, in the absence of rain or irrigation, varies with tree size. Generally 48 hours is sufficient for an application to be taken up by trees of all sizes. Absorption is quicker in small trees. In a tree with a trunk diameter of a pencil, sufficient material for pest control is absorbed in four hours (see Table 5).

After sufficient systemic material has been taken up, the time taken by foliage feeders such as triozids and aphids to become affected will also vary.

On nursery trees the insects will be affected within four hours while on mature trees they may take six days to respond to the treatment.

Table 5. Monocrotophos and Citrimet/Bacmet/Methastem dosages in relation to tree trunk circumference

Trunk circumference (mm)*	Treatment application			Time lapse between application and rain or irrigation (hours)
	ml per tree (applicator)		mm band width* (brush) mono-crotophos & Citrimet	
	Monocrotophos (not in South Africa)	Citrimet/Bacmet /Methastem		
30	0.1	0.08	9	4
40	0.18	0.15	13	5
50	0.3	0.25	16	6
100	0.8	0.6	32	8
150	1.6	1.0	48	10
200	2.8	2.0	64	15
250	4.5	3.8	80	24
300	6.5	6.0	96	30
350	10.0	8.0	111	40
400	15.5	12.0	127	48
450	24.0	17.0	143	54
500	35.0	25.0	159	60

** The band widths correspond to the trunk diameters of trees with circumferences as tabulated.*

4.4 Caution - Water stress and low temperatures

Trunk treatments should not be applied to trees under stress from lack of water or which are water-logged. These conditions may result in phytotoxicity and also in poor uptake and distribution of the material in the tree. It is not advisable to apply stem treatments to trees less than one year old that do not have a well-established root system or are occasionally stressed between irrigation cycles. Stem treatments will be ineffective, or only partially effective, during winter when roots are relatively inactive.

4.5 Phytotoxicity

4.5.1 Effect of solvent in formulation

The active ingredients of Monostem (monocrotophos) and Citrimet (methamidophos) are available in formulations with differing solvents and proprietary names. Trials have shown that hexalene glycol, the solvent used in the above products is not phytotoxic to citrus. Therefore these are the only formulations currently recommended for trunk application.

4.5.2 Cultivar differences

There have been several cases of gum exudation on trunks and occasionally framework branches of various cultivars with Volckameriana (VA) rootstocks, following monocrotophos and Citrimet stem applications in the period January to April. Trials have confirmed that these two insecticides do not cause gum formation on the following VA/cultivar combinations: Eureka lemon, Washington navel, Amanzi Valencia and Clementine.

4.5.3 Growth response

Where trunk treatments are initially applied to young trees for bud mite and thrips control on flush, the reduction of these pests may result in a virtual doubling of the foliage canopy volume. As a result, the trunk and framework branches can increase in size so rapidly that bark splitting occurs. The gum that exudes from the split is usually assumed to be a phytotoxic symptom resulting from the treatments. The severity of splitting can be aggravated by a nitrogen application following a treatment.

If a second treatment is applied within a few months of the first application, tree growth is usually less vigorous and is seldom followed by further bark splitting and gum exudation.

4.5.4 Overdose symptoms

Overdosing produces typical yellow spots on the foliage but is seldom accompanied by leaf drop and/or twig die-back. Such trees usually recover quickly.

Where trees accidentally receive dosages that are several times in excess of those prescribed in Table 5, gum exudation as well as branch die-back will occur which can lead to affected trees dying.

4.5.5 Bark (cork) scaling

With monocrotophos, in the case of VA phytotoxicity, isolated cases of scaling of the corky outer layer of the trunk bark have occurred on mature trees where the trunk diameter was more than 450 mm. Scaling occurred directly beneath the area covered by monocrotophos. Although the trees were not permanently damaged, they initially appeared to be ring-barked. The most noticeable bark scaling occurred after more than one application was administered to the same trunk area in a season. The first symptoms of bark scaling were noticed four to six months after application.

On these mature trees scaling of the corky tissue appeared to be due to lack of spread of the monocrotophos resulting from the absorbent nature of the bark.

4.5.6 Simultaneous treatment of trunks with monocrotophos or Citrimet and other products

It can happen that a trunk treatment coincides with that of a second product. There is a real danger of trunk damage and/or general phytotoxicity if different products are applied simultaneously. The application of more than one material **at one spot** on the trunk should therefore be avoided. If the physical overlapping of treatments cannot be prevented, they must be

applied with at least a **two-week interval**.