Ministry for Primary Industries
Manatū Ahu Matua

Risk Management Proposal:

Review of chemical treatment to manage regulated plant mites on whole plants and cuttings

(Section 2.2.1.6 Import Health Standard 155.02.06: Importation of Nursery Stock)

FOR PUBLIC CONSULTATION

February 2020

New Zealand Government

Growing and Protecting New Zealand

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Submissions

The Ministry for Primary Industries (MPI) invites comment from interested parties on the proposed measures for the management of the regulated mites on whole plants and cuttings to which the measures apply. The proposed measures are supported by this risk management proposal.

The purpose of an import health standard is defined as follows in section 22(1) of the Biosecurity Act 1993 (the Act): "An import health standard specifies requirements that must be met to effectively manage risks associated with importing risk goods, including risks arising because importing the goods involves or might involve an incidentally imported new organism".

MPI must consult with interested parties in accordance with section 23 of the Act and MPI's consultation policy before issuing or amending an import health standard under section 24A of the Act. MPI therefore seeks formal comment on the format and phytosanitary measures in the proposed import health standard.

The following points may be of assistance in preparing comments:

- Wherever possible, comments should be specific to a particular section/requirement of the standard;
- Where possible, reasons, data and supporting published references to support comments are requested;
- The use of examples to illustrate particular points is encouraged.

MPI encourages respondents to forward comments electronically. Please include the following in your submission:

- The title of the consultation document in the subject line of your email;
- Your name and title (if applicable);
- Your organisation's name (if applicable); and
- Your address.

Send submissions to: plantimports@mpi.govt.nz.

If you wish to forward submissions in writing, please send them to the following address.

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All submissions must arrive by close of business on 19 December 2019. Submissions received by the closure date will be considered during the development of the final standard. Submissions received after the closure date may be held on file for consideration when the issued standard is next revised/reviewed.

Official Information Act 1982

Please note that your submission is public information and it is MPI policy to publish submissions and the review of submissions on the MPI website. Submissions may also be the subject of requests for information under the Official Information Act 1982 (OIA). The OIA specifies that information is to be made available to requesters unless there are sufficient grounds for withholding it, as set out in the OIA. Submitters may wish to indicate grounds for withholding specific information contained in their submission, such as the information is commercially sensitive or they wish personal information to be withheld. Any decision to withhold information requested under the OIA is reviewable by the Ombudsman.

Executive summary

(1) Chemicals listed under the basic conditions for mites in the IHS in section 2.2.1.6 '*Pesticide treatment for whole plants and cuttings*' are no longer considered suitable for the management of plant mites. The chemicals may fail to manage all life stages of mites, or their efficacy against mites has not been reported, or they belong to more conventional chemical groups for which mite resistance has been reported.

(2) Kanzawa spider mite (*Tetranychus kanzawai*) is an unwanted organism and regulated in New Zealand. Dicofol treatment offshore is the only risk management option currently available for plants for planting (nursery stock) to manage the risk of this mite specifically. Dicofol is mandatory for whole plants and cuttings of all plant species listed under six schedules in the IHS (155.02.06 Importation of Nursery Stock). Stakeholders have requested equivalent treatment(s) options to be considered.

(3) This summary gives an overview of the proposed changes as follows;

New options proposed for managing regulated mites:

(4) The proposed new treatment options are only for application to whole plants and cuttings; and the options are proposed as a generic treatment for all regulated plant feeding mites;

(5) Eight chemical (acaricides) treatment options are proposed under two chemical treatment approaches i.e. one acaricide treatment (stand-alone chemicals) and two acaricides as a combined treatment (combination chemicals).

(6) Four new chemicals are proposed under one acaricide treatment and another four new chemicals are proposed as a two-acaricide combined option. Dicofol still remains under the two-acaricide combined option for the countries where dicofol is still registered and available for use.

(7) Ten chemicals are included in the proposed eight treatment options (eight of the chemicals are newly proposed chemicals (Abamectin and Dicofol are still remaining but as part of combined treatments).

(8) A new treatment combination (rate/time/temperature) for Methyl bromide fumigation option is proposed.

(9) Changes are proposed to be included in the Approved Biosecurity Treatment Standard (MPI Standard MPI-STD-ATBRT Approved Biosecurity Treatments) and incorporated by reference in the IHS.

(10) MPI proposes to remove specific measures for *T. kanzawai* from the following six schedules in the IHS: *Calanthe, Dahlia, Tricyrtis, Verbena, Hydrangea* and *Gentiana.* Specific measures for *T. kanzawai* are no longer required because the proposed measures for a generic treatment for all regulated plant feeding mites are also effective in managing mites belonging to the genus *Tetranychus*, the spider mites.

Objective

(11) The objective of the proposed phytosanitary measures is to ensure effective management of regulated mites on imported nursery stock.

Purpose

(12) The purpose of this risk management proposal is to:

a. Provide alternative chemical treatment options to manage biosecurity risks that may be associated with imported hosts of regulated mites on whole plants and cuttings;

b. Show how the measures proposed will effectively manage known biosecurity risks, and are consistent with New Zealand's domestic legislation and international obligations;

c. Provide information to support the consultation on the draft amendments to the import health standard.

Background

(13) Under the Basic Conditions, Part 2.2.1.6(b) *Pesticide treatments for whole plants and cuttings* of the IHS (155.02.06 Importation of Nursery Stock), **all** whole plants and cuttings are required to be treated for insects and mites either prior to export or on arrival in New Zealand.

(14) Some schedules in the IHS require additional treatment for the regulated mite, *Tetranychus kanzawai*, because of the potential entry and establishment into New Zealand on imported whole plants and cuttings, causing unacceptable economic and environmental consequences. The mite is polyphagous, infesting more than 145 host genera in 63 plant families, many of which are economically important plants (Migeon and Dorkeld, 2006-2017).

(15) Some chemicals listed as a generic treatment for mites in the current IHS Basic Conditions (section 2.2.1.6b) are no longer suitable to manage *T. kanzawai* (or other mites) because some;

i. do not cause mortality of eggs or non-feeding life stages of *T. kanzawai* or other mites (Abamectin and Chlorpyrifos) (Ormsby 2008).

ii. do not kill *Tetranychus* species, or there is a lack of adequate efficacy data as an acaricide for any mite species (Pirimiphos-methyl and Acephate) (Ormsby 2008).

iii. have a systemic mode of action and thus do not cause mortality on mites which are not feeding on vascular tissues as discussed below (i.e. dimethoate).

(16) The only treatment option currently available in the IHS to manage *T. kanzawai* on its hosts is a pre-export treatment with dicofol. This requires an additional mandatory declaration as follows*:*

"The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".

(17) Dicofol (formerly belonging to the Organochlorine chemical group) is an older broad-spectrum insecticide (Marcic 2012). It is an effective control for spider mites and related *Tetranychus* species and mortality data for all life stages of the mites has been reported: e.g. Concentration of 0.075% of dicofol has been reported to cause 100% egg mortality of *Tetranychus* species (*T. cucurbitaceae*) on brinjal (eggplant) under laboratory conditons (Kavya 2014).

(18) However, dicofol is not registered in New Zealand and also not available in some countries. Dicofol treatment prior to export to New Zealand is mandatory for *T. kanzawai* for some species of whole plants and cuttings in the current IHS for 52 plant genera, as those were considered hosts of *T. kanzawai* which can be imported under six ornamental schedules i.e. *Calanthe, Dahlia, Gentiana, Hydrangea, Tricyrtis, Verbena*.

(19) There are a number of other options for managing *T. kanzawai* and these are dependent upon host and what level of post entry quarantine (PEQ) the plants will be held in on arrival in New Zealand. Measures may include growing season inspection for whole plants and cuttings. These are for *Camellia sinensis*, *Citrus, Fortunella, Poncirus, Prunus, Humulus, Fragaria, Malus* and *Vitis*.

(20) MPI has assessed requests for alternative chemical treatments to dicofol for cuttings of *Loropetalum* (which fall under the conditions of the *Tricyrtis* schedule) from USA and *Hydrangea* (under *Hydrangea* schedule) and *Loropetalum* (under *Tricyrtis* schedule) from Australia and from the UK.

(21) MPI has received requests from the New Zealand industry (importers/exporters) to assess measures equivalent to dicofol for treatment of *T. kanzawa*i as dicofol can no longer be used in some countries e.g. USA and Australia. Some importers have suggested potential alternative chemicals, while Plant and Food Research New Zealand produced a special report for the Ministry for Primary Industries in which other alternative chemicals have been assessed.

Commodity Description

(22) The proposed measures only apply to whole plants and cuttings of all plant species that are listed on the MPI Plants Biosecurity Index (PBI) which require treatment for mites under section 2.2.1.6b of the IHS or, where treatment for *T. kanzawai* is listed as a requirement in a schedule in the IHS.

(23) Definition of terms as per Section 1.4 'Definitions and Abbreviations' of the Import Health Standards (IHS) 155.02.06: Importation of nursery stock:

a. **cuttings:** a nursery stock commodity sub-class for propagation material from the stem only (no roots). Cuttings may be dormant (deciduous species) or non-dormant (evergreens).

b. **dormant:** temporarily inactive/ suspended growth (cuttings of deciduous species should have no leaves; bulbs should have no leaves or roots).

c. **whole plants:** a nursery stock commodity sub-class for rooted cuttings and whole plants.

Trade

(24) The import of germplasm free from *T. kanzawai* is of significant value to New Zealand plant industries for the development of new varieties for domestic consumption as well as to earn export revenue.

(25) Management of the mite if it established in New Zealand can cause huge monetary losses e.g. the cost of chemical control of *T. kanzawai* on strawberries (*Fragaria*) in Taiwan exceeds US$ 233/ha per growing season (Plantwise 2018; Chang & Huang 1995).

Scope

(26) This Risk Management Proposal (RMP) provides the information and process used to assess the efficacy of proposed phytosanitary treatment options to manage regulated mites.

(27) This risk management proposal includes:

a. A review of **existing** chemical treatment for mites under basic conditions in section 2.2.1.6b *Pesticide treatment for whole plants and cuttings* to manage regulated mites on whole plants and cuttings and;

b. A review of **other** chemical treatments for the management of mites on whole plants and cuttings;

c. How the proposed measures will effectively manage the biosecurity risks posed by regulated mites.

(28) This document is in four parts.

a. Part 1 provides the context used to inform development of the IHS for plants for planting.
b. Part 2 provides a summary of risk assessment.
c. Part 3 provides a description of the risk management proposed.
d. Part 4 provides a discussion on the feasibility of the proposed risk management measures.

(29) The proposed measures are the subject of consultation under section 23(3) of the Biosecurity Act 1993. This RMP provides information to support the consultation on the proposed measures but is not itself the subject of consultation. However, MPI will accept comments and suggestions on the RMP in order to improve future IHS consultations.

Part 1: Context

Domestic

(30) The New Zealand biosecurity system is regulated through the Biosecurity Act 1993. Section 22 of the Act describes the meaning of an IHS, and requires that the IHS specifies requirements to be met for the effective management of risks associated with importing risk goods (including plants and plant products) into New Zealand.

(31) MPI is the government authority responsible for the effective management of risks associated with the importation of risk goods into New Zealand (Part 3, Biosecurity Act 1993).

(32) MPI engages with interested parties and/or affected New Zealand stakeholders when amendments are made to an IHS.

(33) MPI follows MPI guidance for decision makers and procedures for the amendment of an IHS and consultation.

International

(34) Where possible, phytosanitary measures are aligned with international standards, guidelines, and recommendations[1] as per New Zealand's obligations under Article 3.1 of the World Trade Organisation (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement); WTO, 1995 and section 23(4)(c) of the Biosecurity Act 1993.

[1] Note that international standards, guidelines or recommendations referred to in the WTO agreement are those of Codex, OIE (World Organisation for Animal Health) and the IPPC.

(35) The SPS Agreement states that phytosanitary measures must not discriminate unfairly between countries or between imported or domestically produced goods, and where there is a choice of phytosanitary measures to reduce risk to an acceptable level, WTO members must select the least trade restrictive measure.

Part 2: Risk assessment

Source information

(36) The following source information was used to identify proposed measures for regulated mites to prevent their introduction (entry and establishment) into New Zealand:

a. Plant and Food Research report 2014, Review of insecticide biosecurity treatments for the importation of nursery stock (Park & Walker 2014).
b. MPI Technical advice on: Four mite families and why acaricides are justified on imported nursery stock. Biosecurity, Science and Risk assessment (see Appendix 5)
c. MPI risk analyses (MAF 2009. Import risk analysis: Table grapes (*Vitis vinifera*) from China) ;
d. CTO decision documents related to equivalence of treatments for dicofol;
e. Import health standard 155.02.06: Importation of Nursery Stock;
f. Information from domestic stakeholders;
g. MPI's Plant Biosecurity Index (PBI) database;
h. MPI's Biosecurity Organisms Register for Imported Commodities (BORIC)
i. Relevant literature for acaricides (scientific journals, webpages, reports, books, databases etc.);
j. MPI ACVM register (Agricultural compounds and veterinary medicines database) (https://eatsafe.nzfsa.govt.nz/web/public/acvm-register)

(37) Conclusion on the proposed chemicals for effectiveness on regulated mites in Part 2: Risk management are based on published literature (Palmer and Vea 2012; Stamps and Osborne 2009;), product labels (see Appendix 3), Insecticide Resistance Action Committee research project reports (IR-4 2015; IRAC 2018a; IRAC 2019); technical reports/ product news fact sheets (Park & Walker 2014; Gilrein u.d.; Cloyd 2004, 2008, 2011; Ormsby 2008; Nursery Management and Production i.e. NMPRO 2007; Turner 2011; Haviland 2005; California Department of Pesticide Regulation i.e. CDPR u.d.); international databases (Pesticide Properties DataBase i.e. PPDB) and experts communication.

Summary of risk

(38) Risk organisms are regulated on the commodity if they are;

a. present in the exporting country and not known to be present in New Zealand (or under official control);
b. have potential to be introduced on the import pathway if the risk is unmitigated;
c. known to be associated with the commodity;
d. their hosts include species which are present in New Zealand including environmentally and economically significant hosts;
e. could establish in New Zealand (climate matching) and;
f. have potential to cause significant impact to the New Zealand economy.

(39) The most economically important plant feeding mites that can damage whole plants and cuttings belong to four major families (Marcic 2012; Dr Qing Hai Fan, Principal Adviser, MPI Plant Health and Environment Laboratory, pers. comm., 30/05/2018; Manners 2015; Appendix 5):

1. Tetranychidae: spider mites
2. Eriophyidae: blister mites, bud mites, gall mites, rust mites or bladder mites
3. Tenuipalpidae: false spider mites, flat mites
4. Tarsonemidae: tarsonemid mites

(40) There are species of concern to New Zealand in each family that meet the criteria for being quarantine pests[2] e.g. *T. kanzawai* and *T. evansi* (Tetranychidae), *Eriophyes inequalis* (Eriophyidae), *Steneotarsonemus furcatus* (Tarsonemidae), *Brevipalpus californicus* (Tenuipalpidae) and are regulated (BORIC).

(41) Mites belonging to these four families are most commonly found on above ground plant parts including leaves, growing tips, flower buds, stems and fruit (Manners 2015). Mites damage plants by piercing plant cells (leaf tissues) and feeding on the chlorophyll which causes chlorosis, reduces photosynthesis and weakens plants. In cases of severe infestation this can lead to plant death (Palmer & Vea 2012; Sarwar 2015).

(42) Biology and potential impact of each mite family is summarised from the MPI Technical advice (see Appendix 5) as follows;

a. **Tetranychidae:** The most important plant-feeding mites in many cropping systems worldwide that can have a significant economic impact. There are over 1,200 species described globally from over 70 genera. Many are highly polyphagous (damaging a large number of host plant species). They damage plants through feeding. There are five stages in the development of tetranychids: egg, larva, protonymph, deutonymph and adult. Adults are more likely to be visible due to their larger size. In temperate regions some species overwinter in diapause i.e. a period of suspended development, usually during unfavourable environmental conditions. Diapausing mites are likely to be well protected from pesticides. Only *Tetranychus urticae* is reported to show differing tolerances to pesticides. Tetranychid mites have both males and females so reproduction can be either sexual or by arrhenotokous parthenogenesis[3].

   All spider mites produce silk to varying degrees, with some species producing masses of damaging webbing over the plant which can lead to plant mortality. *Tetranychus kanzawai (*kanzawa spider mite, Desert spider mite, Hydrangea Mite), *T. evansi*, *Oligonychus punicae*, *Panonychus elongatus*, *Eutetranychus orientalis* are amongst tetranychid mites that are quarantine pests for New Zealand. The MPI risk assessments on imported table grapes (2009) and Wollemia pine nursery stock (2009), identified *Tetranychus kanzawai* as a potential hazard to New Zealand. *T. kanzawai* is a priority pest in the Organism Ranking System (ORS) in New Zealand. The New Zealand's Government Industry Agreement (GIA) partners have also listed the mite as a priority plant pest for New Zealand plant industries.

b. **Eriophyidae:** After spider mites, the second most important mite plant pests (Marcic 2012). Eriophyid mites are often called blister mites, bud mites, gall mites, rust mites or bladder mites. There are about 3790 species, and 274 genera described (see Appendix 5). The stages of development for eriophyid mites are egg, larva, protonymph and adult. They cannot be seen by the naked eye, but they induce visually detectable symptoms on the infected plants which indicate their presence, e.g: blisters and galls, some of which can be quite colourful. Reproduction is mainly by arrhenotokous parthenogenesis.

   Many species are of economic importance to specific plant species. Over 50 species within the Eriophyidae are considered injurious to economic plants and about 30 of these mite species cause severe damage. High infestation can cause significant yield reduction and plant death. Some species vector fungal, viral and bacterial pathogens e.g. *Fusarium mangiferae*, *Rose rosette virus* (Manners 2015). Some are pests of broadleaved plants and nearly all the gall-forming species. Some attack monocot plants, conifers, other gymnosperms and ferns but most live on dicotyledons.

c. **Tenuipalpidae:** They are commonly known as false spider mites because they are mostly related to spider mites and are also called flat mites. There are currently over 1100 valid species belonging to 38 genera in this family. They can be difficult to see without magnification. The tenuipalpid lifecycle includes egg, larva, protonymph, deutonymph and adult.

   All tenuipalpid mites are phytophagous and feed on epidermal cells of the stems, fruits, leaves of various cultivated and wild plants. Feeding activity causes direct damage to plants, and some species can vector viruses causing severe damage and economic impacts. Some species are reported to carry the spores of fungal pathogens. Some of these tenuipalpids include *Raoiella indica*, *Tenuipalpus pacificus*, *Brevipalpus*

[2] are not recorded as being present in New Zealand or are present and vector pathogens not present in New Zealand (PPIN, NZOR, NZInverts), could potentially establish and cause unwanted impacts, and some have the ability to vector pathogens not reported from New Zealand (ISPM 2, ISPM 11)

[3] The phenomenon by which unfertilized eggs produce haploid males and fertilized eggs produce diploid females (http://www.oxfordreference.com/view/10.1093/oi/authority.20110810104404423)

lewisi and *Brevipalpus phoenicis*. *Brevipalpus phoenicis* is present in New Zealand but is known to vector *Citrus leprosis virus* which is not reported from New Zealand.

d. **Tarsonemidae:** Economically harmful mites wordwide. There are about 530 species in 40 genera described in this family. The tarsonemid lifecycle develops through egg, larva and adult, with a quiescent nymphal stage inside the larval cuticle. They can be difficult to see without magnification. Reproduction is largely arrhenotokous parthenogenesis.

Feeding causes direct damage to plants and can distort growing tips and may even kill the plant. The genera known to include phytophagous species are *Polyphagotarsonemus*, *Hemitarsonemus*, *Steneotarsonemus*, *Phytonemus* and *Tarsonemus.* Some tarsonemids are reported to carry pathogenic fungi spores on their bodies. *Hemitarsonemus tepidariorum* is a pest of ferns grown in glasshouses. Some species of *Tarsonemus* are primarily fungivorous but will also feed on plants, e.g: *T. confusus, T. bilobatus* causing serious damage to ornamentals and food crops in greenhouses e.g. Bromeliaceae are mainly attacked by *Stenotarsonemus ananas* (WRU 2017); *Stenotarsonemus laticeps* is a major pest on Amaryllidaceae (*Amaryllis, Narcissus, Hippeastrum)* (Zhang 2003); *Stenotarsonemus furcatus* is a serious pest on *Maranta* and *Calathea* spp. (Denmark and Nickerson 1981).

(43) *Tetranychus kanzawai* is the only mite species MPI currently requires specific measures i.e. application of dicofol at a specific rate. This requirement is applied only for six schedules in the IHS. However there are some other regulated mite species that MPI requires effective risk management measures. Therefore the following risk management approach (see Part 3) would replace the current measures for *T. kanzawai* introducing generic chemical treatment effective for all regulated mites.

Part 3: Risk management

Approach

(44) MPI currently requires specific measures (pre-export treatment with dicofol) to manage the spider mite *Tetranychus kanzawai* on specified imported whole plants and cuttings. This is because current chemical treatments for whole plants and cuttings under basic conditions for all mites are not sufficient to manage this mite, and it is in the list of priority pests and diseases of biosecurity concern to plant and aquatic health (see background section and MPI Website on https://www.biosecurity.govt.nz/protection-and-response/finding-and-reporting-pests-and-diseases/priority-pests-plant-aquatic/horticultural-pests/kanzawa-spider-mite/). *T. kanzawai* is the only mite species which requires additional mandatory chemical treatment, whereas all other regulated mites are managed under basic conditions.

(45) The chemicals (acaricides/miticides[4]) that are reported in this document are effective to manage a range of plant feeding mite species belonging to the mite families discussed in summary of risk, including spider mites. It is not practically feasible to specify selective chemicals for each high impact mite species; thus a broad generic approach is proposed to manage all regulated mite species including *T. kanzawai*.

(46) Revision of the chemicals for mites listed in the section 2.2.1.6b *Pesticides for whole plants and cuttings* in the current IHS were reviewed for suitability to remain in the IHS or not, and new chemicals were proposed as alternatives.

(47) "Effective", 'effect' and "efficacy" terms found in the literature and used in this RMP refer to the ability of the chemicals to cause mortality by direct contact, knockdown (paralysis so that mortality occurs due to starvation) or provide residual efficacy e.g. translaminar activity i.e. translaminar refers to absorption by one side of the leaf surface so that the active ingredient is available to insect and mite pests feeding on the other or untreated leaf surface (Cloyd 2016a). Efficacy of translaminar activity acaricides would remain for a period of time for approximately 14-40 days against foliar feeding insects and mites (Cloyd 2016) to cause lethal effect on motile stages and/or eggs of the mites.

[4] Acaricides/ miticies are a type of pesticide. Acaricides are pesticides that kill members of the arachnid subclass *Acari*, which includes ticks and mites https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Acaricide.html . Miticides are specific to kill mites. In this RMP generic name Acaricide is being used throughout the document as some pesticides that kill mites may also kill ticks, although the specificity discussed in the RMP is as a miticide

This is mentioned on the label claim. The type of efficacy for the proposed chemicals is listed in the Appendices 1 and 2.

(48) Proposed chemicals either as a stand alone or a combination treatment are sufficient to manage mite species belonging to all four major mite families as well as all life stages of them as discussed in summary of risk.

(49) Chemicals with contact mode of action are proposed for both dormant and non-dormant plant material because these chemicals can kill mites by direct contact (Cloyd 2016).

(50) Chemicals with translaminar activity are proposed only for non-dormant plant material because these are effective only on foliage (leaves).

(51) Chemicals that have systemic mode of action were not proposed because;

a. Systemic pesticides[5] are not effective at managing mites (Cloyd 2002). Systemic pesticides move within the vascular tissues (either xylem or phloem) and mites do not feed within the vascular plant tissues (Cloyd, 2002). They feed on plants by piercing plant parenchymal cells (leaf tissues) and ingesting the contents. They feed primarily on the lower surface of leaves of the host plant (Botha *et al.*, 2014).

b. Systemic pesticides will not necessarily be absorbed into dormant plant material (Park & Walker 2014) and therefore may not affect plant feeding pests.

c. A related plant mite (*Tetranychus urticae*) is known to be best managed using acaricides that either have contact or translaminar activity (Cloyd *et al.*, 2009).

(52) In addition to chemical treatment, other risk management measures currently available in New Zealand, such as inspection of plant material prior to export and phytosanitary certification, inspection on arrival in New Zealand, and a defined period in post entry quarantine (PEQ) with regular inspection for signs or symptoms of pests and diseases, are considered necessary to manage regulated mite species. This is because there are some circumstances in which the biology or life stage of the mite enables it to avoid exposure to any chemical treatment applied to the cutting/whole plant;

a. Mites which may have entered diapause (see paragraph 41a) are likely to be protected from chemicals. For example, *Tetranychus urticae* is reported to have differing tolerances to a number of pesticides amongst diapause and non-diapause female mites (see Appendix 5). *T. urticae* is non-regulated in New Zealand. Dip treatment of cuttings/whole plants in chemical solution/s proposed (see paragaraph 68) would also allow sufficient time to penetrate these suspended development stages.

b. Webbing of mites (Tetranychidae) may protect mite eggs from physical contact of chemicals (see Appendix 5), however visual inspection is likely to detect webbing.

c. Mites residing inside the galls (gall forming mites in Eriophyidae) are likely to be protected from chemicals (see Appendix 5). Gall production is a symptom on plants that can be visually detected during inspections.

d. Arrhenotokous reproduction (a form of asexual reproduction) is reported to cause chemical resistance development. That is, resistance to various chemicals through a state of homozygous recessive allele carriers (see Appendix 5). This type of reproduction is reported for some strains of mites in Tetranychidae, Eriophyidae and Tarsenomidae (see Appendix 5). This type of resistance can be managed by using proposed multiple treatment options from different chemical groups of the proposed acaricides and combination of measures such as growing season inspection, fumigation etc.

Current chemical treatment options

(53) Currrently, there are limited chemical treatment options available under section 2.2.1.6b in the current IHS to manage regulated mites on whole plants and cuttings. The options are Abamectin (Avermectin) as a stand alone treatment or treatment with two active ingredients belonging to two different chemical groups (see table below) i.e. Dicofol (Organochlorine) with one of the following chemicals: Acephate, Chlorpyrifos, Dimethoate or Pirimiphos-methyl (Organophosphorous). When dicofol is not registered in an exporting country or not available for use as a pre-export

[5] Systemic insecticides are those in which the active ingredient is taken up, primarily by plant roots, and transported (translocated) to locations throughout the plant, such as growing points, where it can affect plant-feeding pests. Systemics move within the vascular tissues, either through the xylem (water-conducting tissue) or the phloem (food-conducting tissue) depending on the characteristics of the material. However, most systemic insecticides move up the plant in the xylem with the transpiration stream. Systemic insecticides are most effective on insects with piercing—sucking mouthparts, such as aphids, whiteflies, mealybugs, and soft scales (Cloyd 2002).

biosecurity treatment the only option is to treat with Abamectin, and Abamectin is known not to be effective against mite eggs (see paragraph 55).

Chemical group	Active ingredient (a.i.)	Stand alone chemical treatment option?
Avermectin	Abamectin	Yes
Organochlorine	Dicofol	No (*see below combinations*)
Organophosphorous	Acephate	No (Dicofol-Acephate)
Organophosphorous	Chlorpyrifos	No (Dicofol-Chlorpyrifos)
Organophosphorous	Dimethoate	No (Dicofol-Dimethoate)
Organophosphorous	Pirimiphos-methyl	No (Dicofol-Pirimiphos-methyl)

(54) MPI proposes to remove Acephate, Chlorpyrifos, Dimethoate and Pirimiphos-methyl from the current list because;

a. Acephate and Pirimiphos-methyl are not known to be effective against mites (pesticide label and pesticide databases were checked). Ormsby (2008) recommended that these pesticides should not be adopted as a miticide until adequate efficacy data can be obtained.

b. Acephate, Pirimiphos-methyl, Chlorpyrifos and Dimethoate belong to the Organophosphorus chemical group which contains conventional (traditional) pesticides. Mites, especially tetranychids (Marcic 2012) are reported to have developed resistance to these organophosphates (IRAC 2018b). With the introduction of every new insecticide class including organophosphates (other classes arecyclodienes, carbamates, formamidines, Pyrethroids), cases of resistance surfaced within 2-20 years (IRAC 2018b). The last review for the section 2.2.1.6 in the current IHS is in 2004 which was 15 years old.

(55) MPI proposes to retain Dicofol as a suitable chemical to manage mites because;

a. Dicofol (Kelthane) is effective on all life stages of mites (IRA-4 2015; see Appendix 1b). Only exclusion is it is not effective for tarsonemid mites (Haviland 2005, IR-4 2015, Kelthane label: see Appendix 1a). However a combination of dicofol with another chemical of a different chemical group that is effective on tarsonemid mites is proposed (see paragraph 55).

b. Dicofol is not considered a carcinogenic organochlorine and does not belong to the former group 2A (IRAC 2018a). The 2A group organochlorines are probably carcinogenic to humans and include the prohibitied pesticide DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane). Dicofol is classified as UN i.e. compounds of unknown or uncertain mode of action or action is uncharacterized.

c. As dicofol is a UN compound, having unknown mode of action, is not thought to have a target site in the mites that is in common with other UN compounds; thus it may be freely used in rotation with other chemicals of the same group (UN) unless there is reason to expect cross-resistance (IRAC 2017). This is in contrast to compounds within the non-UN groups (which are specific chemical groups) which do share a common target site within the pest, and thus do share a common mode of action. When there is a common mode of action, there is a high risk of development of cross-resistance to all compounds in the same group (IRAC 2017). This is not expected in the UN group chemicals which dicofol belongs to.

d. Resistance of some mites e.g. *T. kanzawai* strains, has been reported to dicofol in some countries (PPDB 2018). However a review of the methods for detection of resistance development, including for dicofol against Tetranychidae mites, concluded that the methods were not satisfactory for determining whether such failures were due to development of resistance or lack of control e.g. poor spray coverage contributed to inadequate control of the mite (Singh 2010). MPI is mindful to manage resistance development by ensuring the use of proposed multiple chemicals from different chemical families to target all life stages of the mites along with PEQ which can act as an opportunity to observe the efficacy of the treatments.

e. Resistance to a particular chemical may be stable or unstable. For example, Dicofol resistance in citrus rust mite (Eriophyidae) was detected throughout the citrus industry about 10 years ago, but resistance proved to be unstable and usage of dicofol has continued in Florida (Rogers & Dewdney 2017).

(56) MPI proposes that Abamectin remains as a suitable chemical to manage mites but, as a combined treatment with a pesticide from another chemical group. Abamectin on its own is not effective against the eggs of mites and

Abamectin is not effective on flat mites (Tenuipalpidae). The proposed combination is outlined in the following section.

Proposed chemical treatment options

(57) Ten chemicals are proposed (eight are new). Four of the chemicals are used under the **one acaricide treatment option,** and six of the chemicals are used under the **two-combined acaricide treatment option.** These particular chemicals are proposed because they are known to be effective on plant-eating mite species of economically important mite families discussed in summary of risk. The number of treatment options proposed is eight: 4 use stand-alone chemicals; and 4 use combination chemicals.

(58) This can be applied either on arrival in New Zealand at an MPI approved facility at the importer's expense or offshore prior to export. Pre-export treatment must be endorsed by the National Plant Protection Organisation (NPPO) of the exporting country on the phytosanitary certificate including active ingredient/s of the chemical/s used, rate of application, mode of application (i.e. dipping or spraying with a surfactant), treatment time (i.e. how long the treatment was applied for) and date of application.

OPTION 1: One acaricide treatment (stand-alone chemicals)

(59) **One-acaricide treatment** option is proposed because some of the available chemicals;

a. can target all life stages of the mites i.e. it is adulticidal (killing adults), ovicidal (killing eggs) and nymphicidal (immature stages) and;

b. are effective against mite species belonging to all four major mite groups discussed in summary of risk.

(60) The four **One-acaricide treatment** options proposed are as follows (see Appendix 1a for registered countries, example of crops and targeted pests);

Active ingredient	**Chemical group**	**Targeted mites groups**[6]	**Primary site of action**[7]	**Trade name e.g.**
Spiromesifen*	Tetronic and Tetramic acid derivatives; group 23	spider mites (including *T. kanzawai*), eriophyid mites, flat mites, tarsonemid mites	Lipid biosynthesis inhibitor (Acetyl CoA carboxylase inhibitor)	JUDO®
Milbemectin	Avermectins, Milbemycins; group 6	spider mites (including *T. kanzawai*), eriophyid mites, flat mites, tarsonemid mites	Chloride channel allosteric modulator	MILBEKNOCK®
Fenpyroximate	METI acaricides and insecticides; group 21A	spider mites (including *T. kanzawai*), eriophyid mites, flat mites, tarsonemid mites	Mitochondrial complex I electron transport inhibitor	Pyromite®
Bifenazate+Abamectin*	Bifenazate; group 20D Avermectins, Milbemycins; group 6	spider mites (including *T. kanzawai*), eriophyid mites, flat mites, tarsonemid mites	Mitochondrial complex III electron transport inhibitor + Chloride channel allosteric modulater	SIROCCO™

*Re-treatment required according to label and NOVACHEM agrichemical manual, depending on crop/plant species

(61) All of the above active ingredients in the proposed list of acaricides have been reported as accepted to apply as a general miticide (acaricide) by the Rutgers University USA (IR-4 2015).

(62) The lable and NOVACHEM agrichemical manual should be consulted for potential re-treatment options. Two of the One-acaricide treatemt options mentioned above (Abamactin, Spiromesifen) require re-treatment depending on the import commodity as indicated under the active ingredient.

OPTION 2: Two-acaricides combined treatment (combination chemicals)

(63) **Two-acaricides combined** treatment option is proposed because;

[6] References used are Palmer and Vea (2012), Stamps and Osborne (2009), Gilrein (u.d.) among some other litereature and acaricide labels. Also see Appendix 1 for details.

[7] See Appendix 1a for detailed descriptions.

a. This will ensure the treatment is targetting all mite life stages and avoids repeating a particular chemical treatment 10-14 days after the initial treatment to manage the more difficult-to-kill life stages such as eggs (Ormsby 2008). Some chemicals are known to be effective only on particular life stages as individual chemicals, therefore, an acaricide which is effective on mite eggs might be combined with another acaricide which is effective on other life stages (nymphs, larvae, adult) (Cloyd 2008; Mark Braithwaite, pers. comm. 2018 May).

b. Two acaricide combined treatments will ensure mite species and life stages belonging to all four major mite families are effectively managed.

(64) **Two acaricides combined** treatment options proposed are as follows:

a. **Option 2A:** Etoxoazole either with Abamectin or Chlorfenapyr selected from Group 'a' (see the table below);

i. Etoxazole is not effective at managing mite adult stage, whereas Group 'a' chemicals are effective against adults. A treatment combining both chemicals will ensure the proposed treatment is effective for all life stages of mites.

ii. Etoxazole is effective only at managing spider mites and flat mites, whereas Group 'a' chemicals are effective against eriophyid and tarsonemid mites. This combination will provide an effective broad spectrum treatment for a range of mite species.

iii. Option 2A is proposed for non-dormant plant material because Etoxazole has strong translaminar activity but no contact activity. Acaricides with translaminar activity are effective only on foliage as discussed in paragaraph 46.

b. **Option 2B:** Fenazaquin either with Aceqinocyl or Dicofol selected from Group 'b' (see the table below);

i. All three proposed chemicals are effective at managing all life stages of mites but are not effective on one of the economically important plant-feeding mite families; i.e. Fenazaquin is not effective against flat mites, whereas Acequinocyl and Dicofol are effective against flat mites. Combination treatments will ensure mites belonging to all four major mite families are effectively managed.

Note: Label of each of the acaricides must be checked for manufacturer's instructions for compatibility when acaricide combinations are used.

Active ingredient	**Chemical group**	**Targeted mite groups**[8]	**Life stages of efficacy**	**Primary site of action**[9]	**Trade name e.g.**
OPTION 2A (for non dormant material only)					
Etoxazole	Etoxazole; group 10B	spider mites (including *T. kanzawai*), flat mites	All except adult stage	Mite growth inhibitor	Paramite
Group 'a'					
Abamectin	Avermectins, Milbemycins; group 6	spider mites (including *T. kanzawai*), eriophyid mites, tarsenomid mites	All except egg stage	Chloride channel allosteric modulater	Abamectin 0.15 EC
Chlorfenapyr	Pyrroles; group 13	Spider mites (including *T. kanzawai*), Eriophyid mites,tarsonemid mites	All except egg stage	Uncouplers of oxidative phosphorylation via disruption of proton gradient	Pylon®
OPTION 2B					
Fenazaquin	METI acaricides and insecticides; group 21A	spider mites (including *T. kanzawai*), eriophyid mites, tarsonemid	All life stages	Mitochondrial complex I electron transport inhibitor	MAGUS®

[8] References used are Palmer and Vea (2012), Stamps and Osborne (2009), Gilrein (u.d.) among some other literature and acaricide labels. Also see Appendix 1 for details.

[9] See Appendices 2 and 1b for detailed descriptions.

		mites			
Group 'b'					
Aceqinocyl	Acequinocyl; group 20B	spider mites (including *T. kanzawai*), eriophyid mites, flat mites	All life stages	Mitochondrial complex III electron transport inhibitor	SHUTTLE™15 SC
Dicofol	Dicofol; group UN	spider mites, eriophyid mites, flat mites	All life stages	Unknown or non-specific target	KELTHANE*18.5 EC

Guidance: Chlorfenapyr, Dicofol and Fenazaquin are not registered in New Zealand.

Proposed rate and method of chemical application

(65) MPI proposes maximum/ full label rate for mites (in terms of active ingredient) to provide optimum acaricide efficacy to manage biosecurity risk. Proposed application rates are as follows (see Appendix 3 for rate calculations);

Active ingredient (a.i.)	Chemical group	Example product trade name	Formulation type	[2]Maximum a.i. rate calculated for mites (g/L water)
Abamectin	Avermectins, Milbemycins (group 6)	Abamectin 0.15 EC	EC	0.012
Aceqinocyl	Acequinocyl (group 20B)	SHUTTLE™15 SC	SC	0.150
Bifenazate+Abamectin	Bifenazate (group 20D) Avermerctins, Milbemycins (group 6)	SIROCCO™	SC	0.135 0.007
Chlorfenapyr	Pyrroles (group 13)	Pylon®	SC	0.087
Dicofol	Dicofol (group UN[10])	KELTHANE*18.5 EC	EC	0.694
Etoxazole	Etoxazole (group 10B)	Paramite	SC	0.038
Fenazaquin	METI acaricides and insecticides (group 21A)	MAGUS®	SC	0.352
Fenpyroximate	METI acaricides and insecticides (group 21A)	Pyromite®	SC	0.025
Milbemectin	Avermectins, Milbemycins (group 6)	MILBEKNOCK®	SC	0.012
Spiromesifen	Tetronic and Tetramic acid derivatives (group 23)	JUDO®	SC	0.152

EC - Emulsifiable concentrate; SC - Suspension concentrate

(66) The rate of dicofol in the current IHS for *T. kanzawai* is 0.7 g a.i./ L which remains unchanged because the maximum label rate calculated is equivalent to this rate (0.693 g a.i./L)

(67) MPI does not propose rates based on available efficacy data from published literature. This is because experimental evaluation to assess suitable application rates is insufficient for plant quarantine purposes, as per the 'Guidelines on efficacy evaluation for the registration of plant protection products, published by the Food and Agriculture Organization of the United Nations 2006 (FAO 2006). Some reasons that FAO do not suggest accepting published efficacy trials are that;

a. They are solely laboratory evaluations on detached plant parts such as leaf discs and efficacy has not been evaluated on whole plants.

   E.g. Kumari *et al.* (2017) – efficacy data was based on laboratory trial on excised leaf discs

b. There are no assessments on plant phytotoxicity[11] of the treatment. The assessment of crop tolerance is an essential element of the efficacy evaluation of a chemical (FAO 2006); Plant protection products should not have an unacceptable effect on plants or plant parts used for propagation (FAO 2006); thus there is no assurance of efficacy and phytotoxicity.

[10] Group UN pesticides represent compounds of unknown or uncertain mode of action as per the mode of action classification by the Insecticide Resistance Action Committee (IRAC) in the IRAC Mode of Action Classification Scheme, issued on May 2018 (http://www.irac-online.org/modes-of-action/)
[11] The capacity of a plant protection product to cause temporary or long-lasting damage to plants (FAO 2006) (plant protection product refers to the pesticide/chemical)

E.g. Ormsby (2008) - recommended dipping rates at 10 times the label rate for insecticides based on the original recommendation of Derraik (2006). Ten times the label rate may affect plant viability.

c. They are limited to particular plant species; thus effect of the tested chemicals on a range of hosts are not known. Extrapolation of efficacy information may be possible for control of the same target pest on one crop to a closely related crop (FAO 2006); thus efficacy of the chemical on many other crops is unknown.

   E.g. Kumari *et al.* (2017) – efficacy assessment is specific to bean plants
   Whalen and Cissel (2013) – efficacy assessment is specific to watermelon

d. They have not been repeated and therefore reproducibility is unknown. A total of about 8 – 10 fully supportive trials are needed over a period of at least two growing seasons to develop high degree of confidence in the efficacy of a new chemical product (FAO 2006).

e. They do not have statistical analysis or analysis is not satisfactory. As per the FAO guidelines (FAO 2006), results from a field trial or a trial series should, in principle, always be statistically analysed.

(68) The proposed application rates are derived from the label rates because,

a. MPI follows the EPPO principles of acceptable efficacy guideline 1/214 (4) (EPPO 2017)] that is consistent with the approach or the guidelines by the FAO (FAO 2006) and UK (Mattock u.d.) for the purposes of registration of chemicals.

b. According to these guidelines, 'acceptable efficacy' for approval of any chemical product other than biological products is dependent on the high level of control of pests i.e. control over 80% (Mattock u.d.) either by direct mortality or knockdown etc. This is a satisfactory level of risk management in New Zealand plant quarantine. There are additional measures MPI currently has in place to manage regulated mites on imported plants for planting (see paragraph 51. Biological products are not proposed in this RMP as label claims for biological products are mostly based on lower effectiveness such as 40% control level (Mattock u.d) and does not provide an acceptable level of control.

c. All proposed chemicals in this RMP have a performance level claimed as 'control' on the label (see Appendices), meaning the efficacy is above 90% within 30 seconds either as knockdown, kills on contact etc. This is the acceptable efficacy for pesticide registration in the USA (EPA 2017) and Brazil (Bicalho *et al.*, 2001).

d. The data requirement for chemical registration must be high quality, generated in accordance with sound scientific and experimental procedures and on principles of good laboratory practices (FAO 2010), thus label claim reflects a high level of confidence of product effectiveness.

(69) Use of maximum label rate (full rate) is proposed, based on the following reasons and/or assumptions;

a. Active ingredient rates given for foliar applications in the field are difficult to extrapolate accurately to dipping as a biosecurity treatment (Ormsby 2008).

b. Some of the chemical label rates vary for different crops i.e. ornamental or tree species.

c. Lower rates, such as average label rate, may not be sufficient to kill mites if the rate is designed to control mites below a threshold level i.e. may not achieve 100% mortality (Ken Glassey, Senior Adviser, MPI, pers. comm., 05/2018).

d. When mixtures of pesticides are used each component of a mixture belongs to a different class of insecticide mode of action and so must be used at its full rate (IRAC 2018a: Insecticide Resistant Mangement (IRM) principles endorsed by Insecticide Resistance Action Committee).

e. The maximum label rate is known to be used in plant quarantine (Ken Glassey, Senior Adviser, MPI, pers. comm., 05/2018) and there is no label claim for dipping applications (Mark Braithwaite, Consulting Diagnostician, Plant Diagnostics Ltd., pers. comm., 29/05/2018).

f. When the label rate would provide the maximum lethal effect for the targeted mites it may also be effective for its related mite species. Extrapolation of efficacy information may be possible for control of one target (i.e. pest, disease or weed) to another closely related one (FAO 2006).

g. Ormsby (2008) recommended dipping rates at 10 times the label rate for insecticides based on the original recommendation of Derraik (2006). However, phytotoxicity of the crop plants is also an important parameter to consider when pesticide application rate is derived. Ten times the label rate application may affect plant viability.

(70) Dip treatment is proposed over spray treatment. Dip treatments are more effective than foliar sprays as contact chemicals are required to have thorough coverage for better efficacy. Dipping in chemicals (insecticide dip) for cut flowers and foliage are reported to be more effective than field control of insects (Tenbrink *et al.*, 1914). When dipping is less feasible e.g. large size of consignments, spraying for full coverage with suitable surfactants[12] is proposed. Systemic acaricides are not proposed in this RMP (see paragaraph 50); thus spray treatment making sure thorough coverage is also proposed to be effective.

(71) MPI proposes to keep the same dipping method and dipping time as currently specified in the IHS as follows; "[*For dipping, the treatment time is normally 2 minutes but must be increased to 5 minutes if bubbles remain present on the plant surface. Dip solutions must be used no more than twice or as per manufacturer's recommendations. All treatments must be carried out in accordance with manufacturer's recommendations using either the recommended maximum label rate or the rates shown in the table below*]".

Current Methyl bromide fumigation option

(72) The other option to treat mites (additional to the chemical treatment option) under the Basic Conditions, Part 2.2.1.6(b) *Pesticide treatments for whole plants and cuttings* of the current IHS is Methyl bromide fumigation. This option is limited to dormant plant material and the current combination of application rate and temperature at atmospheric pressure for 2 hours is the same as the treatment for insects (see table below). This combination is considered to be ambiguous and the efficacy of the treatment is not optimal against mites (Dr Michael Ormsby, Manager, Plants and Pathways Biosecurity Science and Risk Analysis, Ministry for Primary Industries, Technical Advise, 06/12/2019, Appendix 6)

Rate (g/m3)	Temperature (°C)
48	10-15
40	16-20
32	21-27
28	28-32

Proposed Methyl bromide fumigation option

(73) MPI proposes a new Methyl bromide fumigation schedule for mites for dormant plant material under Part 2.2.1.6(b) in the IHS. Any of the Methyl bromide treatment combinations (rate/time/temperature) in Table 1 below are effective to manage all life stages of plant feeding mites including *Tetranychus kanzawai* (Dr Michael Ormsby, Manager, Plants and Pathways Biosecurity Science and Risk Analysis, Ministry for Primary Industries, Technical Advise, 06/12/2019, Appendix **6**).

Table 1: Methyl bromide fumigation schedules (dormant plant material only): For mites (non-diapausing), fumigation for a minimum of (i) 2, (ii) 2.5 or (iii) 3 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)*			Minimum concentration-time product (CT)/ achieved dose ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)**		
2 h[i]	2.5 h[ii]	3 h[iii]			2 h[i]	2.5 h[ii]	3 h[iii]
68	56	48	120	10	51	41	34
57	48	40	100	16	43	35	28

[12] Surfactants or tensides are chemical species that act as wetting agents to lower the surface tension of a liquid and allow for increased spreadability (https://www.thoughtco.com/definition-of-surfactant-605928) .

48	40	34	85	21	36	29	24
40	32	28	70	28	30	23	20

*The shaded area of the table is guidance only. It is guidance on the minimum initial methyl bromide concentration that can achieve the required CT values at the optional temperature and treatment-duration combinations.

**Minimum concentration during fumigation (g/m^3) must be achieved throughout the treatment and depends on the temperature and duration of the treatment, but must not be less than 2 hours

[i] Treatment duration is over a minimum of 2 continuous hours

[ii] Treatment duration is over a minimum of 2.5 continuous hours

[iii] Treatment duration is over a minimum of 3 continuous hours

(74) The treatment is required to be completed offshore prior to export, or on arrival in New Zealand by an MPI approved treatment provider. Pre-export treatment must be endorsed by the NPPO on the phytosanitary certificate including the achieved concentration-time product (CT; the minimum achieved dose (concentration over time) of Methyl bromide) minimum temperature over duration of treatment, minimum concentration during treatment (including the final residual concentration), duration of the treatment at atmospheric pressure, OR if done on arrival in New Zealand, must be completed at an MPI-approved facility.

(75) The concentration-time product (CT) utilized for methyl bromide treatment in this standard is the sum of the products of the concentration (g/m^3) and time (h) over the duration of the treatment. This is in accordance with International Standard for Phytosanitary Measrues ISPM 43: *Requirements for the use of fumigation as a phytosanitary measure*,

Changes to the IHS

(76) The key changes to the IHS are as follows:

a. To replace chemical treatment option for mites for whole plants and cuttings in the section 2.2.1.6b (see Appendix 4a).

b. To remove the mandatory additional declaration for dicofol treatment for *T. kanzawai* from the six schedules in the IHS (*Calanthe*, *Dahlia*, *Gentiana*, *Hydrangea, Tricyrtis, Verbena* and *Gentiana) (*see Appendix 4b*).*

c. To replace Methyl bromide fumigation treatment combinations for whole plants and cuttings in the section 2.2.1.6b (see Appendix 4a).

Part 4: Feasibility

(77) The proposed options are operationally feasible for the management of regulated mites on plants for planting because:

a. Revision of general chemical treatment for mites for whole plants and cuttings (section 2.2.1.6b) will provide stakeholders with a number of chemical treatment options to select from. The current IHS has only five chemical treatment options where four of the options contain dicofol which is not registered in most exporting countries. Eight chemical treatment options are proposed in this RMP and only one of them contains dicofol for those countries where dicofol is registered.

b. Of the eight chemical treatment options proposed six of them can be applied to either dormant or non-dormant plant material as they all have contact mode of action and not translaminar action. Therefore it is not necessary for the plant material to contain foliage.

c. Removal of mandatory treatment for *T. kanzawai* from a number of nursery stock plant species (all six schedules in the IHS) will benefit most of the stakeholder countries.

d. The broad range of options that are proposed, including some chemicals proposed by the stakeholders, will effectively manage risk while increasing opportunities for importers, e.g. Spiromesifen and Milbemectin proposed by USA and Australia.

e. Impact on trade is considered to be minimal as all plants for planting currently require a generic mite treatment and the proposed change will add many options.

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Appendix 1: Acaricides assessed as being effective for all life stages of;

a) all four economically important plant feeding mite families

Active ingredient	Chemical group[1]	Trade name examples	Mode of action[2] & performance claim on the label	Registered countries[3]	Example of crops / Uses	Example of mite species controlled under each mite family	Mite life stages affected/ controlled & Primary site of action
Bifenazate+Abamectin	Bifenazate (group 20D-Mitochondrial complex III electron transport Inhibitors + (group 6-Glutamate-gated chloride channel (GluCl) allosteric modulators) (IRAC 2018a) (Sirocco Label contains UN as the chemical group for Abamectin as per the previous classificaton)	Sirocco	Contact and translaminar (control)	Many European countries Australia USA (PPDB 2018)	Greenhouse and field crops: avocado, curcubit, tomato, pomefruit, quince, eggplant, watermelon, strawberry, hop (PPDB 2018; Cloyd 2004; Gilrein u.d.; Sirocco label)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai*, Two spotted spider mite (*T. urticae*), Pacific mite (*T. pacificus*), European red mite (*Panonychus ulmi*), Southern red mite (*Oligonychus ilicis*), Spruce spider mite(*Oligonychus ununguis*), Clover mite (*Bryobia* sp.), Citrus red mite (*Panonychus citri*), Bamboo spider mite, Lewis mite (*Eotetranychus lewisi*) **Tarsonemid mites (Tarsonemidae):** Strawberry mite (*Cyclamen* sp.), **Flat mites/false spider mites (Tenuipalpidae):** Broad mite **Eriophyid mites (Eriophyidae):** rust mite, bud mite (Cloyd 2004; IR-4 2015; PPDB 2018; Gilrein u.d.; Sirocco label; Ozawa & Yoo 2006)	Fast knock down effect (in less than 1 day) (IR-4 2015; Sirocco label) on all life stages of the mites i.e.eggs, immatures and adults (IR-4 2015; Sirocco label) Action on the nervous system of mites by inhibiting the electron transfer of mitochondria (IRAC 2018a; IRAC 2019)
Fenpyroximate	METI acaricides and insecticides (group 21A - Mitochondrial complex I electron transport Inhibitors) (IRAC 2018a)	Akari Fenamite Pyromite	Contact (control)	Many European countries, Australia New Zealand (PPDB 2018)	Greenhouse and field crops: citrus, apple, pear, peach, grape (PPDB 2018; acaricide	**Spider mites (Tetranychidae) including *Tetranychus kanzawai,*** **Tarsonemid mites (Tarsonemidae),** **Flat mites/false spider mites (Tenuipalpidae)** **Eriophyid mites (Eriophyidae)**	Fast knock down effect (in less than 1 day) (IR-4 2015) on all life stages i.e. eggs, immatures and adults (IR-4 2015; NMPRO 2007; Cloyd 2008) Action on the energy metabolism of mites by inhibiting the mitochondrial complex I electron transport) (IRAC

					labels)	(PPDB 2018; IR-4 2015; acaricide labels; dos Santos et al., 2017)	2018a; IRAC 2019)
Milbemectin	Avermectins, Milbemycins (group 6- Glutamate-gated chloride channel (GluCl) allosteric modulators) (IRAC 2018a)	Milbeknock Ultiflora™	Contact (control)	Many European countries Some American country (including USA) Some African countries Some Asian countries Australia New Zealand (PPDB 2018)	Greenhouse and field ornamentals and crops: pome fruit, stone fruit, strawberry, capsicum, tomato, carnation, rose (PPDB 2018; Factsheet 2013; acaricide labels)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai*, two-spotted spider mite, European red mite, Carmine spider mite, Pacific spider mite, Strawberry spider mite **Eriophyid mites (Eriophyidae):** Pink citrus rust mite, Apple rust mite, Pink tea rust mite, Purple tea mite, Pear rust mite, Citrus bud mite **Tarsonemid mites (Tarsonemidae):** broad mite, Cyclamen mite **Flat mites/false spider mites (Tenuipalpidae):** (Stamps and Osborne 2009; PPDB 2018; Factsheet 2013; acaricide labels; Ozawa & Yoo 2006)	Fast knock down effect (in less than 1 day) (IR-4 2015) on all life stages i.e. eggs, immatures and adults (IR-4 2015; NMPRO 2007; Milbeknock label) Action on the nervous and muscle system of mites by inhibiting the glutamate-gated chloride channel allosteric modulators (IRAC 2018a; IRAC 2019). Also has insecticidal activity
Spiromesifen	Tetronic and Tetramic acid derivatives (group 23- Inhibitors of acetyl CoA carboxylase) (IRAC 2018a)	Forbid Judo Oberon Optimite	Contact Translaminar (control)	Some European countries USA New Zealand Australia (PPDB 2018))	Greenhouse and field ornamentals and crops: cucurbit, tomato, eggplant, French bean, melon, strawberry, rose, carnation (PPDB 2018;; acaricide labels)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai*, Two spotted spider mite, southern red mite, Lewis mite, tumid mite, maple spider mite, spruce spider mite, honeylocust spider mite, euonymus mite, boxwood spider mite **Tarsonemid mites (Tarsonemidae):** broad mite, cyclamen mite **Flat mites/false spider mites (Tenuipalpidae):** false spider mite **Eriophyid mites (Eriophyidae):** Rust and blister mites (IR-4 2015; PPDB 2018; CDPR u.d.;	Medium knock down effect (in 1-7 days) (IR-4 2015) on all mite life stages i.e. eggs, immatures and adults (IR-4 2015; NMPRO 2007; CDPR u.d.; Judo label) Action on the lipid synthesis and growth regulation of mites by inhibiting the acetyl CoA carboxylase (IRAC 2018a; IRAC 2019). Toxic on some ornamentals *Tetranychus urticae* shows some resistance

						acaricide labels; Ozawa & Yoo 2006)	

[1]Chemical group classification as per the Insecticide Resistance Action Committee (IRAC): http://www.irac-online.org/documents/moa-classification/ (accessed 13 April 2018).
[2]Mode of action of the pesticide: the pesticide stays on the surface of the plant (contact), move to small distance inside the plant (translaminar) or move long distance inside the plant (systemic).
[3]The list of registered countries may not be accurate, references could not be found for some countries but it does not mean the chemical is not approved.
*Target protein responsible for biological activity is unknown, or uncharacterized

b) only three economically important plant feeding mite families

Active ingredient	**Chemical group[1]**	**Trade name examples**	**Mode of action[2] & performance claim on the label**	**Registered countries[3]**	**Example of crops / Uses**	**Example of mite species controlled under each mite family**	**Mite life stages affected/ controlled & Primary site of action**
Acequinocyl	Acequinocyl (group 20B) (IRAC 2018a)	Shuttle 0 15SC Kanemite	Contact and also to a lesser extent by ingestion (control)	Some European countries USA (PPDB 2018)	Greenhouse, shadehouse and field ornamentals and nursery plants (PPDB 2018; Gilrein u.d.; Cloyd 2008; acaricide labels)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai,* Two-spotted spider mite (*T. urticae*) and Spruce spider mite (*Oligonychus ununguis*), European red mite (*Panonychus ulmi*) **Flat mites/false spider mites (Tenuipalpidae):** Red palm mite (*Raoiella indica*) **Eriophyid mites (Eriophyidae):** Bud mite (IR-4 2015; Gilrein u.d.; Cloyd 2011; PPDB 2018; acaricide labels; Wakasa & Watanabe 1999)	Fast knock down effect (in less than 1 day) (IR-4 2015) on all life stages eggs, immatures and adults (IR-4 2015; Cloyd 2008; Cloyd 2011; Shuttle label) Action on the nervous system of mites by inhibiting the electron transfer of mitochondria (IRAC 2018a; IRAC 2019)

Fenazaquin	METI acaricides and insecticides (group 21A-Mitochondrial complex I electron transport inhibitors) (IRAC 2018a)	Magus Magister	Contact (control)	Few European countries (PPDB 2018))	Greenhouse and field ornamentals and crops including apple, pear, citrus, nuts (PPDB 2018; Gilrein u.d.; acaricide labels)	**Spider mites (Tetranychidae):** *Eutetranychus*, *panonychus*, *Tetranuchus*, citrus mites (including *Tetranychus kanzawai)*, red mites **Eriophyid mites (Eriophyidae):** rust mite, bud mite **Tarsonemid mites (Tarsonemidae):** broad mite (PPDB 2018; Gilrein u.d.; acaricide labels; Turner 2011)	Fast knock down effect (in less than 1 day) (IR-4 2015; Magus label) on all life stages including eggs (Turner 2011; IR-4 2015). Action on the energy metabolism of mites by inhibiting the mitochondrial complex I electron transport (IRAC 2018a; IRAC 2019) Highly toxic to bees
Dicofol	Dicofol (group UN* Compounds of unknown or uncertain MoA (IRAC 2018a)	Kelthane	Contact (control and ovicidal)	This is banned in many countries including New Zealand	It is applied in a wide variety of crops, fruits, vegetables, Ornamental and field crops. (Kelthane label)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai,* European red mite, two-spotted (red-spider) mite, sixspotted mite, Pacific mite, Schoene mite, spruce mite, yellow (carpini) mite, **Flat mites/false spider mites (Tenuipalpidae):** privet mite, McDaniel mite, **Eriophyid mites (Eriophyidae):** pear rust mite and apple rust mite (Haviland 2005; IR-4 2015; Kelthane label; Osakabe 1967)	Direct contact on all life stages including juveniles, adults and eggs (IR-4 2015; Haviland 2005; Kavya 2014; Ormsby 2008). Ovicidal effect on eggs (Kelthane label) Unknown or non-specific targets (IRAC 2019)

Appendix 2: Acaricides effective for some life stages of a range of plant feeding mite families

Active ingredient	Chemical group[1]	Trade name examples	Mode of action[2] & performance claim on the label	Registered countries[3]	Example of crops / Uses	Example of mites controlled	Mite life stages affected/ controlled & Primary site of action
Abamectin	Avermerctins, Milbemycins (group 6- Glutamate-gated chloride channel (GluCl) allosteric modulators) (IRAC 2018a)	Avid	Contact and Translaminar (control)	Many European countries, USA Australia New Zealand (PPDB 2018)	Field crops, shade house & greenhouse Ornamental; Horticultural crops: citrus, pear, curcubits, beans, eggplant, tomatoe, watermelon (PPDB 2018; Avid label)	**Spider mites (Tetranychidae):** *Tetranychus kanzawai,* European Red Mite,Two-spotted Spider Mite, Carmine Spider Mite, Southern Red Mite, Spruce Spider Mite **Tarsonemid mites (Tarsonemidae):** Cyclamen, Broad Mites **Eriophyid mites (Eriophyidae):**: Rust and Bud Mites (IR-4 2015; PPDB 2018; Avid label; UC IPM 2019)	Fast knock down effect (in less than 1 day) on immatures and adults (IR-4 2015) but not effective on mite eggs (IR-4 2015; NMPRO 2007; Cloyd 2008) Action on nerve and muscle by inhibiting the glutamate-gated chloride channel allosteric modulators (IRAC 2018a; IRAC 2019)
Chlorfenapyr	Pyrroles (group 13- Uncouplers of oxidative phosphorylation via disruption of the proton gradient) (IRAC 2018a)	Pylon 2SC	Contact and translaminar (control)	Australia (PPDB 2018)	Greenhouse ornamentals (PPDB 2018; Cloyd 2004; Pylon label)	**Spider mites (Tetranychidae):** Tetranychus spp. (e.g. T. urticae, *T. kanzawai*) **Tarsonemid mites (Tarsonemidae):** Cyclamen, Broad Mites (*Polyphagotarsonemus latus*) **Eriophyid mites (Eriophyidae):** Rust and Bud Mites (Cloyd 2004; PPDB 2018; IR-4 2015; Pylon label; Yokohama 2002)	Medium knock down effect (in 1-7 days) (IR-4 2015) on mobile life stages (larvae, nymphs, adults) but not eggs (IR-4 2015; Cloyd 2008; Pylon label) Action on the energy metabolism by uncoupling oxidative phosphorylation via disruption of the proton gradient (IRAC 2018a; IRAC 2019)
Etoxazole	Etoxazole (group 10B- Mite growth inhibitors)	Paramite Baroque TetraSan	Translaminar (control)	Some European countries, USA, Australia,	Greenhouse, shadehouse and field ornamentals and crops: stonefruit,	**Spider mites (Tetranychidae):** *Tetranychus kanzawai,* Two-spotted spider mite. European red mite, Citrus red mite, Pacific spider mite, Yellow spider mite,	Medium effect (within 7 days control) (Paramite label) only on the egg, larvae, and nymphal stages. It has minimal effect on adult mites. However, adult female mites that

	(IRAC 2018a)			New Zealand (PPDB 2018)	pomefruit, citrus, tomato, eggplant, strawberry, avocado (PPDB 2018; Gilrein u.d.; acaricide labels)	McDaniel spider mite **Tarsonemid mites (Tarsonemidae):** Broad Mites **Eriophyid mites (Eriophyidae):** Yellow citrus rust mite, Brown citrus rust mite (Gilrein u.d.; PPDB 2018; acaricide labels; Ozawa & Yoo 2006)	are treated do not produce viable eggs (sterile) (NMPRO 2007; Gilrein u.d.; Paramite label)). Action on the growth regulator of mites (IRAC 2018a; IRAC 2019)

[1]Chemical group classification as per the Insecticide Resistance Action Committee (IRAC): http://www.irac-online.org/documents/moa-classification/ (accessed 13 April 2018).
[2]Mode of action of the pesticide: the pesticide stays on the surface of the plant (contact), move to small distance inside the plant (translaminar) or move long distance inside the plant (systemic).
[3]The list of registered countries may not be accurate, references could not be found for some countries but it does not mean the chemical is not approved.

Appendix 3: Calculation of dipping rate for proposed acaricides as a.i. (g) per Litre water

Active ingredient (a.i.)	Chemical group	(a.i.) % in the acaricide	[1]Maximum label rate for mites	Calculation	Max. dipping rate calculated (g/L water)	Label
Abamectin	Avermectins, Milbemycins (group 6)	1.9% (W/W)	8 fl.oz./100 gallons water	$\frac{(1.9/100 \times 236.59)}{378.541}$	0.012	Abamectin 0.15 EC
Aceqinocyl	Acequinocyl (group 20B)	NA	NA	NA	0.150	SHUTTLE™ 15 SC
Bifenazate+ Abamectin	Bifenazate (group 20D) Avermerctins, Milbemycins (group 6)	43.2% (W/W) 2.2% (W/W)	4 fl.oz./100 gallons water	$\frac{(43.2/100 \times 118.29)}{378.541}$ $\frac{(2.2/100 \times 118.29)}{378.541}$	0.135 0.007	SIROCCO™
Chlorfenapyr	Pyrroles (group 13)	21.4% (W/W)	5.2 fl.oz./100 gallons water	$\frac{(21.4/100 \times 153.78)}{378.541}$	0.087	Pylon®
Dicofol	Dicofol (group UN)	185 g/L	75 mL/20 L water	$\frac{(185/1000 \times 75)}{20}$	0.694	KELTHANE* 18.5 EC
Etoxazole	Etoxazole (group 10B)	110 g/L	35 mL/100 L water	$\frac{(110/1000 \times 35)}{100}$	0.038	Paramite
Fenazaquin	METI acaricides and insecticides (group 21A)	18.79% (W/W)	24 fl.oz./100 gallons water	$\frac{(18.79/100 \times 709.76)}{378.541}$	0.352	MAGUS®
Fenpyroximate	METI acaricides and insecticides (group 21A)	50 g/L	50 mL/100 L water	$\frac{(50/1000 \times 50)}{100}$	0.025	Pyromite®
Milbemectin	Avermectins, Milbemycins (group 6)	9.3 g/L	125 mL/100 L water	$\frac{(9.3/1000 \times 125)}{100}$	0.012	MILBEKNOCK®
Spiromesifen	Tetronic and Tetramic acid derivatives (group 23)	480 g/L	120 mL./100 gallons water	$\frac{(480/1000 \times 120)}{378.541}$	0.152	JUDO®

List of acaricide labels referred are retrieved online from;

- SIROCCO™: http://www.ohp.com/Labels_MSDS/PDF/sirocco_label.pdf
- Paramite: https://sumitomo-chem.com.au/sites/default/files/sds-label/paramite_0217.pdf
- MILBEKNOCK®: http://www.herbiguide.com.au/Labels/MILB9_61269-103004.PDF
- Pyromite®: https://www.adria.nz/docLabel/Pyromite%201L%20label.pdf
- SHUTTLE™ 15 SC: https://www.tlhort.com/crop_protection_label_search/Shuttle_15_SC_Miticide_-_Acequinocyl.pdf
- MAGUS®: http://www.plantproducts.com/us/images/Magus_Label.pdf
- Pylon®: https://www.domyown.com/msds/PylonMiticideLabel2014.pdf
- JUDO®: http://www.ohp.com/Labels_MSDS/PDF/judo_label.pdf
- Abamectin 0.15 EC https://s3-us-west-1.amazonaws.com/www.agrian.com/pdfs/Abamectin_0.15_EC_Label1d.pdf?_sm_au_=isVPH7bPWL3vSP45
- KELTHANE* 18.5 EC: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0ahUKEwjQjqTQvZjcAhVQEqYKHcMWDh0QFgg3MAI&url=http%3A%2F%2Fwww.griculture.co.ke%2Flabels%2Fkelthane18_5ec.doc&usg=AOvVaw10W8NyhTVs8qbVSkwUlklP

[1]The following unit converters were used for calculations of rates- a) for conversion of fluid ounzes (fl.oz.) to grams https://www.convertunits.com/from/US+fluid+ounce/to/grams; b) for gallons to Litres https://www.metric-conversions.org/volume/us-liquid-gallons-to-liters.htm. 100 US gallons=378.541L, 4 fl.oz=118.29g, 5.2 fl.oz=153.78g, 8 fl.oz.=236.59g.
For some acaricides calculation was not needed as it was already given on the label. Therefore relevant rows in the table are shown as 'NA' (Not Applicable).

Appendix 4: Proposed changes for the IHS 155.02.06

A) Proposed changes for Section 2.2.1.6 *Pesticides treatment for whole plants and cuttings*

*New section proposed is in blue, new wording added is highlighted in yellow and wording proposed to remove has a strike through

2.2.1.6. Pesticide treatments for whole plants and cuttings

Mites (non-diapausing)

Treatment must be completed either offshore prior to export or on arrival in New Zealand at the importer's expense.

- If performed offshore, the exporting country NPPO must confirm that this treatment is endorsed in the disinfection and/or disinfection treatment section of the phytosanitary certificate including active ingredient/s of the chemical/s used, rate of application, mode of application (i.e. dipping or spraying with a surfactant), treatment time (i.e. how long the treatment was applied for) and date of application.
- If performed on arrival (on-shore), plant material must be treated at an MPI approved facility in accordance Approved Biosecurity Treatments (ABTRT) by an MPI-Approved Treatment Provider.
- A copy of the chemical label must be supplied if different to the table below.

One of the following two treatments is required:

(1) Methyl bromide (dormant material only): continuous fumigation at atmospheric pressure in accordance with a schedule that achieves the minimum concentration-time product (CT) (minimum achieved dose ($g{\cdot}h/m^3$)) at a minimum temperature (ºC) that must not be less than 10 ºC, is specified in the table below. Treatment must be achieved over the minimum exposure time (minimum duration (h)) that must not be less than 2 hours and not fall below a minimum concentration (final residual concentration (g/m^3)) during that treatment, as per the schedules in Table 1. Alternative options for longer exposure times with weaker concentrations or at higher temperature (ºC) are also specified in the table below.

Table 1: Methyl bromide fumigation schedules (dormant plant material only): For mites (non-diapausing), fumigation for a minimum of (i) 2, (ii) 2.5 or (iii) 3 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)*			Minimum concentration-time product (CT)/ achieved dose ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)**		
2 h[i]	2.5 h[ii]	3 h[iii]			2 h[i]	2.5 h[ii]	3 h[iii]
68	56	48	120	10	51	41	34
57	48	40	100	16	43	35	28
48	40	34	85	21	36	29	24
40	32	28	70	28	30	23	20

*The shaded area of the table is guidance only. It is guidance on the minimum initial methyl bromide concentration that can achieve the required CT values at the optional temperature and treatment-duration combinations.

**Minimum concentration during fumigation (g/m^3) must be achieved throughout the treatment and depends on the temperature and duration of the treatment, but must not be less than 2 hours

[i] Treatment duration is over a minimum of 2 continuous hours

[ii] Treatment duration is over a minimum of 2.5 continuous hours

[iii] Treatment duration is over a minimum of 3 continuous hours

Guidance

- While a number of combinations of time and initial concentration may be used to achieve the minimum requirements (CT and minimum final concentration (g/m^3)) of the treatment, care must be taken to avoid phytotoxicity. Phytotoxic effects of the treatment may increase when a higher initial concentration at lower temperature and reduced duration is used.
- It is the importers responsibility to choose which 'duration of treatment (time (h))' option will be undertaken.
- The importer undertakes treatments at their own risk (see legal disclaimer in Approved Biosecurity Treatments (ABTRT))

The concentration-time product (CT) utilized for methyl bromide treatment in this standard is the sum of the products of the concentration (g/m^3) and time (h) over the duration of the treatment. This is in accordance with ISPM 43*: Requirements for the use of fumigation as a phytosanitary measure*.

OR

(2) Chemical treatment: spray to the point of runoff (with a suitable surfactant), or preferably immerse in a dip(s) with agitation, according to the following conditions. The plants must be sprayed/dipped using either OPTION 1 (one-acaricide treatment option) or OPTION 2 (two-acaricides combined treatment option) as indicated below. For dipping, the treatment time is normally 2 minutes but must be increased to 5 minutes if bubbles remain present on the plant surface. Dip solutions must be used no more than twice or as per manufacturer's recommendations. All treatments must be carried out in accordance with manufacturer's recommendations at the maximum label rate as shown in the table below;

OPTION 1: One acaricide treatment

Select any single acaricide from the list below for dormant or non dormant plant material.

Active ingredient	Chemical group	Rate (g/L water)**	Formulation type*	Re-treatment period ***
Spiromesifen	Tetronic and Tetramic acid derivatives; group 23	0.152	SC	7 -10 days
Milbemectin	Avermectins, Milbemycins; group 6	0.012	SC	
Fenpyroximate	METI acaricides and insecticides; group 21A	0.025	SC	
Bifenazate+ Abamectin	Bifenazate; group 20D Avermectins, Milbemycins; group 6	0.135 0.007	SC	7 -10 days

*SC-Suspension concentrate

**concentration of active ingredient (not amount of concentrate solution)

***Retreatment must apply according to the NOVACHEM agrichemical manual or label

OPTION 2: Two acaricides combined treatment

OPTION 2A: Etoxazole + one of the chemicals selected from *Group a*
OPTION 2B*:* Fenazaquin + one of the chemicals selected from *Group b*

Active ingredient	**Chemical group**	**Rate (g/L water)**	**Formulation type***
OPTION 2A (Non-dormant material only)			
Etoxazole	Etoxazole; group 10B	0.038	SC
Group 'a'			
Abamectin	Avermectins, Milbemycins; group 6	0.012	EC
Chlorfenapyr	Pyrroles; group 13	0.087	SC
OPTION 2B			
Fenazaquin	METI acaricides and insecticides; group 21A	0.352	SC
Group 'b'			
Aceqinocyl	Acequinocyl; group 20B	0.150	SC
Dicofol	Dicofol; group UN	0.694	EC

*SC-Suspension concentrate; EC-Emulsifiable concentrate

If satisfied that the pre-shipment activities have been undertaken, the exporting country NPPO must confirm this by recording the treatments applied in the "Disinfestation and/or Disinfection Treatment" section of the phytosanitary certificate.

B) Proposed changes for the six schedules for removal of conditions for *T. kanzawai* as follows;

Calanthe

Approved Countries: All
Quarantine Pests: *Phytophthora capsici, Phytophthora palmivora,* Uredinales, *Tetranychus kanzawai*
Entry Conditions: Basic; with variations and additional conditions as specified below:
A. For Whole Plants
PEQ: Level 2
Minimum Period: 1 year
a. Additional declarations
"The plants have been dipped in propiconazole at the rate of 0.5g a.i. per litre of water, prior to export".
~~**AND**~~
~~"The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

Dahlia

Approved Countries: All
Quarantine Pests: *Phymatotrichopsis omnivore, Phytophthora capsici, Potato spindle tuber viroid, Tetranychus kanzawai,* Uredinales
Entry Conditions: Basic; with variations and additional conditions as specified below:
A. For Whole Plants
PEQ: Level 2
Minimum Period: 3 months
a. Additional Declarations
"The nursery stock in this consignment has been sourced from a "Pest free area" or "Pest free place of production" [choose one], free from *Potato spindle tuber viroid"*.
AND
"Rust diseases are not known to occur on *Dahlia* in _ (the country in which the plants were grown) _".
~~**AND**~~
~~"The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

Tricyrtis

Approved Countries: All
Quarantine Pests: *Tetranychus kanzawai*
Entry Conditions: Basic; with variations and additional conditions as specified below:
A. For Whole Plants:
PEQ: Level 2
Minimum Period: 3 months
~~**Additional Declaration:**~~
~~"The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

Verbena

Approved Countries: All
Quarantine Pests: *Phytophthora tentaculata, Tetranychus kanzawai,* Uredinales, *Xylella fastidiosa*
Entry Conditions: Basic; with variations and additional conditions as specified below:
A. For Whole Plants
PEQ: Level 2
Minimum Period: 3 months
a. Conditions for *Phytophthora tentaculata*[1]

One of the following Additional Declarations must be endorsed on the phytosanitary certificate:
"The [insert species name] plants in this consignment have been sourced from [insert country name], which is free from *Phytophthora tentaculata*".
OR
"The [insert species name] plants in this consignment were produced in a "pest free area" for *Phytophthora tentaculata*".
OR
"The [insert species name] plants in this consignment were produced in a "pest free place of production" for *Phytophthora tentaculata*".

~~b. Conditions for *Tetranychus kanzawai*~~
~~Additional declaration: "The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

Gentiana

Approved Countries: Japan
Quarantine Pests: *Cronartium flaccidum*; *Tetranychus kanzawai*
Entry Conditions: **Basic;** with variations and additional conditions as specified below:
A. For Whole Plants
PEQ: Level 2
Minimum Period: 3 months
Additional Declarations:
1. "The plants have been dipped in oxycarboxin at 1.5g a.i. per litre of water, prior to export".
2. ~~"The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre.~~

Hydrangea

Approved Countries: All
Quarantine Pests: *Tetranychus kanzawai*; *Phellinus noxius; Xylella fastidiosa*
Entry Conditions:
Basic; with variations and additional conditions as specified below:
A. For Whole Plants
PEQ: Level 2
Minimum Period: 3 months
a. Conditions for *Xylella fastidiosa* (section 2.2.1.12)

Guidance for importers: The minimum quarantine period will be 6 months for nursery stock sourced from countries not recognised by MPI as free from *Xylella fastidiosa*
b. Conditions for *Phellinus noxius* (section 2.2.1.13)
Note: Only applies to the following species: *Hydrangea chinensis* and *Morus alba*

c. ~~Additional declaration: "The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

B. For Cuttings
PEQ: Level 2
Minimum Period: 3 months
a. Conditions for *Xylella fastidiosa* (section 2.2.1.12)
Guidance for importers: The minimum quarantine period will be 6 months for nursery stock sourced from countries not recognised by MPI as free from *Xylella fastidiosa*

b. ~~Additional declaration: "The plants have been dipped prior to export in dicofol at the rate of 0.7g a.i. per litre of water".~~

Appendix 5: Four mite families and why acaricides are justified on imported nursery stock (Biosecurity Science and Risk assessment MPI)

Technical advice on: Four mite families and why acaricides are justified on imported nursery stock

Date: 14 August 2018
Name: Deb Anthony
Position: Senior adviser

Purpose of document

The information provided here is a brief overview of four mite families. It is designed to give sufficient understanding to support the requirement for an acaricide treatment of whole plants and cuttings entering New Zealand for planting. This information is being provided for the Plant Germplasm Imports team.

Background

Tetranychus kanzawai [Tetranychidae] is identified as a quarantine pest by New Zealand and requires measures that will target it in particular. The acaricide Dicofol was being used overseas but is no longer considered acceptable in the USA and Australia. Consequently other chemical control was researched for this species and family. At the same time three other mite families which contain species well known to be injurious to economically important plants were also considered in the review of chemical control by the Plant Germplasm Imports team.

Summary of advice

There are mites in the Families Eriophyidae, Tarsonemidae, Tenuipalpidae and Tetranychidae that are injurious to plants of economic importance to New Zealand, are not reported from New Zealand and are considered quarantine pests.

- Many of these mites have the potential to establish in certain areas of New Zealand and have significant impacts.
- Some species of these mites are vectors of serious plant pathogens that are not reported from New Zealand.
- Damage by some mite species includes formation of blisters, galls and distortions (eriophyids); webbing (tetranychids); disease (eriophyids, tarsonemids, tenuipalpids, few tetranychids); feeding damage causing discolouration, reduction in photosynthesis, plant weakness, stunting, distortion and sometimes death (eriophyids, tarsonemids, tenuipalpids and tetranychids).
- Damage can reduce the value of ornamentals or make them unsaleable; can reduce the value of fruit and vegetables, reduce crop yields or destroy large proportions of crops.
- Many of these mites and/or lifestages are too small to be seen with the naked eye and require special magnification (e.g. eriophyids, some tarsonemids and tenuipalpids).
- The reproductive strategies of these mites show that very few individuals are necessary to found a population under suitable conditions.

- Dispersal over distances can be easily achieved through human-assisted movement of infested plant material, by air currents, wind and by phoresy (insects, other invertebrates, humans).
- Acaricide treatment is necessary to avoid introduction of quarantine pest mites into New Zealand, as some mites species could go undetected until their population is too large and widespread to enable feasible eradication.
- Choice of acaricide/s are dependent on the type of mite, the lifestage, certain biological characteristics of the mite (gall forming, diapause, reproductive strategy etc.) and knowledge of any resistant strains.

Supporting information

Most of the following information is taken from the textbook 'The handbook of mites of economic plants: identification, bio-ecology and control' by Vincenzo Vacante, published by CABI in 2016. It is a comprehensive and trusted source suitable for a request for technical advice. Other equally reputable sources are used where applicable.

There are four mite families considered in this technical advice: Eriophyidae, Tarsonemidae, Tenuipalpidae and Tetranychidae. These families are widespread in the world and have taxa that are injurious to plants of economic importance. Many of these taxa can be found in regions with sufficient similarity to New Zealand to suggest they could establish here.

Arachnida: Acaromorpha: Acari: Acariformes: Trombidiformes: Prostigmata:

Family Eriophyidae

There are 6 subfamilies and 12 tribes in the family Eriophyidae. Zhang et al. (2011, cited in Vacante 2016) reported 274 genera and 3790 species.

Description

Members of the Eriophyidae are tiny, worm-like mites between 90 µm and 350µm long and have only 2 pairs of legs. They cannot be seen by the naked eye, but they induce physical and chemical changes in their hosts which indicate their presence, e.g: blisters and galls, some of which can be quite colourful. Eriophyid mites are often called blister mites, bud mites, gall mites or bladder mites. The following images show a micrograph of the typical eriophyid body form and two types of leaf damage by eriophyid mites

The microscopic rose bud mite, *Phyllocoptes fructiphilus,* which carries the rose rosette virus. Photo by Electron and Confocal Microscopy Unit. USDA

Blisters from the apple/pear blister mite. Eriophyid mite galls on blackgum. (authors unknown)

Quarantine pest criteria

Over 50 species within the Eriophyidae are considered injurious to economic plants and about 30 of these mites species cause severe damage. They include pathogen vectors, pests of broadleaved plants and nearly all the gall-forming species. Some attack monocot plants, conifers, other gymnosperms and ferns but most live on dicotyledons (Vacante 2016). There are a number of eriophyid mites not reported from New Zealand that could potentially establish and have significant impacts on crops of economic importance. These include *Eriophyes insidiosus, E. inaequalis, E. padi, E. similis, Aceria lycopersici, A. medicaginis, Phyllocoptes fructiphilus* (NZInverts 2018; NZOR 2018; PPIN 2018; Gordon 2010) and more.

Lifecycle

The stages of development for eriophyid mites are egg, larva, protonymph and adult. A quiescent phase occurs between larva and protonymph and between the nymph and adult. In some species the female produces hatched larvae. Although there are males, females tend to be more numerous and reproduction is mainly by arrhenotokous parthenogenesis (produces male offspring). Males lack an aedeagus so they deposit sperm packages (spermatophores) on the leaves. Females that come across spermatophores may self-fertilise from these.

Eriophyid mites can develop two types of lifecycle. The first type has females that are structurally similar to males and are referred to as a 'protogynes'. The second type has females that are structurally different to the protogynes, and are called 'deutogynes'. The significance of the deutogynes is that they survive through adverse conditions, and/or can overwinter, by certain physical adaptations such as a change to the cuticle that makes it more resistant to water loss (In Vacante 2016). It is not stated if deutogynes are likely to be more resistant to acaricides than protogynes. However, emphasis is given to knowledge of phenology and developmental biology as being fundamental in the control of eriophyid mites (Vacante 2016).

Eriophyid mites have a strong relationship with their host plants and reproduce on a precise range of plants. They tend to be either monophagous-(specific to one species of host plant), genus specific or family specific. There are free-living 'leaf vagrant' species, mites that have refuges- e.g: live in domatia, and those that cause the plant to form galls or distortions by affecting the plant physiology.

Dispersal and colonisation of new habitats occurs by active 'walking', rain, wind and phoresy (insects, phytoseiid mites, spiders, mole crickets, humans).

Damage

Obvious symptoms of damage are various sorts of galls – (leaf galls, stem galls, bud galls, fruit galls) and other distortions. Eriophyids that do not induce galls or distortion cause other symptoms such as toxaemias and feeding damage to the epidermis. Some eriophyids produce webbing, or wax-like or liquid secretions. The effects of such damage is that ornamentals are reduced in value or become unsaleable; crop yields can be reduced significantly, and; plants can be weakened or stunted, become susceptible to pathogens or have pathogens directly transmitted to them (Vacante 2016).

Amongst the eriophyids are species that can vector plant pathogens. These are mostly viruses (e.g. *Peach mosaic virus*-PMV*; Cherry mottle leaf virus*-CMLV, *Agropyron mosaic virus*- AgMV, which are not reported from New Zealand- PPIN 2018, Veerakone 2015). CMLV affects several stonefruit including cherry, peach, plum apricot and mahaleb cherry. There is a wide range of strains with differing severity, some reduce fruiting, some reduce fruit size. Long established infections lead to stunting and crop failure. Sweet cherry has the most pronounced symptoms, and generally infected trees should be removed (Ogawa 1995). There are some fungal pathogens that can be vectored by some eriophyids, for instance, *Fusarium mangiferae* spores are vectored by *Aceria mangiferae* in mango buds.

Family Tarsonemidae

Worldwide the Tarsonemidae has three subfamilies and contains about 530 described species in 40 genera. The Tarsonemidae is diverse in its feeding habits, which includes algivorous, fungivorous, insectophilous, nidicolous and phytophagous species. The genera known to include phytophagous species are *Polyphagotarsonemus, Hemitarsonemus, Steneotarsonemus, Phytonemus* and *Tarsonemus* (Vacante 2016).

Description

Tarsonemids are tiny mites between 100µm-300µm long, translucent, pale or whitish but their colour is affected by the food they ingest (Zhang 2003). They can be difficult to see without magnification.

Tarsonemus confusus. Image by Qing Hai Fan.

Quarantine pest criteria

Some tarsonemid species are damaging of economically important plants, some of cultivated mushroom crops and some are pests of stored products. There are a number of tarsonemid species that are not reported from New Zealand and have the potential to establish in parts of the country and have unwanted economic impacts. For instance the following tarsonemid species fall into this category: *T. bakeri, T. bilobatus, T. confusus, Hemitarsonemus tepidariorum*, and *Steneotarsonemus furcatus* ((NZInverts 2018; NZOR 2018; PPIN 2018; Gordon 2010) and more.

Lifecycle

The tarsonemid lifecycle develops through egg, larva and adult, with a quiescent nymphal stage inside the larval cuticle. Generally tarsonemid larvae are active and feed like adults. Reproduction is largely arrhenotokous parthenogenesis, however, amphitoky (both sexes produced from unfertilised females) has been observed in *T. fusaria* (Vacante 2016).

Dispersal can be by infested plant material, air-currents and wind and phoretically by insects: e.g. the broad mite, *Polyphagotarsonemus latus*, is known to be dispersed by the whitefly *Trialeurodes vaporariorum* in glasshouses in China (Vacante 2016).

Damage

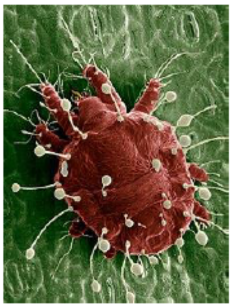
Feeding causes direct damage to plants and can distort growing tips. Some tarsonemids are reported to carry pathogenic fungi spores on their bodies. *H. tepidariorum* is a pest of ferns grown in glasshouses, typically species of *Asplenium*, *Polystichum* and *Pteris*. Heavy infestations can arrest plant growth and may even kill the plant (Zhang 2003). Some species of *Tarsonemus* are primarily fungivorous but will also feed on plants, e.g: *T. confusus, T. bilobatus* causing damage to ornamentals and food crops in greenhouses (Zhang 2003).

Family Tenuipalpidae

There are currently over 1100 valid species belonging to 38 genera in this family (Vacante 2016).

Description

Tenuipalpid mites can be macroscopically confused with tetranychid mites because of their red-orange body colour, however, they are slow moving and do not produce silk webbing. The body of tenuipalpids are dorsoventrally flattened and are 200µm - 400µm long with reticulations and ridges. They can be difficult to see without magnification. Tenuipalpids are commonly called 'false spider mites' or 'flat mites' (Vacante 2016).



Raoiella indica, red palm mite.
SEM x300. Photo credit: Eric Erbe

Tenuipalpus pacificus (author unknown)

Quarantine pest criteria

There are numerous mites in the Tenuipalpidae that are not reported from New Zealand and could potentially establish in parts of the country causing significant economic impacts. Some of these tenuipalpids include *Raoiella indica, Tenuipalpus pacificus, Brevipalpus lewisi* (NZInverts 2018, NZOR 2018, PPIN 2018, Gordon 2010) and *Brevipalpus phoenicis*, which is present in New Zealand and is known to vector *citrus leprosis virus* which is not reported from New Zealand (Veerakone 2015; PPIN 2018).

Lifecycle

The tenuipalpid lifecycle includes egg, larva, protonymph, deutonymph and adult. In between these active stages are quiescent developmental phases. Some species in the genus *Brevipalpus* reproduce by thelytokous parthenogenesis and males are infrequently seen (Vacante 2016). Thelytokous parthenogenesis produces females and is likely to facilitate rapid increase in population size. Females overwinter in protected places (leaf underside, crevices on host plant, base of plant etc.) Dispersal hasn't been studied and is most likely via aircurrents and movement of infested plants and equipment (Zhang 2003).

Damage

All tenuipalpid mites are phytophagous and feed on epidermal cells of the stems, fruits, leaves of various cultivated and wild plants. Feeding activity causes direct damage to plants, and some species can vector viruses causing severe damage and economic impacts. Some species are reported to carry the spores of fungal pathogens (Vacante 2016).

Family Tetranychidae

There are two sub-families, Bryobinae and Tetranychinae, which between them have approximately 77 genera and about 1275 species (Vacante 2016).

Description

Mites in the family Tetranychidae are soft-bodied and are more or less ovoid or round. They can be red, orange, yellow or green in colour with a body length between 350µm to 1000µm. Adults are more likely to be visible due to their larger size than eggs or immatures. Tetranychid mites are commonly referred to as spider mites as many species in the sub-family Tetranychinae produce webbing.

Adult female Tetranychus kanzawai (author unknown)

Tetranychid mites and webbing (author unknown)

Quarantine pest criteria

A number of tetranychid species of economical importance are not reported from New Zealand, and have the potential to establish and have an impact in some areas of the country. For instance, *Tetranychus kanzawai, T. evansi, Oligonychus punicae, Panonychus elongatus, Eutetranychus orientalis* (NZInverts 2018; NZOR 2018; PPIN 2018; Gordon 2010) are amongst tetranychid mites considered to be quarantine pests by New Zealand.

Lifecycle

Tetranychid mites have both males and females so reproduction can be either sexual or by arrhenotokous parthenogenesis. There are five stages in the development of tetranychids: egg, larva (6 legs), protonymph (8 legs), deutonymph and adult, with a quiescent phase between each instar or stase before moulting. The lifecycle varies according to species and ecological factors such as climate, food plants, population etc. In the subtropics and tropics various species are active all year on their host plants and if the temperatures drop below their development threshold then they may stop reproduction for a period of time. In temperate regions some species overwinter in diapause Vacante 2016). Gravid female *T. urticae* seek shelter towards the end of summer. Diapausing adults are red/orange in colour (Zhang 2003). Diapause eggs are produced by about 18 species of tetranychid mite; of these, 5 species undergo a summer diapause and the rest of the species undergo a winter diapause (Vacante 2016).

Dispersal
Generally tetranychid mites live their lives on one plant, however, if there is severe overcrowding and/or the plant is dying then the mites will attempt to disperse. Dispersal mostly occurs by the release of silk strands which enables the mite to 'balloon' on air currents. Zhang (2003) notes that tools, people and movement of infested plants are also dispersal mechanisms.

Damage
Tetranychid mites commonly infest leaves, often the underside, but will also feed on the upper surface, and flowers, shoot tips, fruits and cotyledons. Mite damage to plants is specifically from their feeding. Tetranychid mites (and most phytophagous mites) do not feed in the vascular tissue (http://hyg.ipm.illinois.edu/pastpest/200501f.html). Their mouthparts pierce cells of the palisade tissue (primary area of photosynthesis) and remove chloroplasts and other cellular contents. This produces pale punctures over the feeding area which may take on a white or greyish colour. The saliva of some mites may also contribute to the feeding damage. Heavy infestations will weaken and may even kill the plant. Profuse webbing from some mites can also have a detrimental affect on the health of the plant.

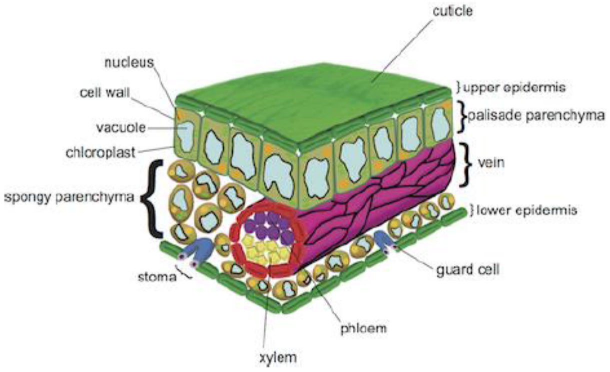


Illustration of a leaf transection naming the key elements

Biological factors affecting control of mites (eriophyids, tarsonemids, tenuipalpids and tetranychids)
Non-feeding stases
There are several biotic factors that can impede the effectiveness of acaricides and miticides. Eggs are a non-feeding lifestage. Most mites have a quiescent stase between each developmental stage. This quiescent stase is often a period of non-feeding. In some species of mites the larva and protonymph (and some deutonymphs) may not feed at all (Vacante 2016). Mites do not feed from the vascular tissues (xylem and phloem) so systemic pesticides are generally not appropriate for control of mites unless they have been developed specifically for mites. Acaricides with translaminar mode of action will target feeding mites. *Translaminar* is a term that refers to insecticides/miticides

that penetrate the leaf tissue, including the spongy mesophyll and palisade parenchyma cells, providing a reservoir of active ingredient (Cloyd et al. 2008).

Diapause

Diapause is a period of suspended development, usually during unfavourable environmental conditions. Diapause and non-diapause females of *Tetranychus urticae* exhibited differing tolerances to a number of pesticides (in Vacante 2016). It is uncertain if this has been shown in other species of spider mite or other mite families. As diapausing mites tend to seek shelter this can impede the ability to control them as they are likely to be well protected and usually unlikely to be feeding.

Arrhenotokous reproduction

Arrhenotoky is relatively common in several acarine groups. It may have some bearing on chemical resistance developing. In *Tetranychus urticae* it was shown that single major genes control specific types of resistance. The survival and success of the character of resistance to various chemicals is through a state of homozygous recessive allele carriers facilitated by arrhenotokous reproduction. In mites the major resistance mechanisms include greater degradation of acaricides by esterases and the activity of glutathione-*S*-transferases and cytochrome-P450-dependent monoxygenases, decreased penetration of acaricides through the cuticle and also a change in the target site is known (In Vacante 2016).

Webbing

Mites that produce webbing do so for protection of their various lifestages. The webbing may protect eggs from predators, regulate humidity around the eggs and protect from wind and rain. It would seem likely that there may be some protection conferred by the webbing against acaricides that rely on physical contact with the target species.

Gall production

Mites that form galls on the plant usually live within the galls and are likely to be protected from acaricides that are active by contact with the mite (e.g. delivered through the integument).

Conclusion

The biology of the mite target species and its lifestages need to be considered in determining the choice of acaricide thus ensuring it has the appropriate mode of action. Problems with resistance to certain chemicals is well known. It has been noted that if a mite population is suppressed it often vigorously re-emerges and show signs of resistance to the chemical that had been used previously (Chapt. 9 in Vacante 2016).

Some existing pest risk assessments for specific mites

PRA *Tetranychus evansi*- Externally peer reviewed, but unpublished. Sent to Biosecurity Australia for discussions regarding imported potential hosts.

PRA *Tetranychus neocaledonicus* in: IRA Citrus from Samoa 2008.

PRA *Aceria litchi*: IRA Taiwan Litchi 2007

PRA *Tarsonemus bakeri*; PRA *Tetranychus humorous, T. mcdanieli, T. pacificus*: IRA Stonefruit PNW – draft 2009.

PRA *Tetranychus kanzawai*: IRA Rosa cutflowers 2011; IRA Table grapes China 2009

PRA *Eutetranychus orientalis*: IRA Rosa cutflowers 2011

PRA *Brevipalpus lewisi*: IRA Table grapes China 2009

PRA *Tenuipalpus pacificus*: IRA Phalaenopsis Taiwan

PRA *Brevipalpus chilensis*: IRA Blueberries Chile-draft

Time: 49.5 hours

Reviewed by: Ursula Torres

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V 1.0	Melanie Newfield	15 Aug 2018
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Appendix 6: Methyl bromide schedules for Mites on Nursery Stock (Biosecurity Science and Risk assessment MPI)

Status: DRAFT
Activity: Scientific technical advice

Plants & Pathways
Biosecurity Science & Risk Assessment

Technical advice on: Methyl bromide schedules for Mites on Nursery Stock

Date: 27 November 2019

Name: Dr Michael Ormsby

Position: Manager

Purpose of document

Dicofol is currently a mandatory treatment to manage T. kanzawai on nursery stock, but is being removed due to regulatory restrictions on its use. In order to support the new proposed Methyl bromide fumigation rates for mites on nursery stock, can you please provide the scientific evidence indicating that these treatment combinations will effectively manage mites infesting nursery stock, including all life stages of *Tetranychus kanzawai*?

Also please note in Appendix 5 of the table in your technical review for Proposed treatments for Brown Marmorated Stink Bug (2018), it was mentioned that a Methyl bromide fumigation rate of 48 g/m^3 for 2 hours at >15°C achieved an estimated mortality rate of 99.9915% (1 survivor in 11,734) *Tetranychus kanzawai* at the 95% level of confidence. As the proposed rate also includes a temperature below 15°C (10-15°C), can you please also provide the scientific evidence indicating that this treatment will effectively manage mites infesting nursery stock, including all life stages of *Tetranychus kanzawai*?

Background

The plant imports team are proposing to replace current MeBr fumigation rates applied for mites under the basic conditions for whole plants and cuttings in the current nursery stock import health standard (IHS).

Current Methyl bromide fumigation option

(1) The other option (additional to the chemical treatment option) under the Basic Conditions, Part 2.2.1.6(b) *Pesticide treatments for whole plants and cuttings* of the current IHS to treat mites is Methyl bromide fumigation. This option is limited to dormant plant material and the current combination of application rate and temperature at atmospheric pressure for 2 hours is as same as the treatment for insects (see table below). This combination is considered to be ambiguous and the efficacy of the treatment is not optimal against mites (**need to reference technical advice**)

Rate (g/m^3)	Temperature (°C)
48	10-15
40	16-20
32	21-27
28	28-32

Proposed Methyl bromide fumigation option

(2) MPI proposes a new Methyl bromide fumigation schedule for mites for dormant plant material under Part 2.2.1.6(b) in the IHS. Any of those treatment combinations

(rate/time/temperature) are effective to manage all life stages of plant feeding mites including *Tetranychus kanzawai* (**need to reference technical advice**).

Methyl bromide (dormant material only): Fumigation for a minimum 2.5 hours at atmospheric pressure at one of the following combinations;

Minimum initial concentration (g/m^3)	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
56	120	10	41
48	100	16	35
40	85	21	29
32	70	28	23

*concentration over time

Summary of advice

An international best practice example for describing methyl bromide fumigation schedules is available in the International Plant Protection Convention International Standard for Phytosanitary Measures number 15: *Regulation of wood packaging material in international trade* (ISPM 15). In ISPM 15 there are four minimum requirements in the schedule (see table 1 in insert below from ISPM 15):

1. **A minimum exposure period**. The efficacy of a methyl bromide fumigation is reduced if the exposure time is reduce (everything else being equal). Conversely the level of achieved efficacy is increased if the exposure period is extended. As long as the treatment exposure period is equal to or longer than the minimum exposure time, the required level of efficacy should be met or exceeded.
2. **A minimum temperature for the commodity and treatment space.** The efficacy of a methyl bromide fumigation is reduced if the temperature is reduced (everything else being equal). Conversely the level of achieved efficacy is increased if the temperature is increased. As long as the treatment temperature is equal to or higher than the minimum temperature, the required level of efficacy should be met or exceeded.
3. **A minimum exposure dose (described as the C/T value).** The efficacy of a methyl bromide fumigation is reduced if the dose is reduced (everything else being equal). Conversely the level of achieved efficacy is increased if the dose is increased. As long as the treatment dose is equal to or higher than the minimum dose, the required level of efficacy should be met or exceeded.
4. **A minimum gas concentration over the duration of the treatment**. A minimum gas concentration is required to ensure the period of exposure to the fumigant is not lower than intended. If the gas concentration drops below the minimum level, the level of efficacy achieved may not meet the required level.

ISPM 15 provides a single example (guidance material) on how the required schedule can be met operationally (see table 2 in insert below from ISPM 15). The guidance material provides the concentrations of the gas that are required to be met at intervals over the exposure period, assuming a 50% reduction in atmospheric gas concentration in the enclosure. Other examples could be provided that provide operational guidance on how to meet the standard using fumigation chambers (30% loss after 24 hours) or under tarpaulin (70% loss after 24 hours).

(rate/time/temperature) are effective to manage all life stages of plant feeding mites including *Tetranychus kanzawai* (**need to reference technical advice**).

Methyl bromide (dormant material only): Fumigation for a minimum 2.5 hours at atmospheric pressure at one of the following combinations;

Minimum initial concentration (g/m^3)	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
56	120	10	41
48	100	16	35
40	85	21	29
32	70	28	23

*concentration over time

Summary of advice

An international best practice example for describing methyl bromide fumigation schedules is available in the International Plant Protection Convention International Standard for Phytosanitary Measures number 15: *Regulation of wood packaging material in international trade* (ISPM 15). In ISPM 15 there are four minimum requirements in the schedule (see table 1 in insert below from ISPM 15):

1. **A minimum exposure period.** The efficacy of a methyl bromide fumigation is reduced if the exposure time is reduce (everything else being equal). Conversely the level of achieved efficacy is increased if the exposure period is extended. As long as the treatment exposure period is equal to or longer than the minimum exposure time, the required level of efficacy should be met or exceeded.
2. **A minimum temperature for the commodity and treatment space.** The efficacy of a methyl bromide fumigation is reduced if the temperature is reduced (everything else being equal). Conversely the level of achieved efficacy is increased if the temperature is increased. As long as the treatment temperature is equal to or higher than the minimum temperature, the required level of efficacy should be met or exceeded.
3. **A minimum exposure dose (described as the C/T value).** The efficacy of a methyl bromide fumigation is reduced if the dose is reduced (everything else being equal). Conversely the level of achieved efficacy is increased if the dose is increased. As long as the treatment dose is equal to or higher than the minimum dose, the required level of efficacy should be met or exceeded.
4. **A minimum gas concentration over the duration of the treatment.** A minimum gas concentration is required to ensure the period of exposure to the fumigant is not lower than intended. If the gas concentration drops below the minimum level, the level of efficacy achieved may not meet the required level.

ISPM 15 provides a single example (guidance material) on how the required schedule can be met operationally (see table 2 in insert below from ISPM 15). The guidance material provides the concentrations of the gas that are required to be met at intervals over the exposure period, assuming a 50% reduction in atmospheric gas concentration in the enclosure. Other examples could be provided that provide operational guidance on how to meet the standard using fumigation chambers (30% loss after 24 hours) or under tarpaulin (70% loss after 24 hours).

Table 2b: Methyl bromide fumigation schedules (dormant material only): For mites including Tetranychus kanzawai (non-diapausing), fumigation for a minimum 2.5 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)#	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
56	120	10	41
48	100	16	35
40	85	21	29
32	70	28	23

The shaded column is guidance information only

*C/T is "concentration over time"

Table 3c: Methyl bromide fumigation schedules (dormant material only): For mites including Tetranychus kanzawai (non-diapausing), fumigation for a minimum 3 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
48	120	10	34
40	100	16	28
34	84	21	24
28	70	28	20

The shaded column is guidance information only

*C/T is "concentration over time"

Table 4a: Methyl bromide fumigation schedules (dormant material only): For insects and mites (non-diapausing), fumigation for a minimum 3 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
56	140	10	40
48	120	16	34
40	100	21	26
32	80	28	21

The shaded column is guidance information only

*C/T is "concentration over time"

Table 5b: Methyl bromide fumigation schedules (dormant material only): For insects and mites (non-diapausing), fumigation for a minimum 4 hours at atmospheric pressure.

Minimum initial concentration (g/m^3)	Minimum achieved dose (C/T*) ($g{\cdot}h/m^3$)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m^3)
44	140	10	29
38	120	16	25
32	100	21	21

26	80	28	17

The shaded column is guidance information only
*C/T is "concentration over time"

Supporting information

Methyl bromide is a general purpose fumigant that at relatively low doses provides a high level of mortality against a very wide range of pest species[1]. Methyl bromide is a gas at room temperature but a liquid at temperatures below around 4°C. As the gas begins to condense at temperatures approaching 4°C, it is generally accepted that effective fumigation (pest mortality) can only be achieved consistently at temperatures at or exceeding 10°C. Methyl bromide gas penetrates substrates such as wood reasonably well, but penetration is limited by higher moisture content.

Examples from a review of the literature on the effectiveness of methyl bromide fumigation on insects found on or near the surface of commodities are provided in ***Appendix 1***. It is apparent from numerous studies that methyl bromide is generally effective on direct application to exposed insects and mites at C/T levels of <140 g·h/m^3 and temperatures >10°C (or 120 g·h/m^3 at > 15°C). Higher doses are required when the insects or mites are partially or completely imbedded in the commodity. To achieve a C/T value of 120 g·h/m^3 under operational conditions (final atmospheric concentrations of 50% after 24 hours), the following treatment rates would be required:

Minimum initial concentration (g/m^3)	Minimum exposure time	Minimum achieved dose (C/T*) (g·h/m^3)	Minimum concentration during fumigation (g/m^3)
68	2 hours	120	51
56	2.5 hours	120	41
48	3 hours	120	32
44	3.5 hours	120	30

The shaded column is guidance information only
*C/T is "concentration over time"

Katayama *et al*. (2001) completed treatment efficacy trials on all life stages of *Tetranychus kanzawai* and found that all life stages were killed at C/T values ranging from 93.5 to 97.3 g·h/m^3 in temperatures of 15°C. To achieve a C/T value of 100 g·h/m^3 under operational conditions (final atmospheric concentrations of 50% after 24 hours), the following treatment rates would be required:

Minimum initial concentration (g/m^3)	Minimum exposure time	Minimum achieved dose (C/T*) (g·h/m^3)	Minimum concentration during fumigation (g/m^3)
56	2 hours	100	42
48	2.5 hours	100	35
40	3 hours	100	28
35	3.5 hours	100	25

The shaded column is guidance information only
*C/T is "concentration over time"

[1] Methyl bromide fumigation is an internationally approved treatment against a wide range of insects of concern in the international movement of wood packaging material (FAO 2009).

26	80	28	17

The shaded column is guidance information only
*C/T is "concentration over time"

Supporting information

Methyl bromide is a general purpose fumigant that at relatively low doses provides a high level of mortality against a very wide range of pest species[1]. Methyl bromide is a gas at room temperature but a liquid at temperatures below around 4°C. As the gas begins to condense at temperatures approaching 4°C, it is generally accepted that effective fumigation (pest mortality) can only be achieved consistently at temperatures at or exceeding 10°C. Methyl bromide gas penetrates substrates such as wood reasonably well, but penetration is limited by higher moisture content.

Examples from a review of the literature on the effectiveness of methyl bromide fumigation on insects found on or near the surface of commodities are provided in ***Appendix 1***. It is apparent from numerous studies that methyl bromide is generally effective on direct application to exposed insects and mites at C/T levels of <140 g·h/m^3 and temperatures >10°C (or 120 g·h/m^3 at > 15°C). Higher doses are required when the insects or mites are partially or completely imbedded in the commodity. To achieve a C/T value of 120 g·h/m^3 under operational conditions (final atmospheric concentrations of 50% after 24 hours), the following treatment rates would be required:

Minimum initial concentration (g/m^3)	Minimum exposure time	Minimum achieved dose (C/T*) (g·h/m^3)	Minimum concentration during fumigation (g/m^3)
68	2 hours	120	51
56	2.5 hours	120	41
48	3 hours	120	32
44	3.5 hours	120	30

The shaded column is guidance information only
*C/T is "concentration over time"

Katayama *et al*. (2001) completed treatment efficacy trials on all life stages of *Tetranychus kanzawai* and found that all life stages were killed at C/T values ranging from 93.5 to 97.3 g·h/m^3 in temperatures of 15°C. To achieve a C/T value of 100 g·h/m^3 under operational conditions (final atmospheric concentrations of 50% after 24 hours), the following treatment rates would be required:

Minimum initial concentration (g/m^3)	Minimum exposure time	Minimum achieved dose (C/T*) (g·h/m^3)	Minimum concentration during fumigation (g/m^3)
56	2 hours	100	42
48	2.5 hours	100	35
40	3 hours	100	28
35	3.5 hours	100	25

The shaded column is guidance information only
*C/T is "concentration over time"

[1] Methyl bromide fumigation is an internationally approved treatment against a wide range of insects of concern in the international movement of wood packaging material (FAO 2009).

Generally it is considered appropriate to increase the initial concentration of gas by around 6-8 g/m³ (depending on treatment duration) or the C/T dose by around 10-20 g·h/m³ for every 5°C drop in temperature. This rule is applied in international or domestic methyl bromide fumigation schedules in Australia (see Table 3) and USA (see Table 4). In the USDA example, the increase in the initial concentration of gas is inconsistent but averages out to around 6-8 g/m³ over the entire range.

Table 6: Methyl bromide fumigation schedule (2 hours) from ICA 4 (from Bond 1984).

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Demonstrated level of efficacy (at the 95% LoC)
48	77	10	Unknown
40	64	15	99.9913
32	51	21	99.9954
24	39	26	99.9956
16	26	32	Unknown

The shaded column is guidance information only
*C/T is "concentration over time"

Table 7: Methyl bromide fumigation schedule (2 hours) from USDA (T101-a-1 in USDA Treatment Manual 2019).

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m³)
48	86	4	38
38	68	10	29
32	58	15	24
26	47	21	19
19	34	26	14

The shaded column is guidance information only
*C/T is "concentration over time"

Therefore for a target C/T value of 100 g·h/m³ at 15°C, a suitable treatment table for a 2.5 hour treatment across a range of temperatures would be:

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m³)
56	120	10	41
48	100	16	35
40	85	21	29
32	70	28	23

The shaded column is guidance information only
*C/T is "concentration over time"

Generally it is considered appropriate to increase the initial concentration of gas by around 6-8 g/m³ (depending on treatment duration) or the C/T dose by around 10-20 g·h/m³ for every 5°C drop in temperature. This rule is applied in international or domestic methyl bromide fumigation schedules in Australia (see Table 3) and USA (see Table 4). In the USDA example, the increase in the initial concentration of gas is inconsistent but averages out to around 6-8 g/m³ over the entire range.

***Table 6**: Methyl bromide fumigation schedule (2 hours) from ICA 4 (from Bond 1984).*

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Demonstrated level of efficacy (at the 95% LoC)
48	77	10	Unknown
40	64	15	99.9913
32	51	21	99.9954
24	39	26	99.9956
16	26	32	Unknown

The shaded column is guidance information only
*C/T is "concentration over time"

***Table 7**: Methyl bromide fumigation schedule (2 hours) from USDA (T101-a-1 in USDA Treatment Manual 2019).*

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m³)
48	86	4	38
38	68	10	29
32	58	15	24
26	47	21	19
19	34	26	14

The shaded column is guidance information only
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Therefore for a target C/T value of 100 g·h/m³ at 15°C, a suitable treatment table for a 2.5 hour treatment across a range of temperatures would be:

Minimum initial concentration (g/m³)	Minimum achieved dose (C/T*) (g·h/m³)	Minimum temperature over duration of treatment (°C)	Minimum concentration during fumigation (g/m³)
56	120	10	41
48	100	16	35
40	85	21	29
32	70	28	23

The shaded column is guidance information only
*C/T is "concentration over time"

Appendix 1: Efficacy data for Methyl bromide on direct exposure to insect species

Treated Insect Name (Common and Scientific)	Treated Insect Family	Treatment Schedule	C/T dose (g.h/m³)	Efficacy (% mortality) (95% LoC)	Reference
Pink hibiscus mealybug (*Maconellicoccus hirsutus*)	Pseudococcidae	48 g/m³ for 2 hours at >15°C	90 at 15°C	99.9783% (1 in 4,610) (15°C)	Zettler *et al.* (2002)
Burnt pine longhorn beetle (*Arhopalus ferus*); Golden-haired bark beetle (*Hylurgus ligniperda*); Black pine bark beetle (*Hylastes ater*)	Cerambycidae Scolytidae	59 g/m³ for 4 hours at >10°C 28 g/m³ for 4 hours at >20°C	90 at 10°C 90 at 20°C	99% (1 in 100)	Pranamornkith *et al.* (2014)
Melon thrips (*Thrips palmi*); Western flower thrips (*Frankliniella occidentalis*); Flower thrips (*Frankliniella intonsa*)	Thripidae	35 g/m³ for 3 hours at >10°C 26.5 g/m³ for 3 hours at >15°C	93 at 10°C 71 at 15°C	99.469% (1 in 188) (10°C) 99.6269% (1 in 268) (15°C)	Misumi *et al.* (2009)
Cowpea aphid (*Aphis craccivora*); Potato aphid (*Macrosiphum euphorbiae*); Green peach aphid (*Myzus persicae*); Cotton aphid (*Aphis gossypii*)	Aphididae	35 g/m³ for 3 hours at >10°C 26.5 g/m³ for 3 hours at >15°C	93 at 10°C 71 at 15°C	99.8325% (1 in 597) (10°C) 99.8956% (1 in 744) (15°C)	Misumi *et al.* (2009)
Oriental leafworm moth (*Spodoptera litura*); Cotton bollworm (*Helicoverpa armigera*)	Noctuidae	35 g/m³ for 3 hours at >10°C 26.5 g/m³ for 3 hours at >15°C	93 at 10°C 71 at 15°C	99.8442% (1 in 642) (10°C) 99.8227% (1 in 564) (15°C)	Misumi *et al.* (2009)
American serpentine leafminers (*Liriomyza trifolii*); Vegetable leafminer (*Liriomyza sativae*)	Agromyzidae	46 g/m³ for 3 hours at >10°C 40 g/m³ for 3 hours at >15°C	123 at 10°C 107 at 15°C	99.6341% (1 in 273) (10°C) 99.7186% (1 in 355) (15°C)	Misumi *et al.* (2009)
Tephritid fruit flies	Tephritidae	48 g/m³ for 4.5 hours at >10°C 40 g/m³ for 4 hours at >15°C	141 at 10°C 108 at 15°C	Min 99.99% (1 in 10,000)	Willink *et al.* (2007) Jessup (1994)
Kanzawa spider mite (*Tetranychus kanzawai*); Six-spotted mite (*Eoetranychus sexmaculatus*)	Tetranychidae	48 g/m³ for 2 hours at >15°C	97 at 15°C	99.9915% (1 in 11,734) (15°C)	Katayama *et al.* (2001)
Tropical citrus aphid (*Toxoptera citricida*)	Aphididae	48 g/m³ for 2 hours at >15°C	91 at 15°C	99.6939% (1 in 327) (15°C)	Katayama *et al.* (2001)
Citrus psyllid (*Diaphorina citri*)	Psyllidae	48 g/m³ for 2 hours at >15°C	88 at 15°C	99.9740% (1 in 3,842) (15°C)	Katayama *et al.* (2001)