Australian Government

Australian Pesticides and Veterinary Medicines Authority

Public Release Summary

on the evaluation of iodomethane in the product MIPIC 990 Soil Fumigant

APVMA product number 89913

September 2022

ISSN 1443-1335 (electronic)

Assistant Director, Communications
Australian Pesticides and Veterinary Medicines Authority
GPO Box 3262
Sydney NSW 2001 Australia

Telephone: +61 2 6770 2300

Email: communications@apvma.gov.au.

This publication is available from the APVMA website.

Contents

List of tables

Preface

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the Australian Government regulator responsible for assessing and approving agricultural and veterinary chemical products prior to their sale and use in Australia. Before approving an active constituent and/or registering a product, the APVMA must be satisfied that the statutory criteria, including the safety, efficacy, trade, and labelling criteria, have been met. The information and technical data required by the APVMA to assess the statutory criteria of new chemical products, and the methods of assessment, must be consistent with accepted scientific principles and processes. Details are outlined on the APVMA website.

The APVMA has a policy of encouraging transparency in its activities and seeking community involvement in decision making. Part of that process is the publication of Public Release Summaries for products containing new active constituents. This Public Release Summary is intended as a brief overview of the assessment that has been conducted by the APVMA and of the specialist advice received from advisory agencies, including other Australian Government agencies and State departments of primary industries. It has been deliberately presented in a manner that is likely to be informative to the widest possible audience to encourage public comment.

About this document

This Public Release Summary indicates that the APVMA is considering an application for registration of an agricultural or veterinary chemical. It provides a summary of the APVMA's assessment, which may include details of:

- the toxicology of both the active constituent and product
- the residues and trade assessment
- occupational exposure aspects
- environmental fate, toxicity, potential exposure and hazard
- efficacy and target crop or animal safety.

Comment is sought from interested stakeholders on the information contained within this document.

Making a submission

In accordance with section 13 of the Agvet Code, the APVMA invites any person to submit a relevant written submission as to whether the application for registration of MIPIC 990 Soil Fumigant should be granted. Submissions should relate only to matters that the APVMA is required, by legislation, to take into account in deciding whether to grant the application. These matters include aspects of public health, occupational health and safety, chemistry and manufacture, residues in food, environmental safety, trade, and efficacy and target crop or animal safety. Submissions should state the grounds on which they are based. Comments received that address issues outside the relevant matters cannot be considered by the APVMA.

Submissions must be received by the APVMA by close of business on 4 October 2022 and be directed to the contact listed below. All submissions to the APVMA will be acknowledged in writing via email or by post.

Relevant comments will be taken into account by the APVMA in deciding whether the product should be registered and in determining appropriate conditions of registration and product labelling.

When making a submission please include:

- contact name
- company or organisation name (if relevant)
- email or postal address (if available)
- the date you made the submission.

Please note: submissions will be published on the APVMA's website, unless you have asked for the submission to remain confidential, or if the APVMA chooses at its discretion not to publish any submissions received (refer to the public consultation coversheet).

Please lodge your submission using the public consultation coversheet, which provides options for how your submission will be published.

Note that all APVMA documents are subject to the access provisions of the *Freedom of Information Act 1982* and may be required to be released under that Act should a request for access be made.

Unless you request for your submission to remain confidential, the APVMA may release your submission to the applicant for comment.

Written submissions should be addressed to:

Case Management and Administration Unit
Australian Pesticides and Veterinary Medicines Authority
GPO Box 3262
Sydney NSW 2001

Phone: +61 2 6770 2300
Email: casemanagement@apvma.gov.au

Further information

Further information can be obtained via the contact details provided above.

Copies of technical evaluation reports covering chemistry, efficacy and safety, toxicology, occupational health and safety aspects, residues in food and environmental aspects are available from the APVMA on request.

Further information on Public Release Summaries can be found on the APVMA website.

Introduction

This publication provides a summary of the data reviewed and an outline of the regulatory considerations for the proposed registration of MIPIC 990 Soil Fumigant in conjunction with approval of the active constituent, iodomethane. Iodomethane, was previously approved by the APVMA (approval number 59053) in 2003 but cancelled at the request of the holder in 2014.

Applicant

Saluterra Pty Ltd.

Purpose of application

Saluterra Pty Ltd has applied to the APVMA for registration of the new product MIPIC 990 Soil Fumigant, as a liquid formulation (LD) containing 990 g/kg of the active constituent iodomethane. Iodomethane is not currently approved in Australia. Iodomethane was previously approved (approval number 59053, held by Arysta LifeScience North America LLC) but this approval was cancelled at the request of the holder in 2014. Saluterra Pty Ltd has applied for the approval of iodomethane as part of the registration for MIPIC 990 Soil Fumigant.

Proposed claims and use pattern

MIPIC 990 Soil Fumigant is intended for use as a broad-spectrum fumigant to control weed seeds, nematodes and soil-borne diseases in the strawberry runner production industry. Iodomethane is intended to replace soil fumigation using methyl bromide, which is being phased out under the Montreal Protocol.

MIPIC 990 Soil Fumigant will be co-injected into the soil at the proposed rate of 130 to 165 kg/ha, alongside 270 to 300 kg/ha of an approved 985 g/kg chloropicrin product, using a pressurised, sealed fumigation unit calibrated to deliver the recommended dose. The treated area will be covered with plastic film immediately after application and sealed at the edges for a minimum exposure time of 5 days and planting interval of 28 days.

MIPIC 990 Soil Fumigant is intended for use only by professionally licensed and authorised fumigators, to ensure effective and compliant application.

Mode of action

The generally accepted mode of action of iodomethane as a fumigant is via the nucleophilic displacement (S_N2) reactions with functional groups such as NH_2 and SH in various amino acids and peptides within target organisms. Iodomethane is a member of the alkyl halide group of compounds which are designated as Group 8A insecticides by the Insecticide Resistance Action Committee (IRAC 2020).

Overseas registrations

Iodomethane is registered for use in Mexico, Morocco, Japan, Turkey and New Zealand, under various product trade names, as a pre-plant, broad-spectrum fumigant to control insects, plant parasitic nematodes, soil borne pathogens and weed seeds.

Chemistry and manufacture

Active constituent

The active constituent iodomethane is manufactured overseas. Details of the chemical name, structure, and physicochemical properties of iodomethane are listed below (Tables 1 to 2).

Iodomethane was previously approved by the APVMA (approval number 59053), and the approval was cancelled at the holder's request in 2014.

Iodomethane is a yellow liquid. The boiling point (42.5°C) and Henry's law constant (0.22 $molL^{-1}Pa^{-1}$) indicate that volatilisation is expected to be a significant route of dissipation for iodomethane. There are no flammable, explosive, self-ignition or other properties of safety concern for iodomethane.

Table 1: Nomenclature and structural formula of the active constituent iodomethane

Common name:	Iodomethane
IUPAC name:	Iodomethane
CAS registry number:	74-88-4
Molecular formula:	CH_3I
Molecular weight:	141.95 g/mol
Structural formula:	$CH_3–I$

Table 2: Key physicochemical properties of the active constituent iodomethane

Physical form:	Liquid
Colour:	Colourless (bright yellow with a Gardner colour designation of 7+ on exposure to light)
Odour:	Pungent, ether-like
Melting point:	–66.5°C
Boiling point:	42.5°C
Specific gravity/density/bulk density	2.27 at 25°C
Stability:	The active was tested for 2 weeks storage at 55°C and one year at 25°C. No noticeable change in the concentration of the active was determined during that time. Iodomethane is expected to be stable during storage under normal conditions for at least 2 years.
Safety properties:	Not considered flammable. Not explosive. Not corrosive to stainless steel. No self-ignition observed. Incompatible with strong oxidisers, powdered metals and reducing agents.
Solubility in water:	14.2 g/L
Organic solvent solubility:	Miscible with acetone, alcohols, carbon tetrachloride, chloroform, diethyl ether
PH:	5.0 to 5.2 (1% dilution)
Octanol/water partition coefficient (Log K_{ow}):	1.51
Vapour pressure:	398 mm Hg (20°C) 410 mm Hg (25°C)
UV/VIS absorption spectra:	Strong absorbance at wavelengths shorter than about 215 nm, and a weaker absorbance band centred at 250 nm.

Formulated product

The product MIPIC 990 Soil Fumigant will be manufactured overseas. Tables 3 and 4 outline some key aspects of the formulation and physicochemical properties of the product.

MIPIC 990 Soil Fumigant will be available in 100 kg stainless steel containers with a micromatic 4F 100 kg macro valve system.

Table 3: Key aspects of the formulation of the product MIPIC 990 Soil Fumigant

Distinguishing name:	MIPIC 990 Soil Fumigant
Formulation type:	Liquid (LD)
Active constituent concentration:	990 g/kg iodomethane

Table 4: Physicochemical properties of the product MIPIC 990 Soil Fumigant

Physical form:	Colourless to bright yellow with a Gardner colour designation of 7+ liquid
PH:	5.0 to 5.2 (1% dilution)
Specific gravity:	2.27 @ 25°C
Kinematic viscosity:	0.53 mPa·sec @ 10°C 0.45 mPa·sec @ 30°C
Safety properties:	Not considered flammable. Not explosive. Not corrosive to stainless steel. No self-ignition observed. Incompatible with strong oxidisers, powdered metals and reducing agents.
Storage stability:	The product was tested for 2 weeks storage at 55°C and one year at 25°C. No noticeable change in the concentration of the active was determined during that time. MIPIC 990 Soil Fumigant is expected to be stable during storage under normal conditions for at least 2 years.

Recommendations

The APVMA Chemistry section has evaluated the chemistry of the active constituent iodomethane and associated product MIPIC 990 Soil Fumigant – including the manufacturing process, quality control procedures, stability, batch analysis results and analytical methods – and found them to be acceptable. The available storage stability data indicate that the formulated product is expected to remain stable for at least 2 years when stored under normal conditions.

Based on a review of the chemistry and manufacturing details, the registration of MIPIC 990 Soil Fumigant, and approval of the active constituent iodomethane, are supported from a chemistry perspective.

Toxicological assessment

The applicant submitted a complete data package, which was sufficient to assess the toxicity of iodomethane.

Evaluation of toxicology

Chemical class

Iodomethane (methyl iodide) is a member of the alkyl halide group of compounds. Methyl halides are used as agricultural fumigants, and precursors in industrial chemicals production.

Pharmacokinetics

Iodomethane is absorbed via both inhalation and oral routes, and widely and rapidly distributed amongst tissues. Immediately following oral dosing, the concentration of iodomethane in tissues (except the GI tract and liver) in rats and rabbits, was lower than levels observed in the blood. Iodomethane concentration in the blood was dose-related, with a bi-exponential elimination rate.

For the initial phase, which lasted approximately 4 to 12 hours post exposure, the half-life of Iodomethane ranged from 5 to 7 hours. For the terminal phase, which was taken as 24 hours post-exposure, the half-life ranged from 116 to 136 hours. About 50 to 60% of the oral dose, and about 40 to 47% of the inhalation dose was eliminated as carbon dioxide within 48 hours.

Urinary elimination (over 168 hours) accounted for 30 to 35% of the administered dose, regardless of the dose level, or route of exposure. The primary metabolite of iodomethane metabolism appears to be S-methyl glutathione, which undergoes further metabolism to S-methyl cysteine, methylthioacetic acid, and finally to carbon dioxide. Several other metabolites were identified in urine including N-(methylthioacetyl) glycine, S-methylglutathione and methylmercapturic acid.

Acute toxicity (active constituent)

Acute toxicity studies indicate iodomethane has low dermal and inhalational toxicity, moderate oral toxicity; severe eye irritation potential; moderate skin irritation potential, but it is not a skin sensitiser.

Acute toxicity (product)

No acute toxicity studies were submitted on MIPIC 990. Based on extrapolation from the toxicity of the active constituent, the product is expected to be of low dermal and inhalation toxicity, and moderate oral toxicity. It is expected to be a severe eye irritant, a moderate skin irritant, but is not expected to be a skin sensitiser.

Repeat-dose toxicity

In short-term oral studies conducted in rats and mice, rats appeared to be more sensitive to iodomethane. In a 21-day dietary study in ICR mice, no deaths, abnormal clinical signs, or treatment-related macroscopic findings were observed up to the maximum dose 168.0 mg/kg bw/d. The NOAEL for this study was

11.3 mg/kg bw/d, based on decreased body weight gain in males. In a 14-day study in SD rats, the low dose (10 mg/kg bw/d) appeared to induce few ill effects, whereas higher doses (25 mg/kg bw/d and above in females, and 75 mg/kg bw/d and above in males) produced salivation, decreased body weight and various abnormalities and adhesions in abdominal organs. Three males and 2 females died at 125 mg/kg bw/d, and one female died at 50 mg/kg bw/d. A NOAEL was not established for this study as increased salivation was observed at all doses.

In a 21-day dermal toxicity study, SD rats were exposed to iodomethane at doses up to 1,000 mg/kg bw/d. Four male rats were found dead or were euthanized *in extremis*; one at 300 mg/kg bw/d and 3 at 1,000 mg/kg bw/d. Deaths were attributed to treatment-related urinary tract obstruction, and/or severe dermal irritation. Decreases in mean body weights, body weight gain, food consumption and changes in serum chemistry parameters were noted, including decreased mean T4 and increased mean T3 values in the 300 mg/kg bw/d group males, and the 30 and 1000 mg/kg/day group females. A NOAEL was not established due to effects on thyroid serum hormone levels in females at the lowest dose.

In a 90-day inhalational (whole body) toxicity study in SD rats, treatment-related effects included decreased body weight gain, increased serum cholesterol, and alterations in the nasal epithelium of both sexes, plus an increase in relative liver weights in females at the high dose level (70 ppm). Histological changes in nasal epithelium consisted of cellular degeneration and epithelial metaplasia. The NOAEL was 20 ppm (116 mg/m^3).

In a 90-day oral (capsule) toxicity study in beagle dogs, iodomethane was administered at up to 15 mg/kg bw/d. One male was euthanized *in extremis* due to moribund condition in the high dose group. Iodomethane dosing at 6 and 15 mg/kg bw/d was associated with increased salivation, emesis, decreased albumin and total protein levels, nasal epithelium degeneration (females), gastric ulceration (one male) and microscopic changes to the stomach, oesophagus and/or caecum and rectum (both sexes). Treatment-related increases in injected sclera were seen at all doses. A NOAEL was not established in this study due to observations of injected sclera at the lowest dose of 1.5 mg/kg bw/d.

Chronic toxicity and carcinogenicity

In an 18-month dietary carcinogenicity study, groups of ICR mice were exposed to microencapsulated iodomethane. Mortality was not affected by iodomethane treatment. Bodyweights were significantly decreased in both sexes at and above 28 mg/kg bw/d. The main effects were on the thyroid and cervix. Treatment-related enlargement of the thyroid was observed in animals of both sexes, with histopathological correlates of increased colloid, cytoplasmic vacuolation, and follicular cell hyperplasia. Fibromas observed in females at the highest dose were not considered to be associated with treatment due to their low incidence, microscopic size, absence of precursor lesions, benign appearance, and lack of evidence of progression to malignancy.

The NOAEL for non-neoplastic effects in this study was 8 mg/kg bw/d, based on decreased bodyweight gain and food consumption. The NOAEL for carcinogenic effects was 28 mg/kg bw/d, based on neoplastic lesions observed in the thyroid glands (males), and cervix at 84 mg/kg bw/d. Iodomethane was not considered to be carcinogenic in mice under the conditions of the study.

In a 24-month inhalational, combined, chronic toxicity/carcinogenicity study, SD rats were exposed to iodomethane for 5 days/week for 12 or 24 months. Iodomethane did not affect mortality, clinical, behavioural or ophthalmological findings in this study. Bodyweights and food consumption were significantly decreased in both sexes in the high dose groups (60 ppm to 348 mg/m^3). Notable treatment-related blood chemistry effects at 6 months included statistically significant increased mean thyroid-stimulating hormone (TSH) levels (both sexes, 60 ppm groups), which rebounded to elevated levels in males and females at 24 months. A significantly greater incidence of thyroid follicular cell adenomas was found in both sexes at 60 ppm, when compared to the concurrent and historical control values in males.

The NOAEC for non-neoplastic effects in this study was 5 ppm (29 mg/m^3). The NOAEC for thyroid follicular neoplasia in this study was 20 ppm (116 mg/m^3).

The body of evidence supports a mechanism of action by which iodomethane induces thyroid neoplasia via disruption of thyroid hormones T3 and T4, and thyroid stimulating hormone (TSH). As rodents are more sensitive to sustained perturbation of thyroid hormone homeostasis than other species, it was concluded that iodomethane is unlikely to be carcinogenic in humans. This is consistent with the conclusions reached by the International Agency for Research on Cancer (IARC) in 1999.

Reproductive and developmental toxicity

In a 2-generation reproduction study, male and female rats were exposed to iodomethane vapour for 6h/day, for at least 70 consecutive days prior to mating. F0 and F1 females were exposed throughout mating, and up to gestation day 20. After parturition, exposure of the F0 and F1 females was re-initiated on lactation day 5 to study end. The NOAEL for reproductive toxicity was 20 ppm, based on decreased mean numbers of corpora lutea, and implantation sites observed in the F1 generation. The NOAEL for parental toxicity was 5 ppm (29 mg/m^3) based on reduced food consumption and increased absolute and relative thymus weights. The NOAEL for neonatal toxicity was also 5 ppm, based on reduced F1 and F2 pup body weight gains at 20 ppm (116 mg/m^3).

Treatment-related inhalational developmental toxicity in NZW rabbits manifested as significantly increased foetal resorptions, in conjunction with decreased litter sizes at non-maternotoxic dose levels (decreased litter sizes were also seen in rats, but no developmental toxicity was observed at any exposure level). The NOAEL for developmental effects was 2 ppm (12 mg/m^3), and the NOAEL for maternal toxicity based on reduced body weight gain and food consumption, was 10 ppm (58 mg/m^3). Iodomethane was therefore considered to be a developmental toxicant in rabbits.

Genotoxicity

Based on the results and interpretations of a suitable battery of *in vitro* genotoxicity studies, it was concluded that iodomethane is unlikely to be genotoxic *in vivo*.

Neurotoxicity

Neurotoxicity was observed in rats exposed to 100 ppm or 400 ppm iodomethane in air for 6 hours. Effects included abnormal gait, decreased arousal, uncoordinated righting reflexes, and decreased motor activity. The NOAEL for acute neurotoxicity was 25 ppm (145 mg/m^3).

Toxicity of metabolites and/or impurities

S-methyl glutathione appears to be the primary metabolite of iodomethane metabolism, which undergoes further metabolism to S-methyl cysteine, methylthioacetic acid, and finally to carbon dioxide. Several other metabolites, including N-(methylthioacetyl) glycine, S-methylglutathione, and methylmercapturic acid were identified in urine. Around 45 to 60% of an oral or inhalation dose was eliminated as carbon dioxide within 48 hours. The only reported impurity in the DoC for iodomethane is methanol at <1%.

The reported metabolites and impurities in iodomethane are not considered to be of toxicological concern.

Reports related to human toxicity

Relatively few detailed reports of iodomethane poisoning appear in the scientific literature. All reports were work-related. No details of actual exposure levels or work activities were available. From 4 case reports, 5 workers (all male) reported poisoning. Effects were mainly neurological, with some cases showing liver effects or burns. While none of the detailed case reports were fatal, a number were of sufficient severity to prevent a return to work.

A total of 115 fatalities and 843 poisonings were reported from methyl bromide during the period 1939–81. The symptoms observed were similar to those from iodomethane intoxication and included: nausea, vomiting, vertigo, ataxia, headache, and neurological effects. Reported topical effects included skin blistering, and irritation of the eyes and lungs.

Health-based guidance values and poisons scheduling

Poisons Standard

Iodomethane is in S7/Appendix J of the SUSMP, due to the potential for developmental, reproductive and neurotoxic effects.

Appendix J of the SUSMP states that iodomethane containing products will not be available except to authorised or licensed persons and that special precautions are required during manufacture, handling and/or use.

As MIPIC 990 contains iodomethane, a Schedule 7 classification is appropriate, which requires a DANGEROUS POISON label signal header.

Health-based guidance values

Acceptable daily intake and acute reference dose

As iodomethane is a reactive compound, it is likely to rapidly degrade and/or be metabolised in the environment. Its low affinity for sorption into soil (Koc 34.8 L Kg^{-1}) and its high vapour pressure (405.9 mm Hg) suggests that iodomethane volatilises as a major route of dissipation.

On this basis, APVMA concludes that no ADI or ARfD is required for iodomethane, when used as a soil fumigant.

Occupational airborne exposure limits

The Safe Work Australia occupational exposure standard for iodomethane is 2 ppm (12 mg/m^3), time (8 hour) weighted average concentration.

Bystander airborne exposure limits

Based on short term (up to 30 days), non-occupational (bystander) exposure, iodomethane concentration in air should not exceed 0.04 ppm (40 ppb). This is based on a human equivalent concentration (HEC) of 1.25 ppm derived from a NOAEC of 5 ppm, based on decreased pup weight, decreased thymus weights, and delays in vaginal patency acquisition seen in a rat multigenerational reproduction toxicity study at the LOAEC of 20 ppm. A total uncertainty factor of 30, comprising an inter-species uncertainty factor of 3 and an intra-species uncertainty factor of 10, was applied.

Based on long term (months or years), non-occupational (bystander) exposure, air concentrations should not exceed 0.03 ppm (30 ppb). This is based on a HEC of 0.89 ppm, derived from a NOAEL of 5 ppm, due to an increased incidence of salivary gland squamous cell metaplasia at the LOAEC of 20 ppm in a rat combined chronic toxicity/carcinogenicity study. A total uncertainty factor of 30, comprising an inter-species uncertainty factor of 3, and an intra-species uncertainty factor of 10, was applied.

Recommendations

APVMA has no objections on human health grounds to the approval[1] of the active constituent iodomethane when manufactured by approved facilities.

As MIPIC 990 contains 99% iodomethane, a Schedule 7 classification is appropriate, which requires a DANGEROUS POISON label signal header.

[1] Iodomethane has been previously approved by APVMA, but was the approval was cancelled by the applicant on commercial grounds.

Residues assessment

Metabolism

Metabolism studies for iodomethane on strawberries and tomatoes have been provided. The studies involved treatment of soil with ^{14}C-iodomethane at approximately 264 g ai/ha, covered by a tarp for 6 days. Tarps were removed and bare-root strawberry plants or tomato seedlings planted. Strawberry and tomato fruit were harvested at maturity.

The levels of parent ^{14}C-iodomethane were below the level of quantitation (LOQ) (0.005 mg/kg) in 2 of the 21 strawberry samples analysed, and below the level of detection (LOD) (0.001 mg/kg) in the remaining strawberry samples and all tomato samples.

The majority of fruit radioactive residue was characterised as (natural) carbohydrates, in soluble monomers, short polymers and starch by use of HPLC, acetylation of extracts and enzyme digests of PES, suggesting entry of ^{14}C into general metabolic pathways. Due to the simplicity of the structure of the test material, ^{14}C could be distributed throughout the plant after conversion of iodomethane, and no residues of concern are expected in the raw agricultural commodity.

Fruit samples were also analysed for iodide anion. The results for strawberry were characterised as <0.03 mg/kg. However, for tomato, measured residues of iodide anion were detected in fruit from treated plots (<0.07 to 0.26 mg/kg). These results were considered to be qualitative in nature.

Analytical methods and storage stability

In a strawberry residue study, samples were homogenised on dry ice and extracted with 10% dimethylformamide in water. Iodomethane was quantified by gas chromatography head space analysis, with an electron capture detector. The LOQ was 0.005 mg/kg, the LOD was 0.001 mg/kg. The mean recovery from 10 fortifications in the 5 to 50 ppb range was 101% with a standard deviation of 26.

For iodide analysis, a macerated sample was mixed with water, centrifuged, filtered, and analysed by ion chromatography. The LOQ was 0.030 mg/kg. The mean iodide recovery (n = 4) from samples fortified at 30 to 304 ppb was 97% ± 12.

Storage stability

In the strawberry residue study, samples were sent to the analytical laboratory overnight on dry ice, with samples analysed as soon as possible after harvest (within 7 to 19 days) due to the instability of iodomethane. The storage of samples for iodide analysis ranged from 29 to 104 days. This is acceptable for the purposes of the current application.

Residue definition

A Table 5 entry for iodomethane is being considered as residues are not expected to occur if the plant-back restriction is observed. Therefore, it is not necessary to consider a residue definition for iodomethane.

Residues in food and animal feeds

Iodomethane is highly volatile and lost to the atmosphere where it undergoes photolysis. In addition to being lost to the atmosphere, iodomethane also undergoes substitution reactions with organic matter in soil to release iodide. Two US studies conducted in Florida and California investigated the dissipation of iodomethane in soil from tarped, bare-ground plots. The studies showed that residues of iodomethane in the top layer of treated soil were at, or below 0.01 mg/kg by 28 to 29 days after treatment at rates higher than proposed. In addition, the soil in the Florida trial was covered by tarpaulin for the course of the study (punctured 16 days after treatment (DAT)). Given that iodomethane concentrations in the top layer of soil in the Florida study were <0.01 mg/kg by 29 DAT when the tarpaulin was left in place, the proposed restraint "*DO NOT plant or sow for at least 28 days after removal of plastic sealing sheet*" should prevent potential exposure to plants producing strawberry runners.

It is recognised that if any fumigant did remain after the recommended planting intervals, plant growth may be affected. In addition to the 28-day planting interval, there will also be a period of time between planting and the harvesting of any crop for consumption. Commercial runners are generally ready for distribution to fruit growers by 6 months, after planting of mother plants. In addition, there is generally a further 6 month interval from planting of a runner to maturity of the fruit. These additional time periods minimise the risk of any residues of iodomethane occurring in strawberry fruit for human consumption.

In all samples of strawberries from 5 North American residue trials, after application to soil at higher rates (target rate 264 kg ai/ha, 1.6× proposed), and a shorter planting interval (6 to 7 days) than proposed, no residues of iodomethane were observed above the LOQ (0.005 ppb). For 3 of the 5 locations, no iodide residues were observed above the LOQ (30 ppb) in strawberry samples from treated plots. Average iodide residues in treated samples from the other locations ranged from 0.034 to 0.053 mg/kg.

Iodide residues in soil were also considered in the field dissipation study. The maximum iodide residue was 2.32 mg/kg in California 0-6'' soil at 15 DAT and 1.70 mg/kg in Florida 0-12'' soil at 14 DAT. Iodide residues in the top layer subsequently declined to 0.08 and 0.36 mg/kg by 28 to 29 DAT at the California and Florida sites respectively. The decline did not appear to be due to leaching of iodide to lower soil depths, which contained very low or undetectable levels of iodide at all sampling points.

The levels of iodide in the soil at 28 to 29 DAT were significantly lower than the total iodine content of selected soils, referenced in a WHO report considered in earlier evaluations (report no longer available online). Soils from igneous rocks were reported to have an iodine content up to 9 mg/kg, while soils from metamorphic and sedimentary rocks had iodine contents of 5 and 4 mg/kg respectively. The source of these soils was not recorded in the WHO report. It is noted that many Australian soils are considered to be iodine deficient, and this has led to proposals for mandatory iodine fortification of foods.

Table 5 lists uses of substances where MRLs are not necessary. MRLs are not necessary in situations where residues do not, or should not, occur in foods or animal feeds; or where the residues are identical to, or indistinguishable from, natural food components; or otherwise are of no toxicological significance. The field dissipation study and the strawberry residue study support the conclusion that a Table 5 entry is appropriate for the proposed use, as residues of iodomethane should not occur in food as a result of the proposed use.

Crop rotation

As iodomethane is expected to have degraded or dissipated from the soil prior to planting, the potential for residues in following crops is low.

Residues in animal commodities

Strawberries are not considered to be an animal feed commodity, and detectable residues are not expected to occur. Consideration of animal commodity MRLs is not required.

Spray drift

Iodomethane will be injected into the soil. A spray drift assessment is not required.

Dietary risk assessment

No Health-Based Guidance values have been set for iodomethane. A Table 5 entry has been proposed for iodomethane, as residue exposure to plants producing strawberry fruit or any other food is not expected as a result of the proposed use. It is not necessary to conduct a dietary exposure assessment at this time as residue exposure is not expected.

Recommendations

The following amendments are required to be made to the APVMA MRL Standard (Table 5).

Table 5: Amendments to the APVMA MRL Standard

Amendments to Table 5	
Substance	**Use**
DELETE:	
Iodomethane	• {T} As a soil fumigant prior to the cultivation of strawberry runners
ADD:	
Iodomethane	• As a soil fumigant prior to the cultivation of strawberry runners

Assessment of overseas trade aspects of residues in food

Strawberries are not considered to be a major export commodity. Given the proposed use pattern, iodomethane is expected to have degraded or dissipated from the soil prior to planting, and there will then be a further interval between planting and harvest. As residues are not expected to occur in crops or animal feeds as a result of the proposed use, the risk to trade is considered to be low.

Work health and safety assessment

Health hazards

As MIPIC 990 essentially comprises 98% iodomethane, its health hazards are equivalent to those of the active constituent. It has severe eye irritation potential, moderate skin irritation potential, is neurotoxic, and may cause developmental effects in humans.

Occupational exposure and risk

The APVMA concluded that adequate data was available to characterise the toxicological profile of iodomethane, and to undertake occupational and bystander health risk assessments for MIPIC 990.

Risk during use

During its use as a fumigant, iodomethane exposure occurs mainly via inhalation. Although dermal exposure is also possible, it is not expected to be significant due to the application delivery system, field tarping, high vapour pressure of iodomethane, and reactivity/degradation potential in soil. However, dermal exposure to iodomethane may cause severe skin irritation and burns.

For characterising any potential risks from inhalation exposure to iodomethane, the APVMA adopted the methodology used by US EPA, calculating human equivalency concentration (HEC) values from the submitted animal studies. An acceptable airborne exposure level of 120 ppb (daily dose of 0.28 mg/kg bw/d) was estimated, based on an occupational HEC of 3.7 ppm. Exposure monitoring studies indicate that airborne iodomethane ranges from 1 ppb up to 175 ppb during soil fumigation activities (except during tarp removal – see risks during re-entry below).

Risks to professional fumigators were considered to be low, particularly as extensive PPE (including a full facepiece respirator) will be used during the handling of MIPIC 990 cylinders and product application.

Risk during re-entry or rehandling

According to the directions for use, re-entry to treated areas will normally take place 5-days after the commencement of fumigation, when the plastic tarp is cut and removed. During tarp removal, air levels of iodomethane were measured at up to 2,000 ppb directly above the tarp. Average levels measured between days 6 to 10 were <35 ppb. Risks during tarp removal, or re-entry to treated areas before completion of the fumigation period were considered to be low for professional fumigators, provided workers wear the recommended PPE (including a full facepiece respirator).

In a study on workers involved in hand planting of strawberry runners, personal air monitoring samples were obtained at 7-days post fumigant application (i.e., 2 days after tarp removal). The application rate of iodomethane was approximately 200 kg iodomethane/ha. Airborne levels were <1 ppb and the estimated worker dose was 1.4 µg/kg bw/d, 200-fold lower than the acceptable worker daily dose of 0.28 mg/kg bw/d. Dermal exposure from handling iodomethane residues in soil is considered to be very low (see above). The risk for planters is therefore considered negligible, and no PPE is indicated for re-entry/planting activities 2-days post-tarp removal.

Public exposure

Fumigation of soil may lead to unintended bystander exposure via inhalation of iodomethane downwind of the treatment area. This may be in the form of a single random exposure, or repeated exposures of persons who reside near areas being fumigated.

Human equivalency concentration (HEC) values were calculated by the APVMA for non-occupational exposures to iodomethane. Unacceptable risks were determined at airborne exposure levels of 40 ppb acute-, and 30 ppb long-term exposure. The highest offsite air level of iodomethane measured in US and Australian fumigation trials was 39 ppb at 10 metres from the edge of the tarp (measured during the first 8 h of fumigation). At the same distance immediately after tarp removal, the highest level was 34 ppb, which dissipated to 6.7 ppb 12 hours post removal. Both pre- and post-tarp removal air levels, measured in an adult's breathing zone at distances greater than 10 metres from the plot, were between 0.1 and 4.5 ppb, with measurements taken 4 to 56 h during fumigation and 60 to 72 h post tarp removal.

To account for larger (commercial) size plots and different fumigant application rates, the APVMA adopted the US EPA bystander buffer zones, calculated from air dispersion modelling (Industrial Source Complex Short Term Model (ISCST3) and Probabilistic Exposure and Risk model for FUMigants (PERFUM2)). Because MIPIC 990 is to be used with a registered chloropicrin co-fumigant, recommended buffer zones for chloropicrin also need to be taken into account. Provided recommended buffer zones are followed, and fumigation is carried out according to Australian Standard 2476-2008 (General fumigation procedures), APVMA consider bystander risk will be adequately mitigated.

Recommendations

The APVMA has no objections on human health grounds to the registration of the product, MIPIC 990.

Taking into consideration the potential toxicological hazard and use pattern of iodomethane, the following first aid instructions, safety directions, and precautionary (warning) statements and restraints/restrictions are recommended for the product label.

First aid instructions

If swallowed, splashed on skin or in eyes, or inhaled, remove from contaminated area if safe to do so. Give oxygen and if necessary, artificial respiration. If giving mouth-to-mouth resuscitation wash out patient's mouth and lips – do not inhale patient's expired air. If in eyes, hold eyes open, flood with water for at least 15 minutes. While using appropriate personal protective equipment remove any contaminated clothing and wash contaminated skin thoroughly for at least 5 minutes (avoid hypothermia). Do not induce emesis. Do not give anything by mouth to an unconscious person. Immediately contact a doctor or Poisons Information Centre. Phone Australia 131126; New Zealand 0800 764 766.

Safety directions

Poisonous if swallowed. Harmful if inhaled. Attacks eyes. Will irritate the nose and throat and skin. Avoid contact with eyes and skin. Do not inhale vapour. When using together with other products, consult their label safety directions. If applying product by tractor drawn injection equipment, single-use hooded chemical resistant coveralls, impervious footwear and full facepiece respirator with a canister specified for iodomethane. In addition, when attaching the container to the injection unit or replacing empty containers or adjusting injection equipment, wear elbow length chemical resistant gloves. After each day's use, wash gloves, respirator (if rubber, with detergent and warm water). Do not re-use footwear until thoroughly aired.

Precautionary (warning) statements

May produce severe burns.

May cause birth defects.

Vapour is harmful to health on prolonged exposure.

Restraints/restrictions

Available to authorised or licensed persons only.

The risk of occupational and non-occupational exposure is expected to be mitigated by adherence to the relevant Australian Standard 2476 (General fumigation procedures) and its associated detection, monitoring, emergency venting and clearance provisions.

DO NOT remove valve protection bonnet and safety cap until immediately before use. Replace safety cap and valve protection bonnet when cylinder is not in use. Empty contents fully into application equipment. Close all valves replace safety cap and valve protection bonnet and return to point of supply for refill or storage.

Apply only using a pressurised, sealed fumigation unit, calibrated to deliver the recommended dose.

DO NOT use within 500 m of buildings inhabited by humans, including schools, day care facilities, nursing homes and prisons or sensitive sites e.g., playgrounds.

Cover the treated area with plastic tarp immediately after application and seal edges.

DO NOT use a water seal.

Product is intended for co-injection with a registered chloropicrin product.

The following bystander buffer zones for **iodomethane** fumigant should be adhered to:

Application rate (kg a.c./ha)	Size of contiguously treated area (hectares)	Buffer zone distance (metres)*
300	8 to 16	225
	4 to 8	135
	2 to 4	45
	<2	30
270	8 to 16	200
	4-8	120
	2 to 4	40
	<2	25
180	8 to 16	140
	4 to 8	80
	2 to 4	30
	<2	20
165	8 to 16	125
	4 to 8	65
	2 to 4	25
	<2	15
130	8 to 16	100
	4 to 8	50
	2 to 4	20
	<2	10

Shading= label rate for MIPIC 990; *for use with LDPE tarp.

The greater buffer zone distance for each of iodomethane and chloropicrin (at the relevant application rates) should be adopted for the fumigation.

Re-entry statement

Do not enter treated work areas until 5 days after treatment and until the monitored levels of iodomethane are less than or equal to 2 ppm (12 mg/m^3). For removal/perforation of the tarp wear single-use hooded chemical resistant coveralls, chemical resistant gloves, impervious footwear and full facepiece respirator with canister specified for iodomethane. A minimum interval of 2 hours is required between perforation and tarp removal.

DO NOT plant strawberries for at least 28 days after removal of plastic tarp.

Other label statements

A fumigation plan and records should be kept as outlined in Australian Standard 2476 (General fumigation procedures).

Warning signs "DANGER KEEP OUT, FUMIGATION WITH MIPIC 990" (in letters not less than 10 cm high) must be prominently shown at all approaches to the fumigation site at the designated buffer zone distance. Fumigator contact name and telephone number should also appear on the signs.

The risk area should be marked with a physical barrier around the perimeter. Non-handler entry is prohibited while tarps are being removed. Where required, a guard should be stationed at the perimeter to prevent entry of unauthorised persons, children and animals during the first day of ventilation.

Ensure adequate ventilation when washing gloves and respirator.

Environmental assessment

Fate and behaviour in the environment

Soil

The rapid dissipation of iodomethane in aerobic soil is primarily the result of volatilization rather than microbial degradation (geomean DT_{50} 10 days at 20°C under laboratory conditions). However, carbon dioxide was detected and gradually increased to 1.1% of the total applied radioactivity by the end of the aerobic soil study. This indicates that limited microbial degradation of iodomethane still occurs. In batch equilibrium studies, iodomethane shows low absorption potential in nine soils tested (mean Koc mL/g).

Iodomethane was not persistent in tarped soil under field conditions (geomean DT_{50} 4.9 d). Following application at 263 kg a.c./ha, the maximum measured time-zero concentration of iodomethane in the soil was 20 mg ac/kg dry soil (37% of the applied rate) with 2% soil residues remaining in the top 30 cm after 5 days. Iodomethane was more confined to the layers adjacent to the 30 cm depth of iodomethane placement than soil layers below 60 cm. However, since iodomethane is soluble in water and has low adsorption to soil, there is the possibility of leaching through soil profile into ground water if removal or slicing of the tarpaulin is followed soon by a rain event.

Several field volatility studies were conducted in the USA, with one Australian study conducted in Toolangi, Victoria that was designed to meet APVMA requirements. The flux rates at Toolangi were well below those measured in comparable USA studies; only about 6% of applied iodomethane was emitted to the air during the 10 days of the study. It was noted that mass loss estimates for 2 comparable studies in California, at Manteca (sand) and Watsonville (sandy loam), were 93% and 57% respectively for the entire monitoring after the application. Differences between the soils could account for the reduced mass loss at Watsonville in comparison with Manteca, with significantly lower mass loss at Toolangi due to the much heavier clay soil type, higher organic matter content and lower soil temperatures. The maximum flux rate was 481 $\mu g/m^2/s$ in the USA trials (Manteca, CA), while the maximum flux rate in the Australian study was 7.5 $\mu g/m^2/s$.

Water

The rapid dissipation of iodomethane in anaerobic aquatic conditions is primarily the result of volatilization rather than microbial degradation (DT_{50} 1.7 days in the total system). However, carbon dioxide was detected and gradually increased to 2.5% of the total applied radioactivity by the end of the study. This indicates that limited microbial degradation still occurs. Iodomethane was hydrolyzed slowly (DT_{50} 94 to 108 days) in acidic, neutral, and alkaline conditions at ambient temperature yielding up to 18% methanol. Photolysis occurs both in gas and solution phases (DT_{50} 31 days in early summer sunlight in Ohio), which forms up to 19% methanol and 36% formaldehyde.

Air

The distribution and lifetime of iodomethane in the atmosphere is a factor of the rate of emission and removal and is important for determining the build-up of the chemical in the atmosphere. Assuming evenly distributed flux of iodomethane with latitude, an atmospheric lifetime for iodomethane of 6.9 days was calculated based on predicted rates of direct photolysis and reaction with OH radicals.

Methyl halide compounds such as iodomethane are very reactive agents when released into the atmosphere. Ozone depletion can be caused by an increase in the concentration of halogen radicals (such as iodine) in the stratosphere. Photodissociation of iodomethane produces iodine radicals that can reach the stratosphere in two ways: iodomethane can drift into the stratosphere before photo- dissociation releases iodine radicals (Pathway A), or dissociation can occur in the troposphere and a fraction of the iodine radicals can be transported into the stratosphere (Pathway B). Because iodomethane is short-lived in the atmosphere, pathway B is likely to be quite important because the iodine radicals will generally be released in the troposphere, rather than the stratosphere, where the ozone layer is located. An ozone depletion potential (ODP) of 0.0015 was calculated for iodomethane considering its accumulation in the troposphere and the two possible pathways to the stratosphere, which is well below the 0.65 ODP for methyl bromide.

Radiative forcing is the ability of a gas to absorb infrared radiation, changing the balance of radiation absorbed or emitted by the atmosphere. A gas that strongly absorbs radiation in the atmospheric window, reduces the direct transmission of radiation emitted by the earth to space, enhancing the greenhouse effect. One measure of the effectiveness of a gas to act as a greenhouse gas is the change in radiative forcing at the tropopause. Radioactive forcing for iodomethane was calculated to be 5.0×10^{-3} Watt m^{-2} $pbbv^{-1}$. For comparison purposes, the radiative forcing for methyl bromide was 1.0×10^{-2} Watt m^{-2} $pbbv^{-1}$. Based on the radiative forcing results and its atmospheric lifetime, iodomethane is expected to have negligible impact on greenhouse warming.

Effects and associated risks to non-target species

Terrestrial vertebrates

Following oral administration, iodomethane has high toxicity to mammals (lowest LD_{50} 80 mg a.c./kg bw, *Rattus norvegicus*) and birds (LD_{50} 57 mg a.c./kg bw, *Colinus virginianus*); however, as iodomethane is a gas, the oral route of exposure is not considered to be relevant.

Following inhalation exposure, the 4-hour LC_{50} values were 4015 mg a.c./m^3 for mammals (*Rattus norvegicus*) and 2230 mg a.c./m^3 for birds (*Colinius virginianus*). Following long-term inhalation exposure, foetal malformations and reduced body weights were observed at concentrations as low as 58 mg a.c./m^3 in mammals (NOAEC 12 mg a.c./m^3, *Oryctolagus cuniculus*). This long-term value is set at the regulatory acceptable level (RAL) for terrestrial vertebrates. No long-term inhalational studies are available for birds.

Since the treated field remains covered by tarp for 5 days after application, terrestrial vertebrates will not gain access to the treated area during this lapse of time. Furthermore, plant metabolism data showed that the radiocarbon present in plants grown in treated soil consisted of (natural) carbohydrates, insoluble monomers, short polymers, and starch suggesting entry into general metabolic pathways. Therefore, risks of terrestrial vertebrates consuming plants grown in treated soil are considered to be acceptable.

Although it is considered that there is no direct route of exposure to terrestrial vertebrates during fumigation of soil, it is possible that birds and mammals visiting the treatment area could be exposed to iodomethane via inhalation following ventilation. The maximum measured air concentration was 11 mg a.c./m^3 at 15 cm in the Australian field study following tarp removal, which is below the RAL for terrestrial vertebrates (12 mg a.c./m^3). Therefore, risks to terrestrial vertebrates are considered to be acceptable and no protection statements are required.

Aquatic species

Iodomethane has moderate toxicity to fish (lowest LC_{50} 1.2 mg a.c./L, *Cyprinus carpio*), aquatic invertebrates (EC_{50} 0.57 mg/L, *Daphnia magna*), algae (E_bC_{50} 1.7 mg a.c./L, *Selenastrum capricornutum*), and aquatic plants (E_rC_{50} 3.7 mg a.c./L, *Lemna gibba*). Following long-term exposure to iodomethane, reduced reproduction of aquatic invertebrates was observed at concentrations as low as 0.32 mg a.c./L (NOEC 0.16 mg ac/L, *Daphnia magna*). A protection statement is required on the label to identify the hazard to aquatic species.

Acceptable runoff risks to aquatic species could be concluded after considering spatial and temporal characteristics typical of Australian strawberry growing regions, provided a runoff event is not expected soon after tarp removal. General runoff restraints are advised to mitigate this risk. Vapour deposition of iodomethane onto water surfaces is expected to be negligible based on its physical and chemical properties.

Bees and other non-target arthropods

There are no data available on toxicity of iodomethane to bees or other non-target arthropods. In the absence of data, the product is not considered to be compatible with integrated pest management (IPM) programs utilising ground-dwelling arthropods. In addition, beekeepers should be notified before treatment so that they can move hives to avoid vapour exposure, if necessary.

Soil organisms

In eleven field trials, iodomethane treatments greatly reduced soil populations of various microorganisms, but beneficial bacteria and fungi recovered quickly (4 to 5 weeks). No information on soil macro-organisms is available. At the proposed use rates, iodomethane is expected to adversely affects soil organisms in the topsoil. Overall, areas of use are expected to be very small and the cultivation of fields to prepare the soil for treatment will essentially limit populations of soil organisms likely to be exposed in the upper layers. For example, earthworms generally prefer undisturbed soil, and even if they are present in treated topsoil, they would move to undisturbed areas or deeper down the soil profile during cultivation.

Iodomethane rapidly degrades in soil, while field data indicate that the concentration in deeper layers to be <1.0% compared to topsoil (0-30 cm), which further dissipates to negligible levels in 3 to 4 weeks after treatment. Therefore, it is expected that populations of soil macro-organisms can recover to normal levels within a few months after treatment. Therefore, no protection statements are required for soil organisms.

Non-target terrestrial plants

Iodomethane vapour was phytotoxic to some species of non-target terrestrial plants following pre-emergent exposure (lowest ER_{25} 9,300 g a.c./ha, *Lycopersicon esculentum*) and post-emergent exposure (lowest ER_{25} 5,400 g a.c./ha, *Allium cepa*). Based on these data, risks of vapour deposition to non-target terrestrial plants within one metre of the treatment area were determined to be acceptable. Negligible impacts on non-target terrestrial plants interrow and around the treatment area were confirmed in Australian strawberry field trials under the proposed conditions of use. Therefore, no protection statements are required for non-target terrestrial plants.

Recommendations

In considering the environmental safety of the proposed use of MIPIC 990 Soil Fumigant, the APVMA had regard to the toxicity of the active constituent in relation to relevant organisms and ecosystems. Based on the available information, the APVMA can be satisfied that the proposed use of the product is unlikely to have an unintended effect that is harmful to animals, plants or things or to the environment.

Efficacy and safety assessment

Proposed product use pattern

Saluterra Pty Ltd have applied to register MIPIC 990 Soil Fumigant, containing 990 g/L technical iodomethane, for use as a broad-spectrum fumigant to control weed seeds, nematodes and soil-borne diseases in the strawberry runner production industry. Iodomethane is intended to replace soil fumigation using methyl bromide, which is being phased out under the Montreal Protocol.

MIPIC 990 Soil Fumigant will be co-injected into the soil with an approved chloropicrin product, using a pressurised, sealed fumigation unit calibrated to deliver the recommended dose at a depth of 15 to 20 cm, with a maximum tyne spacing of 25 cm.

Proposed rates for the control of soil-borne pathogens and plant parasitic nematodes are 130 kg/ha MIPIC 990 of soil fumigant and 270 to 300 kg/ha chloropicrin. For the control of weed seeds, proposed rates are 130 to 165 kg/ha MIPIC 990 of soil fumigant and 270 to 300 kg/ha chloropicrin. Higher rates were recommended for difficult to control weed species, or where a high weed density is expected.

The treated area will be covered with plastic film immediately following application and sealed at the edges for a minimum exposure time of 5 days, and planting interval of 28 days.

MIPIC 990 Soil Fumigant will be approved for use only by professional, licensed fumigators, to ensure effective and compliant application.

Efficacy and target crop safety

Efficacy

Overseas data

The applicant provided a review of international data on iodomethane to support the proposed use of MIPIC 990 Soil Fumigant in the Australian strawberry runner production industry as a viable replacement for methyl bromide.

Over 20 published research papers, including extensive laboratory and field trials conducted in the USA over a seven-year period, were cited to substantiate the efficacy and crop safety of iodomethane when applied as a pre-plant soil-fumigant for the control of insect pests, soil-borne plant pathogens (including fungi, bacteria, nematodes) and weed seeds, in a variety of cropping situations. The review indicated that iodomethane, when applied alone or co-injected with chloropicrin, is equivalent or superior to methyl bromide in controlling various pathogens, nematodes and weeds, at equivalent or lower rates. Chloropicrin aids the diffusion of iodomethane through the soil profile, thus increasing overall efficacy.

Australian trials

Data from 14 Australian field trials, conducted across 3 States (Victoria, South Australia, and Queensland) and 6 agricultural industries (strawberry runners, strawberry fruit, protected flowers, flower bulbs, vegetables and turf), were submitted to support the efficacy of technical iodomethane when co-injected with technical chloropicrin at ratios of 30:70 or 50:50, to control various pathogens and weed seeds.

Rates of iodomethane tested ranged from 82 to 250 kg/ha when applied alone, and/or co-injected with chloropicrin at 168 to 335 kg/ha. The efficacy of iodomethane + chloropicrin mixtures was compared with equivalent rates of methyl bromide + chloropicrin, chloropicrin alone, and/or other industry standard fumigants (1,3 – dichloropropene, metham sodium or propylene oxide) applied at label rates, and untreated controls.

Strawberries

Three randomised, complete block (RCB) trials were conducted on a commercial strawberry runner production farm in Victoria. Iodomethane + chloropicrin (30:70) and methyl bromide + chloropicrin (33:67) were applied using the tyne injection method through single tynes, at a rate equivalent to 250 to 500 kg/ha. Application of iodomethane + chloropicrin did not require modification of the apparatus. previously used for methyl bromide. Fumigants were delivered evenly to a depth of 40 cm when the tynes were set at a depth of 20 cm. Iodomethane moved 25 cm laterally in the soil, indicating that tyne spacing could be increased above the 20 cm used for methyl bromide.

Muslin bags containing inoculum of 6 soil-borne pathogens (*Pythium ultimum*, *Phytophthora cactorum*, *Fusarium oxysporum*, *Rhizoctonia solani*, *R. fragariae* and *Sclerotum rolfsi*) and three weed species (*Trifolium subterraneum*, *Lolium perenne* and *Actosella vulgaris*) were buried in each plot at depths of 10, 20 and 40cm, and at distances of 25 and 75 cm from the injection point immediately prior to fumigant application. Five days after fumigation, inoculum and weed seeds were recovered from field plots and assessed for viability in the laboratory.

A further 3 trials were conducted in strawberries at a commercial farm in Queensland – 2 in strawberry runners and one in a strawberry fruit crop. In strawberry runner trials, treatments of iodomethane + chloropicrin (30:70 @ 250-500 kg/ha) were compared with methyl bromide (50:50 @ 500 kg/ha) and 1,3 – dichloropropene (350 kg/ha). All products were shank injected using a tractor. An untreated control was not included in this trial as a commercial runner production area was used. Untreated areas along adjacent headlands and at the end of rows were used to estimate the base weed load. The trial site had not been previously fumigated. Assessment included counts of weeds, runners and a lettuce seed germination test. In the strawberry fruit crop trial, fumigants were applied to the soil using shank injection and hot-gas methods.

The trial area had been carefully nurtured for several years for its uniform dense stand of nutgrass (*Cyperus rotundus*). It was also adjacent to an area that had high levels of soil-borne *Fusarium oxysporum* f.sp. *fragariae*. Iodomethane + chloropicrin (30:70 @ 250, 350 or 500 kg/ha) treatments were compared with methyl bromide + chloropicrin (50:50 @ 500 kg/ha), and nearby untreated control. At one to 2 days after treatment, inoculum of *Fusarium* and *Rhizoctonia solani* were buried at a depth of 100 mm. The inoculum was recovered after one week to assess viability. Counts of nut grass emergence were made soon after fumigation, and then at 6 to 8 weekly intervals until harvest. In the fruit trial, total yields were compared in each treatment.

Other crops

Similar replicated trials were conducted in various horticultural crops (capsicums, protected bulbs, and flowers) and turf. The efficacy and safety of iodomethane + chloropicrin (30:70 and 50:50), methyl bromide alone, methyl bromide + chloropicrin (50:50), and/or other industry standard soil fumigants was compared. Assessment of plant diseases, nematode populations and weed emergence were made at various intervals after treatment. These trials also included lettuce seed (horticultural crops) or fescue seed (turf) germination experiments to determine safe plant-back times.

Efficacy against soil-borne pathogens and nematodes

In a Victorian strawberry runner trial, iodomethane + chloropicrin applied in a 30:70 ratio at 250 kg/ha and 500 kg/ha, controlled buried inoculum of *Sclerotium rolfsii* (southern blight) *Rhizoctonia fragariae* (strawberry root rot) and *Phytophthora cactorum* (strawberry collar rot) to a depth of at least 30 cm.

In a Queensland strawberry fruit production trial, iodomethane: chloropicrin applied at 500 kg/ha successfully controlled *Fusarium* wilt.

In addition to the measurement of direct effects on selected plant pathogenic organisms, the effects of iodomethane + chloropicrin on populations of fungi, bacteria, and actinomycetes in soil and their biodiversity were monitored in several trials. Assessments were made of the abundance of total bacteria, gram negative bacteria, *Pseudomonas* spp, total fungi and, in some trials *Fusarium* spp., and actinomycetes. Evaluations of gram-negative bacteria, pseudomonas and actinomycetes were intended to gauge the effect of the treatment on beneficial growth promoting rhizobacteria and beneficial fungi, while the assessment of *Fusarium* abundance provided an indication of control of potential pathogens. The results showed that the effects of iodomethane + chloropicrin on total fungal and bacterial populations and on potentially beneficial microbes were similar to those of methyl bromide.

Studies in vegetable and cut flower soils also demonstrated that fumigation with iodomethane + chloropicrin (30:70 @ 250 and 500 kg/ha) resulted in reduced nitrate nitrogen and increased ammonium nitrogen, to an extent equivalent to that of fumigation with an equivalent methyl bromide + chloropicrin mix.

In the vegetable field trial at Bundaberg Qld, iodomethane + chloropicrin (30:70 @ 250 and 500kg/ha) successfully controlled pathogenic nematodes (*Meloidogyne hapla* and *Paratrichodorus* spp). At 40 DAF, no pathogenic nematodes were found at any treated sites. At harvest (111 DAF), the nematode population in the untreated controls increased 50-fold but remained low in plots treated with iodomethane + chloropicrin, methyl bromide, and 1,3 dichloropropene, while the chloropicrin and propylene oxide treatments resulted in higher pathogenic nematode populations than controls.

Efficacy against weeds

In a strawberry runner trial in Queensland, iodomethane + chloropicrin (30:70 @ 250 to 500 kg/ha) completely controlled *Amaranthus* spp, *Solanum nigrum*, *Galinsoga parviflora*, *Tagetes minuta*, *Cynodon dactylon*, and *Chenopodium album* while providing substantial but incomplete control of summer grass.

In a strawberry runner trial in Victoria, iodomethane + chloropicrin applied at a higher rate (30:70 @ 500 kg/ha) produced complete control of winter, spring and total emerging weeds, while the lower rate tested (250 kg/ha) resulted in complete control of the dominant weed *Spergula arvensis*. At 250 kg/ha however, control of winter grass (*Poa annua*) was inadequate. Treatments increased the early vegetative growth of strawberry mother plants and resulted in runner yield increases of up to 170%.

In a strawberry fruit production trial in Queensland, difficulties in setting the flow rates for the application equipment resulted in application of the product at rates ranging from 183 kg/ha to 1,000 kg/ha. Nevertheless, all rates were associated with greatly reduced nutgrass (*Cyperus rotundus*) counts and increased fruit yields.

In a vegetable trial at Bundaberg, iodomethane + chloropicrin (30:70 @ 500kg/ha) application resulted in excellent control of the three most dominant weeds, *C. album*, *Sida retusa*, and *C. rotundus.* Other industry standard fumigants tested tended to increase weed numbers, particularly *C. rotundus*, in comparison with the untreated control site.

Two trials conducted in turf grass soils (one in loamy sand, the other in a heavy clay loam) tested various rates of iodomethane + chloropicrin applied in a 30:70 or 50:50 ratio and provided further evidence of the efficacy of these actives to control both broadleaf and graminaceous weed seeds when applied as a pre-plant soil fumigant.

Crop safety

Crop safety of MIPIC 990 Soil fumigant is reliant on the complete dispersal or breakdown of toxic molecules in the soil prior to planting. The safety of iodomethane and chloropicrin to crops grown in treated soils was monitored during several of the efficacy trials (described above) by sowing lettuce seeds highly susceptible to these toxins. In treated soil sampled at various intervals following removal of tarps, levels of germination were recorded and seedlings were evaluated for symptoms of phytotoxicity.

In a strawberry runner trial in Queensland, a lettuce bioassay conducted in soil samples taken 2 hours following fumigation, germinating seedlings demonstrated extensive phytotoxicity. When the bioassay was repeated 3 weeks later, no signs of phytotoxicity were observed, with similar seedling height in all samples.

In the second strawberry runner trial in Queensland, lettuce bioassays were performed on soil samples collected from 2 depths, 8 days after fumigation (DAF) and from one depth at 15 and 36 DAF. The results showed that lettuce seed germination was significantly reduced in treated soils at 8 and 15 DAF, but not at 36 days, suggesting that the fumigants had dispersed.

Similar germination bioassays were conducted in vegetable field trials and confirmed a safe plant-back interval of 4 weeks. The performance of crops planted in plots treated with iodomethane + chloropicrin was generally better than crops from untreated plots in almost all trials, providing further support for the crop safety of the product when adequate time is provided for dispersal of the fumigant prior to planting. Therefore, the draft label contains an appropriate restraint not to plant strawberry runners for at least 28 days after the removal of plastic sealing sheet.

As an added precaution, the label general instructions also recommend conducting a seedling bioassay using lettuce seeds to ensure no residual fumigants remain in the treated soil. Users of MIPIC 990 Soil Fumigant will be able to access instructions for conducting the bioassay from Saluterra Pty Ltd.

Recommendations

The results of the field trials support the proposed label rates of 130 kg/ha iodomethane co-injected with 270 to 300 kg/ha chloropicrin for pathogen and nematode control, 130 to 165 iodomethane and 270 to 300 kg/ha to control the seeds of susceptible weed species.

The APVMA has no objections on efficacy and target-crop safety grounds to the registration of MIPIC 990 Soil Fumigant.

Labelling requirements

DANGEROUS POISON

KEEP OUT OF REACH OF CHILDREN

READ SAFETY DIRECTIONS BEFORE OPENING OR USING

MIPIC 990 SOIL FUMIGANT

ACTIVE CONSTITUENTS: 990 g/kg IODOMETHANE,

GROUP **8 A** INSECTICIDE

For use by professionally licensed and authorised fumigators for control of weed seeds, nematodes and soil borne diseases and pests.

NOT TO BE AVAILABLE EXCEPT TO AUTHORISED OR LICENSED PERSONS

CONTENTS: 100 kg

saluterra

APVMA Approval Number:
Batch Number:
Date of Manufacture:

Directions for use – all states

Restraints:

DO NOT treat soil if temperature at 15 to 20 cm depth is below 13°C.

DO NOT treat soil when very wet or very dry.

DO NOT treat seeds intended for planting or sowing.

DO NOT fumigate within 1 m of roots of desirable vegetation.

DO NOT plant or sow for at least 28 days after removal of plastic sealing sheet.

DO NOT remove tarp if heavy rains or storms are forecast within 3 days.

DO NOT irrigate to the point of runoff for at least 3 days after tarp removal.

For PROFESSIONAL use. Available to authorised or licensed persons only.

The risk of occupational and non-occupational exposure is expected to be mitigated by adherence to the relevant Australian Standard (AS 2476-2008 – General fumigation procedures) and its associated detection, monitoring, emergency venting and clearance provisions.

DO NOT remove valve protection bonnet and safety cap until immediately before use. Replace safety cap and valve protection bonnet when cylinder is not in use. Empty contents fully into application equipment. Close all valves replace safety cap and valve protection bonnet and return to point of supply for refill or storage.

Apply only using a pressurised, sealed fumigation unit, calibrated to deliver the recommended dose.

DO NOT use within 500 m of buildings inhabited by humans, including schools, day care facilities, nursing homes and prisons or sensitive sites e.g., playgrounds.

DO NOT use water seal.

Product is intended for co-injection with a registered chloropicrin fumigant.

The following bystander buffer zones for iodomethane fumigant should be adhered to:

Application rate of iodomethane kg a.i./ha)	Size of contiguously treated areas (ha)	Buffer zone distance (metres)
165	8 – 16	125
	4 – 8	65
	2 – 4	25
	<2	15
130	8 – 16	100
	4 – 8	50
	2 – 4	20
	<2	10

The following bystander buffer zones for chloropicrin fumigant should be adhered to:

Application rate of chloropicrin kg a.i./ha)	Size of contiguously treated areas (ha)	Buffer zone distance (metres)
300	8 – 16	140
	4 – 8	75
	2 – 4	30
	<2	10
270	8 – 16	130
	4 – 8	70
	2 – 4	25
	<2	10

The greater buffer zone distance for each of iodomethane and chloropicrin (at relevant application rates) should be used for co-fumigation.

Situation	Pest	Application Rate	Minimum exposure time	Critical Comments
Broadacre fumigation Strawberry runner production	Damping off fungi: *Fusarium, Pythium, Phytophthora, Rhizoctonia, Sclerotium rolfsii, Macrophomina phaseolina*, and plant parasitic nematodes	130 kg/ha co-injected with chloropicrin 270 to 300 kg/ha	5 days	Thoroughly cultivate the soil and ensure that it is kept moist for 5-7 days before treatment. Apply using a pressurised, sealed fumigation unit calibrated to deliver the recommended dose at a depth of 15 –20 cm with a maximum tyne spacing of 25 cm. Cover the treated area with plastic film immediately after application and seal the edges. Use the high rate for control of weeds such as mallow and vetch and related species, or where a high population of weed seeds is expected.
	Seeds of susceptible weed species	130 to 165 kg/ha co-injected with chloropicrin 270 to 300 kg/ha	5 days	

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

GENERAL INSTRUCTIONS

IMPORTANT

Fumigation and aeration should be performed in accordance with the appropriate Code of Practice for fumigation in the State or Territory.

A fumigation plan and records should be kept as outlined in Australian Standard AS2476.

Warning signs “DANGER KEEP OUT, FUMIGATION WITH MIPIC 990” (in letters not less than 10 cm high) must be prominently shown at all approaches to the fumigation site at the designated buffer zone distance. Fumigator contact name and telephone number should also appear on the signs.

The risk area should be marked with a physical barrier around the perimeter. Non-handler entry is prohibited while tarps are being removed. Where required, a guard should be stationed at the perimeter to prevent entry of unauthorised persons, children and animals during the first day of ventilation.

DO NOT drop, bump or drag cylinders.

DO NOT unload by rope-sling, hooks or tongs.

Keep cylinders upright in tamper-proof airy stores, away from dwellings, food and feedstuffs. Put out all pilot lights and glowing heating units.

Transport cylinders using hand truck, forklift or other device to which the cylinder can be firmly secured.

DO NOT apply near buildings inhabited by humans or livestock.

Soil Fumigation:

Apply according to the Directions for Use. Co-inject with a registered product containing chloropicrin, such as Chlorofume Soil Fumigant and follow the label. Ensure that chemical is turned off at the end of each row.

Be sure treated soil or material is free from MIPIC 990 before seeding. Working the soil will help aeration.

A seedling bioassay using lettuce seeds can be carried out to determine if all fumigant has dispersed. Instructions for the bioassay are available from Saluterra Pty Ltd, Phone 0417526667

Prevent re-contamination of fumigated areas. If necessary, to avoid contamination by flooding, trench around them or build wooden or earthen dams. Clean shoes carefully when walking from untreated to treated soil. Do not use tools, transplants or crop remains that may carry pests from unfumigated areas.

Fumigation with MIPIC may slow down soil nitrification. Certain ammonia-sensitive plants such as tomatoes, may suffer growth inhibition or stand reduction when placed in soil containing high ammonia-nitrogen. This hazard can be overcome by delaying planting for several months or by the application of nitrate from nitrogenous fertilisers.

PRECAUTION

RE-ENTRY PERIOD

Do not enter treated work areas until 5 days after treatment and until the monitored levels of iodomethane are less than or equal to 2 ppm (12 mg/m3), For removal/perforation of the tarp wear single-use hooded chemical resistant coveralls, chemical resistant gloves, impervious footwear and full facepiece respirator with canister specified for IODOMETHANE. A minimum interval of 2 hours is required between perforation and tarp removal.

DO NOT plant strawberries for at least 28 days after removal of plastic tarp.

INSECTICIDE RESISTANCE WARNING

For insecticide resistance management MIPIC 990 is a Group 8A insecticide. Some naturally occurring insect biotypes resistant to MIPIC 990 and other Group 8A insecticides may exist through normal genetic variability in any insect population. The resistant individuals can eventually dominate the insect population if MIPIC 990 and other Group 8A insecticides are used repeatedly, resulting in significant reduction in the effectiveness of MIPIC 990 on resistant individuals. Saluterra Pty Ltd accepts no liability for any losses that may result from the failure of MIPIC 990 to control resistant pests.

STORAGE AND DISPOSAL

Store in a locked room or place away from children, animals, food, feedstuffs, seeds and fertilisers. Store in the closed, original container in a cool, well- ventilated area. Do not store for prolonged periods in direct sunlight.

Do not remove valve protection bonnet and safety cap until immediately before use. Replace safety cap and valve protection bonnet when cylinder is not in use. Empty contents fully into application equipment. Close all valves replace safety cap and valve protection bonnet and return to point of supply for refill or storage.

INTEGRATED PEST MANAGEMENT

Not compatible with integrated pest management (IPM) programs utilising ground-dwelling arthropods.

PROTECTION OF WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

Toxic to aquatic life. DO NOT contaminate wetlands or watercourses with this product or used containers.

PROTECTION OF HONEYBEES AND OTHER INSECT POLLINATORS

Before treatment, notify beekeepers to move hives to a safe location, if there is potential for managed hives to be affected by vapour drift.

SAFETY DIRECTIONS

Poisonous if swallowed. Harmful if inhaled. Attacks eyes. Will irritate the nose and throat and skin. Avoid contact with eyes and skin. Do not inhale vapour. When using together with other products, consult their label safety directions. If applying product by tractor drawn injection equipment, single use hooded chemical resistant coveralls, impervious footwear and full facepiece respirator with a canister specified for iodomethane. In addition, when attaching the container to the injection unit or replacing empty containers or adjusting injection equipment, wear elbow length chemical resistant gloves. After each day's use, wash gloves, respirator (if rubber, with detergent and warm water). Do not re-use footwear until thoroughly aired.

FIRST AID

If swallowed, splashed on skin or in eyes, or inhaled, remove from contaminated area if safe to do so. Give oxygen and if necessary, artificial respiration. If giving mouth-to-mouth resuscitation wash out patient's mouth and lips – do not inhale patient's expired air. If in eyes, hold eyes open, flood with water for at least 15 minutes. While using appropriate personal protective equipment remove any contaminated clothing and wash contaminated skin thoroughly for at least 5 minutes (avoid hypothermia). Do not induce emesis. Do not give anything by mouth to an unconscious person. Immediately contact a doctor or Poisons Information Centre. Phone Australia 131126 New Zealand

May produce severe burns. Vapour is harmful to health on prolonged exposure. WARNING – may cause birth defects. Use only in well ventilated area.

SAFETY DATA SHEET

For further information refer to the Safety Data Sheet (SDS).

Acronyms and abbreviations

Shortened term	Full term
ac	Active constituent
ADI	Acceptable daily intake (for humans)
ai	Active ingredient
ARfD	Acute reference dose
bw	Bodyweight
d	Day(s)
DAT	Days after treatment
DT_{50}	Time taken for 50% of the concentration to dissipate
EC_{50}	concentration at which 50% of the test population are immobilised
E_bC_{50}	concentration at which 50% reduction of biomass is observed
E_rC_{50}	concentration at which the rate of growth of 50% of the test population is impacted
ER_{25}	Effective rate, 25th percentile
F_0	Original parent generation
g	Gram
h	Hour
ha	Hectare
Hg	Symbol for mercury
HPLC	High pressure liquid chromatography or high performance liquid chromatography
in vitro	Outside the living body and in an artificial environment
in vivo	Inside the living body of a plant or animal
kg	Kilogram
K_{OC}	Organic carbon partitioning coefficient
L	Litre
LC_{50}	Concentration that kills 50% of the test population of organisms
LD_{50}	Dosage of chemical that kills 50% of the test population of organisms

Shortened term	Full term
LOD	Limit of Detection—level at which residues can be detected
Log K_{OW}	Log to base 10 of octanol water partitioning co-efficient, synonym P_{OW}
LOQ	Limit of Quantitation—level at which residues can be quantified
mg	Milligram
mL	Millilitre
MRL	Maximum Residue Limit
MSDS	Material Safety Data Sheet
NEDI	National Estimated Daily Intake
NESTI	National Estimated Short Term Intake
n	number
ng	Nanogram
NOEC/NOEL	No Observable Effect Concentration Level
NOAEL	No Observed Adverse Effect Level
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
RAL	Regulatory acceptable level
s	Second
SUSMP	Standard for the Uniform Scheduling of Medicines and Poisons
µg	Microgram
WHO	World Health Organisation

Glossary

Term	Description
Active constituent	The substance that is primarily responsible for the effect produced by a chemical product
Acute	Having rapid onset and of short duration
Carcinogenicity	The ability to cause cancer
CAS number	Unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance
Chronic	Of long duration
Codex MRL	Internationally published standard maximum residue limit
Desorption	Removal of a material from or through a surface
Efficacy	Production of the desired effect
Formulation	A combination of both active and inactive constituents to form the end use product
Genotoxicity	The ability to damage genetic material
Henry's law constant	A gas law that states that the amount of dissolved gas in a liquid is proportional to its partial pressure above the liquid
Hydrophobic	Repels water
IUPAC name	International Union of Pure and Applied Chemistry naming scheme for organic compounds
Leaching	Removal of a compound by use of a solvent
Metabolism	The chemical processes that maintain living organisms
Montreal Protocol	International treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion
Photodegradation	Breakdown of chemicals due to the action of light
Photolysis	Breakdown of chemicals due to the action of light
Subcutaneous	Under the skin
Toxicology	The study of the nature and effects of poisons

References

International Agency for Research on Cancer, 1999. IARC monographs on the evaluation of carcinogenic risks to humans. Geneva, WHO vol. 71: 1503.

IRAC 2021, IRAC mode of action classification scheme, issued September 2021, v. 10.1, Insecticide Resistance Action Committee, available at: irac-online.org/modes-of-action.