Fumigant Alternatives

1,3-D/Pic Products

- Formulations containing 65:35 and 40:60 mixtures of 1,3-D/Pic are registered for use in soils in Australia. Formulations containing 20:80 mixtures of 1,3-D/Pic (i.e. TriForm 80) were registered for use in soils in Australia in late 2016.
- Previous research on 1,3-D/Pic products with high concentrations of 1,3-D (e.g. Telone C-35 (65:35) and TriForm 60 (40:60)) has demonstrated an unacceptable risk of phytotoxicity in runner crops, with plant losses of up to 40% [AUS02 CUN16, A19].
- Recent research shows that formulations of 1,3-D/Pic containing lower concentrations of 1,3-D (e.g. TriForm-80 (20:80)) may reduce the risk of crop phytotoxicity (see Part C 8a for details).
- TriForm-80 is not technically feasible on its own because it does not control pathogens to the same soil depth, and weeds as effectively as MB/Pic (see Part C 8a). Runners produced in soils treated with TriForm-80 in the nursery subsequently produced 15% lower fruit yields than runners produced in soils treated with MB/Pic in the nursery.
- Not approved for use by the runner Certification Authority because of lower pathogen control compared with MB/Pic. Its use would result in a complete loss to growers because runners are unmarketable.

Chloropicrin (Pic)

- Registered for use in soils in Australia.
- On average, Pic has produced 14% lower runner yields than MB/Pic over 13 years of research in the runner industry, and can cause phytotoxicity in runners and plant losses of up to 38% [AUS02 CUN16, A19].
- Not technically feasible on its own because it does not control pathogens and weeds as effectively as MB/Pic (see Part C 8b). Runners produced in soils treated with Pic in the nursery subsequently produced 10% lower fruit yields and had higher levels of root diseases than runners produced in soils treated with MB/Pic in the nursery (see Part C 8b).
- Not approved for use by the runner Certification Authority. Its use would result in a complete loss to growers because runners are unmarketable.

Pic or 1,3-D co-applied with MITC

- A metham spading rig was imported into Australia from Europe in 2013 for application of MITC in trials, but has proved an ineffective application method on clay soils.
- Not technically feasible because co-application of MITC (as spade injected metham sodium or incorporated dazomet) with Pic and 1,3-D/Pic has caused significant phytotoxicity in runner crops (see Part C 8a & b for details).
- Recent research has shown that application of MITC before 1,3-D/Pic and DMDS/Pic did not reduce its phytotoxicity to strawberry crops at Toolangi.
- Not approved for use by the runner Certification Authority. Its use would result in a complete loss to growers because runners are unmarketable.

Pic or 1,3-D co-applied with herbicides

- Recent research has shown that the integrated use of the pre-emergent herbicide isoxaben and the post-emergent herbicides phenmedipham and fluazifop-p with Pic or 1,3-D/Pic can improve weed control without causing phytotoxicity in runner crops (Part C 8a & b).
- Not technically feasible because these combinations do not control pathogens to the same soil depth as MB/Pic (Part C 8a & b).
- Isoxaben and phenmedipham are not yet registered for use in strawberries, but current research is generating efficacy data to support their possible registration.
- Not approved for use by the runner Certification Authority because they are not registered.
- Other herbicides co-applied with Pic or 1,3-D/Pic, including pinene, chlorothal dimethyl, metolachlor, napropamide, oxyfluorfen and terbacil caused phytotoxicity or lower yields in runners compared with MB/Pic, and are not technically feasible (Part C 8a & b).

Ethanedinitrile (EDN)

- Showing promise, but not yet technically feasible because of inadequate pathogen control compared with MB/Pic, particularly at greater soil depths (Part C 8c).
- Not registered and not available to Victorian runner growers, but current research is generating efficacy data to support its possible registration. A registration application for EDN has been submitted to the Australian Pesticides and Veterinary Medicines Authority (APVMA).
- Degradation studies of EDN in soil and water have now been completed (Ajwa et al., 2016) and this is expected to allow registration evaluations by the APVMA to proceed.
- The registrant of EDN in Australia has changed from BOC/Linde to Draslovka Services.

Dimethyl Disulphide (DMDS)

- DMDS and DMDS/Pic were imported into Australia in 2014 for trial purposes.
- Not technically feasible due to inadequate pathogen and weed control compared with MB/Pic, particularly at greater soil depths (Part C 8d).
- Not registered and not available to Victorian runner growers, but current research is generating efficacy data to support its possible registration. The chemical registrants (Arkema) are conducting business analyses to determine the economic viability of registration and commercialisation of DMDS and DMDS/Pic in Australia.
- Long way from registration because DMDS is a new chemistry in Australia.

Propylene oxide (PPO)

- Plans were in place to import PPO and PPO/Pic into Australia for trials in the runner industry in 2016/17. However, instability of formulations of PPO in-cylinder prevented this importation. The registrant is conducting studies to improve the stability of PPO in-cylinder before this fumigant can be imported into Australia.
- Not registered and not available to Victorian runner growers. Registration applications for PPO and PPO/Pic could only be prepared when two years of efficacy trials are completed.
- Very long way from registration.

Methyl iodide

- Withdrawn from registration in 2012 and not currently available to Victorian runner growers.
- Due to the high efficacy of methyl iodide, the runner industry has commissioned a study on the viability of re-registration and commercialisation of methyl iodide in Australia specifically for the runner industry (see Part C 8g). This would require the identification of potential manufacturers of methyl iodide in Australia or overseas, analysis of the suitability of previous data to support registration, and negotiation of commissions and IP transfers with the former registrant. The results of the study are anticipated to be available by May 2017.

Recaptured Methyl Bromide from Quarantine Applications

- Registration of this by-product is required because the properties of recaptured methyl bromide on activated carbon must be reviewed compared with the known properties of virgin methyl bromide.
- Long way from commercial availability because there is no commitment from chemical companies to improve the consistency of formulation to support registration.
- Not registered and not available to Victorian runner growers.

Non-Fumigant Alternatives

Soil-less Systems

- Already adopted for commercial production of Nucleus and Foundation stock runners (first and second generation, respectively) in the multiplication Scheme.
- Plans are in place to adopt soil-less technologies for the production of Mother stock runners (third generation in the scheme) by 2019.
- Partial budget analysis shows that soil-less systems (plug plants) are currently not economically feasible (3-times more costly than bare-rooted runners grown in MB/Pic-treated soil) for production of the last generation of runners (Certified stock) (see Part E 16).
- Not technically feasible for Certified stock because the subsequent fruit yields from runners produced in soil-less systems are lower or equal to those from bare-rooted runners produced in MB/Pic-treated soil (Part C 8g).
- There is no commercial interest from Australian strawberry growers to produce fruit using plug plants (produced in soil-less systems) until all the technical and economic issues are resolved.

Biofumigation

- Biofumigant crops do not release the same concentration of isothiocyanates into soil as commercial fumigants. Consequently, biofumigants have not produced the same level of pathogen and weed control as commercial fumigants (Mattner et al., 2008).
- Current trials (2016/17) are evaluating the integrated use of biofumigants with substitute fumigants (particularly TriForm 80) for application in the strawberry runner industry.

Microwave

- A prototype machine (Fig. 1) has been developed to evaluate this technique integrated with the use of substitute fumigants in the runner industry at Toolangi, Victoria in 2016/17.

Figure 1. Prototype unit under evaluation to disinfestation soil using microwave at Toolangi, Victoria in 2016/17.

Anaerobic Soil Disinfestation

- Pot trials with this method have commenced, but so far have delivered inconsistent pathogen control.
- Component of a new proposed research program to manage *Macrophomina* in the strawberry fruit industry [AUS02 CUN17, A24].
- Long way from commercial trials due to difficulties with implementation on steep slopes.

Steam

- Plans are in place to adopt steam treatments for disinfestation of soil-less mixes for production of Nucleus and Foundation runners by 2018. This method will also be adopted to disinfest soil-less mixes for production of Mother stock by 2019.
- Very difficult to implement for soil disinfestation in the clay soils and steep slopes at Toolangi for production of the Certified generation of runners. However, there is a watching brief on research with steam in the Californian strawberry runner industry, and negotiations have commenced with Marten Barel to develop a prototype machine for evaluation in the specific soil type at Toolangi.

Emission Reduction Strategies

Lower Dose Methyl Bromide

- Research from three consecutive years of trials does not support bioequivalency and registration of rates below 25 g MB.m^{-2} (see AUS02 CUN15).

- Rates below 25 g $MB.m^{-2}$ not registered and not available to Victorian runner growers.

Rotation of MB with alternative fumigants

- Not currently technically feasible because of lower pathogen control and failure to control volunteer strawberries (see AUS02 CUN18 for details).

Impermeable Barrier Films

- Previous trials demonstrated that impermeable barrier films do not retain MB for longer periods in the high organic soils at Toolangi than standard LDPE films (AUS02 CUN16).
- Currently impermeable barrier films do not offer a reliable mechanism for reducing application rates of MB because they do not remain in place for long enough in the runner industry (due to high winds).
- Rates below 25 g $MB.m^{-2}$ are not registered and not available to Victorian runner growers under impermeable barrier films or standard LDPE films.