

Fumigant Substitutes

1,3-D/Pic Products

- Formulations containing 100:0, 65:35, 40:60, and 20:80 mixtures of 1,3-D/Pic are registered for use in soils in Australia.
- Not technically feasible due to inadequate pathogen control at greater soil depths, higher incidences of soil-borne disease in runner crops and subsequent fruit crops, and crop phytotoxicity.
- Not approved for use by the runner certification authority because of they are less effective in controlling pathogens than MB/Pic. Their use would result in a complete loss to growers because runners are unmarketable.

Chloropicrin (Pic)

- Registered for use in soils in Australia.
- Not technically feasible because it does not control pathogens and weeds as effectively as MB/Pic and reduces runner yields and subsequent fruit yields.
- 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 methyl isothiocyanate (MITC) generators

- The MITC-generators, dazomet, metham sodium and metham potassium, are registered for use in soil in Australia.
- 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 at Toolangi, Victoria.
- Not technically feasible because application of MITC (as spade injected metham sodium or incorporated dazomet) on its own or co-applied with Pic and 1,3-D/Pic caused significant phytotoxicity in runner crops, and does not control soil-borne pathogens as effectively as MB/Pic.
- 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/Pic co-applied with herbicides

- The integrated use of the pre-emergent herbicide isoxaben and the post-emergent herbicides phenmedipham and fluzifop-p with Pic or 1,3-D/Pic (20:80) can improve weed control without causing phytotoxicity to runner crops.
- Not technically feasible because these combinations do not control soil-borne pathogens as effectively as MB/Pic.
- Isoxaben and phenmedipham are not yet registered for use in strawberries, but current research is generating efficacy data (residue data) to support their possible registration.
- Fluzifop-p is registered for strawberry, but does not provide adequate weed control unless integrated with the use of phenmedipham, isoxaben and Pic or 1,3-D/Pic (20:80).
- Not approved for use by the runner certification authority. Its use would result in a complete loss to growers because runners are unmarketable.

Ethanedinitrile (EDN)

- Not registered for use in soils in Australia.
- Showing promise, but not yet technically feasible because of inadequate pathogen control compared with MB/Pic, particularly at greater soil depths.
- Current research is evaluating co-application of EDN and Pic, which may improve its efficacy.
- Not approved for use by the runner certification authority because it is not yet effective and not registered.

Dimethyl Disulphide (DMDS)

- Not registered for use in Australia.
- 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.
- Registration of DMDS and DMDS/Pic has commenced, but is expected to take a long time. Not available to runner growers.

Methyl iodide

- Application for registration in Australia withdrawn in 2012 by Arysta LifeSciences and not currently available to Victorian runner growers.
- Not approved for use by the runner certification authority because it is not registered.

- Technically feasible for use in the Victorian runner industry because it has been shown to control soil-borne pathogens and weeds as effectively as MB/Pic without causing crop phytotoxicity.
- The Victorian runner industry has secured registration data and applications from Arysta LifeSciences and aims to register the product in Australia by 2021.
- Key component of industry's plan to transition away from MB/Pic.

Recaptured Methyl Bromide from Quarantine Applications

- QPS uses of MB are not restricted under the Montreal Protocol.
- Research has and is examining the amendment of soils with carbon waste containing recaptured QPS MB as an alternative to soil disinfestation with non-QPS MB.
- Registration of this by-product is required because the properties of recaptured MB on activated carbon must be reviewed compared with the known properties of virgin MB.
- Long way from commercial availability because there is no current commitment from chemical companies to improve the consistency of formulation to support registration.
- Not registered and not available to Victorian runner growers.

Propylene oxide (PPO)

- Not registered for use in soils in Australia.
- 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 potential registration, and not available to runner growers.

Allyl isothiocyanate (AITC) and AITC/Pic

- Dominus® (AITC) and Ally® (AITC/Pic) are currently being imported into Australia for trials, which will commence in 2018/19.
- 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 in the multiplication scheme (first and second generations, respectively).

- Commercial trials of soil-less systems will be completed for production of mother stock runners (third generation) in 2018. Full adoption for mother stock production will occur in 2019.
- Partial budget analysis shows that soil-less systems (plug plants) are currently not economically feasible (three 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 mostly lower than those from bare-rooted runners produced in MB/Pic-treated soil (Part C 8g).

The use of plug plants (produced in soil-less systems) by Australian strawberry fruit growers will not be a commercial proposition until technical and economic issues are resolved.

Biofumigation

- Not technically feasible due to inadequate weed and pathogen control.
- Biofumigant crops do not release the same concentration of isothiocyanates into soil as commercial fumigants. Consequently, biofumigants have not resulted in the same level of pathogen and weed control as commercial fumigants (Mattner et al., 2008).
- Integration of biofumigant crops with substitute fumigants does not provide adequate control of soil-borne pathogens compared with MB/Pic.

Microwave

- A prototype machine (Fig. 1) has been developed to evaluate the potential of microwave for soil disinfestation.
- Not currently technically feasible due to inadequate control of soil-borne pathogens compared with MB/Pic.
- Analysis is underway on the economics of systems that could heat soils to adequate levels to control pathogens.



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

Anaerobic Soil Disinfestation

- Pot trials with this method have commenced, but so far have delivered inconsistent pathogen control.
- Long way from commercial trials due to difficulties with implementation on steep slopes, which occur in the Victorian runner industry.

Steam

- Very difficult to implement for soil disinfestation in clay soils containing rocks and steep slopes at Toolangi for production of the certified generation of runners.
- Presently, too slow and input intensive (fuel and water) for application on large areas of land.
- Economic evaluation and trials with steam compared with microwave are currently underway.
- Study tours have been conducted to view steam units in Europe and California, but these are currently not economically viable (Stanghellini, 2017).

Emission Reduction Strategies

Lower Dose Methyl Bromide

- On-going research 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.