THE STERILE INSECT TECHNIQUE

A tool to benefit Australian Horticulture

Fruit flies are a major pest issue for Australian horticultural industries and impact 99% of commercially produced fruits and nearly half of our vegetables. Commercially this represents a sizeable part of our agricultural production value and constrains industry expansion, not only reducing our market opportunities for trade but also increasing our food security risk.

Whilst there are over 4000 species of tephritid fruit flies globally, only around 350 are recognized as economically important horticultural pests, with some of the most serious pests affecting hundreds of crops types.

In Australia the two major pests are the native Queensland Fruit Fly (*Bactrocera tryoni*) and the introduced Mediterranean Fruit Fly (*Ceratitis capitata*), as well as other minor pest species. However numerous pest fruit fly species have the potential to arrive and establish in Australia, including the highly destructive Oriental Fruit Fly (*Bactrocera dorsalis*).

Oriental Fruit fly is well established just to the north of Australia in Papua New Guinea and, having previously reached Australian shores as a major outbreak in the Cairns region, is the subject of extensive prevention response activity including trapping monitoring and baiting.

Fruit flies are managed using a range of practices including cover sprays, male annihilation technique (MAT), bait sprays, and cultural practices such as crop hygiene and removal or non-crop hosts. However, as we progress into an increasingly chemically limited future, sustainable control techniques will become increasingly important and move to the forefront of use. One such example is the Sterile Insect Technique (SIT).

A significant amount of research has been invested over the past decade to develop SIT to combat pest fruit flies in Australia through the efforts of Hort Innovation's SITplus program, as well as the collective efforts of researchers in universities and government research agencies.

This research has raised local fruit fly SIT practices to a world leading standard, immensely improving performance compared with previous practises.

However, despite the benefits of SIT, there remain some challenges around wide scale implementation of this pest management approach in Australia.

History

SIT is a proven pest control practice dating back to the work of Edward Knipling, who refined the technique for use against New World Screw Worm, *Cochliomyia hominivorax* in the United States during the 1950's and 1960's.

Through SIT, New World Screw Worm was eradicated first in USA, then through Mexico, and its northernmost distribution is now held at Panama.

Since this time the technique has been developed further with use in diverse pest insect species, across different cropping systems and environments amongst numerous nations.

Australia was an early supporter of SIT, with initial research and field trials of the technique targeting QFly in the 1960's (Andrewartha H.G., Monro J Richardson NL 1967). This research saw researchers from the University of Adelaide conduct large scale field trials in NSW which showed promise despite being some of the earliest attempts to develop SIT for management of fruit flies.

Since then, Australian SIT use expanded to combat Mediterranean Fruit Fly in Western Australia and South Australia and was considered for contingency use during the Oriental Fruit Fly (then known as Papaya Fruit Fly) incursion to manage rainforest areas in the 1990's.

SIT has also been used to combat outbreaks of QFly in Western Australia, is currently in use as part of the South Australian response to recent QFly incursions. Australia has also seen research and employment of SIT for use in controlling Sheep Blow Fly, Apple Codling Moth, and Mosquitos.

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How does SIT work?

SIT is a pest control method in which massive numbers of a targeted pest insect species are grown, sterilised, and released into an area. The sterilised insects compete with their wild counterparts for mates, but coupling does not produce any viable offspring.

Over time this reproductive disruption leads to a decrease in the wild population numbers, eventually causing the population in the target area to collapse.

The sterilisation step is usually performed by irradiation, through gamma rays or x-rays, however, genetic methods are being investigated to replace this step.

The released flies need to be of high quality to survive in nature and to be accepted as mates by wild females. They also need to be produced in vast numbers to 'overflood' the pest population. This occurs when more sterile males than wild males are available as mates for wild females, reducing the likelihood of females mating with a fertile wild male, and increasing the effectiveness of SIT.

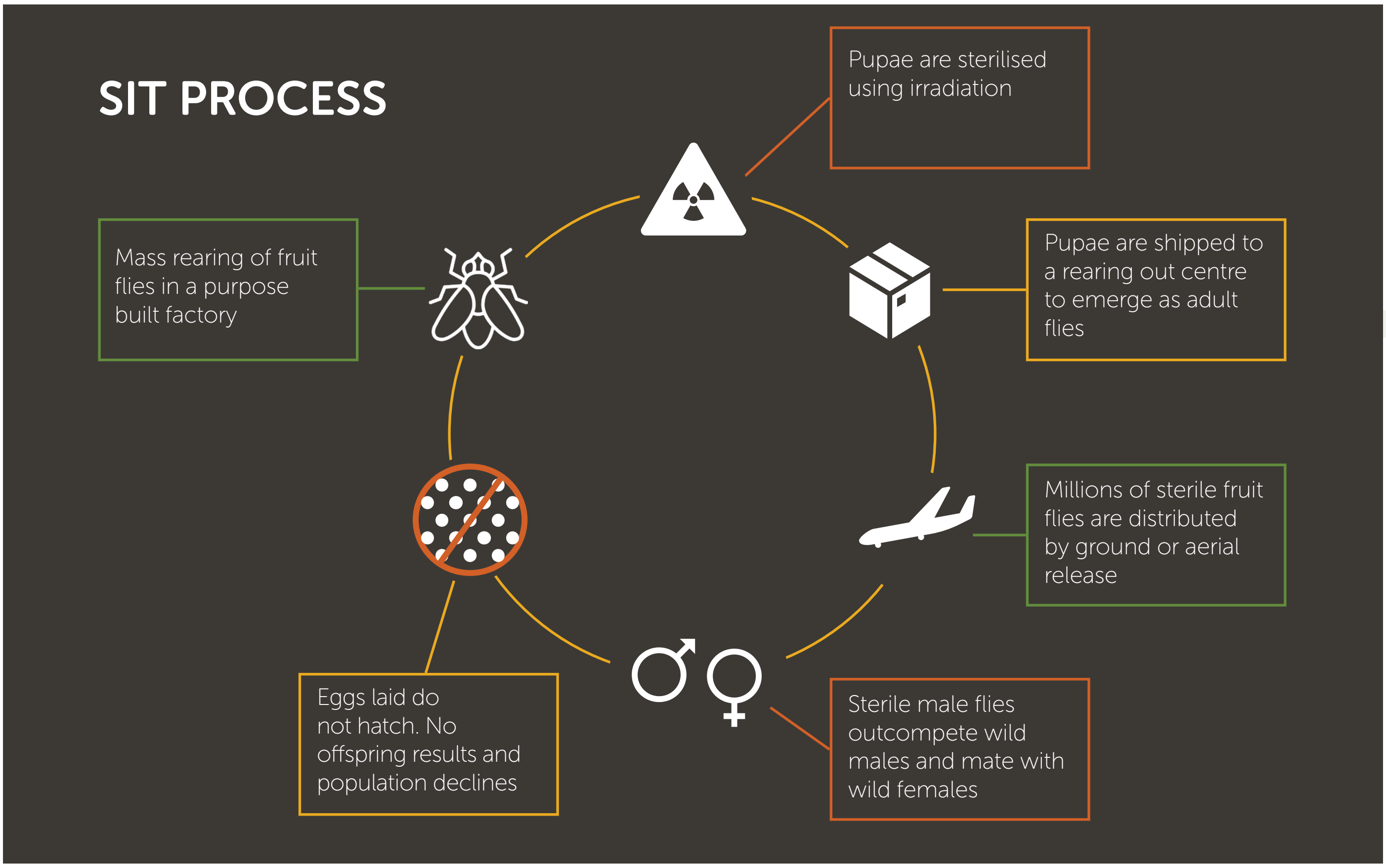
See diagram below:

How is SIT used?

SIT can be employed for different purposes depending upon the situation and the ultimate objective of the control program being implemented. The FAO 2021 publication *ISPM 26 Establishment of pest free areas for fruit flies (Tephritidae)* notes four key uses of SIT:

- suppression, where SIT may be a stand-alone phytosanitary procedure or combined with other phytosanitary procedures to achieve and maintain low population levels
- containment, where SIT may be particularly effective in areas that are largely pest free (such as buffer zones) but that are subjected to regular pest entries from adjacent infested areas
- exclusion, where SIT may be applied in endangered areas that are subject to high pest pressure from neighbouring areas.
- eradication, where SIT may be applied when population levels are low, to eradicate the remaining population.

Each of these applications for SIT has a very different purpose and is employed to achieve a different objective.



Pest species

A range of insects have been controlled using SIT, these include pests of horticulture as well as pests of livestock and humans. Some examples include:

- Tephritid fruit flies (Queensland-, Mediterranean-, Oriental-, Melon-, and Mexican fruit fly)
- Codling moth
- Boll weevil
- New world screw worm
- Sheep blow fly
- Mosquitos
- Tsetse fly.

Case studies of SIT use

SIT has been successfully employed in numerous locations around the world. The following table presents examples of existing SIT operations to combat fruit flies:

Location	Purpose	Target Pest
Japan	Eradication	Melon fly *(Zeugodacus cucurbitae)*
USA California	Prevention	Mediterranean fruit fly *(Ceratitis capitata)*
Mexico	Prevention	Mediterranean fruit fly *(Ceratitis capitata)*
Mexico	Suppression	Mexican fruit fly *(Anastrepha ludens)*
Israel	Suppression	Mediterranean fruit fly *(Ceratitis capitata)*
South Africa	Suppression	Mediterranean fruit fly *(Ceratitis capitata)*
Croatia	Suppression	Mediterranean fruit fly *(Ceratitis capitata)*
Peru	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Peru	Prevention	Mediterranean fruit fly *(Ceratitis capitata)*
Argentina	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Chile	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Dominican Republic	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Spain (Valencia)	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Australia	Suppression	Queensland fruit fly *(Bactrocera tryoni)*
Australia	Eradication	Queensland fruit fly *(Ceratitis capitata)*
Australia	Eradication	Mediterranean fruit fly *(Ceratitis capitata)*
Madagascar	Eradication	Oriental Fruit Fly *(Bactrocera dorsalis)*

Benefits of SIT

SIT has many benefits as a pest management tool, including:

- no off-target impacts
- integrates well with IPM approaches and as part of a systems-based approach
- alternative or supplement to other control options
- suitable for use in Area Wide Management (AWM) programs
- can control pest sources not on-farm e.g. backyard fruit trees, feral fruit trees, native hosts
- trade access and marketing benefits for economically lucrative premium markets with no chemical residues
- acceptable for use in sensitive areas for example. suburban areas and ecological critical areas such as national parks.

Challenges with SIT

SIT is not without challenges, and some of these include:

- monitoring and trapping networks
- single pest target
- time to achieve pest reductions and release timing.
- use in pest-free areas
- incompatibility with the Male Annihilation Technique (MAT) at the same time
- SIT works best when used in combination with other techniques, which means it is usually not a single standalone solution
- infrastructure and logistical needs – factory, irradiation source, distribution method, transport to rearing out and release sites, trained staff
- knowledge intensive (similar to IPM)
- who pays and how much?

Risks

At present there are some risks that need to be addressed before SIT is more broadly available as a tool for on-farm fruit fly management:

- conditions of use along with trading partner acceptance and regulatory uncertainty

- funding - will it be a commercial delivery model or government/public/private partnership?
- sustainable delivery mechanisms – AWM coordination
- incomplete knowledge about pest management, SIT and genetic approaches by growers, legislators and the general public
- incorporating SIT into fruit fly management practices (SIT readiness).

Improvements to the technique

As with any innovation there is a need for ongoing improvements to further refine and enhance SIT's performance and application. The following points highlight some of the current and future opportunities for improvement:

- genetic sexing strains (male-only lines) so that only males flies are released:
  - pupal colour variation between male and female flies to allow visual sorting
  - Temperature Sensitive Lethal (TSL) strain to kill of any female eggs when exposed to a particular temperature threshold ensuring that only males progress
- GM lines (sterile). This has already been developed for Medfly but opportunity remains for development with other species and broader deployment in the field
- reduced lure responsiveness so that SIT might be combined with Male Annihilation Technique (MAT)
- sterile fly identification:
  - isotopic markers to confirm factory bred origins
  - incorporation of distinct genetic markers
  - noticeable differences for easy visual identification (Yellow strain)
- improved diets for optimising performance, consistency and reducing the cost of rearing. This includes further enhancing gel-based diets
- improved fitness for longevity, resilience, and sexual competitiveness in the field
- virus management within the production facility as insects can get viruses as well
- operational improvements to improve the operation, and cost effectiveness of SIT programs:
  - reducing rear-out times
  - release timing (prior to start of season)
  - overflooding ratios i.e. how many sterile to wild flies are required to reduce wild poplulations, and release frequency
  - survivability of pupae and flies in transit
  - development of Standard Operating Procedures
  - ongoing refinement of quality control
  - improved and diverse release mechanisms (aerial, drones, ground release) to ensure fit for purpose delivery
  - combination with other tools
- multi-species facilities/insectaries facilitating the production of other species for SIT as well as parasitoids, entomopathogenic nematodes and mass reared insects for other purposes such as waste management
- automation of processes to reduce labour costs
- support for local AWM programs (multi-species).

The National Fruit Fly Council

Convened through Plant Health Australia (PHA), the National Fruit Fly Council (NFFC) brings together governments, growers and research funders to oversee implementation of the National Fruit Fly Strategy and to drive delivery of a cost-effective and sustainable approach to managing fruit flies across Australia.

The Council provides leadership and advice on strategic policy, research, development and extension issues around fruit fly, connecting with a range of stakeholders that include the National Biosecurity Committee, Plant Health Committee, Hort Innovation, industry and the community.

The NFFC is funded through Hort Innovation with contributions from fruit fly affected industry research and development levies, PHA, state and territory governments, and the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

References

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