Pesticide Application

Singapore's tropical climate presents unique year-round pest challenges for our urban farms. Common agricultural pests, including aphids, whiteflies, and diamondback moths, can rapidly impact crop yields in controlled environment agriculture (CEA) systems. Additionally, our limited growing space and diverse farming practices require effective pest management and solutions that balance both productivity and food safety standards.

Pesticides should be used as a last resort and chosen to target only persistent pests. It should be incorporated into a comprehensive integrated pest management (IPM) strategy. This approach reduces reliance on chemical pesticides while addressing resistance development. Once pest numbers and plant damage decrease, emphasis should shift to preventive and sustainable long-term management techniques.

Each pest situation is unique, varying with crop types, weather conditions, and farming practices. The following guide provides step-by-step instructions for selecting appropriate pesticides for your specific pest management needs.

What is a Pesticide?

A pesticide is any substance or mixture of substances prepared or used for preventing, destroying, repelling or mitigating any pest and any substance or mixture of substances prepared or used as a plant regulator, defoliant or desiccant. Different types of pesticides can be selected based on the target pests, as classified below.

*definition from Control of Plant Acts

Insecticides and Acaricides
(for insects and mites)

Fungicides (for fungi)

Herbicides (for weeds)
Not commonly encountered in CEA

Step 1: Identify pests of concern

Pests respond differently to various pesticides based on their physical characteristics and behaviour. Some pests have hard exoskeletons that prevent pesticide entry via contact. Others may fly or shelter beneath leaves. Pest physiology, behaviour and lifecycle all influence pesticide selection, timing and application methods.

For pest identification, look for direct signs of pests (e.g. larvae, frass) or plant symptoms (e.g. yellowing/wilting leaves, bite marks, speckled/mottled patterns). For more detailed information on monitoring and identification, refer to the *Guide to Integrated Pest Management (IPM) for Singapore Vegetable Farms* on SFA's website.

NOTE: Pesticide applications can only be conducted by or under the supervision of an SFA-certified pesticide operator. To obtain Pesticide Operator Certificate, refer to https://www.sfa.gov.sg/farming/pesticides/certification-of-pesticides-operators

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Step 2: Select appropriate pesticide to target identified pests

Below is a list of common pesticides and their targeted pests.

Active Ingredient	Target pests	Mode of Action
Insecticides		
Abamectin	leaf miners, spider mites, thrips, white flies	nerve & muscle inhibitor
Bacillus thuringiensis (Bt)	caterpillars and moths (e.g. diamondback moth)	midgut disruptor
Cypermethrin	aphids, scale insects, white flies	nerve & muscle inhibitor
Cyromazine	fungus gnats, leaf miners	growth disruptor
Emamectin benzoate	aphids, caterpillars and moths (e.g. diamondback moth), leaf miners, spider mites, thrips, white flies	nerve & muscle inhibitor
Indoxacarb	caterpillars and moths (e.g. diamondback moth)	nerve & muscle inhibitor
Permethrin	aphids, mealybugs, white flies	nerve & muscle inhibitor
Spinosad	caterpillars and moths (e.g. diamondback moth), leaf miners, spider mites, thrips	nerve & muscle inhibitor
Fungicides		
Carbendazim	anthracnose, fungal wilts, leaf spot diseases, root rots	growth inhibitor
Chlorothalonil	foliar diseases, powdery mildews	multi-function inhibitor
Metalaxyl+Mancozeb	*Phytophthora* root and stem diseases	nucleic acids metabolism + multi-function inhibitor
Propineb	blight, downy mildew, foliar diseases, rust diseases	multi-function inhibitor
Thiram	foliar diseases, rust diseases	multi-function inhibitor
Thiophanate-methyl	anthracnose, downy mildew, leaf spot diseases, powdery mildew	growth inhibitor

NOTE: Farms must only use registered pesticides. For the complete list of registered pesticides, please refer to the following link: https://www.sfa.gov.sg/tools-and-resources/pesticides-search.

Things to consider when deciding on most appropriate pesticide:

Active ingredient(s) are ingredients that target the pest(s). Other ingredients serve other functions (e.g. stabilise, help with storage).

Mode of action(s) determine how the pesticides target or affect the pests and are divided into various categories.

Formulation determines the application. Liquids are convenient for spraying over large or targeted areas. Solids may be granules which act as insect bait or dissolved in water to be sprayed. Storage may also vary between the two formulations.

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Step 3: Apply the pesticide under the right conditions and at the recommended timing

Most effective use of pesticides is achieved from proper application. Proper application also ensures worker safety, environmental protection, and food safety. Where in doubt, always defer to pesticide labels.

Before

- Check there is no/low wind, and the farm is dry (i.e. from rain, overhead watering) to avoid pesticides being blown or run off targeted locations.
- Ensure temperature is cool (i.e. early morning or late evening). High temperatures increases pesticide evaporation and volatility. The cooler conditions also minimize plant stress. Both help maximize pesticide effectiveness.
- Verify that time between pesticide application and harvest meets the required Preharvest Interval (PHI)

> **Preharvest Interval (PHI)** = the minimum amount of time between pesticide application and when crop can be harvested. This ensures that the resulting residue on the crop does not exceed the maximum residue limit.

- Equip appropriate Personal Protective Equipment (PPE). See below for details.
- Follow pesticide label instructions, and do not mix with other chemicals (e.g. pesticides, fertilizers) which can lead to unwanted chemical reactions.
- Use pesticides directly after mixing or as per instructions. Do not leave mixed pesticide overnight.

During

- Apply to hard-to-see areas such as under leaves, on stems and between flowers and fruits.
- Follow pesticide instructions for optimal results.

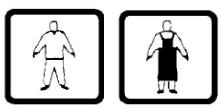
After

- Thoroughly wash any equipment (e.g. sprayers) and PPEs after pesticide application. This prevents residue when performing next round of application.
- Avoid entry into pesticide-applicated area, known as Restricted Entry Interval (REI). Refer to pesticide labels.

Personal Protective Equipment (PPE)

Required PPE varies based on pesticide toxicity and application method. Always check the product label and Safety Data Sheet (SDS) for specific PPEs requirements, which may include:

Gloves, chemical resistant



Protective suits or aprons, chemical resistant

Boots, chemical resistant

Eye protection (googles, face shield)

Masks/ respirators

Ear protection, if using heavy machinery

Image from Guidelines for personal protectionwhen handling and applying pesticides (WHO)

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Step 4: Maintain records of all pesticide applications

Maintaining detailed pesticide application records is essential for regulatory compliance and effective farm management. These records demonstrate food safety adherence, enable tracking of treatment effectiveness, provide traceability for incidents, and support long-term pest management planning. They also serve as crucial documentation for audits and help monitor potential pest resistance development.

Records should include: farm name, certified pesticide operator, pesticide name, registration number and supplier, date of purchase, and for each application - the date used, quantity used, remaining balance, and applicator name.

Records are subjected to checks by SFA.

Dispose any unused pesticides through a chemical disposal company licensed by the National Environment Agency (NEA). Keep letter/certificate from disposal company for record purposes.

Avoid Pesticide Resistance

Pests can develop resistance to pesticides over time. This happens when individual pests containing pesticide-resistance traits survive a pesticide application and successfully produce the next generation, that is also resistant to said pesticide. As pests' reproduction are often in days, not months, the resistant populations can establish quickly.

To avoid pesticide resistance:

- Apply pesticide only when pests population and damage is deemed to be too high for other pest management methods.
- Combine use of pesticides with other pest management methods (e.g. physical netting, crop rotation, sticky traps) for multi-pronged and most effective long-term solution.
- When multiple pesticide applications are needed, alternate pesticides by selecting pesticide with different active ingredients and modes of action.
- When possible, spot treat or leave untreated areas within growing area. This allows pesticide-susceptible individuals to interbreed with resistant ones and dilute the resistance genes in the population.
- Keep records of pesticide use to check for effectiveness and guide future applications.

About the author

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