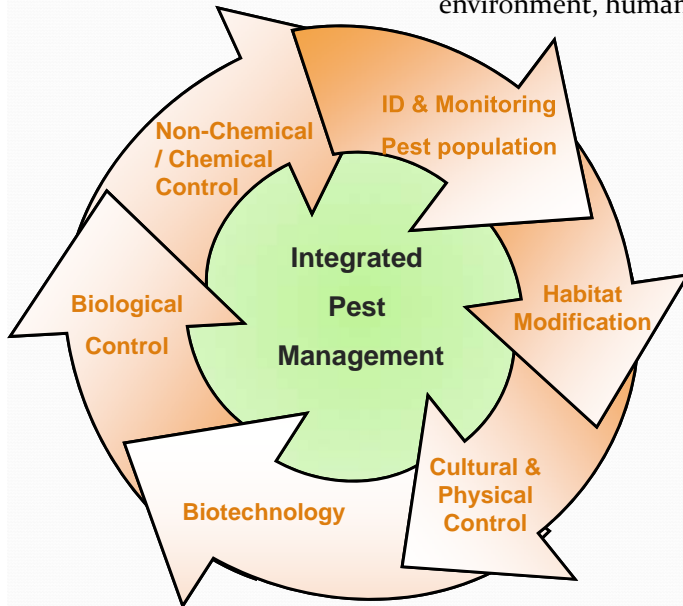


# Integrated Pest Management for Soil & Soil-less Systems



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IPM uses **all possible pest control methods** in a well organized and harmonious way in order to achieve long-term pest control. It is important to understand the crop, pests, control strategies, mode of actions, and pest control limitations. The primary goal of IPM is to retain or improve production without negatively impacting the environment, human and aquaculture safety.



## BENEFITS

- ✓ Effective
- ✓ Flexible
- ✓ Informed decision makers
- ✓ Potential cost savings
- ✓ Environmentally responsible
- ✓ Enhances worker and workplace safety
- ✓ High decision making
  - ✓ Established economic threshold
  - ✓ Selection of the least hazardous control
  - ✓ Chemicals applied on an 'as needed' basis



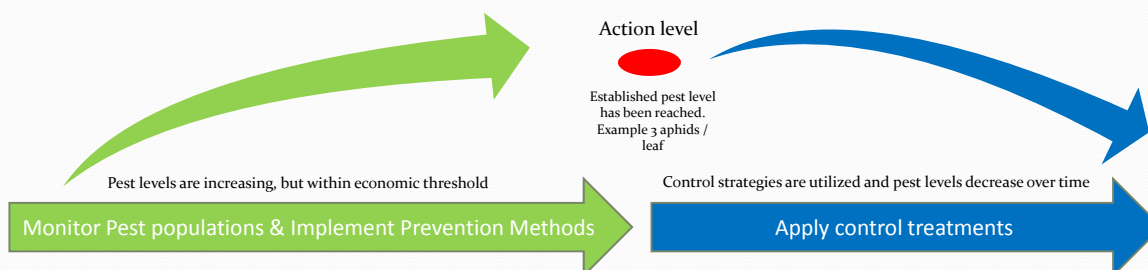
## Monitoring

Monitoring allows growers to: assess pest population levels; determine pest activity; track changes over time, create a field history.

Important to monitor: pest population, level of infestation, plant location, natural enemies, time of the year, contributing conditions, environmental conditions, etc.

## Action Thresholds

Action thresholds are an established levels that a pest population must reach before pest control action is needed.



**PREVENTATIVE TACTICS:**  
 Habitat Modification  
 Physical Measures  
 Cultural Measures  
 Biotechnology  
 Enhance Natural Enemies

**CONTROL STRATEGIES**  
 Release Bio-control agents  
 Implement Non-Chemical Control  
 Chemical Control (as last resort)



# Integrated Pest Management

## Pest Identification: Common Pests

Proper identification and understanding the nature of the pest are the key steps in selecting the best pest management strategy.

### Chewing Pests



Chewing pest feed on the foliage, stems, fruit or roots. Pests within this group include beetles, caterpillars, earwigs, leaf miners, etc.

### Ants



Ants are honeydew consumers and protect pests from natural enemies. Honey dew secretions promote sooty mold development. There are: sugar vs. fat loving ants.

### Sucking Pests



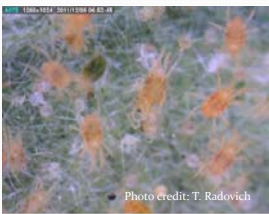
These pest pierce plant's vascular tissue and withdraw plant sap. They cause plants to discolor, twist and distort. Pests within this group include aphids, whiteflies, mealy bugs, scales and leaf hoppers.

### Fruit Flies



There are 4 fruit flies in Hawaii: Oriental fruit fly, Melon fly, Mediterranean fruit fly, Malaysian fruit fly. Adult females sting fruits and vegetables resulting in blemishes. Larvae tunnel within fruit.

### Mites



Mites have rasping and sucking mouthparts. Damage results in a brown to russet discoloration of leaves, stems, fruit and flowers.

### Thrips



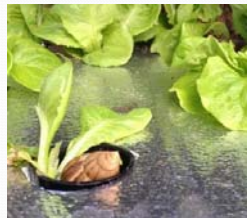
Thrips have rasping and sucking mouthparts. Damage results in discoloration and scarring of leaves, stems, fruit and flowers.

### Nematodes



Roundworms that attack the root system of plants and impair water and nutrient uptake. Symptoms: stunting, poor plant growth, narrow and weak stems, foliar chlorosis, root rotting and galling, plant toppling and poor root development.

### Slugs and Snails



Slugs and snail are problem for low-growing vegetables. They are active in the evenings and are commonly associated with seedlings magically disappearing overnight.

### Plant Hoppers



Plant hoppers damage leaves, stems, fruits, and flowers. They also serve as vectors for plant diseases, especially phytoplasmas.

### Weeds



Weeds (annuals, biennials, perennials, etc.) often outcompete plants for food, sunlight, etc. They are fast growing, prolific seed producers, etc. Some weeds may be alternative hosts for crop pests (insects and diseases).

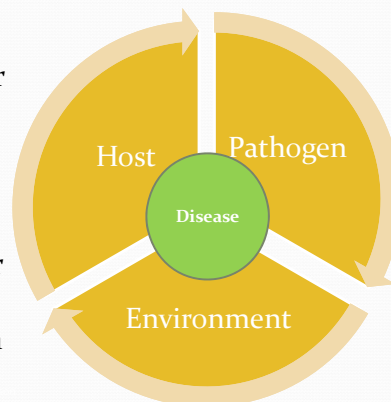


# Integrated Pest Management

## Pest Identification: Common Diseases

Plant diseases are the result of a physiological or morphological change in a plant that results in abnormal growth, appearance or development due to a pathogen. Pathogens are parasitic organisms that cause a disease. Pathogens include: fungi, bacteria, viruses, nematodes, phytoplasma.

The diagram to the right illustrates the three factors required for disease development: a host plant, casual pathogen and a favorable environmental conditions. Managing these factors can also help prevent and suppress disease populations.



### Fungal Pathogens



Common plant disease composed of threadlike structures called hyphae. Reproduce and disperse by spores. Common fungal pathogen include: powdery mildew, downy mildew, *Alternaria*, *Cercospora*, *Phytophthora*, etc.

### Nematode Pathogens



Roundworms that attack the root system of plants and impair water and nutrient uptake. Symptoms: stunting, poor plant growth, narrow and weak stems, foliar chlorosis, root rotting and galling, plant toppling and poor root development.

### Viral Pathogens



Viruses have a nucleic acid surround by a protein coat. They can only survive on living plant tissue. Once infected there is no cure. They are mainly transmitted by insect vectors. Common plant viruses include: Banana Bunch Top Virus, Tomato Spotted Wilt Virus, etc.

### Bacterial Pathogens



Bacterial pathogens reproduce quickly and form masses called colonies. They are spread primarily via rain, or splashing water. They often enter plant tissue through natural openings or injury sites. Examples include: *Xanthomonas*, *Pseudomonas*, *Erwinia*, etc.

### Phytoplasma



Phytoplasma is a bacteria which parasitizes on the phloem of plant tissue via an insect vector. Symptoms range from yellowing of plant tissue, cupping of leaves and even death of infected plants. Leafhoppers are often associated with vectoring of phytoplasmas like the Watercress Aster Yellow (WAY)

### Example of a Plant Vector

Plant vectors are organisms that can transmit a pathogen such as a bacterium, virus, or phytoplasma into a plant.

EXAMPLES:

- Banana aphid → Banana Bunchy Top Virus (BBTV)
- Western flower thrips → Tomato Spotted Wilt Virus (TSWV)
- Aster Yellow Leaf Hopper → Watercress Aster Yellow Phytoplasma
- Onion thrips → Iris Yellow Spot Virus (IYSV)



Banana Aphid

BBTV



# Integrated Pest Management Prevention Strategies

\* Prevention is an important strategy in avoiding and keeping a pest populations below economic threshold levels. Prevention strategies include practices such as but not limited to: field and equipment sanitation, utilizing pest free or resistant planting materials, managing alternative host materials, installation of physical barriers, reflective mulches, crop rotation, modifying crop spacing, trap crops, encouraging beneficial insects, timely crop destruction, etc.

## Habitat Modification



Eliminate pests breeding sites. Eliminate favorable conditions such as pest / disease build up, removal of food or habitat sources, sanitation of fields and adjacent areas, etc.

## Physical Measures



Installation of physical barriers or devices to discourage the pests such as: screens, barriers, sprinkler systems, wires, etc.

## Cultural Measures



Manipulation of cultural practices to disadvantage the pest such as: crop rotation, fallow periods, crop spacing, companion planting, crop selection, aeration, worms-waste converter, reflective mulches, etc.

## Biotechnology



Application of scientific techniques to modify and improve plants, insects and pathogens such as selective breeding (hybridization), variety screening, genetically modified crops, etc.

## Encouraging Beneficial Insects



The use of natural predators, parasites, parasitoids, etc. to manage pests. Examples include ladybugs, hoverflies, spiders, etc.

## EXAMPLES



Timely knockdown & clean plants



Screen & Hoop Houses



Reflective Mulch & Trap Crops



Hybridization & Variety Selection





# Integrated Pest Management Control Strategies

\* Control strategies are often utilized after action thresholds are surpassed. IPM aims to utilize all possible pest control methods in a well organized and harmonious way in order to achieve long-term pest control. Chemicals are not prohibited but often used as a last resort.

## Biological Releases

The use of natural predators, parasites, parasitoids, etc. to manage pests. Examples include ladybugs, hoverflies, spiders, etc.



## Other Non-Chemical Measures i.e., Mulch, Hot Water Treatments

Out of the box, non-chemical control strategy are also utilized in IPM. Pesticide are not encouraged in aquaculture systems. However, it is allowed if label language does not prohibit it and the crop is listed on the label.



## Chemical Measures

Use of a chemical to prevent, destroy, or repel pests. Typically considered after other control methods. Low toxicity chemicals are considered first. If available, use selective vs. broad spectrum chemicals. Chemicals should always be rotated with other chemicals to minimize resistance issues. Application and timing intervals are important.



## Pesticide Safety Reminders:

A pesticide is defined as a chemical used to prevent, destroy, or repel pests in all types of systems and farming operations.

- Read and follow the label
- Calculate the treatment area
- Calibrate your equipment
- Do not apply more than the maximum allowable limit



Wear **REQUIRED** Personal Protective Equipment (PPE).



Crop	Target Pests	Use Rate	REI	Remarks
Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.
Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.
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Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.

Follow Re-entry Intervals (REI), Pre-harvest Intervals (PHI), and post appropriate signage according to crop labels.

**EXAMPLE ONLY:** Crop sprayed

REI: 24 hours OK to enter field

DO NOT HARVEST: PHI: 4 days

OK to harvest / sell

## Pesticide Use in Aquaponics are allowed IF:

- Label language does not prohibit it
- If there is a reference that the pesticide is harmful to fish, then be aware of consequences if used.
- Crop is listed on the label

Crop	Target Pests	Use Rate	REI	Remarks
Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.
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Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.
Apple & Apple branch	Apple Maggot	0.5-1.0 lb/1000 sq ft	48 hours	Do not apply more than 1.0 lb/1000 sq ft of product/season.

**ENVIRONMENTAL HAZARDS**  
This product is hazardous to fish and aquatic invertebrates.  
For Terrestrial Uses: Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate.



**\*\* NOTE: Workers who enter fields within the specific REI MUST wear appropriate PPE.**





# Integrated Pest Management Chemical Control Strategies

## Reduced Risk Products (1 of 2)



### **Bacillus subtilis/ pumilus**

Derived from a soil bacterium that is antagonistic to fungal and disease pathogens by means of nutrient competition, site exclusion, colonization, attachment of the bacteria to the fungal pathogen, etc.

Example: Serenade Max (o), Sonata (o)

### **Bacillus thuringiensis (Bt)**

Derived from a bacterium which is selectively toxic to many moth and larvae. When ingested, Bt produces an endotoxin in the insects gut which is toxic to the insect

Examples: Dipel (o), Crymax, XenTari (o)

### **Beauveria bassiana**

Spores of the Beauveria bassiana come into contact with the body of an insect host, germinate, enter the body, and grow inside, eventually killing the insect. The fungus multiplies and destroys the internal structures of the host under high humidity environments

Examples: BotaniGard, Mycotrol (o)

### **Copper products**

Controls blights, mildew, anthracnose, but commonly associated with bacteria control

Example: Basic Copper 53 (o), Nucop 50DF (o), Champ WG (o)

### **Diatomaceous earth:**

Naturally occurring substance comprised of the fossilized remains of diatoms. Insects such as roaches, ants, silverfish, fleas, etc. come in contact with this powder and die from desiccation.

### **EM, Compost Teas:**

Fungicidal and nutritional supplement

Examples: Bokashi, Agripower

### **Horticultural Oils:**

Cover, wet, and suffocate, over wintering eggs, nymphs and adults. Effective on scale insects.

Examples: Volck oil, JMS Stylet-oil (o), Biocover

### **Hydrogen Dioxide**

Oxidizes rapidly on contact.

Examples: Oxidate (o)

### **Insecticidal Soaps:**

Potassium Salts of Fatty Acids typically disrupt membranes of soft body pests leading to rapid death by evaporation.

Example: Mpede (o)

### **Kaolin Clay:**

Common food additive approved by the FDA. It primarily serves as a protective barrier, distracts pest from the host plant and deters pest movement and damaging behavior.

Examples: Surround WP (o)

### **Neem Oil/ Azadirachtin: (IGR) \*\* many labels say it is toxic to fish**

Disrupts insects' hormonal balance so they die before they molt, suppresses some insects' desire to feed, and it also repels. It has fungicidal properties as well.

Examples: Trilogy (o), Neemix (o), Debug Turbo (o), Molt-X (o)

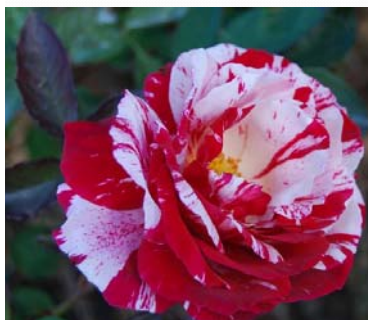


NOTE: (o) Refers to products approved for organic production by the Organic Material Review Institute (OMRI).



# Integrated Pest Management Chemical Control Strategies

## Reduced Risk Products (2 of 2)



### **Natural / Essential Oils:**

Pepper, citrus, clove, mint, oils. Caution as oils can burn. Herbicide properties.

Examples: Ecotec (o)

### **Phosphorous Acid**

Different from P fertilizers, phosphorus acid has fungicide properties that are especially effective against

Oomycete pathogens, such as *Phytophthora*, *Phythium*, and Downy mildews.

Systemic properties.

Examples: Aliette, Fungi-Phite, Fosphite

### **Potassium Bicarbonate**

Used as a contact fungicide mainly for powdery mildew in organic farming systems.

Examples: Armicarb (o), Kaligreen (o), Milstop (o)

### **Pyrethrin:**

Derived from the blossoms of the pyrethrum flower, a chrysanthemum (contact). Breaks down in the environment quickly.

Example: Pyganic (o)

### **Reynoutria sachalinensis**

Bio fungicide used to enhance plant health and trigger the plant's natural defenses to control fungal and bacterial diseases. Delays onset of disease through multiple modes of actions. Plant based extract with systemic properties.

Example: Regalia (o)

### **Spinosad**

Derived from a bacteria in the soil. Kills by contact and ingestion. (Nerve and stomach poison)

Examples: Entrust (o), Radiant, GF-120 NF (o)

### **Spirotetramat**

A new insecticide with a novel mode of action which interferes with lipid biosynthesis. It prevents molting and causes death of immature pest stages.

Example: Movento

### **Steinernema carpocapsae**

Entomopathogenic nematodes are used as a biological control of insect pests.

Entomopathogenic nematodes only infect insects. Entomopathogenic nematodes live inside the body of their host and are most effective on soil dwelling insect pest.

Example: Nematac

### **Streptomyces lydicus WYEC 108**

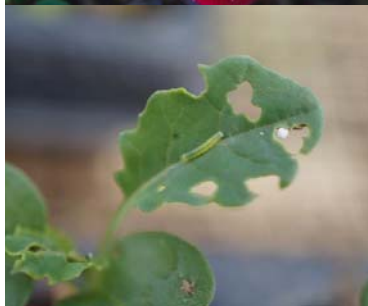
Beneficial bacterium that colonizes on the surface of the roots and leaves. It attacks many soil borne and foliar diseases via different modes of action.

Example: Actinovate (o)

### **Sulfur**

Inhibits the attack of healthy plants by fungus disease by creating an environment that is not conducive to disease growth. Also effective on selected mites.

Examples: Sulfur DF (o), Kumulus DF (o)





# Integrated Pest Management Chemical Control Strategies

## Chemical Mode of Actions:

### AFFECTS NERVOUS SYSTEM

#### **Avermectin**

It is derived from a soil microorganism. They bind to the chloride channel and when activated can inhibit the channels effectiveness, cause twitches, tremors, and death.

Examples: Agri-Mek, Avid, Proclaim

#### **Carbamates**

They are known as *cholinesterase inhibitors*. Carbamates also act like a nerve poison which causes the neurotransmitters to continue to fire and over stimulates the pest to death.

Example: Sevin, Furadan, Lannate, Vydate

#### **Neonicotinoids/ Imidicloprid**

Neonicotinoids continue to stimulated the nerves of pest and similar to cholinesterase inhibitors, they overstimulate the nervous system which causes poisoning and death.

Example: Assail, Admire Pro, Provado

#### **Organophosphates**

They are known as cholinesterase inhibitors. Organophosphates acts like a nerve poison which causes the neurotransmitters to continue to fire and over stimulates the pest to death.

Example: Orthene, Lorsban, Diazinon, Nema-cur, Malathion, Dursban, Dibrom

#### **Pyrethroid**

Synthetic versions of pyrethrins, from the chrysanthemum family. They overexcite the sodium channel and prevent the channel from closing.

Example: Baythroid, Asana, Warrior, Pounce, Ambush

### AFFECTS ENERGY LEVELS

#### **Hydramethylnon**

This chemical binds to a protein in the electron transport system which blocks the formation of ATP. Insects basically "run out of gas" and die.

Example: Amdro, Combat, Max Force

### AFFECTS INSECT DEVELOPMENT (MOLTING)

#### **Insect Growth Hormones (IGR)**

IGR's stops the molting transition to the adult stage and keeps the insects in the immature state. Inhibits chitin synthesis which interrupts molting, suppresses female oviposition & reduces egg viability. Insects are unable to transition to the adult stage and often cannot produce viable offspring.

Example: Intrepid, Esteem, Applaud





# Integrated Pest Management

## Beneficial Insects & Insectary Plants



Sustainable Pest Management Lab  
University of Hawai'i at Mānoa,  
College of Tropical Agriculture and Human Resources

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Insectary plants are plants that produce pollen or nectar, or provide baits to attract arthropod predators including lady beetles, hoverflies, lacewing, spiders, parasitoid wasps etc.

### Lady Beetle (Coccinellidae)



The lady beetle, both the larvae and adult, eat aphids, scales, and mealybugs.

Insectary plants for lady beetles:

- Cilantro, Buckwheat, dill, fennel
- Cowpea
- Marigolds, cosmos
- Oleander (globe lady beetle)
- Morning Glory (*Convolvulus minor*)

### Green Lacewing (Chrysopidae)



The lacewings, the adult will eat pollen, nectar, and honeydew, and the larvae eat aphids, various larvae and the eggs of other insects.

Insectary plants for lacewings:

- Cowpea
- Bay Leaf
- Carrot (*Daucus* sp.)
- Oleander (*Nerium oleander*)
- Red Cosmos
- Wild Lettuce (*Lactuca* sp.)

### Parasitoids & Wasps



Parasitoid wasps, such as *Lysiphlebus testaceipes* parasitized aphids and mummified the aphids (tan in color). Aphid collecting wasp (*Passaloecus* sp.) collect aphids to feed to their offspring in their nests. They like to find burrows in woody materials to build their nests. *Trichogramma* wasps lay eggs in many Lepidopteron eggs that are pests of many crops.

Insectary plants for parasitoid wasps:

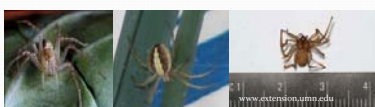
- Cilantro
- Buckwheat
- Milkweed
- Almost all insectary plants



Eggs of Lycaenidae being parasitized by *Trichogramma* inside sun hemp flower.

Sunn hemp and cowpea act indirectly as an insectary plants for *Trichogramma* wasps because the wasp like to come to parasitize Lycaenidae eggs commonly found on sun hemp flowers. Sunn hemp can be planted as border crop or intercrop.

### Spiders



Spiders are generalist that can attack many insect pests especially when no harmful broad-spectrum insecticides are used. They are frequently found wondering on the cinder grow beds, or building webs to catch their preys.

### Hoverflies (Syrphidae)



Hoverflies: larva eat aphids and other soft bodied insects, and adults eat nectar and pollen.

Insectary plants for hoverflies:

- Cilantro
- Buckwheat
- Marigold, cosmos
- Basil
- Carrot

### Pirate or Assassin Bug



The pirate bug, adults feed on small arthropods like thrips, aphids and insect eggs. The assassin bug, adults will eat beetles, caterpillars and flies.

Insectary plants for pirate or assassin bugs:

- Macaranga (*Macaranga tanarius*)
- Carrot (*Daucus carota*)
- Oleander (*Nerium oleander*)
- Sunn hemp (*Crotalaria juncea*)
- Cowpea (*Vigna unguiculata*)
- Marigold, cosmos



### Function of Insectary Plants

- Increase pollen and nectar resources required by the natural enemies of insect pests such as hoverflies and parasitoids (Cowgill et al., 1993; Lavandero et al., 2005; Hogg et al., 2011).
- Attract pollinators.
- Supply food source for spiders (Taylor and Pfannenstiel, 2008).
- Act as trap crops for insect pests.

### Attracting Beneficials to Aquaponic System

- Devoting a grow bed of diverse insectary plants around your aquaponic system will draw a variety of beneficial insects and natural enemies of insect pests to your crops. Examples: fennels, marigolds, milkweeds, buckwheat, and cilantro.
- Plant an attractant crop like buckwheat around the border of hydroponic benches to serve as insectary plants that attract hoverflies and wasps. Sunn hemp can be planted on the borders to attract *Trichogramma* wasps.
- Wasp's nesting box can be constructed and placed around production areas to attract solitary wasps. Most solitary wasps are predators of beetle larva and caterpillars. Photos on the right (below) show how the predatory wasp use the nesting boxes to collect insect pest. Holes that are plugged with soil indicate mud wasps are present and they have laid their eggs (and insect catches) in the nesting boxes.



Grow bed devoted to insectary plants

Hydroponic bench with buckwheat in first row, sunn hemp as boarder, and a wasp nesting block

Close up of the wasp nesting box

Reference and Photo Credit:

<http://www.organicgardeninfo.com/beneficial-insectary-plants.html>

Concept and photo by Koon-Hui Wang and Jane Tavares, unless specified otherwise in the photo.