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IPM methods deployed in soilless cultivation: Review and Case study

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The concept of integrated pest management (IPM)

According to Food and Agriculture Organization (FAO), Integrated Pest Management (IPM) is defined as „A pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury" (FAO 2018).

IPM is an ecosystem-based strategy that focuses on the long-term prevention of pests or their damage through:

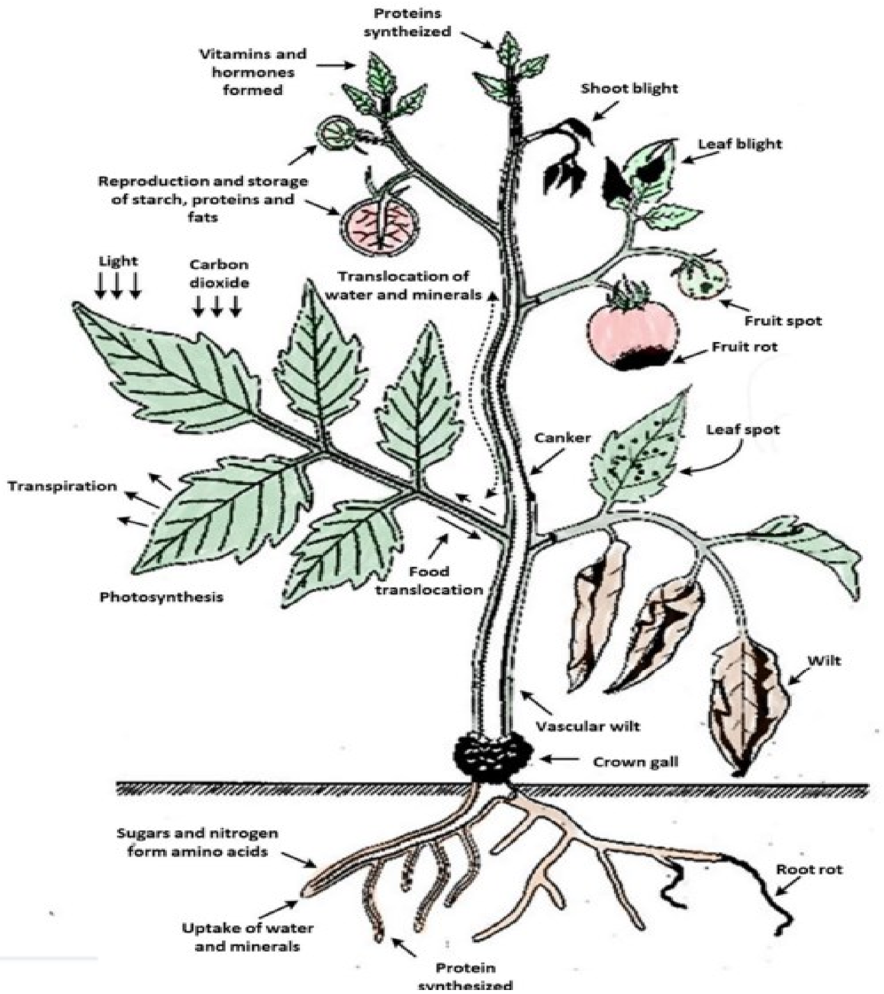
- combination of techniques such as biological control, habitat manipulation
- modification of cultural practices
- use of resistant varieties

Identification of pests and diseases

» Whether the pest is an insect, rodent, phytopathogenic fungus, or other organism, correct identification makes controlling it easier and more effective

» A mistake in identification can lead to improper control tactics that cost time and money

» It may also lead to unnecessary risks to people, to the fish, or to the environment



Identification of pests and diseases

1. Affected areas

- Identify affected areas: leaves, flowers, fruit, growing tip, stem, crown area, or roots. It may be a combination of these.
- For example, if the plant wilts during the day (high light and temperature), the roots could be infected which reduces water uptake.

2. Roots

- Cut some roots to determine whether they are turgid and white or soft and slimy.
- Soft and slimy roots indicate a root problem.

3. Overall plant form

- Is the overall plant form stunted or dwarfed? Is the top of the plant very bushy with many small leaves and short internodes?
- Any discolouration or softness at the collar (crown) of the plant would indicate a disease

4. Leaves

- Look for the following symptoms: deformed, wrinkled, rolled, curled, mottled, chlorotic, or necrotic leaflets.
- Look for the presence of concentric or curved spots of white, powdery, hair-like growth on the leaves (caused by some fungi, such as powdery mildew and *Botrytis*).

5. Stem

- Cut the stem on a plant to find out whether or not the vascular tissue is clear and white; if it is brown and soft that would indicate the presence of a disease organism.

6. Fruit

- A fruit may be deformed or have spots or lesions pointing to the presence of a disease, nutrient imbalance or blossom and rot disease.

IPM Methods in hydroponics, bioponics and in aquaponics

Deal with different

kind of biological threats

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Both insects and diseases benefit from controlled climate conditions in greenhouses as they are sheltered from rain, wind, and strong temperature fluctuations.

Insects and diseases damage:

- vectors for bacterial or viral diseases
- direct damage they cause to the plant

Environmental conditions in greenhouse also allow an effective use of beneficial organisms against insects!

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- Aquaponics systems also usually feature a high density of fish and plants in one location, which facilitates the rapid spread of disease or pests throughout the whole system.

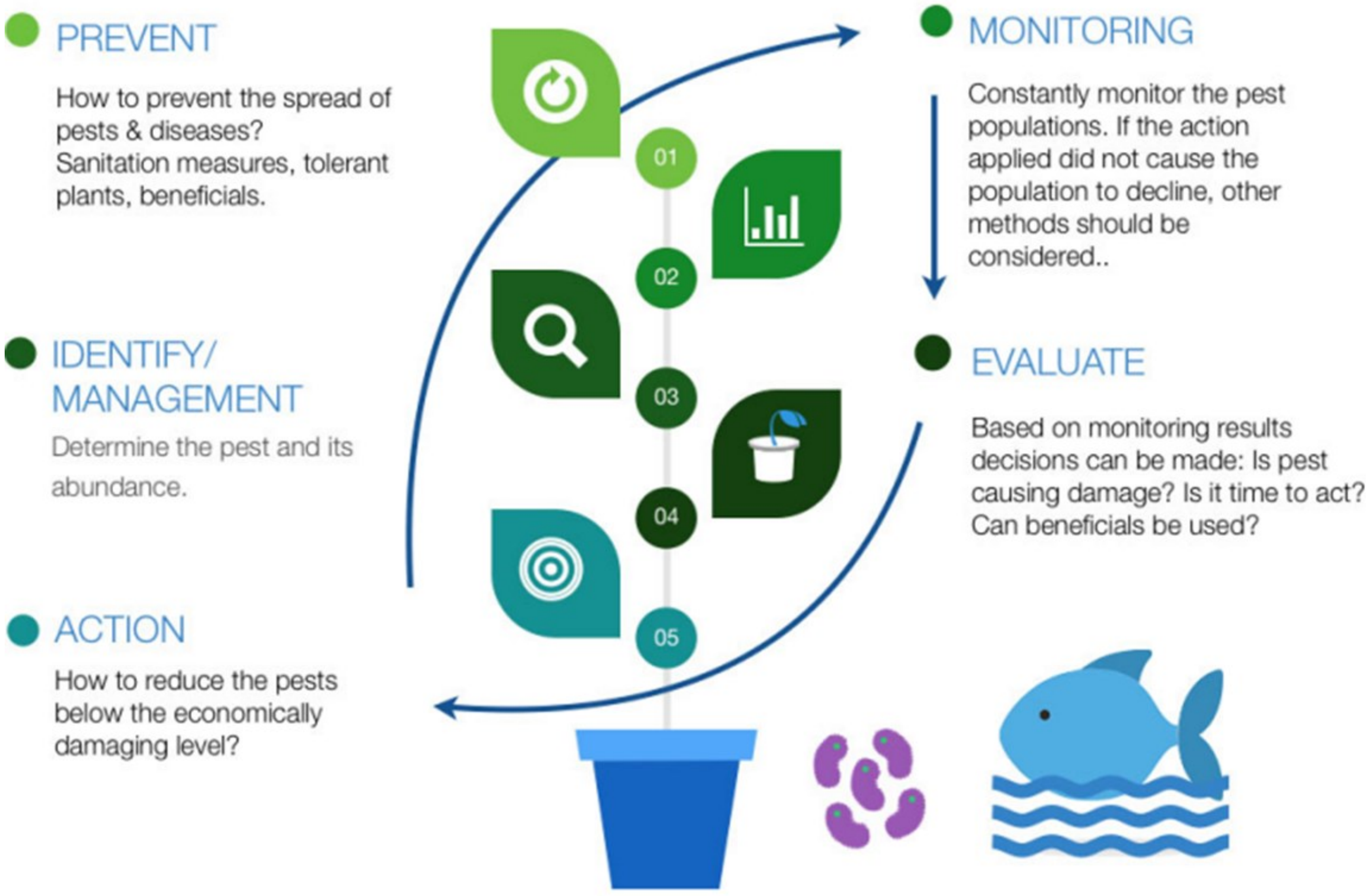
- In contrast to conventional cultivation systems, where the use of chemical pesticides is part of the daily routine, such methods are not suitable for aquaponics.

- The consequences of severe disease infection or of pest infestation are compounded, as losses or removal of either plants or fish will upset the balance between the fish, plants and water chemistry.

- The use of chemical products should be considered very carefully.

- **The input of organic or inorganic chemicals could be fatal for aquatic animals as well as for the microbiological balance in the system. Therefore, it is better to abstain from chemical products than to risk fatal consequences for the whole aquaculture system.**

The five-step IPM program in aquaponics



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The IPM response to disease and/or pests in aquaponics is therefore constrained by:

- combination of fish, plants and bacteria, since fish may be sensitive to plant treatments and vice-versa, and bacteria may be sensitive to both fish and plant treatments
- the desire to maintain chemical free or organic status

Prevention methods in integrated pest management

Control measure

1. Hygiene of cultivating conditions
2. Physical water treatment
3. Physical barriers against insect vectors
4. Respect of good agricultural practices
5. Management of environmental conditions
6. Support the natural community of disease suppressing organisms

Examples of actions

1. Respecting sanitation rules, specific clothes, separate room for plant germination, avoiding algae development.
2. UV treatments; Heat treatment
3. Netting; Trapping
4. Use of tolerant and resistant crop varieties; Adequate supply of nutrients; Correct plant spacing; regular monitoring
5. The regulation of humidity and temperature is central to the prevention of fungal and bacterial diseases in covered crops. Manipulate the heating, the ventilation, the shading, the supplement of lights, the cooling and the fogging to find the optimal conditions allowing both plant production and disease control
6. Beneficial microorganisms; Beneficial insects; Compost extracts

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Prevention methods in integrated pest management

Greenhouse production

Hygiene of cultivation conditions

- Every year the exterior of the greenhouse should be washed to improve the light level for the crops
- Cleaning empty greenhouses, irrigation systems, plant containers and harvesting equipment.

Tolerant and resistant crop varieties

- The development of tolerant and resistant crop varieties is remarkable, and seed catalogues should be studied carefully in order to choose varieties that are resistant against diseases.
- In some crops grafting is good solution.

Appropriate plant spacing

- High planting density increases competition for light, weakens plant vigour, and invites pest and diseases to settle.

Adequate supply of nutrients

- Adding soluble fertilizer according to the nutrient requirements of the crop
- Regulating the nutrition according to the salt concentration in the water (EC level).

Monitoring

- Monitoring and identification remove the possibility that pesticides will be used when they are not really needed, or that the wrong kind of pesticide will be used.

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Physical defense

Physical control methods can be categorized as active and passive.

Active methods involve:

- Removal of individual pests by hand, pruning out infested plant tissues, and removing heavily infested plants

Passive methods involve:

- Passive methods usually include the use of a device or tool for excluding or removing pests from a crop.
- These devices serve as barriers between the plants and the insect pests, thus protecting plants from injury and damage.
- Other passive tools include repellents and traps

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Trapping

- Traps may be used to monitor or detect a pest population, to catch and identify the pest, and to reduce local pest density.
- Commercial traps are available for controlling or detecting various moth species (pheromone traps), whiteflies and thrips (sticky traps), flies and yellow jackets, snails and slugs, bed bugs, spiders, cockroaches and many other pests. Coloured sticky traps attract different pests.
- They should be positioned slightly above the canopy of plants. Blue sticky cards trap adult stages of thrips.
- Yellow sticky cards are used for whiteflies and harmful butterflies.

Netting

» Use of netting is a simple way of preventing pests from coming into contact with the crop. The mesh size depends on the pest targeted:

- 0.15 mm against thrips
- 0.35 mm to exclude whitefly and aphids
- 0.8 mm to exclude leaf miners and beetles
- 20 mm against birds

» However, netting also has a negative side: it reduces light and raises humidity, and therefore increases the risk of fungal diseases. This is especially true for nets with a mesh size of < 2 mm.

Support the natural community of disease suppressing organisms

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- The use of beneficial organisms is well established in greenhouse farming. Pests and disease can appear even with the best prevention.
- One of principles of integrated and organic farming is for plants to thrive in the presence of pathogens or pests. This is only possible if beneficial macro- or microorganism support the control of pests and diseases.
- A natural community of disease suppressing organisms can be supported by adding biological agents to the water as a stimulant for plant, resistance.

Beneficial organisms

Beneficial microorganisms

- *Bacillus amyloliquefaciens* or *Trichoderma atrobrunneum* as prevention against root diseases (e.g. *Pythium*) in early stages of the crop (e.g. seedling stage).
- *Bacillus subtilis* against *Rhizoctonia*.
- *Gliocladum catenulatum* against *Fusarium, Phytophthora, Pythium, Rhizoctonia* on cucumber, tomato, pepper, and culinary herbs.

Beneficial insects and banker plants

- *Ichneumonids* against aphids, whitefly and similar,
- Gall midges (*Aphidoletes aphidimyza*) against aphids,
- Predator mites against spider mites,
- Mirid bugs (*Macrolophus pygmaeus*) against whitefly.

Table 2: Some pests and their common natural enemies

Pests	Lace wings	Lady beetles	Parasitic flies	Parasitic wasps	Predatory mites	Other groups and examples
Aphids	x	x		x	x	Entomopathogenic fungi, soldier, beetles, syrphid fly larvae
Catepillars	x		x	x		Bacillus thuringiensis, birds, entomopathogenic fungi and viruses, predatory bugs and wasps, *Trichogramma spp.* (egg parasitic wasps), spiders
Spider mites	x	x			x	Big-eyed bugs and minute pirate bugs, *Feltiella spp*. (predatory fly larvae), six-spotted thrips, *Stethorus picipes* (spider mite destroyer, lady beetle)
Thrips	x			x	x	Minute pirate bugs, predatory thrips
Whiteflies	x	x		x		Big-eyed bugs and minute pirate bugs, *Cales*, *Encarsia*, and *Eretmocerus spp*., parasitic wasps, spiders
Slugs, snails			x			*Rumina decollata* (predatory snail), predatory ground beetles, birds, snakes, toads, and other vertebrates

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Examples of biological agents

Different countries have different regulations about who is allowed to use these products.

PLANT DISEASES

1. Powdery mildew
2. Powdery mildew, grey mould, white mould (*Sclerotinia*)
3. White mould (*Sclerotinia*)
4. Grey mould, downy mildew, Fusarium wilt, damping off
5. Soil cryptogam
6. Damping off

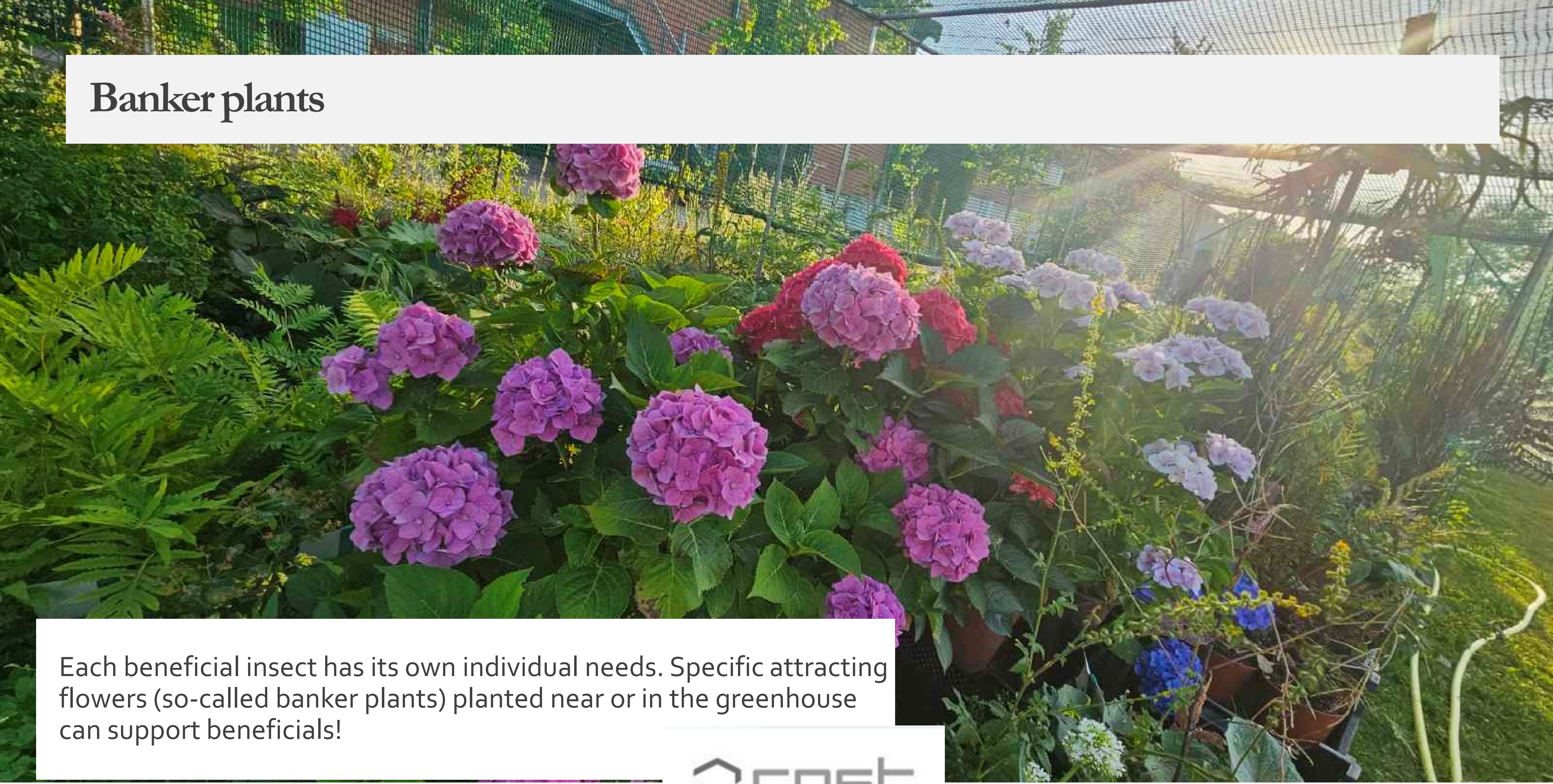
BCA (selected biological control agents)

1. *Ampelomyces quisqualis*
2. *Bacillus amyloliquefaciens* ssp. *Plantarum strain* D747, *Bacillus subtilis strain* QST 713,
3. *Coniothyrium minitans*
4. *Gliocladium catenulatum*
5. *Streptomyces K61*
6. *Trichoderma asperellum, Trichoderma atrobrunneum*

CROPS

1. Strawberry, tomato, pepper, cucurbits
2. Strawberry, tomato, cucumber, pepper, cucurbits, watercress, lettuce, spinach, aromatic herbs
3. Any crop
4. Strawberry, tomato, cucurbits, pepper, watercress, lettuce, spinach, aromatic herbs
5. Any crop
6. Any crop

Banker plants



Each beneficial insect has its own individual needs. Specific attracting flowers (so-called banker plants) planted near or in the greenhouse can support beneficials!

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If all else fails …

- Sometimes interventions with chemical products can be justified, but in that case stringent regulations have to be considered.
- Whenever possible botanical pesticides should be used first, because they are of biological origin. Some extracts from microorganisms are safe for fish and can be used in aquaponics.
- One is a toxin from *Bacillus thuringiensis*, which can be used against caterpillars, leaf rollers or other butterfly larvae. The other is *Beauveria bassiana*, a fungus that enters the insect’s skin, and is effective against pests such as termites, thrips, whiteflies, aphids and beetles.
- Most of the chemical synthetic fungicides and insecticides, but also some products permitted in organic farming, are toxic and harm aquatic organisms. An application is only worth considering in young plants before being transplanted into the aquaponic system. If chemical control is the last resort, the specific fish toxicity of the product has to be considered very carefully..

CASE STUDY: Intercropping as good agricultural practice

- Intercropping of some plant combinations is a chemical-free pest management approach that is based on enhanced biodiversity of microbiome inhabiting roots of plants.

- The production of leafy vegetable in combination with aromatic plants in hydroponic and bioponic offers therefore the potential to protect the plants from pest and diseases and reduce the need for chemical pesticides.

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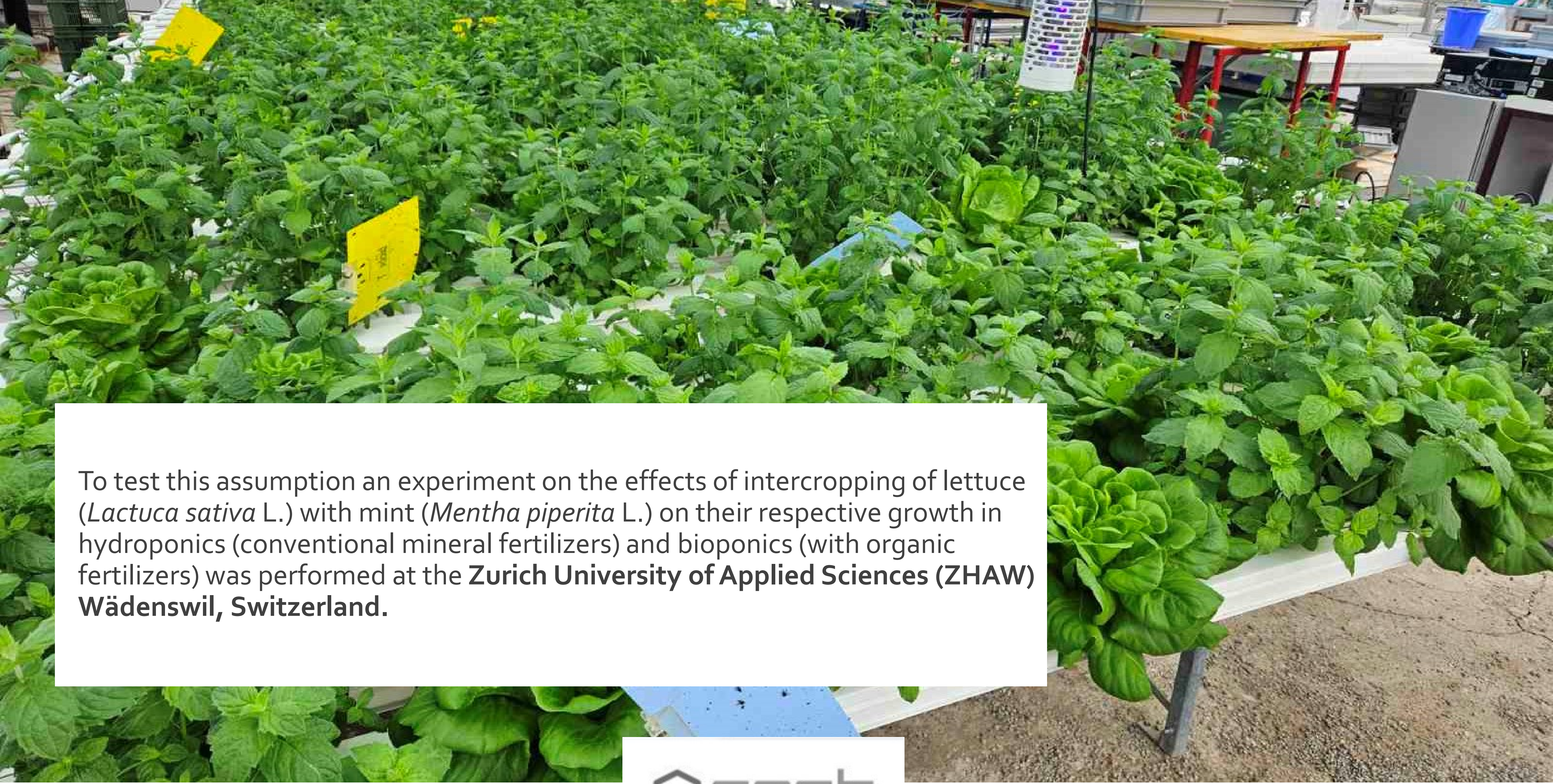

To test this assumption an experiment on the effects of intercropping of lettuce (*Lactuca sativa* L.) with mint (*Mentha piperita* L.) on their respective growth in hydroponics (conventional mineral fertilizers) and bioponics (with organic fertilizers) was performed at the **Zurich University of Applied Sciences (ZHAW) Wädenswil, Switzerland.**

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Integrated crop protection and pest management (IPM) encompassed:

- ✓ general preventive measures
- ✓ barrier-based approaches (sticky traps for white flies, tobacco flies, shield moth and thripis)
- ✓ as ultima ratio, application of organic insecticides (Neem oil, Pyrethrum FS) that are allowed in organic farming.

CASE STUDY: Trapping

During 35 days vegetation period!

Damage on lettuce and mint caused by insects!

CASE STUDY

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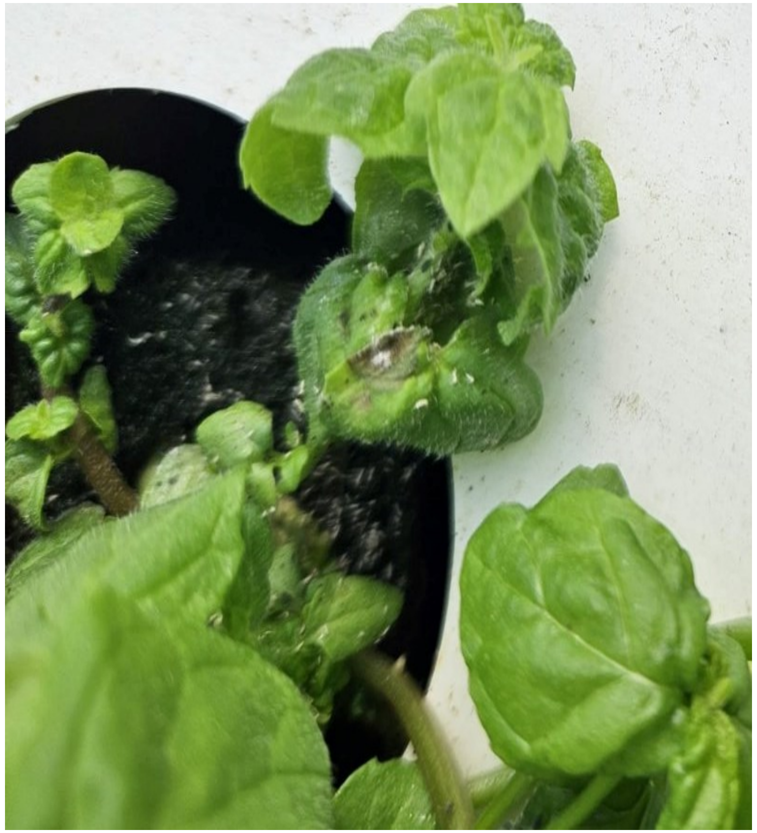
Damage on lettuce and mint caused by insects!

CASE STUDY



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Solutions

NeemAzal®-T/S contains NeemAzal®, the pure active ingredient from the kernels of the tropical neem tree *Azadiracta indica* A. Juss.
Pyrethrum FS is a broad and fast acting insecticide obtained from the dried flowers of chrysanthemum species (Tanacetum cinerariifolium).

- ➢ accepted for organic farming
- ➢ inactivates pests within a short time
- ➢ efficient control of a broad range of insect pests
- ➢ non-toxic to honey bees
- ➢ harmless for most beneficial organisms
- ➢ highly suitable for resistance management
- ➢ miscible with many other preparations
- ➢ no or short waiting periods until harvest

CASE STUDY: End of experiment

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Scan me!

Thank You

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MOOC Aquaponics - the circular food production system.Course readerWeek 5 – Hydroponics Part 2.ZHAW Zurich University of Applied Sciences, Waedenswil, Switzerland.
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