

Field Guide to
**Non-chemical
Pest Management**



in Orange Production

Pesticide Action Network (PAN)

Founded in 1982, the Pesticide Action Network is an international coalition of over 600 citizens groups in more than 60 countries, working to oppose the misuse of pesticides and to promote sustainable agriculture and ecologically sound pest management.

PAN Germany was established in 1984 as part of this global network and has continually been involved in initiatives to reduce the use of hazardous pesticides and to promote sustainable pest management systems on national, European and global levels.

Acknowledgements

First, we want to express our gratitude to the universities and organisations that have given the permission to use their photos for the OISAT project. (For more details see p. 26f)

We also wish to thank all the individuals, groups and organizations that have prepared the bases for most of the control measures presented in this field guide, may it have been by preserving traditional experience, on field trials, on field research, or in the lab.

© Pesticide Action Network (PAN) Germany
Nernstweg 32, 22765 Hamburg, Germany
Phone: +49 (0) 40 – 399 19 10-0
Fax: + 49 (0) 40 – 399 19 10-30
Email: info@pan-germany.org
Internet: <http://www.pan-germany.org>
<http://www.oisat.org>

Prepared by: Dr. Jewel Bissdorf
Editor: Carina Weber / Susan Haffmans

Revised 2nd edition
Hamburg, 2018

Apart from the photos, permission is granted to reproduce any and all portions of this publication, provided the publisher, title, and editor are acknowledged.

Table of contents

Prologue	4
How to use this field guide	5
Recommended practices	6
I. Introduction.....	7
II. Climatic and soil requirement.....	7
III. Selection of planting materials	7
IV. Planting materials requirement	7
V. Land preparation.....	8
VI. Method of planting	8
VII. Fertilizer and water requirements	8
VIII. Water Requirement.....	8
VIII. Pest management.....	9
IX. Weed management	9
X. Harvesting.....	9
Insects/Mites	10
Aphids	10
Fruitflies.....	11
Mealybugs	12
Leafminers.....	13
Psyllids	14
Scales.....	14
Snails.....	15
Citrus rust mite	16
Thrips	17
Whiteflies.....	18
Diseases	19
Citrus canker	19
Greasy Spot	19
Gummosis	20
Huanglongbing disease (HLB)	20
Melanose.....	20
Scab	21
References	22
Photo credits/sources:	25

Prologue

Pesticides worth more than 47 million US dollar are intentionally released into the global environment every year. A high proportion of these is highly toxic and has immediate adverse effects on human health, wildlife, local food sources such as cattle or fish, beneficial insects and biodiversity. Some of them have chronic effects including cancers, reproductive problems, birth defects, hormonal disruption and damage to the immune system. Impacts come from direct exposure in use, spray drift, washing work clothes used while spraying, home pesticide storage, pesticide dumps, and persistence in the environment.

Overall aim of the international Pesticide Action Network (PAN) is to eliminate the use of hazardous pesticides, reduce the overall use, risk and dependence on pesticides, and to increase support for community-based control over a sustainably produced food supply. PAN is committed, in its projects, strategies and campaigns to place pesticide concerns in the broad political and economic context in ways that will advance the fight against rural poverty and enhance pro-poor development and ethical trade. PAN aims to help local communities use the initiatives to benefit their day-to-day lives.

PAN Germany is part of the international Pesticide Action Network. It is supporting non-chemical pest management on tropical crops that are commonly grown by small landholder farmers through the project: Online Information Service for Non-chemical Pest Management in the Tropics, OISAT (www.oisat.org).

OISAT is a web-based information system to distribute information on non-chemical pest management in the tropics and sub-tropics that is easy to read and easy to understand. Information provided via www.oisat.org is relevant to small-scale farmers who intend to produce crops using safer and more affordable non-chemical pest management practices. It provides varied information on how to lower the cost of production based on recommended insect/mites pests, disease, and weeds control methods.

The 'Field guide to Non-chemical Pest Management in Orange Production' provides farmers with practical guidelines and alternatives to eliminate the use and their dependence on synthetic pesticides for the management of squash pests. The recommended practices are safer, more affordable, and easy to follow. Most of the farm practices, the farmers can do by themselves and the materials that are needed are found in their backyards or in their kitchens or can be purchased in the local agricultural suppliers.

Carina Weber
(PAN Germany)

How to use this field guide

This field guide is designed to let you grow orange as easy as possible.

It provides you with the suggested appropriate management practices on how to grow oranges. In the pest pages, each pest has a brief description of its lifecycle, damage it causes, and its control measures. It is very important to know how the insect/mite pest develops, because the adult does not always cause the damage and sometimes it is not even found where the damage occurred. Included in the control measures are cultural practices, physical control, plant extracts, other homemade solutions, and practical methods.

For example, you notice that the orange leaves are having large holes when you're out in the field. What would you do? First, have a closer and careful examination of your plant. If you find the pest and cannot identify it, turn the following pages and look at the illustration of an insect and/or the damage or symptom in each pest entry. Once you have identified the pest, look into the corresponding control measures on how to eliminate and/or lessen its population density. You have various options like: cultural practices (e.g. removal of weeds); physical control (e.g. handpicking); plant extract (e.g. neem spray); other homemade solution (e.g. soap spray); other method (use of baits).

However, with every effort made to provide you with complete information on the pest control in orange growing, the recommendations may vary from location to location. It is highly recommended that you try the various control practices in small scale especially for the plant extracts and other homemade solutions, in order to make adjustments that are adaptable to your local farm conditions before going into large scale application.

Recommended practices

Throughout this field guide, you will find suggestions for stopping or lessening the pests' population before they have control over your orange field. To make a plan for you to grow a healthy crop, the following tips are the steps you ought to take:

1. Learn to identify the pests and other causal agents and the natural enemies.
2. Select the proper orange variety that is well adapted to your local conditions.
3. Always select good and disease-free planting materials.
4. Have a healthy soil, but always keep in mind that over-fertilizing is not necessarily better.
5. Practice crop rotation by planting in the next cropping season crops of a different family group.
6. If possible, practice intercropping to improve the field's diversity and to encourage natural enemies.
7. Follow the recommended planting distances.
8. Prepare the soil thoroughly by appropriate tillage.
9. Always practice proper field sanitation by removing and pruning infested plant parts, keeping the area free of weeds and other plant residues, and cleaning regularly all farm tools and implements.
10. Monitor your plants regularly.
11. When in doubt, always ask for assistance from your local agriculturists.

When controlling pests using the plant extracts and other homemade solutions, the following are the standard procedures for their preparation and application:

- I. Select plants/plant parts that are pest-free.
- II. When storing the plants/plant parts for future usage, make sure that they are properly dried and are stored in an airy container (never use plastic container), away from direct sunlight and moisture. Make sure that they are free from molds before using them.
- III. Use utensils for the extract preparation that are not used for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every time after using them.
- IV. Do not have direct contact with the crude extract while in the process of the preparation and during the application.
- V. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.
- VI. Always test the plant extract formulation on a few infested plants first before going into large scale spraying.
- VII. Wear protective clothing while applying the extract.
- VIII. Wash your hands after handling the plant extract.

I. Introduction

About Oranges

Scientific name: *Citrus sinensis*
 Order: Sapindales
 Family: Rutaceae

The *Citrus sinensis* is subdivided into four classes; round orange, blood or pigmented orange, navel orange, and acidless orange.

a) Round orange constitutes about 2/3 of all the orange production which is used mostly for juice extraction. The most popular ones are the Valencia orange, Hart's Tardiff Valencia, and Hamlin.

b) Blood orange is a natural mutation of *C. sinensis*. However, today the majority of cultivars are hybrids. The color of the fruit is dark red in color, hence the name. The high concentrations of anthocyanin make the rind, flesh, and juice of the fruit dark red color.

c) Navel orange is characterized by the growth of a second fruit at the apex that protrudes slightly and resembles a human navel. It is primarily grown for human consumption. The fruit has a thicker skin which is easy to peel, it is less juicy and a little bit sour because of the high concentration of limonin and other limonoids.

d) Acidless orange is an early-season fruit with very low levels of acid. It commonly known as the "sweet orange". It is for table consumption and has a very low shelf life.

Uses

Fresh fruits and juices

II. Climatic and soil requirement

Citrus will grow with temperature ranges from 13 - 38°C. The optimum temperature is 25 - 35°C. Ideally, the orange trees grow well under moderate temperatures, from 15.5 - 29°C. Extremely high temperature or if a cool temperature is followed by a hot period is not ideal during the flowering stage because the flowers and leaves will drop. The plants require a cool climate, with a warm temperature during the daytime and a cooler one during the night. This kind of climatic condition enhances the desired orange color development. The absence of cool nights during the maturation stage will make the rind (peel) green or greenish-yellow because of the lack of anthocyanin pigments' formation that will turn

the fruit into orange in color. Another significant elements in the full development of the fruits are the temperature variation between summer and winter and between the day and night durations. Areas with low humidity are most ideal.

Orange grows in different soil types. Loamy and sandy loam soils are ideal for its growth and development. Heavy clays and poorly-drained soils will result in poor growth and production, as well as shorter life. Orange trees on sour orange rootstock are well-adapted to deep, well-drained soils.

III. Selection of planting materials

Select the healthy seedlings, either budded or grafted and/or marcotted. They must be free from pests and diseases. If you do the propagation by yourself, select the rootstocks from diseased-free seeds. Do the vegetative propagation when the rootstocks are least a year old and the sources of the scions are from healthy mother trees of the desired cultivars.

IV. Planting materials requirement

Planting distance = Planting materials needed/hectare

3.3m x 3.3m	=	918 trees/ha
3m x 4.5 m	=	740 trees/ha
4m x 4m	=	625 trees/ha
4.5m x 6m	=	370 trees/ha
5m x 5m	=	400 trees/ha
6m X 7.5m	=	222 trees/ha

The 7.5 x 7.5 m planting distance was the standard in the past. Many orange groves today are being closely planted and hedged due to the following advantages: provide greater and earlier return on the investment of capital; full utilization of the area suitable for planting oranges; improve water usage efficiency; and reduce the utilization pesticides and fertilizers (organic or inorganic) because of the spray interception by the tree canopies and the fertilizer uptake by the root systems.

The disadvantage of closer spacing are: as the trees grow they become more crowded; less aeration; longevity declines; and requires regular pruning.

The distance of planting should be wide enough to facilitate both manual and mechanical production activities such as;

fertilizing, weeding, spraying, pruning and harvesting.

V. Land preparation

For large areas, use a tractor to prepare the soil for planting. For smaller areas, use farm animal to plow and harrow the field. Remove the weeds and other plant debris and level the field before preparing the field layout.

VI. Method of planting

To prepare the farm layout, the materials needed are; bamboo pegs, string, and measuring tape.

The hole sizes varied; from 40 cm x 40 cm x 40 cm up to 60 cm x 60 cm x 60 cm.

Dig the holes with the desired sizes using hoe and spade for small areas and/or other mechanical digging implements for larger ones. Separate the top soil from the subsoil. First, cover the hole with top soil and compost. Remove the plastic potting bag. Position the seedling in the middle of the hole. Then add soil up to the original level of the plastic bag's sleeve. Ensure that the graft joint or the budded portion is above the ground to avoid early disease infection. To keep the seedling erect, it must be firmly planted into the soil and tie it to a bamboo stake.

Intercrop leguminous and other cash crops during the first three years or until the tree canopies are fully developed. Make sure the intercrops do not come in contact with the growing orange plants to avoid root rot diseases. Plant the seedlings on the onset of the rainy season.

VII. Fertilizer and water requirements

Fertile soil is very necessary for any type of agricultural production. There are several ways to make the soil fertile wherein the oranges are grown, either using organic or inorganic fertilizers or combination of both, or green manuring by planting and plowing under leguminous crops.

The different soil types have varied nutrient needs. For example, sandy loam needs different fertilizer doses from those of clayey and loamy soils.

The following are the general recommendations for fertilizer applications:

a) Apply compost at 10-15 kg, or cattle manure at 5-6 kg, or 3-4 kg poultry dung on each planting hole as basal fertilizer. In acidic soil, liming is necessary at ½ kg of rock phosphate/plant. Mix lime with organic fertilizer to speed up decomposition of organic matter and to save labor cost. A month after transplanting, apply 200 grams of urea/tree/year for the first 3 years. Split the applications, during the onset and before the end of the rainy seasons. During fruit development, side-dress complete fertilizer (NPK) at a rate of ½ -1 kg/tree (OISAT, 2015).

b) Apply Sodium Super Phosphate before planting at a rate of 1/2kg/hole. About 10 - 20 kg of manure can also be added to the soil, mixed together and put back at planting. Apply NPK fertilizer at a rate of 1/2kg/plant/year of growth, split into 2- 3 applications per year. For example, apply about 250gm during the rainy season. Increase the fertilizer by about 300gm NPK per year of growth up to year 10, when each tree gets 2.5 – 3kg/year. Application of Muriate of Potash at 750gm/tree/year increases the fruit sweetness (NAADS, 2000).

c) Orange trees need to be fertilized with N P K very soon after harvesting. The balance of major nutrients has to be considered in relation to the ultimate use of the crop. For example, more Nitrogen increases the oil content of the peel, while extra potassium decreases it. 0.45 kg N/tree/year has been found sufficient to maintain high productivity. Apply 0.9 kg N/year for 8-year-old trees (Morton, 1987) .

However, fertilizer recommendations based on soil testings/analyses are preferred in getting the right amount of fertilizer to be applied. Ask for assistance from the nearby local agriculturist office for the soil testing/analysis.

VIII. Water Requirement

Planting of orange seedlings must be on the onset of rainy season or when water is readily available. Newly planted ones need to be watered everyday.

Be observant on your trees to make sure that they are not water stress. The first noticeable sign of water stress occurs when the leaves turn dull-green in color and begin to curl from the edges inward. The continued lack of water will cause the leaves to dry-out and become crisp, starting at the tips and progressing, until the leaves are dried. The leaves, flowers and fruits will eventually fall. The entire tree will die

if there is continuous lack of water for an extended period of time.

Water is essential because it is an integral component of the plants' growth and development. Water carries the nutrients and other substances throughout the tree and helps maintain plant temperature through transpiration.

Mulching is one way to conserve water by maintaining soil moisture within the root zone. Apply 2 - 4 inches of mulch under the plant canopy. Mulch can consist of cut grasses, leaves, bark, wood chips, rice straw, compost, or any other organic materials. Mulch should be kept away from the trunk and the distance should be extended as the plant grows. Trees that are mulched can be irrigated less frequently than those that are not mulched. Mulches also lower soil temperature allowing for better root growth development. The decomposed mulches will then improve the soil condition.

VIII. Pest management

See pests/mites and diseases information.

IX. Weed management

Weeds are the unwanted plants found in the soil. They compete for nutrients, moisture, and sunlight which can decrease the crop quality, raise production costs due to increased cultivation and hand weeding, and considerably reduce the crop yields. They also serve as the alternate hosts for insect/mite pests and diseases.

Careful management and good sanitation help limit weed infestations. Do not allow weeds

around the orchard to mature and produce seeds. Remove the weeds before they flower to prevent production of more seeds. Remove the weeds around tree trunks for the may create a favorable environment for pathogens that infect the trunk and roots. They also provide shelter to field mice. Ring weed around the plant to get a weed-free area for watering and application of manure or other fertilizers.

A good cover of mulch will help to control weeds under the tree canopy, as well as reduce water evaporation.

The young trees must be carefully tended and kept weed-free for the first 2 - 3 years in the field.

X. Harvesting

Budded or grafted or macotted plants start bearing fruits at about 2.5 years from planting, depending on the climatic conditions and management practices. Full productivity is reached in about 10 years. Oranges stay on the tree from 6-9 months depending on the variety and climatic conditions. Maturity is indicated by the color change from green to slightly-yellowish. Most trees bear twice a year.

With small orange orchards, harvesting is done manually. The harvesters (persons) climbed ladders and pulled the fruits off by hand, putting them into pails or sacks. For very large orchards, mechanized harvesters are used.

In other countries, with the right climatic conditions and proper care and management practices, the average yield is up to 40 tons/ha/year.



Insects/Mites

Several pests will infest orange during its growth stages. Table 1 shows the pests that might damage the plant growth.

Table 1. The orange growth stages and its pests

Affected parts	Insects/mites
Leaves	Aphids Citrus mealybugs Fruitflies Leafminers Psyllids Spider mites Scales Snails Whiteflies
Stems, trunks	Aphids Citrus mealybugs Psyllid Scales Snails Whiteflies
Flowers and fruits	Aphids Citrus mealybugs Fruitflies Psyllid Scales Snails Thrips Whiteflies

Aphids

Order: Hemiptera

Family: Aphididae

Scientific name: (*Toxoptera aurantii*; *T. citricidus*)

Other names: Blackflies, Green flies, Plant lice



Damage

The mouths of the aphids are like tiny straws. The aphids, both the nymphs and the adults, pierce the plant tissues to feed on plant sap. The leaf becomes severely distorted when the saliva of aphids are injected into it. The heavily infested leaves can turn yellow and will eventually wilt because of excessive sap removal. Aphids feeding on flower buds and fruits cause malformed flowers and fruits.

Aphids produce large amounts of a sugary liquid waste called honeydew. A fungus, called sooty mold grows on honeydew deposits that accumulate on leaves and branches, turning leaves and branches black. The appearance of a sooty mold on plants is an indication of an aphid infestation.

Description

The eggs are very tiny, shiny black, and are found in the crevices of bud, stems, and barks of the plant.

The nymphs look like the young adults, mature within 7-10 days, and are then ready to reproduce.

The adults are small, 3-4 mm long, soft-bodied insects with two projections on the rear end and two long antennae. Their body color varies from yellow, green, brown, to purple. Females can give birth to live nymphs as well as lay eggs. However, the primary means of reproduction for most aphid species is asexual, with eggs hatching inside their bodies, and then giving birth to living young. Winged adults, black in color, are produced only when it is necessary for the colony to migrate, or there is either overcrowding in colonies, or unfavorable climatic conditions.

Control measures

Control and kill ants. Cultivate and flood the field. This will destroy ant colonies and expose eggs and larvae to predators and sunlight. Ants use the aphids to gain access to nutrients from the plants.

1. Water spray
Spray a steady stream of water on the host plant to knock-off aphids. Once on the ground, the fallen aphids are prey to ground predators and they have difficulty returning to the plant.
2. Soap spray

Mix 1 tablespoon of dishwashing soap to 4 liter of water.

2. **Water traps**
Half-fill yellow pan or basin with soapy water. Place the pan close to the plant but exposed enough so that aphids will see it. Trapped aphids sink and drown because soap breaks the surface tension of the water. The yellow color attracts the pests. However, if more beneficial insects are trapped, stop using this, as beneficials might be sufficient enough to control the pests.
3. **Yellow sticky traps**
Place 1-4 sticky cards per 300 sq m field area. Replace traps at least once a week. To make your own sticky trap, spread petroleum jelly or used motor oil on yellow plywood, 6 cm x 15 cm in size or up. Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 60cm above the plants.
4. **Yellow basin trap**
Half-fill a yellow pan or basin with soapy water. Place the pan close to the plant but exposed enough so that aphids will see it.
5. **Ginger rhizome extract**
Grind 50 g of ginger and make into paste. Mix with 3 liters of water. Strain. Add 12 ml of soap. Mix well. Ten (10) kg of ginger is needed for 1 ha.
6. **Custard apple leaf extract**
Boil 500 g of leaves in 2 liters of water until the remaining liquid is about ½ liter. Strain and dilute the filtrate with 10 -15 liters of water.

Fruitflies



Order: Diptera
Family: Tephritidae

Kinds of fruit flies:

Mediterranean fruit fly or Med fly (*Ceratitis capitata*)

Oriental fruit fly (*Bactrocera dorsalis*)

Damage

Adults and larvae-maggots cause fruit damage. Egg-laying females puncture the fruits leaving scars and holes on the fruit surface. Larval feeding causes premature fruit drop and destroys the pulps of the fruit. The fruit eventually rots making it unsuitable for harvesting and human consumption.

Description

The adult Medfly is slightly smaller than a common housefly and is very colorful. It has dark-blue eyes, a shiny-black back, and a yellowish abdomen with silvery cross bands. Its wings, normally drooping, display a blotchy pattern with yellow, brown, and black spots and bands. This adult Medfly attacks all fruits and it is the most widespread and destructive.

The adult Oriental fruit fly is somewhat larger than a housefly, about 8 mm in length. The body color is generally bright-yellow with a dark T-shaped marking on the abdomen. The wings are transparent. The female has a pointed slender ovipositor use to deposit eggs under the skin of host fruit. Eggs are minute

The morphology of the various fruit fly species is similar.

Eggs of fruits flies are small, white, and slender. These are laid, or inserted into fruit in groups of up to 37 eggs. They hatch within 2-4 days. Larvae are cylindrical, elongate, narrowed, and

somewhat curved downward with their mouth hooks at the head. The larvae live and tunnel through the fruit, feed on the pulp, and continue feeding inside the fruit. They jump rather than crawl. When the larvae are ready to pupate, they emerge from the fruit and drop to the ground. Pupae occur in the soil beneath the host plant. The pupal stage lasts for about 10 days. Adult fruit flies are very small insects which lay their eggs in various plant tissues. Wide heads, black or steely green or blue bodies, bright greenish to bluish eyes, and wings that are usually mottled brown or black, characterize the Tephritidae. The Drosophilidae are yellowish and in the wild are largely found around decaying vegetation. The larvae living in fruit feed on the yeasts growing in the fruit. A female adult lays eggs in groups within the fruit and may lay as many as 1,200 eggs in her lifetime. The average life span of the adult is about 30 days. The life cycle of the fruit fly ranges from 12-28 days depending on the climatic condition. In countries with high temperatures, its life cycle is 12 days and longer in areas with cool weather.

Remove the shells of 3-5 kg of neem seeds. Pound the cleaned seeds gently. Soak in 10 liter of water for 3 days in a covered container. Strain to get a clear extract. Add 1 liter of neem seed extract and 100ml of soap to 9 liters of water.

Control measures

1. Garden hygiene is essential because fruit trees with fallen and rotting fruit around them are a major source of uncontrolled fruit fly infestations. Sanitation may help to prevent fruit fly eggs and maggots from developing in infested fruit. All fallen and unwanted fruit should be collected and destroyed. Destroying this fruit ensures that maggots do not survive to pupate in the ground to later emerge as adult flies. Fallen and unwanted fruit should not be left in a waste heap or added to compost.
2. All purpose insect pests spray - for leaf eating pests
Combined 1 tsp red hot pepper, 1 medium sized finely chopped onion, 1 bulb chopped garlic. Add into a liter of water. Soak for 1 hour. Strain. Add 5 liters of water and 2 - 3 drops of liquid soap or 2 tbsp of powdered soap when ready for application.
3. Neem leaves extract
Soak 1-2 kg of fresh and pounded neem leaves in 2-4 liter of water for 3 days in a covered container. Strain to get a clear extract. Add 1 liter of neem leaf extract and 100ml of soap to 9 liters of water.
4. Neem seeds extract - for Aphids, Fruit flies, Scales, Thrips and Whiteflies

Mealybugs



Order:Hemiptera
Family: Pseudococcidae

Citrus mealybug
Scientific name: *Planococcus citri*

Damage

Leaves are distorted (rolled or folded), stunted, and yellow. Attacked fruits drop prematurely. Like the other sap-feeding insects, mealybugs excrete (eliminate) large quantities of honeydews which promote sooty mold that caused blackened-malformed leaves, stems, and fruits.

Description

The ggs are very tiny, yellow in color, and are laid in a cottony mass of up to 500 eggs. The eggs hatch, in 1-2 weeks, into tiny mobile red-eyed yellow crawlers (nymphs). The crawlers move onto the fruit and leaves to feed on plant's sap. Within a month, males form a mass of cottony filaments and 2 weeks later become winged adults. Female crawlers mature in a month. The adult citrus mealybug is 1.5-4 mm long.

Control measures

1. Spray a steady stream of water (reasonably high pressure) on the host plant to knock-off mealybugs. Once on the ground, the fallen ones will be available to ground predators

and this will also make their return to the plant difficult. Wetting mealybugs encourages fungal pathogens that may infest on them.

2. Rub or handpick mealybugs from affected plants to reduce populations. They release chemicals that signal others to drop and leave.
3. Prune affected plant parts to remove mealybugs. Remove and destroy heavily infested plant. This will cut down sites and reduce future populations.
4. *Lyptomastix dactylopii* is a tiny (about a size of a pin head), deep-yellow colored parasitic wasp species. It attacks the adults and the large nymphs of the citrus mealybug. The female lays eggs in the body of the mealybug. When the wasp larva emerges, it feeds on the inside of the host. It forms a small cocoon, called 'mummy', from the wax covered remains before pupating. Parasitized mealybugs look like a bunch of tiny cotton-covered grapes attached to the plants. The tiny wasp cuts a neat hole into the mummy and climbs out to feed and mate. One wasp can parasitize 50-100 mealybugs. This is available on a commercial basis in North America and Europe.
5. Practice proper sanitation. Clean tools after used. Avoid movements of working animals and yourself from infested to non-infested areas the same day. Mealybugs can be transported from one area to another through farm tools and equipments, trellis materials, plant parts, and working animals.
6. Infested plants and plant parts should not be used as mulch. These should be removed from fields and destroyed.
7. Control and kill ants. Flood and plow the fields. This will destroy ant colonies and expose eggs and larvae to predators and sunlight. Ants use mealybugs to gain access to nutrients from the plants

Leafminers



Order: Lepidoptera
Family: Gracillariidae

Citrus leafminer

Scientific name: *Phyllocnistis citrella*

Damage

The leaflets have snake-like tunnels and severely damaged leaves are curled and distorted. Heavy infestation can cause stunted growths to young trees and production of seedlings in the nursery is lessened. Their effect on the mature trees is less serious.

Description

The eggs are laid singly on the underside, mostly along the mid-vein. They will hatch around 1 week. The larvae immediately feed into the leaves and initially produce very tiny snake-like tunnels. As the larvae grow, the tunnels become visible, wherein they later pupate inside causing the leaves to curl. The pupal stage lasts from 1 - 3 weeks. The adult is small, and delicate. It has narrow paired wings and fringed with long hairs.

Control measures

Proper management of seedlings in the nursery. Remove the infested leaves and crushed the larvae or pupae inside. Do not put the collected leaves in the compost pit as the pupae may emerge. For established trees, control is not necessary.

Psyllids



Order: Hemiptera
Family: Psylloidea

Common name: Asian citrus psyllid
Scientific name: *Diaphorina citri*

Damage

The nymphs and adults feed and suck on the juices of the young leaves causing the leaves to twist or roll. Waxy crystals of waste or white powder from nymphs can be observed on the plants. In severe infestation, the young leaves are burnt. Psyllids are the carrier of the bacteria, *Candidatus liberibacter sp asiaticus*, that cause the Huanglongbing disease also known as Citrus greening disease. The psyllid becomes a bacteria-carrier when it feeds on the bacteria-infected plants. The disease spreads when a bacteria-carrying psyllid feed on healthy plants and injects the bacteria as it feeds.

Description

The eggs are laid in the folds of the newly developing flush leaves, which are almond-shaped and yellow-orange in color. The eggs hatch into nymphs that are wingless, flattened, yellow or orange to brownish in color. The nymphs are flattened and somewhat scale-like with a fringe of short spines around the edge. Newly hatched nymphs are yellowish and turn pale-brown to green as they mature. They undergo four nymphal stages and are usually found on lower leaf surfaces. The adult is a small, brownish in color with a pointed front end, red eyes, and short antennae. The wings are mottled-brown and with greenish, yellow, or orange abdomens. The adults live in about 1 - 2 months.

Their common names are derived from their ability to jump backwards when disturbed.

Control measures

1. Several predators and parasites feed on different life stages of the psyllid. The nymphs are killed by tiny parasitic wasps and various predators, including lady beetle adults and larvae, syrphid fly larvae, lacewing larvae, and minute pirate bugs. Some spiders, birds, and other general predators feed on adult psyllids.
2. Horticultural oil. They are concentrated and must be mixed with water. Spray 2% solution against insects and mites. To make a 2% solution, pour 1/3-cup oil into a 1-gallon container, and then fill with water to make a 1-gallon solution. For a 3% solution, start with 1/2 cup of oil. Apply successive sprays at least 6 weeks apart. You can apply 1% oil solution by mixing 2.5 tbsp of oil in 1 gallon of water. Application of Vaseline, camphor, eucalyptus oils should be tested on small area, prior to large scale spraying, because as some leaves are sensitive to these oils. If done for the first time, ask for assistance from your local agricultural office. Avoid using horticultural oil for at least 1 month after using sulfur. The sulfur residues can trigger phytotoxic reactions (burnt leaves) on plants.
3. Soap spray. Mix 1 tablespoon of dishwashing soap to 4 liter of water.
4. Sticky board trap. To make your own sticky trap, spread petroleum or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or up. Place traps near the plants but far away enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 61 cm zone above the plants.

Scales

Order: Homoptera

Armored scales
Family: Diaspididae

Oystershell scale: *Lepidosaphes ulmi*
Greedy scale: *Hemiberlesia rapax*
California red scale: *Aonidiella aurantii*
Oleander scale: *Aspidiotus nerii*

San Jose scale: *Quadraspidiotus perniciosus*

Soft scales

Family: Coccoidea

Brown soft scale: *Coccus hesperidum*

Green scale: *C. viridis*

Damage

Scales remove plant saps by using their sucking mouthparts. Leaves become stunted and turn yellow. Twigs and branches dieback and eventually the plant dies when the population level is high. Some scale species produce honeydews which they secrete while feeding. Honeydews on fruits, leaves, twigs, branches, and barks attract black sooty molds to feed and grow, causing these plant parts to blacken.

Description

Armored scales

Armored scales are small, about 3 mm long. Their colors vary from white, yellow, gray, reddish or purplish. Adults are oval or round, hard bumps, and sometimes bearing a nipple or dimple in the center. They do not produce honeydews but they secrete armor wax in an oyster shell or circular pattern. They remain attached to the host plant when shells are lifted up.

Soft Scales

The eggs are covered or found under the mother scales. Eggs hatch into crawlers (nymphs), which are flattened and looking like dusts on the plant surface. Adult females are either oval or round, soft, legless bumps, and are wingless. Males are tiny yellow-winged soft scales. Soft scales secrete honeydews which attract ants. The shells of the soft scales are not left on the plant when lifted up. The soft covering they secrete cannot be separated from the scale's body. Soft scales typically move between branches and leaves during their lifecycle.

Control measures

1. Horticultural oil is synonymous with Petroleum oil. They are concentrated and must be mixed with water. Spray 2% solution against insects and mites. To make a 2% solution, pour 1/3-cup oil into a 1- gallon container, and then fill with water to make a 1-gallon

solution. For a 3% solution, start with 1/2 cup of oil. Apply successive sprays at least 6 weeks apart. You can apply 1% oil solution by mixing 2.5 tbsp of oil in 1 gallon of water. Application of Vaseline, camphor, eucalyptus oils should be tested on small area, prior to large scale spraying, because as some leaves are sensitive to these oils. If done for the first time, ask for assistance from your local agricultural office.

2. To use safely without the risk of the harming plants (phytotoxicity), observe the following recommendation: a) increase the spray volume to ensure wetting and canopy penetration. High volume spray gives a thorough coverage of the diluted spray while the excess runs-off the tree. b) Constantly shake the sprayer to prevent oil from separating out and floating on the surface of the water. Inadequate 'shaking' results in reduced effectiveness and increases the risk of harming the plants as spraying continues. Sprays of 250 ml petroleum oil/100 liters water can be applied throughout the year.
3. Use high-pressure water jet treatment to dislodge dead scales from trees following mineral oil spray. It is important to remove dead scales remaining on the plant because this will ensure protection against newly hatched scales.
4. Seedlings for planting must be free from scale insects. They are usually introduced to the field because the planting materials were already infested.

Snails

Order: Stylommatophora

Family: Helicidae



Common name: Common garden snail; Brown garden snail

Scientific name: *Helix aspersa*



Damage

The brown garden snail can feed on ripe and ripening fruits and the leaves of young trees. The fruit damage has circular chewed areas in the rind. The damaged leaves have large chewed areas along the margins. In the nurseries the feed on young tree barks.

Description

The eggs are white and spherical, about 3 mm in diameter in size. These are deposited in a cluster (an average of 86 eggs) in a nest found 2.5 - 4 cm deep below the soil surface. The egg mass is concealed by a mixture of soil with secreted mucus followed by a quantity of excrement. The eggs will hatch in about 2 weeks. The hatchling is fragile and translucent. It will reach maturity in about 10 months and/or 2 years depending upon the environmental conditions. The adult has a large and spherical thin shell that is moderately glossy and sculptured with fine wrinkles. It is yellow or horned-colored with chestnut brown spiral bands, adorned with yellow streaks.

Snails are hermaphrodites, having both the male and the female reproductive organs. They have to mate to reproduce but cases of self-fertilization are reported to occur. Snails are nocturnal and come out to feed at night time. They are very active when the soil is wet. When the temperature is unfavorable, they can hibernate for months in the soil and become active again when the rainy season comes.

Control measures

1. Prune the branches near the ground to make it more difficult for snails to attack low-hanging fruit
2. Band the tree trunks with copper foil or a basic copper sulfate slurry to prevent snails from climbing trees
3. Immediately handpick the snails, do not give them the chance to multiply. Crush their eggs. Feed the snails to ducks or chickens.
4. rap the snails and slugs using 30 cm x 30 cm white painted-surface wooden boards. Place them securely along the plant's rows. At daytime, slugs and snails take shelter underneath the cooler places.

Citrus rust mite

Order: Acarina
 Family: Eriophyidae
 Scientific name: *Phyllocoptruta oleivora*

Description

The eggs are transparent and flat and hatch in about 3 days. The newly hatched larva resembles the adult. changing in color from clear to lemon yellow for Citrus rust mite and pink for Pink citrus rust mite after molting to the nymphal stage. After about 2 days molting occurs. The first nymphal stage resembles the larval and requires about 2 days to molt to an adult at the above temperature. The Citrus rust mite adult has an elongated, wedge-shaped body about three times longer (0.15 mm) than wide. The Pink citrus rust mite is narrower, rounded, and smaller. Males and females have an average life span of 6 and 14 days. The length of the life cycle from egg to adult is 6 days.

Damage

Early rust mite damage to fruit in late spring or early summer is evidenced by bronzing of the rind, a condition commonly called "buckskin" fruit. Severely affected fruits do not expand normally and frequently exhibit rind cracking. Damage occurring later in fruit development is evidenced by a darkening of the peel where heavy feeding took place, generally dark brown to black on green fruit and rust-brown on mature fruit.

A reliable sign of impending rust mite damage to fruit is the dull, cloudy appearance of heavily infested fruit caused by thousands of mite skins cast off during the molting process.

Control measures

1. Horticultural oil spray

They are concentrated and must be mixed with water. Spray 2% solution against insects and mites. To make a 2% solution, pour 1/3-cup oil into a 1- gallon container, and then fill with water to make a 1-gallon solution. For a 3% solution, start with 1/2 cup of oil. Apply successive sprays at least 6 weeks apart. You can apply 1% oil solution by mixing 2.5 tbs of oil in 1 gallon of water. Application of Vaseline, camphor, eucalyptus oils should be tested on small area,

prior to large scale spraying, because as some leaves are sensitive to these oils. If done for the first time, ask for assistance from your local agricultural office.

To use safely without the risk of the harming plants (phytotoxicity), observe the following recommendation: a) increase the spray volume to ensure wetting and canopy penetration. High volume spray gives a thorough coverage of the diluted spray while the excess runs-off the tree. b) Constantly shake the sprayer to prevent oil from separating out and floating on the surface of the water. Inadequate 'shaking' results in reduced effectiveness and increases the risk of harming the plants as spraying continues. Sprays of 250 ml petroleum oil/100 liters water can be applied throughout the year.

Thrips



Order: Thysanoptera

Family: Thripidae

Citrus thrips

Scientific Name: *Scirtothrips citri*

Damage

Thrips have rasping-sucking mouthparts and feed by rasping the surface of the rapidly growing tissues of the leaves and sucking up the released plant fluid. Thrips cause tiny scars on leaves and fruit, called stippling, which can cause stunted growth. Damaged leaves may become papery and distorted. Infested terminals lose their color, rolled, and drop leaves prematurely.

Scabby, gray, or silvery scars on the rind, usually at the stem end of the fruit, result from citrus thrips feeding under the calyx when the fruit are small. The ring pattern around the button helps to distinguish thrips scars from damage caused

by insects or wind scars and other fruit diseases and disorders.

Description

The egg is very tiny and is impossible to see. A single egg is 0.25 mm long and 0.1 mm wide. It is white when freshly laid and turns pale yellow toward maturation.

The nymph is elongated, elliptical, slender, and is pale-yellow in color. It is very small from 0.5-1.2 mm in size. Its eyes have darker coloration and are easy to see. Immature thrips do not have wings. The pupa appears as an intermediate form between the nymph and the adult. It has short wing buds that are not functional. At this stage, they do not do any damage to the plant.

The adult has a slender small body, yellowish to dark-brown in color, and is cigar-shaped. It is 1-2 mm long with a well-pronounced 5-8 segmented antennae. It can exist in two forms, winged or wingless. The winged form has two pairs of elongated narrow wings which are fringed with long hairs. Female thrips can reproduce both sexually and asexually.

Control measures

1. Petroleum oils
2. Flour spray: Add 2 cups of fine flour into 5 - 10 liters of water. Stir well. Spray to plants with the pests.
3. Soap spray: Mix 1 tablespoon of dishwashing soap to 4 liter of water.
4. Neem Spray: Pound finely 3 - 5 kg of peeled neem seeds. Place in a covered container. Add 10 liters water. Let it set for 3 days. Strain. Dilute 1 liter of this extract with 9 liters of water.
5. Blue sticky trap: Thrips are attracted to blue colors. To make your own sticky trap, spread petroleum or mustard on a blue shade painted plywood, 6 cm x 15 cm or up in size. Place traps near the plants with enough distance that the leaves from sticking to the board. The traps when hung should be positioned at a 60-75 cm zone above the plants.

To monitor for thrips population, shake leaves and flowers gently onto a white sheet of paper or into a shallow carton box. The general recommended economic threshold is: 20% of the plant population is infested with thrips. Count the

number of plants with thrips and not the actual number of thrips. When this is reached, control measure is needed.

Whiteflies



Order: Homoptera
Family: Aleyrodidae

Whitefly species

Citrus whitefly (*Dialeurodes citri*); Silverleaf whitefly (*Bemisia argentifolii*); Spiraling whitefly (*Aleurodicus disperses*); Sweet potato whitefly (*Bemisia tabaci*); Woolly whitefly (*Aleurothrixus floccosus*)

Damage

Whiteflies, both the larvae and adults, pierce and suck the sap of the leaves. This causes the weakening and early wilting of the plant resulting in reduced plant growth. Their feeding may also cause yellowing, drying, premature dropping of leaves that result in plant death.

Whitefly produces honeydews that serve as the substrates for the growth of black sooty mold on leaves and fruit. The mold reduces photosynthesis causing the poor plant growth of the plant. Whitefly is the most important carrier of plant viruses that causes diseases to plants.

Description

The eggs are tiny, oval-shaped, about 0.25 mm in diameter, and stand vertically on the leaf surface. Newly laid eggs are white then turn brownish. They are deposited on the underside of leaves, sometimes in a circle or oval-shaped patterns. The larvae of the woolly whitefly are covered with curly and waxy filament while those of other species are transparent, ovate, and about 0.3 to 0.7 mm in size and they move

around on the plants looking for a feeding site upon hatching. The pupae are dirty-white and surrounded by wax and honeydews. During this stage, the red eyes of the emerging adults are visible. The adults are about 1 mm long with two pairs of white wings and light-yellow bodies. Their bodies are covered with waxy powdery materials. They are found feeding on top of the plants. A female can produce as many as 200 eggs in her lifetime and mating is not necessary. It takes about 40 days to develop from egg to adult. All whitefly adults look very similar.

Control measures

1. Sticky board traps. Traps give early warning and serve as natural control method. To use, place 1 to 4 yellow sticky cards per 300 square meter field area. Replace traps at least once a week. It is difficult to determine the population of newly trapped whiteflies on a sticky card to those previously trapped ones. To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or above. Place traps near the plants, preferably 25 cm away from the plant to ensure that the leaves will not stick to the board. Alternatively, the traps can be hung and positioned at 60-75 cm zone above the plants.
2. Chemical spray is generally not necessary. Several predators and parasites feed on different life stages of whiteflies. The nymphs are killed by tiny parasitic wasps and various predators, including lady beetle adults and larvae, syrphid fly larvae, lacewing larvae, and minute pirate bugs. Some spiders and other general predators feed on whiteflies.

Diseases

Citrus canker

Common name: Bacterial spot of citrus

Scientific name: (*Xanthomonas axonopodis* pv. *citri*, *X. axonopodis* pv. *aurantifolii*)

Damage

Citrus canker is a bacterial infection that affects all the plant parts above the ground.

The infected leaves have raised lesions on both sides but are dominantly found on the lower surfaces. The lesions later on become corky with raised margins and sunken centers, which are surrounded with yellow rings. Old cankers sometimes fall-out leaving shot-hole effect.

The infected fruits have raised lesions with scab-like or corky-like appearance on the rinds/peels. The lesions varied in sizes because of the several infection cycles that took place. The lesions may turn black because of another infection caused by fungi.

The infected twigs, branches, and trunks have the same lesions appearance as those found on the fruits. These lesions survive for a long time which cause the continuous presence of the bacteria in an infected tree.

The canker disease usually develops during the emergence of new shoots and in the early stage of fruit development when there is a continuous rain and/or frequent rainfalls during a warm weather.

Heavy infestation causes defoliation, shoot die-back and fruit drop.

Disease management

There is no direct cure for citrus canker. The preventive measures are the following:

1. Control the insect pests. Their feeding wounds are exposed to bacterial and fungal infections.
2. To have marketable fruits, applications of copper-containing materials starting when the fruit is $\frac{3}{4}$ inch diameter. Read the label carefully or ask for the assistance from your local agriculturist.
3. For a heavily infested tree, remove and burn

Greasy Spot

Common name: Greasy spot rind blotch

Scientific name: *Mycosphaerella citri*



Damage

Greasy spot is a fungal infection on the leaves and fruits.

The underside of the leaf is normally infected first, but it can infect the whole leaf at the same time. An infected leaf has yellow to dark-brown or black lesions. The lesions first appear as yellow spots on the upper leaf surface. Slightly raised, pale-orange to yellowish-brown blisters are found on the underside. Further on, the lesions become greasy dark-brown or black in appearance, hence the name. The heavily affected leaves will fall prematurely.

The infected fruit has small black spots and dead tissues on the rinds/peels. Eventually, affected areas coalesced and formed sunken pinkish-brown areas.

Disease Management

1. Field sanitation. Removal of the fallen leaves away from the orange grove.
2. Discing or other types of tillage to bury the fallen leaves.
3. Proper plant spacing, pruning and hedging for proper air circulation among plants.
4. Copper spray. Read the label carefully or ask for the assistance from your local agriculturist.

Gummosis

Scientific name: *Phytophthora gummosis*

Damage

Gummosis is a fungal infection on the bark and trunk.

The infected bark has small cracks where the saps ooze out. It looks like that the tree is bleeding. As the lesions multiply, they spread around the trunk, like girdling the tree. The infested bark hardens, dries-up and then cracks. During heavy rain, the gummy substance are washed off but the pathogens are still present on the tree.

Disease Management

1. Proper selection of the planting materials. Check carefully the lower trunk and rootstock of the seedlings for any symptoms of Gummosis before planting.
2. During the planting of the seedling, ensure that the graft joint or the budded portion is above the ground to avoid early disease infection.
3. Plant the seedlings high enough so that only the first lateral roots are covered with soil.
4. The soil must be properly drained or there is no stagnant water near the plant to prevent pathogen buildup in the soil.
5. Remove weeds and other plant debris.
6. Avoid injuries on barks, they serve as the entry points of the pathogens.
7. Copper spray. Read the label carefully or ask for the assistance from your local agriculturist.
8. Remove the tree, if 50% or more of the trunk is girdled.

Huanglongbing disease (HLB)

Common name: Greening disease

Scientific name: *Liberibacter asiaticus*

Damage

HLB is a serious bacterial disease.

The infected leaves have yellow veins and blotches of yellow allover. The heavily infested ones are totally yellow in color or with just with few spots of green pigments, which is referred to

as “green islands”. These symptoms are called “blotchy mottles”.

The infected fruits are small and misshaped, with odd color. Their seeds are not developed. The ripe fruits taste bitter.

The infected roots are poorly developed and new roots are suppressed to grow.

An infected tree initially has yellow shoots and twigs and branches. The severely infected branches have small upright leaves and shoots with compressed internodes. For a young tree, the yellowing spreads within a year and then die. An older tree fails to produce healthy foliage, the fruits fall prematurely, its growth is stunted, and eventually dies.

Disease Management

There is no cure for Huanglongbing disease. The preventive measures are the following:

1. Select the proper planting materials. During the vegetative propagation, select the healthy scions and rootstocks.
2. Control the insect vectors, the Psyllids.
3. If you are sure that a tree is heavily infected with HLB, remove and properly dispose it

Melanose



Scientific name: *Diaporthe citri*

Damage

The infected leaves have dark-brown to black spots. The spots are raised and rough to touch.

These are superficial and sometimes can be removed by the fingernails.

The infected fruits have raised light-brown to dark-brown raised spots. As the spots coalesce, they become rough and hard. An infected mature fruit rots, which normally originates from the point of insertion of the peduncle. The rind slowly turns dark-brown and becomes rough and hard.

An infected bark has yellow-brown to reddish-brown discoloration with a well-defined margin between the healthy and dead tissues. The infection often has streak of yellow gum.

Disease Management

1. Field sanitation. Removal of fallen fruits and leaves.
2. Proper air circulation among plants. Very humid conditions enhance fungal infection.
3. A single application of copper fungicide after bloom or during the petal fall and before the fruit averages 1/2 inch in diameter.

Disease Management

1. Remove dead twigs and branches on the trees. They harbor the fungal pathogens.
2. Proper air flow among the trees. Very humid conditions enhance fungal infection.
3. Application of copper spray. Always read the label and follow the instruction properly.

Scab

Common name: Citrus scab, Sweet orange scab
 Scientific name: (*Elsinoe australis*, *E. fawcettii*)

Damage

The scab is a fungal disease.

The infected young leaves have water-soaked lesions on the upper sides, found along the edges or mid-veins. They are often small, misshapen and puckered. The mature leaves are often not infested.

The infected fruits have scab-like lesions on the peels. The fruits can also drop prematurely. The scabs initially infest on young fruits which are pink to light-brown in colors. As the lesions expand, the colors change to yellowish-brown to dark-brown. As the scabs coalesce, they are warty and scabby on the peels. The scabs found on the peels do not affect the internal quality of the fruits.

The infected nursery trees and new planted ones have stunted growth.



References

- Basta, A.; Spooner-Hart, R. (undated): Efficacy of an extract of Dorrigo pepper against two-spotted mites and greenhouse thrips. Abstract. Center for Horticulture and Plant Sciences, University of Western Sydney. New South Wales. Australia.
- Beattie, G. (1990). Citrus petroleum spray oils. Agfact H2. AE.5., Department of Agricultural Sciences, Department of Agriculture. New South Wales, Australia. pp. 1-3
- Beattie, G.; Jacas, J.; Nicetic, O.; Watson, D. (undated): Evaluation of rapeseed-based plant oils for control of citrus leafminer (*Phyllocnistis citrella* Stainton [Lepidoptera: Gracillariidae]) and their phytotoxicity to lemon. Beyond oils spray 2000. Abstract. Center for Horticulture and Plant Sciences, University of Western Sydney. New South Wales, Australia.
- Brooklyn Botanic Garden. (1999): Natural insect control: The ecological gardener's guide to foiling pests. Handbook # 139. Brooklyn Botanic Garden, Inc. Washington Avenue, Brooklyn, NY.
- Browning, H.; Childers, C.; Stansly, P.; Pena, J (2002): Soft-bodied insects attacking foliage and fruit. 2003 Florida Citrus Pest Management Guide. University of Florida Extension. University of Florida, USA.
- CABI. (2000): Crop protection compendium. Global module, 2nd edition. CABI Publishing, Wallingford, UK.
- Childers, C.; McCoy, C.; Nigg, H.; Stansly, P. (2001): Spider mites. Florida Citrus Pest Management Guide. University of Florida Extension. University of Florida, USA.
- DA. (2002): Technoguide for citrus production. DA-CAR. Benguet, Philippines. p. 2
- Ellis, B.; Bradley, F. (1996): The organic gardener's handbook of natural insect and disease control. Rodale Press. Emmaus, Pennsylvania.
- FADINAP. (2000): Integrated plant nutrition systems: Training manual. FADINAP Rural Development Section, ESCAP, Population and Rural and Urban Development Division. United Nations Building, Rajdamnern Avenue, Bangkok 10200, Thailand. p. 111
- Fasulo, T.; Brooks, R. (2001): Grasshopper, katydid and cricket pests of citrus. Florida Citrus Pest Management Guide. University of Florida Extension. University of Florida, USA.
- Futch, S.; McCoy, C.; Michaud, J.; Childers, C. (2002): A guide to identification of soft-bodied citrus insect pests. Florida Citrus Pest Management Guide. University of Florida Extension. University of Florida, USA.
- Klien, T. (2000): Grow organic citrus. Creative Marketeam, Suite University. Canada. p. 2
- Morton, J. (2013). Fruits of warm climates. Julia F. Morton, Miami, FL. p. 134–142.
- NRRC. (2003): Technologies developed. National Research Centre for Citrus. Nagpur City.

- Olkowski, W.; Daar, S.; Olkowski, H. (1991): Common sense - pest control. The Taunton Press. USA.
- Olkowski, W.; Daar, S.; Olkowski, H. (1995): The gardener's guide to common-sense pest control. The Taunton Press. USA.
- PFTC. (2003): Fertilizer management for citrus orchard. Food and Fertilizer Technology Center. An international information center for farmers in Asia Pacific Region. p. 2
- Ploetz, R.; et. al. Editors. (1998): Compendium of tropical fruit diseases. APS Press, The American Phytopathological Society. Saint Paul, Minnesota, USA.
- Prakash, A.; Rao, J. (1997): Botanical pesticides in agriculture. CRC Press. USA.
- Samson, JA. (1989): Tropical fruits. 2nd edition. Longman Singapore Publishers. Singapore.
- Sridhar, S.; Arumugasamy, S.; Saraswathy, H.; Vijayalakshmi, K. (2002): Organic vegetable gardening. Center for Indian Knowledge Systems. Chennai.
- Stansly, P.; Childers, C.; Nigg, H.; Simpson, S. (2002): Plant bugs, chewing insect pests, Caribbean fruit fly, and thrips. 2003 Florida Citrus Pest Management Guide. University of Florida Extension. University of Florida, USA.
- Stoll, G. (2000): Natural Crop Protection in the Tropics Margraf Verlag. Weikersheim.
- Thurston, D. (1998): Tropical plant diseases. Second Edition. APS Press. The American Phytopathological Society. St. Paul, Minnesota, USA.
- Vijayalakshmi, K.; Subhashini, B.; Koul, S. (1999): Plants in Pest Control: Pongam, tulasi and aloe. Centre for Indian Knowledge Systems, Chennai, India.
- Wagner, Georg. (2004): Vegetables' pests. Personal Communication. Schopperplatz 14, 4082 Aschach / Donau.

Webpages

- Beneficial insects. <http://www.rodalorganiclife.com/garden/top-10-beneficial-insects-garden>
- Efficacy of Dorrigo pepper. <http://sprayoils.uws.edu.au/sympabs9.shtml>
- Citrus canker.
<http://www.apsnet.org/edcenter/intropp/lessons/prokaryotes/Pages/CitrusCanker.aspx>
- Citrus disease. [http://idtools.org/id/citrus/diseases/factsheet.php?name=Huanglongbing+\(HLB\)](http://idtools.org/id/citrus/diseases/factsheet.php?name=Huanglongbing+(HLB))
- Citrus pests. <http://idtools.org/id/citrus/pests/morphology.php?state%5B%5D=type>
- Citrus greening.
http://www.crec.ifas.ufl.edu/academics/faculty/brlansky/pdf/Citrus_Greening.pdf
- Disease management. <http://aggie-horticulture.tamu.edu/citrus/l2328.htm>
- Fruits of Vietnam. <http://www.fao.org/docrep/008/ad523e/ad523e02.htm#TopOfPage>

Greasy spots. <https://edis.ifas.ufl.edu/hs263>

How to fertilize and water orange trees. <http://homeguides.sfgate.com/water-fertilize-orange-trees-43844.html>

Important pest of citrus in Asia.
<http://www.agnet.org/library.php?func=view&id=20110707233340>

Major diseases of citrus in Asia.
http://www.ffc.agnet.org/library.php?func=view&style=volumes&id=20110708000535&type_id=7

Managing melanose in citrus.
http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0019/138205/Managing-melanose-in-citrus.pdf

Melanose. <http://idtools.org/id/citrus/diseases/factsheet.php?name=Melanose>
<http://aggie-horticulture.tamu.edu/citrus/l2316a.htm>

Orange. <https://www.hort.purdue.edu/newcrop/morton/orange.html>

Orange production. <http://www.naads.or.ug/files/downloads/ORANGE%20PRODUCTION.pdf>

OISAT. www.oisat.org

Pests in Citrus. <https://www.agric.wa.gov.au/citrus/mites-citrus?page=0%2C2>

Plant oils for the control of leafminer <http://sprayoils.uws.edu.au/sympabs9.shtml>

Technologies developed. <http://www.nagpurcity.net/nrcc/5.html>

The kinds of fertilizers in growing oranges <http://homeguides.sfgate.com/kinds-fertilizers-used-growing-oranges-30486.html>

Photo credits/sources:

Page

- 1 Orange cover page
<http://www.sealdsweet.com/products/commodities-and-availability/citrus/orange.php>
<http://wallpaperest.com/orange-fruit-white-background-wallpaper-794610>
- 10 Aphids
<http://cms.cnr.edu.bt/cms/fruitproductionDIP/?citrus>
- 11 Fruitflies
 Agnet. <http://www.agnet.org/library.php?func=view&id=20110707233340>
 Morning Ag Clips. www.morningagclips.com/oriental-fruit-fly-quarantine-in-la-county/
 USDA. <http://www.hungrypests.com/the-threat/mediterranean-fruit-fly.php#>
- 12 Mealybug
 Infonet. <http://www.infonet-biovision.org/default/ct/128/crops>
http://entomology.osu.edu/bugdoc/Shetlar/462/462_GreenH08/GHP03.htm
- 13 Citrus leafminer
http://en.wikipedia.org/wiki/Phyllocnistis_citrella
- 14 Psyllid
 UCCE.
<http://ceventura.ucanr.edu/?blogstart=6&blogtag=Asian%20citrus%20psyllid&blogasset=30680>
 University of Florida. <http://entomology.ifas.ufl.edu/creatures/citrus/acpsyllid.htm>
<http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=1785>
- 16 Snails.
<http://www.ipm.ucdavis.edu/PMG/r107500111.html>
- 17 Thrips
 Forestry images.
<http://www.forestryimages.org/browse/detail.cfm?imgnum=1263058>
- 18 Whiteflies
http://cekern.ucanr.edu/Entomology/Newsletters_and_Other_Entomology_Information_114/Whiteflies/
http://entnemdept.ufl.edu/creatures/citrus/citrus_whitefly.htm
- 20 Greasy spots. Park Barkley
<http://www.gardeningknowhow.com/edible/fruits/citrus/greasy-spot-fungus.htm>
- 22 Melanose
http://www.ftc.agnet.org/library.php?func=view&style=volumes&id=20110708000535&type_id=7



For more information
on non-chemical pest management see:

www.oisat.org

Pesticide Action Network (PAN) Germany

Nernstweg 32 • 22765 Hamburg • Germany

Phone: +49 (0)40 - 399 19 10-0 • Email: info@pan-germany.org

Internet: www.pan-germany.org • www.oisat.org



Please donate to support this work

GLS Gemeinschaftsbank eG,

Account number. 203 209 6800,

Bank code number 430 609 67

IBAN: DE91 4306 0967 2032 0968 00

BIC/SWIFT: GENODEM1GLS