Whitefly management in Tomato

Training course guide

AVRDC
The World Vegetable Center

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CONTENTS

INTRODUCTION

Whiteflies carry and spread diseases that have a major impact on global food production. In the tropics and subtropics, whiteflies have become one of the most serious crop protection problems. Economic losses are estimated in the millions of dollars.

While several species of whitefly cause crop losses through direct feeding, a species complex, or group of whiteflies in the genus Bemisia are important in the transmission of plant diseases.

Efforts to develop environmentally friendly integrated pest management systems, with the goal of reducing insecticide use aim to re-establish the ecological equilibrium of predators, parasitoids, and microbial controls that were once in place.

New crop varieties are also being developed with increased tolerance to whiteflies, and to the plant diseases carried by them.

In 1997, tomato yellow leaf-curl begomovirus was discovered in Florida, USA. This is the worst viral disease transmitted by the whitefly, Bemisia spp[5] and this poses a chronic problem in greenhouses. Whiteflies can also become serious pests during late summer.

Whitefly control is difficult and complex, as whiteflies rapidly gain resistance to chemical pesticides. The USDA recommends "an integrated program that focuses on prevention and relies on cultural and biological control methods when possible."

Tomato plant affected by Yellow Leaf Curl virus carried by Whitefly

A FRAMEWORK FOR TRAINING:

Purpose of this training package:
To provide technical, extension teaching and practical skills to extension workers and community workers.

Participants for the training course:
Agriculture extension workers, field staff, seed company staff, NGOs and community development workers, who propose to train farmers.

Resource personnel:
Scientists from national and international research and extension institutes, leading seed companies, progressive and innovative farmers, agripreneurs who can apply the principles of adult learning.

Training approaches to be used:
The sessions should include both classroom and field oriented hands-on sessions. Group work, role plays and case studies are integral parts of this training program. The manual has suggestions and directions on how to conduct each session.

Duration of the training course:
Ideally a full working day will be required with a field visit to nearby fields for on-the-ground experience. However, the number of days can be varied depending on the need.

Materials needed:
The training package has relevant technical bulletins, pamphlets, formats and survey sheets to be used by the trainers. This package will help the trainees when they actually go to the villages for training the farmers. Ideally the trainees should also develop complementary training packages in local languages as part of this training program.

Monitoring and Feedback mechanism:
To judge the success or failure of any training program, and how it can be improved, it is important to assess its impact. Structured questionnaires will be administered to the participants once or twice after a fixed interval. The first one will be given immediately after the end of the program to measure changes in knowledge, another one after three months and if possible one more after six months to assess the practical impact of the program.

WHITEFLY AND ITS DAMAGE

- Whiteflies are small, soft-bodied sucking insects that look like tiny white triangles, less than one-tenth of an inch long, that often rest on the undersides of plants.
- Several species of whiteflies may infest tomato. Proper identification of sweet potato whiteflies and green-house whiteflies is important because other whitefly species do not cause economic damage in tomato.
- Feeding is concentrated on the leaf undersides, where whiteflies remove so much plant sap that the plants are seriously weakened.
- Infested leaves have numerous chlorotic spots. These spots grow together forming different sized yellow areas. In severe cases, only the veins remain green. Some leaves appear completely brown and dried. Wilting and leaf drop may occur. A sticky, black mould may be found on leaves and stems.
- The *Bemisia sp.* of whiteflies transmit begomo viruses that cause Tomato yellow leaf curl. Active adult insects are responsible for almost all virus spread into and within crops.
- The whitefly acquires the virus while feeding and sucking sap from the phloem tissue of virus-infected plants. The insect needs to feed on an infected plant for at least 15 minutes to acquire the virus and then feed for 15 to 30 minutes to transmit the virus to another host plant.

Whiteflies on the lower surface of the leaves

HOW TO IDENTIFY WHITEFLY THROUGH ITS BIOLOGY

• Pale, wilting leaves are a sign that whiteflies are sucking juices from leaf undersides. As you approach infested plants to inspect the lower sides of wilted leaves, hundreds of tiny white moths take to the air in a cloud.

• If the whiteflies have been feeding for several days, the leaves may have a sticky substance (whitefly honeydew) and ants may be present as honeydew consumers.

Where To Look

• The easiest way to find whiteflies is to brush or shake the leaves and look for the whitefly adults which fly off. Inspect the undersides of the leaves for the stationary immature insects.

• Use a hand lens to examine both immature insects and adults. Whiteflies hold their wings somewhat vertically tilted, or rooflike, over the body; the wings do not meet over the back but have a small space separating them.

Life cycle

• Females lay up to 150 eggs each. Eggs are attached to the underside of the leaf surface, usually younger leaves. Eggs hatch in eight to ten days.

• Eggs hatch into a first instar nymphal stage that has legs and antennae and is mobile; Crawlers or first instar nymphs crawl a short distance before settling to feed on plant tissue.

• There are four immature or nymphal stages. The second and third instar nymphs are stationary and remain attached to the leaf surface, and have a scale-like appearance. They continue feeding until developing into the fourth and final nymphal stage.

• The last/fourth nymphal instar, often called the pupa or the red-eyed nymph, is the easiest to identify. These fourth instar nymphs stop feeding, then pupate and emerge from the pupal case as fully developed adults.

• The active adult whitefly is largely responsible for virus spread from plant to plant. It takes 18 to 28 days from egg to adult in warm weather and 30 to 48 days in winter.

Damage causing stages:

• Second and third instar larval stages that feed on the leaves and suck sap.

• Adults that suck juices and transmit the virus.

Lifecycle of whitefly

TOMATO YELLOW LEAF CURL VIRUS (TYLCV)

• Tomato yellow leaf curl virus is one of the most damaging pathogens of tomato, and it limits production of tomato in many tropical and subtropical areas of the world.
• The virus can be efficiently transmitted during the adult stages. This virus transmission has a short acquisition access period of 15–20 minutes, and latent period of 8–24 hours.
• A study demonstrated that TYLCV is transmitted to offspring for at least two generations through the infected insect's egg[5]. TYLCV DNA was present in the progeny of insects that had acquired the virus through the egg. The adult progeny of the viruliferous insects and their own progeny were able to infect tomato test plants, producing typical disease symptoms. [11]

Infested plant

Symptoms:

• The new growth of plants with tomato yellow leaf curl has reduced internodes, giving the plant a stunted appearance.
• The new leaves are also greatly reduced in size and wrinkled, are yellowed between the veins, and have margins that curl upward, giving them a cup-like appearance.
• Plants often take on a bushy appearance, which is sometimes referred to as 'bonsai' or broccoli'-like growth.
• Flowers formed on infected plants commonly do not develop and fall off (abscise).
• Fruit production is dramatically reduced, particularly when plants are infected at an early age. It is not uncommon for losses of 100% to be experienced in fields with heavily infected plants.

Strategies to effectively manage the disease will be discussed in detail in the chapter on 'Whitefly Management' as the disease is controlled by managing the whitefly.

	Tomato Yellow leaf curl disease	Tobacco Mosaic Virus	Cucumber Mosaic	Tomato spotted wilt virus
Transmitted by	Whitefly: *Bemisia tabaci*	Seed borne and does persist in plant debris in the soil	Aphids in a non-persistent manner	Thrips, *Frankliniella occidentalis*
Symptoms	Chlorotic spots Yellowing Upward curling and drying of leaves	Light and dark green mottled areas on leaves. Leaves on infected plants are often small, curled, and puckered	Leaves often are stunted and bushy (shortened internodes) and may have distorted and malformed leaves. Leaves may appear mottled (intermingling of dark green, light green, and yellow tissue), a similar symptom to those caused by other viruses. The most characteristic symptom of CMV is extreme filiformity, or shoe stringing, of leaf blades	Chlorotic or necrotic rings on the leaves and may also appear on the fruits

Tomato Yellow Leaf Curl

Plant affected by Tobacco Mosaic Virus

Close view of leaf affected by tobacco mosaic

Cucumber mosaic virus

Fruits damaged by cucumber mosaic

Spotted wilt virus on fruits

MANAGEMENT OF WHITEFLY

• An integrated pest management program for whiteflies includes following good cultural practices, such as host-free periods, conserving natural enemies, routinely monitoring fields for trouble spots, and using pesticides only when necessary.

• The best way to control whiteflies is to grow the crop under protected conditions, in green houses or polynethouses. If farmers practice open cultivation, they will have to adopt some preventive practices to avoid complete crop loss.

Biological Control

The natural enemies of whitefly include small birds, spiders, lacewings, hoverflies, ground beetles, mirid bugs and damsel bugs. The adults and larvae of some ladybirds also feed on whiteflies. Habitat, such as a border of perennial plants, needs to be available all year round as a refuge for these predators.

Physical and cultural controls

• At the beginning of the season, hang sticky yellow traps above the plants to provide early detection of an invasion. Tapping the plants with a stick will cause the whiteflies to fly up and stick onto the traps. Whiteflies are strongly attracted to the colour yellow, so avoid wearing yellow clothing around whiteflies or else you may carry them from plant to plant.

• Use a floating row cover such as a Vege Net for early-season protection, when grown in open conditions.

• For small areas, vacuuming in the early morning (when whiteflies are cold and slow moving) can remove many of the adults before they have a chance to lay many eggs. They may also be collected in plastic bags and destroyed.

• Handpick older leaves to remove young whitefly stages.

• Avoid using a lot of nitrogen fertilizer, including manures, as succulent growth will increase whitefly population. It can be useful to check phosphorus and magnesium levels, as deficiencies in these are believed to contribute to whitefly infestations.

Ladybird beetle feeding on larvae

Pirate Bug feeding on whitefly nymphs

Row cover to protect young crop

• Adult whiteflies are repelled by silver-coloured mulches. Place reflective polyethylene mulches on planting beds before seeding or transplanting to significantly reduce the rate of colonization by whiteflies and delay the build up of damaging numbers of whiteflies by 4 to 6 weeks. This delay in infestation can be especially important if virus transmission is a major concern.

Organically acceptable methods

• Cultural and biological control as well as sprays of insecticidal soaps (one tablespoon of soap powder in 4 L of water) and one or two teaspoons of oil plus Azadirachtin (Nimbecidine EC available formulation 0.03% = 300ppm : Dosage @ 5 ml / Litre) spray are acceptable for use on organically certified produce.

• Monitor the activities of the adult whiteflies by setting up yellow pan traps and sticky traps at 30 cm from the ground.

• Yellow empty tins or plates smeared with Castor oil can also be kept in the field. Whiteflies get trapped on them, and they can be wiped off every day and the castor oil re-applied. The number of traps needed depends on the intensity of the pest. 50 traps/ha will be optimum.

• Collect and remove whitefly infested leaves from the plants and those which were shed due to the attack of the pest and destroy them.

Spray a 5% solution of Neem Seed Kernel extracts mixed with neem oil. To prepare enough mixture of the extract to spray an area of 4000 m2, 3-5 kg of neem kernel is required. Remove the outer seed coat and use only the kernel. If the seeds are fresh, 3 kg of kernel is sufficient. If the seeds are old 5 kg is required.

Pound the kernel gently and tie it loosely with a cotton cloth. Soak this overnight in a vessel containing 10 litres of water and filter the next morning. On filtering, 6-7 litres of extract can be obtained. Between 500-1000 ml of this extract should be diluted with 9 or 9.5 litres of water and mixed with 5 ml of neem oil.

Mix 500 to 2000 ml of this solution with water in a 10 litre capacity sprayer, along with 100 ml of khadi soap solution to help the extract stick well to the leaf surface. The concentration of the extract can be increased or decreased depending on the intensity of pest attack.

Yellow sticky trap in the field

Yellow traps in polyhouses

• Apply LASTRAW @ 5 ml/litre of water. This is a specially formulated concoction produced by Pest Control India (PCI) for controlling all soft-bodied sucking pests such as mealy bugs, thrips, white flies, mites, aphids, scale insects and plant hoppers. Apply when sucking pests are noticed and repeat application 2-3 times at weekly intervals for effective control.

SUGGESTED SESSION PLAN

• The preferable location for the training program is a tomato field with or without infestation. Practical insights are more useful than a theoretical presentation.
• If no infestation is found in the field, an open discussion can be facilitated so trainees can share their past experiences with this problem.

S.No	Topic	Duration	Resource person /facilitator
Day I			
1	Identification of the insect pest	30 min	Entomologist
2	Observation of the symptoms and diagnosing them	40 min	Entomologist/Pathologist
3	Symptomatic identification of yellow leaf curl virus		
3	Distinguishing between different viral symptoms	40 min	Pathologist
4	Managing the pest and the disease transmitted	60 min	Entomologist/Pathologist

PRACTICAL EXERCISES

Purpose:

To impart skill in identifying the carrier and disease symptoms
To demonstrate a practical means of managing the infestation.

Activities:

A. Field visit, observation using a lens, collection of symptoms

- Participants will divide into groups with a combination of experienced and beginners in each group.
- Groups will go for a pest survey in the field, check for the presence of adult insects and identify disease symptoms.
- Plants with suspected symptoms should be collected and brought back to the full group for further discussion.
- Groups share their experiences of managing the problem.
- The facilitator/trainer will discuss in detail all the symptoms and management practices.
- How to differentiate leaf curl disease from other viral diseases will also be explained.

B. Powerpoint with interactive discussion

- If the class has to be conducted in a closed room with Powerpoints and images, a video can be played on the identification of life stages of whitefly.
- The group will be divided into small groups and asked to work on their experiences in managing the pest and disease.
- The findings will be consolidated to prepare a common management strategy with input from the facilitator.

COMMUNICATION MATERIALS

Training manual

Handouts of
- Whitefly and its management
- Yellow Leaf curl virus

Videos from YouTube
- Life cycle of whitefly

QUIZ (PRE AND POST TEST)

1. White fly is a tiny sucking insect
   a. Yes
   b. No

2. Whitefly settles and feeds on the underside of leaves
   a. Agree
   b. Disagree
   c. No idea

3. Whiteflies carry leaf curl virus
   a. Yes
   b. No
   c. No idea

4. Controlling whiteflies will free the crop from leaf curl virus
   a. Agree
   b. Disagree
   c. No idea

5. Growing tomatoes under protected conditions can prevent attack by whiteflies
   a. Yes
   b. No

6. Yellow sticky traps can be used to attract adult flies
   a. Yes
   b. No

7. The beneficial insects that can feed on the larvae have to be protected
   a. Agree
   b. Disagree
   c. No idea

8. Using lot of nitrogenous fertilizer will increase whitefly populations
   a. Yes
   b. No
   c. No idea

9. Whitefly attack is greater when tomato is grown in
   a. Open field
   b. Polyhouses
   c. No difference
   d. Can't say

10. Whiteflies do not cause significant damage to the crop
   a. True
   b. False

GLOSSARY

TYLCV	Tomato Yellow Leaf Curl Virus
spp.	Species
Kg	Kilogram
ml	Millilitre
DNA	Deoxyribonucleic acid
Min	Minutes
L	Litres

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