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# MANUAL FOR TOMATO PEST SURVEILLANCE

National Initiative on Climate Resilient Agriculture



National Centre for Integrated Pest Management, New Delhi  
Central Research Institute for Dryland Agriculture, Hyderabad  
Indian Institute of Horticultural Research, Bengaluru  
Indian Institute of Vegetable Research, Varanasi

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ICAR, New Delhi
- Project Coordination* : Central Research Institute for Dryland Agriculture,  
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## Foreword

Indian Council of Agricultural Research (ICAR) launched the National Initiative on Climate Resilient Agriculture (NICRA) during 2010-2011 with three pronged objectives of strategic research, technology demonstrations and capacity building. Assessment of the impact of climate change simultaneous with formulation of adaptive strategies is the major focal point across all sectors of agriculture, dairying and fisheries. Evolving climate resilient agricultural technologies that would increase farm production and productivity *vis-à-vis* continuous management of natural and manmade resources constitute an integral part of sustaining agriculture in the era of climate change.

Plant protection deserves prime importance in crop production because of the fact that potential yield of crops are limited by various pests *viz.*, insects, diseases, weeds, nematode and rodents. Pests are biotic natural resources of universe and their interdependent interactions amongst system variables are equally influenced by the factors of climate change. Climatic effects on pests could be direct as well as crop mediated. NICRA recognized the importance of pest risks associated with climate change and provided a research platform across crops of rice, pigeonpea, groundnut, **tomato** and mango during its first phase of implementation under eleventh plan. Assessing the changing pest scenario, mapping of vulnerable regions of pest risks, and to evolve preventive as well as curative pest management strategies as adaptation towards climatic stress have been emphasized among many approaches to study the impact of climate change on pests. The long term trend analysis of their association with climate is important. Most often, the available historical data lack continuity and their holistic retrieval is cumbersome. Availability of information technological tools has made it possible to create centralized database of desired resources and associated activities with ease, in turn making scientific analyses and inferences more meaningful.

In case of studies relating to pest dynamics, it is essential to streamline methods of surveillance through carefully designed data recording formats relating to crops, pests, production and protection practices in addition to weather. Implementation of pest surveillance across seven different tomato growing agro-ecologies under NICRA offers *per se* heterogeneity of climate, and would help to draw the underlying mechanism of the observed pest status. Analyses with weather would further aid in delineating climate effects on pests. Making pest surveillance operational through provision of pest scouts and data entry operators, makes it possible to capture quality data at field level guided by scientific staff.



Publication of “Manual on Tomato Pest Surveillance” has been a part of systematic attempt to give specific skills to the users to undertake sampling relating to tomato pests. I appreciate the team work of the tomato plant protection specialists of the nation, and wish that the research outcome would be useful for the present and future of tomato pest management.

(Dr. A.K. Singh)  
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# Contents

<i>Foreword</i>	
<b>1. Introduction</b>	<b>1</b>
<b>2. Surveillance plan and procedures</b>	
2.1. Nursery surveillance	2
2.2. General information for nursery	3
2.3. Pest observations in nursery	
Whiteflies	3
Aphids	3
Thrips	4
Leaf miner	4
Mites	5
Damping off	5
Seedling blight	6
2.4. Selection of main fields for surveillance	6
2.4.1. Fixed fields at research station	6
2.4.2. Fixed fields in villages	7
2.4.3. General information for fixed fields	7
2.4.4. Specific guidelines for observations in fixed fields	7
2.5. Pest observations	8
2.5.1. <b>Insect pests</b>	
Aphids	8
Whiteflies	9
Mites	9
Thrips	10
Leaf miner	10
Tobacco caterpillar	11
Mealybugs	11
Fruit borer	12
2.5.2. <b>Beneficials</b>	
Coccinellids	12
Spiders	13
2.5.3. <b>Diseases</b>	
Leaf curl	13
Bud blight	14



Tomato mosaic	15
Cucumo virus	15
<i>Fusarium</i> wilt	16
<i>Ralstonia</i> wilt	16
<i>Sclerotium</i> wilt	17
Early blight	18
Bacterial spot	19
Powdery mildew	20
<i>Septoria</i> leaf spot	21
Bacterial canker	22
Late blight	22
<b>Fruit diseases/damage</b>	24
Buckeye rot	24
Early blight	24
Late blight	25
Bacterial spot	25
Bacterial canker	26
Sun scald	26
2.5.4. Additional details to be recorded for fixed fields	27
2.5.4.1. Pheromone trap catches	27
2.5.4.2. Crop management practices	28
2.5.5. Random field survey	28
2.6. General instructions	28
<b>References</b>	29

### Annexures

<i>Annexure I : Surveillance schedule</i>	30
<i>Annexure II : Data sheet for general information and pest observations in nursery</i>	31
<i>Annexure III : Data sheet for general information for fixed fields</i>	32
<i>Annexure IV : Data sheet for pest observations in fixed and random fields</i>	33
<i>Annexure V : Data sheet for meteorological observations</i>	39



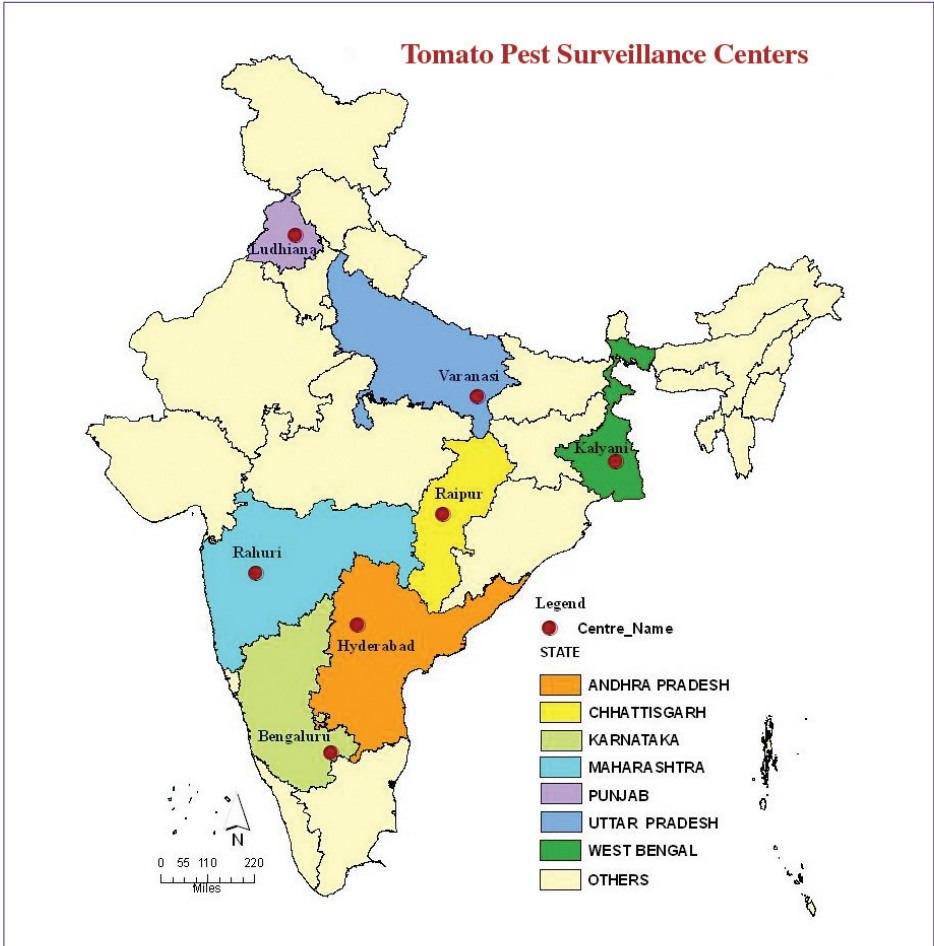
## 1. Introduction

Tomato is an important and nutritive rich vegetable grown in India over an area of 0.60 m ha with an estimated production of 11.9 mt. Productivity of tomato in India is lower (18.6 t/ha) than the world productivity (27 t/ha) (Anonymous 2009). Tomato is grown in a wide range of climatic conditions across states of Andhra Pradesh, Orissa, Karnataka, Maharashtra, West Bengal, Bihar, Gujarat, Uttar Pradesh and Chhattisgarh. Tomato crop is highly sensitive to environmental stress caused by high temperature and low soil moisture. In fact, temperature is rising in the tomato growing locations and can cause reduced fruit set and lower the quality of fruits. In addition, the episodes of insect pests and diseases dependent on prevailing weather, play a significant role in determining quantity and quality of harvest. Recently, earlier onset of warm temperature in the winter has led to whitefly sustenance which boosted the transmission of leaf curl in Varanasi and Mirzapur districts of UP. Unusual showers in AP during 2006 and morning foggy conditions led to the outbreak of bacterial spot in about 6000 acres in Adilabad region. Bacterial spot, a disease of minor concern, is now a cause of great concern in *Kharif* crop. Bacterial wilt is progressing towards higher altitudes. It is in this context that, National Initiative on Climate Resilient Agriculture (NICRA) with its priority of achieving food and nutritional security chose tomato as one of the crops under the study on “pest dynamics in relation to climate change”. Seven centres across seven states from six agro climatic zones have been networked to assess the pest scenario *vis-à-vis* climate (refer the map given on next page). In addition to analyses of historical records of pests and weather, a strong foundation is being created through implementation of systematic surveillance based on carefully designed data recording formats that comprise scientific pest sampling methods and holistic details on crop production. The complex of pests and production and protection practices followed during the season at field level along with meteorological variables to be documented during surveillance of the region were finalized by Plant Protection specialists of tomato. Manual on tomato pest surveillance has been prepared to assist all the stake holders in collecting and compiling data on the occurrence and severity of insect pests and diseases. It is a ready reckoner and guide for identifying the pests. Manual also includes the plan and schedule of pest surveillance. Contents of the manual describe the pests of observation and their sampling procedures followed by the finalized data sheet formats.

## 2. Surveillance plan and procedures

One nursery and two fixed fields at the experimental station, and one nursery and one main field each in ten villages of the region, are to be selected for tomato pest surveillance. Fixed fields are those fields that





once selected in the beginning of the season would be continuously monitored till harvest on weekly basis for insect pests and diseases using the specified data sheet formats. In addition, a random survey covering five villages other than the ten selected villages has to be conducted during each week. The schedule of surveillance is given in Annexure-1.

### 2.1. Nursery surveillance

- One at experimental station and ten nurseries @ one nursery per selected village where fixed field surveillance would be used for surveillance.
- Observations at nursery are to be made at least thrice.
- Use separate sheet for each nursery, during each time of observation.



## 2.2. General information for nursery

One time collection of general information relating to each nursery with details that are self explanatory in Part 1 of Proforma 1 (Annexure II) should be done.

## 2.3. Pest observations in nursery (Proforma 1, Part II)

### Whiteflies ( *Bemisia tabaci* )

#### Identification

Whitefly adults are yellowish covered with milky white waxy coating on wings. Adults often are clustered together on the undersurface of leaves, and fly when disturbed.



Whitefly adults

#### Procedure for observation

Count and record the number of whiteflies adults visible per 10 seedlings per spot.

### Aphids ( *Myzus persicae* and *Aphis gossypii* )

#### Identification

Aphids are tiny, soft-bodied, pale yellowish, green coloured insects with three dark lines on the back of the abdomen. The aphids are found in great numbers on the leaves, petioles and stem. Winged and wingless aphids are common. Aphids are normally associated with ants and develop sooty mold.

#### Procedure for observation

Count and record the number of aphids on 10 seedlings in one spot.



Nymphs and adult of aphids

### Thrips ( *Thrips tabaci*, *Frankliniella* sp. )

#### Identification

Thrips are tiny (<1 mm long), slender, free moving insects. Adults are soft bodied, yellowish to yellowish brown and have a pair of fringed wings with long hairs when observed under magnifying lens. The immature stages have the same body shape as adults but are lighter in color and are wingless.



Thrip

#### Procedure for observation

Count and record the number of thrips on 10 seedlings in one spot.

### Leaf miner ( *Liriomyza trifolii* )

#### Identification

Maggot mines into the leaf between the upper and lower surfaces and feeds on the mesophyll tissues. Young leaves have small and thin mines. In older leaves, mines are long and circular.



Mines on leaves

### **Procedure for observation**

Count and record number of the live maggots on 10 seedlings in one spot.

### **Mites ( *Tetranychus* spp. )**

#### **Identification**

Mites are tiny, elongated to oval in shape, deep orange in colour and microscopic. Immature instars and adults are found under the leaves.



Nymphs and adults

### **Procedure for observation**

Count and record the number of mites on 10 seedlings in one spot.

### **Damping off ( *Pythium* spp. )**

#### **Identification**

In pre-emergence damping off, seeds become soft, turn brown, and decompose. In post-emergence damping-off, roots, hypocotyls and the crown of the seedlings turn pale brown, soft, water soaked and thinner. Infected seedlings topple and collapse. Disease is noticed in patches.



Toppling of seedlings

### ***Procedure for observation***

Number of infected seedlings out of 20 seedlings at each spot should be counted and recorded.

## **Seedling blight**

### ***Identification***

Small, regular to irregular dark brown spots appear on leaves which later coalesce and turn into blight. The spots may or may not have yellow halos.



Blight of leaf

### ***Procedure for observation***

Number of infected seedlings out of 20 seedlings at each spot should be counted and recorded.

## **2.4. Selection of main fields for surveillance**

### **2.4.1. Fixed fields at research /experimental station**

In the experimental station, two experimental plots, each of approximately 250 sq. m, should be planted with local popular variety/hybrid. One of the plots has to be kept unprotected without any plant protection measures for any of the pests on tomato crop (designated as Fixed 1). In the other



plot designated as Protected (Fixed 2), need-based application of pesticides should be followed to keep the crop free from prevailing insect pests and diseases.

#### 2.4.2. Fixed fields in villages

Select 10 tomato growing villages representing the agro-ecology of the identified region in the same district or nearby districts distributed randomly.

In each village, one farmer field (Fixed 1) of near to one acre, should be selected for surveillance during the season. Assigning fields of farmers as Fixed 1 should be made during the first observation and the same should be maintained till the end of season.

Take care to select farmers growing the popular tomato cultivars of the region. The latitude, longitude and altitude of the selected field should be recorded once using GPS unit.

#### 2.4.3. General information for fixed fields (Proforma 2, Annexure III)

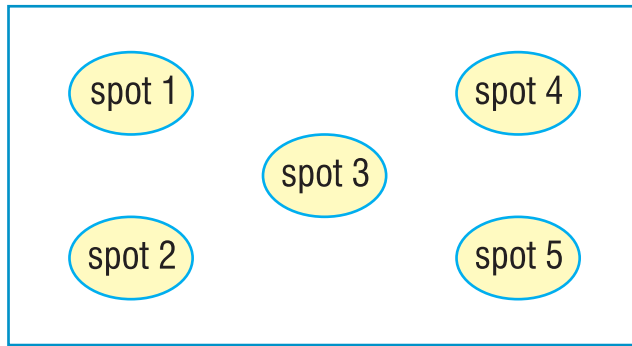
The geographical, cropping system and agronomical details relating to general information which are self explanatory should be collected once in the beginning of the season from experimental fields Fixed 1 (Unprotected) and Fixed 2 (Protected) and fields of farmers in the selected villages. The exact date of planting, growing conditions and cultivar details are very important and are to be noted with great care. If all information cannot be gathered at one stroke, they can be completed during the subsequent visits of surveillance by meeting the farmer.

#### 2.4.4. Specific guidelines for observations in fixed fields (Proforma 3, Annexure IV)

- Observations in all the designated fixed fields should be taken on weekly basis.
- Surveillance on pest occurrence at the main field should commence soon after crop establishment after transplanting and at weekly intervals thereafter.
- Fill in the details on state, district, taluka/tehsil information each time so that it becomes easy for data entry.
- For the plots of experimental station, the name (location) of the centre and field type either Fixed 1 *i.e.*, Unprotected or Fixed 2 *i.e.* Protected, has to be tick marked.
- For the selected fixed fields of farmers in ten villages, only tick mark as Fixed 1 at all the times of observation.
- Write the date of observation and tick mark the general crop health as Excellent/Good/ Poor and the stage of the crop *i.e.* vegetative/first flowering/ 50% flowering / fruit set & development/ripening.



- In each of the fields, select five spots randomly as shown (four in the corners, at least 5 feet inside of the field borders, and one in the centre).
- Select five random plants at each spot for recording counts of insects as per procedure finalised for individual insects.



## 2.5. Pest observations

### 2.5.1. Insect pests

#### **Aphids** (*Myzus persicae* and *Aphis gossypii*)

##### **Identification**

Aphids are tiny insects that are pale yellowish, green in color with three dark lines on the back of the abdomen. Aphids are found in great numbers on the leaves. Both wingless and winged forms are found in colonies. Ants are associated with aphids and sooty molds develop.



Nymphs and adult

##### **Procedure for observation**

Record aphid numbers (both nymphs and adults) by counting on five randomly selected young leaves per plant.



## Whiteflies (*Bemisia tabaci*)

### Identification

Whiteflies adults are yellowish, covered with a milky white waxy coating. They fly when disturbed. Adults are clustered together on the undersurface of leaves.



Nymphs and adults

### Procedure for observation

Count and record the number of whiteflies adults present on five randomly selected leaves per plant.

## Mites (*Tetranychus* spp.)

### Identification

Mites are tiny and spider-like creatures. They are elongated-oval, microscopic and deep orange to red in color. Immature instars and adults are largely found under the leaves.



Nymphs and adults

### Procedure for observation

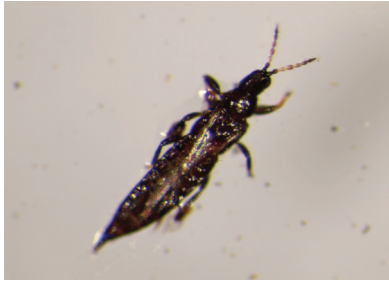
Count and record mite numbers (both nymphs and adults) on five randomly selected leaves per plant.



## Thrips (*Thrips tabaci*, *Frankliniella* sp.)

### Identification

Thrips are tiny, slender and free moving insects. Adults are yellowish to yellowish brown and have a pair of fringed wings with long hairs when observed under magnifying lens. The immature stages have the same body shape as adults but are lighter in color and are wingless.



Thrip

### Procedure for observation

Count and record the number of nymphs and adults of thrips present on five terminal leaves per plant (Tapping method also can be used to count thrips).

## Leaf miner (*Liriomyza trifolii*)

### Identification

Maggot mines into the leaf between the upper and lower surfaces and feeds on the mesophyll tissues making serpentine mines. Young leaves have small and thin mines. In old leaves, white long circular mines are seen.



Leaf miner damaged leaves

### Procedure for observation

Only the number of live mines on five randomly selected leaves per plant should be counted and recorded.



## Tobacco caterpillar (*Spodoptera litura*)

### Identification

Young larvae are light green in color. Full grown larvae are stout, cylindrical and pale greenish brown with dark markings. Colour varies from blackish grey to dark green with dark longitudinal bands on the side of the body. No hairs are seen on the body surface.



Foliar damage



Fruit damage

### Procedure for observation

Count the number of young and grown up larvae on each plant and record.

## Mealybugs (*Maconellicoccus* sp., *Phenacoccus solenopsis*)

### Identification

Mealybugs are soft-bodied, small, oval, cottony in appearance and are white to pink in color. Females are wingless with one pair of tail filaments that are half as long as the body. Crawlers excrete honey dew and sooty mold develops. Adults also secrete waxy material.



Mealybugs

### Procedure for observation

Mealybug severity, based on their plant coverage, must be noted based on the ratings given below.

- Grade 1: Few mealybugs scattered on plant
- Grade 2: 25% plant affected with mealybugs
- Grade 3: 50% plant affected with mealybugs
- Grade 4: Whole plant affected with mealybugs

### **Fruit borer (*Helicoverpa armigera*)**

#### **Symptoms**

Larvae show color variations ranging from greenish to brown. Fully grown caterpillars are apple green with whitish and dark grey broken longitudinal stripes. Larvae feed on leaves and fruits. Advanced stage larvae make clear cut circular holes and eat the contents with rear part of their body seen outside the fruit.



Larva on fruit

#### **Procedure for observation**

Total number of fruits, damaged fruits due to *Helicoverpa armigera* and number of larvae on individual plants should be counted and recorded.

#### **2.5.2. Beneficials**

### **Coccinellids**

#### **Identification**

Adults are brightly coloured, yellow to reddish brown with spots on elytra. Head and ventral side are blackish. Pupa is light brown marked with black dot and fixed on leaves at the posterior end. Grubs are black with whitish or grey markings and possess only thoracic legs.



Coccinellid adult

### **Procedure for observation**

Count the number of grubs, pupa and adults together of coccinellids on whole plant basis and record.

## **Spiders**

### **Identification**

Adults have two major body regions - a head region (cephalothorax) and an abdomen, and have eight legs. They lack wings and antennae. Some are free living and some are web spinners.



Spiders

### **Procedure for observation**

Count the young and adult stages of spiders on whole plant basis and record.

## **2.5.3. Diseases**

### **Leaf curl ( Tomato Leaf Curl Virus (ToLCV) )**

#### **Symptoms**

Leaf symptoms include mosaic, interveinal yellowing, vein clearing, and crinkling and puckering accompanied more often by inward rolling of leaf margins. The older leaves become leathery and brittle. The disease also induces severe stunting, bushy growth and partial or complete sterility depending on the stage of the crop. Infected plants bear few or no fruits.



ToLCV symptoms

### ***Procedure for observation***

Count and record the number of leaf curl infected plants out of 10 plants in a selected spot.

## **Bud blight ( Groundnut Bud Necrosis Virus )**

### ***Symptoms***

Characteristic symptoms on leaves include yellowing, chlorotic and necrotic ring spots and tip necrosis. Presence of longitudinal, brown, necrotic streaks is conspicuous on the petioles, stem and fruit stalks. Chlorotic ring spots



Necrotic ring spots on leaves



Tip necrosis



Bronzing of leaves



Chlorotic rings on fruits



are often observed on fruits. Fruit set is markedly reduced. Die back and stunted plant growth are common.

### **Procedure for observation**

Count the number of infected plants with bud blight out of the 10 plants in the selected spot and record.

## **Tomato mosaic ( TMV, ToMV, PVY, CMV )**

### **Symptoms**

Mosaic symptoms appear on leaves as dark green islands surrounded by light green areas. Leaf size is reduced. The dark green areas of the mottle often appear thicker and somewhat elevated giving the leaves a blister like appearance. Leaves sometimes look fern like and sharply pointed. Early infections reduce fruit set and occasionally cause blemishes and distortions of the fruits.



Symptoms of mosaic virus

### **Procedure for observation**

Count the number of mosaic infected plants out of the 10 plants in the selected spot.

## **Cucumo virus ( CMV )**

### **Symptoms**

Plants at all growth stages may show symptoms. On young leaves, CMV causes a “shoestring” effect with formation of narrow, tendril-like leaflets. Plants with severe shoestring symptoms are stunted with little or no marketable fruits. CMV symptoms may be misdiagnosed as tomato mosaic virus (ToMV) infection for ToMV produces “fern-like” leaves; Both CMV and ToMV produce mosaic symptoms.



Shoestring symptom

Source: [web.avrdc.org](http://web.avrdc.org)

### Procedure for observation

Count the number of cucurbit virus infected plants out of 10 plants in the selected spot and record.

### *Fusarium wilt ( Fusarium oxysporum f.sp. lycopersici )*

#### Symptoms

Lower leaves turn yellow. Yellowing often begins on one side of the plant and progresses upwards. Infected leaves curl downward, followed by browning and drying. Vascular browning is evident in stems and leaf petioles. Young plants when infected, are severely stunted.



Yellowing of lower leaves and wilting upwards



Severe wilting

### Procedure for observation

Count the number of *Fusarium* wilt infected plants out of 10 plants in the selected spot.

### *Ralstonia wilt ( Ralstonia solanacearum )*

#### Symptoms

Wilting occurs among plants in patches. Wilting of terminal leaves followed by sudden and permanent wilting of whole plants are seen in 2-3 days. Adventitious roots develop on the main stems and vascular bundle turns



brown. Bacteria oozes from freshly cut stem when placed in water. Recently wilted plants are green which distinguishes from *Fusarium* wilt, wherein plants develop yellowing of leaves. The discoloration of the pith also distinguishes bacterial wilt from *Fusarium*.



Wilt progressing downwards



Milky oozing

### Procedure for observation

Count and record the number of *Ralstonia* wilt infected plants out of 10 plants in the selected spot.

### *Sclerotium* wilt ( *Sclerotium rolfsii* )

#### Symptoms

Brown lesions are seen on the stem just above the soil surface or at the foot of the plant. Brown lesions later become covered with white radiating mycelium that encircles the affected portion. Subsequently, mustard sized sclerotia appear on the infected area as the disease develops and spreads. Distinct rot occurs beneath the fungal weft leading to wilt like symptoms characterized by yellowing and browning of the foliage. Foot rot symptoms are recognized when young plants are completely griddled and killed.



Wiltling of plants



Whitish mycelial growth at collar and soil regions



### Procedure for observation

Count the number of *Sclerotium* wilt infected plants out of 10 plants in the selected spot.

### Early blight ( *Alternaria* spp. )

#### Symptoms

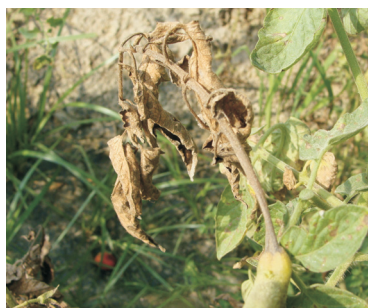
The lower leaves are more susceptible than the upper ones. Similarly, disease is more serious in older than younger plants. Small, dark, circular lesions develop on leaves which later turn distinctly zonate with conidia forming at the necrotic regions. Under severe attack, spots rapidly enlarge, coalesce and turn into complete blight, resulting in death of the leaves. Small, dark, slightly sunken lesions form on the main stem and side branches which enlarge and form dark brown, elongated spots, which occasionally having concentric rings like those appear on the leaves.



Concentric ring



Sunken lesions on stem



Infected branches



Symptoms on lower leaves

### Procedure for observation

The number of infected plants under each of the severity scale in 10 plants in the selected spot should be recorded. The severity scale based on the ratings given ahead (also given in data recording sheet) should be used.



### Disease rating scale for early blight

Scale	Description
0	No symptoms
1	1-4 % area of a plant infected
2	5-10 % area of a plant infected
3	11-25 % area of a plant infected
4	26-50% area of a plant infected
5	>50% area of a plant infected

Horsefall and Barret, 1945

### Bacterial spot ( *Xanthomonas campestris* pv. *vesicatoria* )

#### Symptoms

All above ground parts are affected viz., leaves, stems, petioles and fruits producing varied symptoms. Symptoms appear on leaves as small, discrete light brown to dark brown, water soaked lesions of < 2 mm in diameter. Lesions turn black often surrounded by a yellow halo which later disappear when lesions coalesce. Infected leaves become chlorotic, exhibit epinasty and finally dry out. On petioles and stems, symptoms appear as circular to elongated light brown lesions which later turn into dark brown streaks. On stems, lesions may turn into dark brown and sunken longitudinal cracks.



Dark spots with yellow halo

#### Procedure for observation

The number of infected plants under each of the severity scale out of 10 plants in the selected spot should be counted and recorded. The severity scale based on the ratings given on next page (also given in data recording sheet) should be used.

### Disease rating scale for bacterial spot

Scale	Description
0	No symptoms
1	1-4 % area of a plant infected
2	5-10 % area of a plant infected
3	11-25 % area of a plant infected
4	26-50% area of a plant infected
5	>50% area of a plant infected

Horsefall and Barret, 1945

### Powdery mildew ( *Oidium* sp. and *Oidiopsis* sp. )

#### Symptoms

*Oidium lycopersici* appear as small, powdery white colonies on the upper leaf surface. *Oidiopsis taurica* cause yellow blotches or spots on the upper leaf surface with white powdery growth occurring on the undersurface. Severely affected leaves turn yellow, then brown and later become shriveled. Generally, the lower leaves are affected first and the disease gradually moves up the plant.



Powdery patches due to *Oidium*



Yellow blotches due to *Oidiopsis*

### Disease rating scale for powdery mildew

Scale	Description
0	No symptoms
1	10 % leaves with lesions & minimal defoliation
2	25 % leaves infected with slight defoliation
3	50 % leaves with lesions & moderate defoliation
4	75 % of leaves with lesions & heavy defoliation
5	90 % leaves with lesions with very heavy defoliation

Correll et al. 1988



### Procedure for observation

The number of infected plants under each severity scale out of the 10 plants in the selected spot should be entered. The severity scale based on the ratings given on previous page (also given in data recording sheet) should be used.

### Septoria leaf spot (*Septoria lycopersici*)

#### Symptoms

*Septoria* leaf spot occurs at any stage of the crop with first infection appearing on older leaves. Numerous, small circular water soaked spots appear on the under surface of the lower leaves. These spots develop dark brown margins with sunken white or grey centres containing numerous black dotted pycnidia. Severe spotting results in extensive leaf drying and wilting. A progressive loss of foliage from the bottom upwards is quite characteristic. Fruits are not affected. Uniform, small sized spots and the lack of concentric rings differentiates it from early blight.



Dark rim with grey centre

### Procedure for observation

The number of *Septoria* leaf spot infected plants under each of the severity scale out of 10 plants in the selected spot should be entered. The severity scale is furnished hereunder.

#### Disease rating scale for *Septoria* leaf spot

Scale	Description
0	No symptoms
1	Top leaves free; lesions on basal leaves without coalescence
2	Top leaves free; lesions on basal leaves with rare coalescence
3	Top leaves free; lesions on basal leaves with frequent coalescence
4	Top leaves free; lesions on leaves in middle portion of plant with coalescence
5	Lesions in top leaves, > 50 % of plant with lesions & premature defoliation

Maluf *et al.* 1985

## Bacterial canker ( *Clavibacter michiganensis* subsp. *michiganensis* )

### Symptoms

Dark necrotic lesions at the margins of older leaves are characteristic. Early infection becomes systemic and affects vascular tissue. Entire branch or whole plant wilts and dies.



Marginal necrosis of leaves  
([http:](#))



Stem canker and pith necrosis  
([http:](#))

### Procedure for observation

The number of bacterial canker infected plants under each of the severity scale out of 10 plants in the selected spot should be entered. The severity scale is furnished hereunder. (also given alongside data recorded sheet).

#### Disease rating scale for bacterial canker

Scale	Description
0	No symptoms
1	Trace: one leaf symptomatic
2	Slight: two leaves symptomatic
3	Moderate: > 2 leaves symptomatic
4	Severe: half plant affected
5	Very severe: more than half plant affected
6	Stunted with extensive collapse
7	Dead plant

Shenge *et al.* 2010

## Late blight ( *Phytophthora infestans* )

### Symptoms

Late blight appears on the leaves, stems, and fruits. On the leaves, symptoms appear as pale green, water-soaked spots, often begins at the leaf tip or edge. These lesions are often surrounded by a pale yellowish-green border that merges with healthy tissues. Under favourable conditions, lesions enlarge rapidly and turn dark brown to purplish-black, killing the leaves



instantly. High humidity and leaf wetness, favors the growth of a cottony, white mould on the lower side at the edges of lesions. However, in dry weather, infected leaf tissues quickly dry and the white mould growth disappears. On stem, brown to black lesions which enlarge rapidly under moist conditions and the entire stem may be killed soon.



**Pale green water soaked spots on upper leaf surface**



**Sporulation at the border of the spot on lower leaf surface**



**Black lesions on stem**



**Severe blighting of plants**

**Disease rating scale for late blight**

Mean severity (%)	Limits (%)	Symptoms
0	0	No symptoms
2.5	Tr < 5	Up to 10 lesions per plant
10	5 - 15	Lesions easily seen at closer distance. Maximum foliage area affected up to 20 leaflets
25	15 - 35	About 25 % of foliage is covered with lesions
50	35 - < 65	Lower leaves are dead. About half the foliage area is destroyed
75	65 - < 85	About 75 % leaf area destroyed; field appears neither brown nor green
90	85 - < 95	Only top leaves are green. Many stems have large lesions
97.5	95 - < 100	All plants in a spot are brown-colored. A few top leaves still have some green areas. Most stems have lesions
100	100	All leaves and stems dead

Henfling 1987

### Procedure for observation

For late blight, record the severity of disease on plants in an area of 3 m X 3 m per spot. Mean severity per cent would be entered directly based on the limits depending on symptoms given in the table.

### Fruit diseases/damage

#### Buckeye rot ( *Phytophthora nicotianae* var. *parasitica* )

### Symptoms

Infection first appears on lower immature green fruits which are either on or near to the soil level. Infected lesions have dark brown centre surrounded by water soaked zonations. Lesions enlarge rapidly and within 3-4 days, the entire fruit surface turn dark brown which feels soft on touch. As the spots enlarge, lesions assume a pattern of concentric rings of narrow, dark brown and wide light brown bands. The internal flesh discolours without any rotting on the skin which peels off easily. In warm and humid weather, white flocculent superficial growth of the fungus develops profusely on the diseased fruits.



Concentric rings

### Procedure for observation

Count and record the number of infected fruits with buck eye rot disease from 20 randomly selected fruits in each spot.

#### Early blight

### Symptoms

On green or semi ripe fruits, dark, velvety, sunken spots having distinct concentric rings develop at the stem end.



Fruit infection at stem end

### **Procedure for observation**

Count and record the number of early blight infected fruits from 20 randomly selected fruits in each spot.

## **Late blight**

### **Symptoms**

The fungus produces grey-green water-soaked spots on fruits which enlarge, coalesce, and darken, resulting in large, firm, brown, leathery-appearing lesions on fruits. White moldy growth may also appear on fruits under humid conditions.



Infected fruit

### **Procedure for observation**

Count and record the number of infected fruits with late blight from 20 randomly selected fruits in each spot.

## **Bacterial spot**

### **Symptoms**

On immature green fruits, small, water soaked spots appear with a pronounced yellowish green halo. Later on halo disappears; spots turn brown



with a depression in the centre giving cankered appearance. On ripe fruits, dark brown to blackish brown water soaked spots appears which later develops cracks in these spots.



Raised rim with depression at centre

### ***Procedure for observation***

Count the number of infected fruits from 20 randomly selected fruits in the spot and record.

## **Bacterial canker**

### ***Symptoms***

Small, raised white blisters known as “bird’s-eye” spot seen on young green fruits.



Bird's- eye spots

### ***Procedure for observation***

Count the number of infected fruits from 20 randomly selected fruits in the spot and record.

## **Sun scald ( physiological )**

### ***Symptoms***

Rapid desiccation leads to sunken area which results in white shiny, papery on green or yellow on red fruit patches on the side of the tomato exposed



to the sun. The sunken area becomes wrinkled. Fruits nearing maturity when exposed to sun are more prone to sunscald. Mature green and red tomatoes are most susceptible.



White shiny patches on fruits

### **Procedure for observation**

Count and record the number of fruits affected with sun scald from 20 randomly selected fruits in the spot.

## **2.5.4. Additional details to be recorded for fixed fields**

### **2.5.4.1. Pheromone trap catches**

Pheromone traps for two insects viz., *Helicoverpa armigera* and *Spodoptera litura* @ 2/ fixed field have to be installed. Install the traps for each species separated by a distance of >75 feet in the vicinity of the selected fixed field. Fix the traps to the supporting pole at a height of one foot above the plant canopy. Use a cotton swab dipped in dichlorvos inside the polythene bag to kill the insects getting trapped (take care that the insecticide does not come in contact with funnel at any one time). If insecticide is not used, see to it that the live moths are killed before counting/emptying. Change of lures should be made once a month. During each week of surveillance, the number of moths/trap should be counted and entered. Emptying moths from poly bags and ensuring the trap presence/readiness to replace in case of breakage/missing events should be followed meticulously. Therefore, after initial installation, scouts should carry few traps and lures for attending to unforeseen events immediately.

### **Procedure for observation**

Total number of moths of *Helicoverpa armigera* and *Spodoptera litura* / trap/week should be recorded year round. The trapped moths should be destroyed and removed after each recording.



#### 2.5.4.2. Crop management practices

The crop management practices followed during the week such as plant protection sprays, fertilizer and cultural management, and prevailed/ prevailing unusual weather events are to be indicated in the tables that are explanatory under additional details to be collected for fixed fields. Yield harvested during each picking in respect of fixed fields and the prevailing market price at the picking time of the commodity should be collected. Small diary may be procured and given to each of the selected farmers of the fixed fields that they keep a record of intercultural events and harvest details with day/date that could be checked during the trip for surveillance during each week.

#### 2.5.5. Random field survey

The survey is to be conducted once in a week (Friday) by scientist along with project staff in the villages not covered by scouts. During the survey, the team will cover five fields selected at five different villages having larger area under tomato. Observations on pests are to be made using the same pest data sheet (Proforma 3, Annexure IV) as per the guidelines given. General information and additional details need not be recorded for fields of random survey. All relevant details of random survey viz., date of survey, village name, GPS co-ordinates and crop stage are to be recorded. Cultivar name, if easily available for random fields should also be recorded. Random survey should commence along with fixed field surveillance *i.e.* from crop establishment in the main field.

#### 2.6. General instructions

Centre having automatic weather stations may furnish relevant weather variables important in respect of diseases for use in models (attached as separate files). In case of closed holidays, the surveillance should be adjusted so as to cover the fields on the subsequent day and the same flexibility applies for uploading of data also. Ensure quality data collection by adhering to data sheet and guidelines. Only presence of pests on the crop need sampling and recording of their counts/severity etc., and the columns of pests not present should be entered with zero. In case of non recording of observations in any of the fields during any of the weeks, it should be reported as not recorded with reasons under 'remarks' column a provision that would be made available in the software.



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## Schedule for surveillance

Day	Schedule for pest scouts and data entry operator (DEO)	No. of fields
Monday	Two fixed plots (Fixed 1 Unprotected) and (Fixed 2 Protected) at experimental station; Documentation of historical data of the Centre.	Two fields
Tuesday	@ One fixed field/village in two villages by one Scout (Total of four fields at four villages by two scouts); DEO to enter the data collected on previous day + documentation of historical data.	Four fields in four villages
Wednesday	@ One fixed field/village in two villages by one Scout (Total of four fields at four villages by two scouts); DEO to enter the data collected on previous day + documentation of historical data.	Four fields in four villages
Thursday	@ One fixed field/village /scout (Total of two fields at two villages by two scouts). Scouts would also look for presence of new pests (insects and diseases) and out breaks for general reporting under pest alerts	Two fields in two villages
Friday	Random field survey across five villages (@one field/village) by scientist and surveillance team; look for new/emerging pests for reporting in addition to using prescribed data sheet.	Five fields in 5 villages
Saturday	Checking data/Uploading of pest and weather data	—



## NICRA REAL TIME PEST SURVEILLANCE (TOMATO)

## Annexure - II

### Data sheet for general information and pest observations in nursery

(Proforma - 1)

#### General Information for nursery (One time information)

Nursery survey (Part-1)

Name of the experimental station/village	Name of cultivar		Sowing during the season			Date of sowing	Seed treatment
	Variety	Hybrid	Early	Normal	Late		
							Yes or No If yes, Name of chemical /bioagent

Nursery Survey : (One at Experimental Station and 10 nurseries @ one nursery per selected village for fixed field surveillance ; **Use separate sheet for each nursery**)

#### Data sheet for nursery pests

Nursery survey (Part-2)

Spot no.	Insects (No. on 10 seedlings)					Diseases (No. infected out of 20 seedlings)		Application of pesticides Yes or no If yes, name of the chemical
	Whitefly	Aphids	Thrips	Leaf miner maggots	Mites	Damping off	Seedling blight	
1								Yes or no
2								If yes, name of the chemical
3								
4								
5								

To be collected at least thrice before transplanting



**NICRA REAL TIME PEST SURVEILLANCE (TOMATO)**

**Annexure - III**

**(Proforma - 2)**

**Data sheet for general information of fixed fields**

**(General information for all fixed fields including the experimental station – to be filled only once in the beginning of the season)  
(Use separate sheet for each field)**

**Geographic Details**

Agro climatic zone	State	District	Teshil/Block	Experimental station/ Village name	Latitude	Longitude	Altitude

**Cropping system details of the region**

Major Cropping Systems of region	Growing season (Kharif/ Rabi / Summer)	Normal sowing time		New crops of the region (during last five years)
		Kharif	Rabi / Summer	

**Agronomic details of the field**

Field	Name of the farmer	Previous crop	Sole/intercrop	Name of cultivar		Growth pattern (Determinate or indeterminate)	Seedling		Date of transplanting	Seedling treatment (Y/N)	
				Variety	Hybrid		Own	Purchased		Insecticide	Fungicide
Fixed 1											

Field	Spacing (cm)		Approx. Area (acres)	Soil type	FYM (Yes/No) If yes dosage/acre	Soil application (Yes/No) if yes dosage/acre			Crops in the adjacent fields	Source of irrigation (Canal/Well/ Tubewell/Drip)	Method of irrigation (Drip/ flooding/ sprinkler)
	Plant to plant	Row to row				Neem cake	Trichoderma	Others			
Fixed 1											

Data sheet for pest observations in fixed and random fields

(Proforma - 3)

State	District	Tehsil	Date of observation	
Experimental Station		Fixed fields of farmers		
Location name	Village name		Random survey	Village name
Field type/no.	Unprotected (Fixed 1)/ Protected (Fixed 2)	Fixed 1	Latitude	Longitude
Stage of crop	Vegetative / first flowering / 50% flowering / Fruit set & development / Ripening		Cultivar name	Altitude
			Field area (approximate area) (acres)	

Spot no.	Aphids (Numbers per five young leaves)					Whitefly adults (Number per five random leaves)					Mites (Number per five random leaves)				
	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
1.															
2.															
3.															
4.															
5.															

Spot no.	Thrips (Numbers per five terminal leaves)					Leaf miner ( Number of live mines/ five random leaves)					No. of coccinellids (whole plant basis)				
	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
1.															
2.															
3.															
4.															
5.															







NICRA REAL TIME PEST SURVEILLANCE (TOMATO)

(Page- 2)

Spot no.	No. of spiders ( whole plant basis)					Number of larvae of tobacco caterpillar (S. litura) (whole plant basis)					Mealy bug (Maconellicoccus / Phenacoccus); Grade 1 ( Few insects scattered on plant)/G2 (25% plant affected)/G3 (50% plant affected)/G4 (whole plant affected)				
	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
	1.														
2.															
3.															
4.															
5.															

Spot no.	Fruit borer <i>Helicoverpa armigera</i> (whole plant basis)														
	Plant 1			Plant 2			Plant 3			Plant 4			Plant 5		
	No. of fruits	No. of larvae	No. of Damaged fruits	No. of larvae	No. of Damaged fruits	No. of fruits	No. of larvae	No. of Damaged fruits	No. of fruits	No. of larvae	No. of Damaged fruits	No. of fruits	No. of larvae	No. of Damaged fruits	No. of larvae
1.															
2.															
3.															
4.															
5.															



## NICRA REAL TIME PEST SURVEILLANCE (TOMATO)

Page -3

Viral and wilt diseases							
Spot no. (10 plants)	No. of infected plants out of 10 plants per spot						
	Tomato leaf curl	Bud blight	Tomato mosaic	Cucumovirus	Fusarium wilt	Ralstonia wilt	Sclerotium wilt
1.							
2.							
3.							
4.							
5.							

Early blight						
Spot no. (10 plants)	No. of plants with severity grades (0-5 scale)					
	0	1	2	3	4	5
1.						
2.						
3.						
4.						
5.						

Bacterial spot						
Spot no. (10 plants)	No. of plants with severity grades (0-5 scale)					
	0	1	2	3	4	5
1.						
2.						
3.						
4.						
5.						

Early blight & Bacterial spot
0 = No symptoms
1 = 1-4 % area of a plant infected
2 = 5-10 % area of a plant infected
3 = 11-25 % area of a plant infected
4 = 26-50% area of a plant infected
5 = >50% area of a plant infected



Spot no. (10 plants)	No. of plants with severity grades (0-5 scale)					
	0	1	2	3	4	5
	<b>Powdery mildew</b>					
1.						
2.						
3.						
4.						
5.						

<b>Disease rating scale for powder mildew</b>
0: No symptoms
1: < 10 % leaves with lesions & minimal defoliation
2: 25 % leaves infected with slight defoliation
3: 50 % leaves with lesions & moderate defoliation
4: 75 % of leaves with lesions & heavy defoliation
5: 90 % leaves with lesions with very heavy defoliation

Spot no. (10 plants)	No. of plants with severity grades (0-5 scale)					
	0	1	2	3	4	5
	<b>Septoria leaf spot</b>					
1.						
2.						
3.						
4.						
5.						

<b>Disease rating scale <i>Septoria</i> leaf spot</b>
0: No symptoms
1: Top leaves free; lesions on basal leaves without coalescence
2: Top leaves free; lesions on basal leaves with rare coalescence
3: Top leaves free; lesions on basal leaves with frequent coalescence
4: Top leaves free; lesions on leaves in middle portion of plant with coalescence
5: Lesions in top leaves; > 50 % of plant with lesions & premature defoliation



## NICRA REAL TIME PEST SURVEILLANCE (TOMATO)

Page - 5

Spot no. (10 plants)	No. of plants with severity grades (0-7 scale)							
	0	1	2	3	4	5	6	7
<b>Bacterial canker</b>								
1.								
2.								
3.								
4.								
5.								

Disease rating scale for bacterial canker
0: No symptoms
1: Trace: one leaf symptomatic
2: Slight: two leaves symptomatic
3: Moderate: > 2 leaves symptomatic
4: Severe: half plant affected
5: Very severe: more than half plant affected
6: Stunted with extensive collapse
7: Dead plant

Late blight	
Spot no. ( 3m x 3m)	% mean severity on a scale of 0-100%
1	
2	
3	
4	
5	

Mean severity (%)	Limits	Late blight Symptoms
		0
2.5	Tr.< 5	Up to 10 lesions per plant
10	5-15	Lesions easily seen at closer distance. Maximum foliage area affected up to 20 leaflets
25	15-35	About 25 % of foliage is covered with lesions
50	35<65	Lower leaves are dead. About half the foliage area is destroyed
75	65<85	About 75 % leaf area destroyed; field appears neither brown nor green
90	85<95	Only top leaves are green. Many stems have large lesions
97.5	95<100	All plants in a spot is brown-colored. A few top leaves still have some green areas. Most stems have lesions
100	100	All leaves and stems dead



**Fruit diseases/damage (no. of diseased fruits/20 fruits/spot)**

Spot no.	Buckeye rot	Early blight	Late blight	Bacterial spot	Bacterial canker	Sun scald
1						
2						
3						
4						
5						

**Record the following for fixed fields only**

Trap no.	Pheromone trap catches (no. of moths/trap)	
	<i>S. litura</i>	<i>H. armigera</i>
1		
2		

Plant protection sprays	Name of chemical	No. of applications
Against insects		
Against diseases		
Against weeds		
Use of biorationals		

**Fertilizer and cultural management**

FYM	Yes/No
Earthing up	Yes/No
Poly mulching	Yes/No
Staking	Yes/No
Type of fertilizer used	Over use/ optimal/ deficit use
Name of nutrient spray	

**Unusual weather events of the week**

Unseasonal rains	Yes/No
Hail storms	Yes/No
High intensity rains	Yes/No
Prolonged dry spells	Yes/No
Floods	Yes/No
Temperature	High/ Low/ Normal
Any other Remarks	

Particulars	Pick 1	Pick 2	Pick 3	Pick 4	Pick 5	Additional picks
Yield (Kg/acre)						
Market price (Rs./kg)						



**NICRA REAL TIME PEST SURVEILLANCE (TOMATO)**  
**(Proforma - 4)**

**Annexure - V**

**Data sheet for meteorological observations**

Location	Latitude	Longitude	Altitude
----------	----------	-----------	----------

**METEOROLOGICAL INFORMATION** (based on the nearest location/research station)

Date	Max. Temp.	Min. Temp.	RH (%)		Rainfall	Sun Shine	Wind velocity
	(°C)	(°C)	Morning	Evening	(mm)	(hrs.)	(km h <sup>-1</sup> )









## NOTES

A series of horizontal dotted lines for writing notes.

