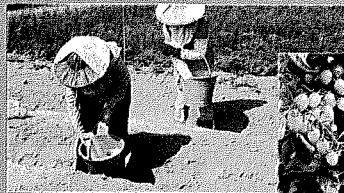


Integrated Management of Tomato Bacterial Wilt

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AVRDC

The World Vegetable Center

Introduction

Tomato is one of the most popular vegetables in the world. The global production area in 2004 was 4,397,873 ha, second only to potato in production among vegetable crops.

The popularity of tomato is rising among consumers, not only because of its good taste, but also because it contains high levels of vitamin C, lycopene, and beta-carotene, which are anti-oxidants that promote good health. The high demand for tomato makes it a high value crop that can generate much income for farmers.

Tomato is best adapted to warm and dry environments, but during the hot-wet season, yields are low due to poor fruit-setting caused by the high temperatures, as well as many severe disease problems.

Among diseases, bacterial wilt (BW) is usually the most damaging (Figure 2). In Taiwan, it has been reported that the incidence of bacterial wilt in tomato crops ranges from 15 to 55% during the summer season. In India, a study showed 10 to 100% incidence of BW during the summer.



Figure 1. Tomato is one of the most important crops in the world. This crop contributes to higher incomes for farmers and improved diets in developing countries.



Other than chemical fumigants, there is no commercial pesticide available for control of BW. The main control strategy has been the use of resistant varieties. However, the stability of BW resistance in tomato is highly affected by pathogen density, pathogen strains, temperature, soil moisture, and presence of root-knot nematode. Private seed companies, AVRDC, and national agricultural research systems have worked on the development of BW-resistant varieties, but there are still only a few varieties showing stable resistance.

Other control methods such as soil amendments, crop rotation, biological control, and field sanitation are often not effective. Because no single control method will provide good and sustainable control of the disease, integrating different methods to manage the disease is a must.

The objective of this brochure is to provide information to farmers and extension specialists on how to implement an integrated management strategy for tomato bacterial wilt. We will discuss the pathogen, the environments favorable for the disease, and then how to manage the disease to reduce yield loss. Once this occurs, farmers can take advantage of the favorable market prices for tomato in the off-season, and consumers will have greater availability to tomatoes year-round.

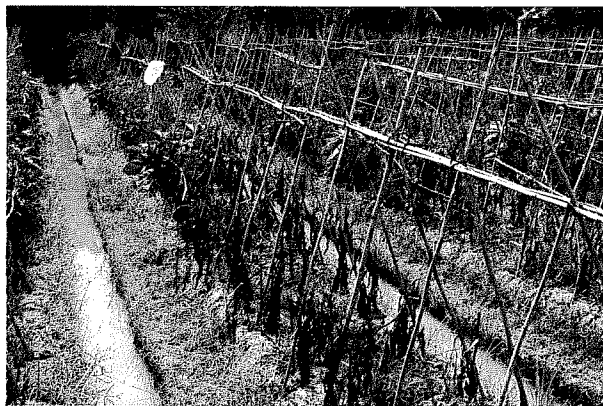


Figure 2. Bacterial wilt is one of the most damaging diseases of tomato, especially in the hot-wet season.

Know the disease

► *The pathogen*

Tomato bacterial wilt is caused by *Ralstonia solanacearum*, formerly known as *Pseudomonas solanacearum*. The pathogen has different races, each of them unique and each of them attacking different plants.

Tomato bacterial wilt is mostly caused by race 1 strain, which has a wide host range and can survive in the soil for a long period of time. Race 1 strains are highly variable in their genotype and aggressiveness on tomato. Some highly aggressive strains can cause severe symptoms, even on “resistant” varieties. Fortunately, such strains are not predominant.

► *Distribution and host range*

The race 1 strain is widely distributed in tropical and subtropical regions, and it infects over 50 families of plants—this includes vegetables, ornamental crops, fruits, and woody perennial plants. Host plants of global importance include tomato, eggplant, pepper, tobacco, ginger, and groundnut. Hosts plants of regional importance include sesame, eucalyptus, custard apple, and aquatic kangkong.

► *Dissemination*

Tomato bacterial wilt is a soil-borne disease. The pathogen is mainly disseminated through soil and enters roots through wounds or natural openings. It multiplies after infection and moves up through the vascular system, and finally blocks water transportation, which causes wilting.

The pathogen is released into soil from infected plants, and neighboring plants can be infected via root

contacts. It can also enter plants through pruning wounds. The pathogen can be disseminated into a clean field through contaminated water sources, symptomless yet contaminated seedlings, as well as humans or machinery carrying infested soils (Figure 3).

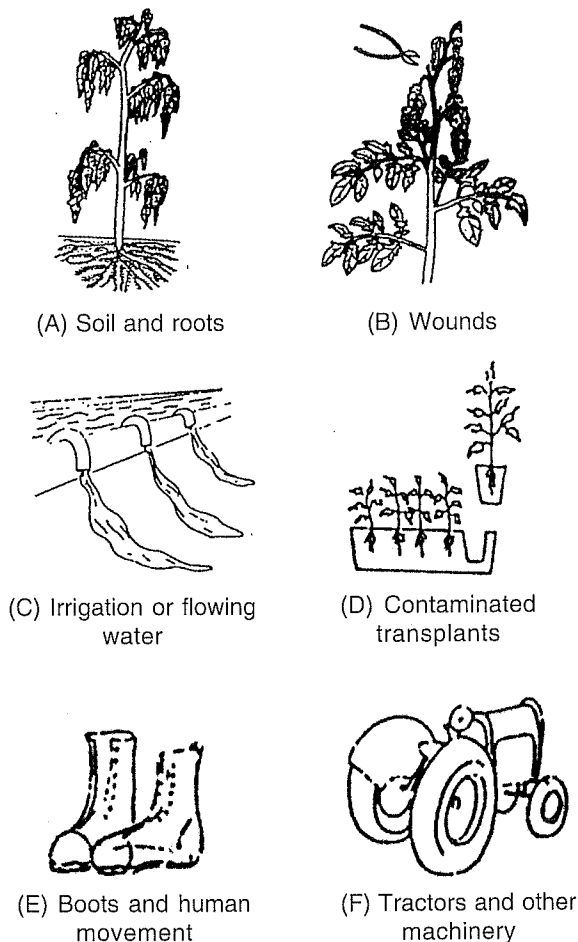


Figure 3. Means of infection and dissemination of *R. solanacearum* for causing tomato bacterial wilt.

(Source of figures: Agrios, G.N. 1988. Plant Pathology. 3rd ed. Academic Press; and Goto, M. 1992. Fundamentals of Bacterial Plant Pathology. Academic Press.)

► Conditions favorable for development

R. solanacearum is favored by high temperatures and moist soil. The disease develops slowly when the soil temperature is lower than 20 °C or soil moisture is low. The pathogen prefers acidic soils (soil pH < 7.0). The disease can occur on all types of soil, including sandy and clay types. The presence of root-knot nematode (*Meloidogyne* sp.) will accelerate disease development.

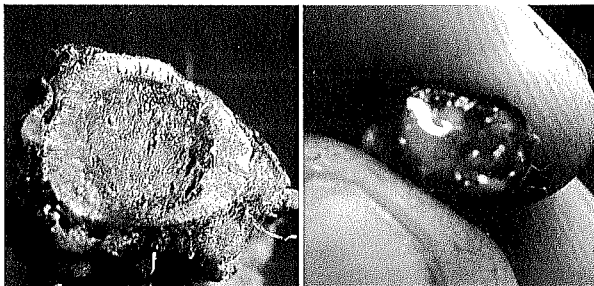
► Symptoms and diagnosis

Disease develops rapidly in warm weather, especially after heavy rain or flooding. Symptoms start as leaf drooping, followed by the complete plant wilting within a few days (Figure 4). Recently wilted plants are green—this is a distinct symptom compared to other vascular diseases like *Fusarium* wilt, which develop yellowing of leaves.



Figure 4. Infected plant displays wilting, but not yellowing of leaves.

After wilting, a vascular discoloration can be observed, sometimes with browning or maceration of the pith (Figure 5). A whitish bacterial mass can be seen when pressing an exposed stem slice (Figure 6).



Figures 5, 6. Vascular browning (left) and whitish bacterial mass observed when pressing the cut site (right).

A simple diagnostic method can be applied in the field to identify BW. Slice a stem and place the base of the stem in a clear container with water. Let it stand for few minutes. If streaming of bacteria can be seen, it is BW (Figure 7).

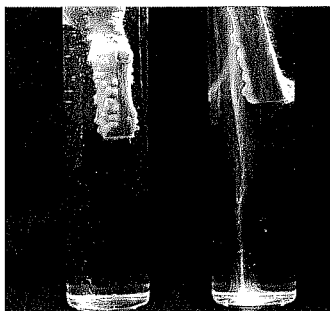


Figure 7. Bacteria streams from an infected stem (right), but not from a healthy stem (left).

Note to plant pathologists: If bacterial streaming is streaked on TZC medium, round to oval shape, fluidal colonies with pink or red center can be observed 48 hours after incubating at 30 °C (Figure 8). The unique colony type on TZC is a key for diagnosis.

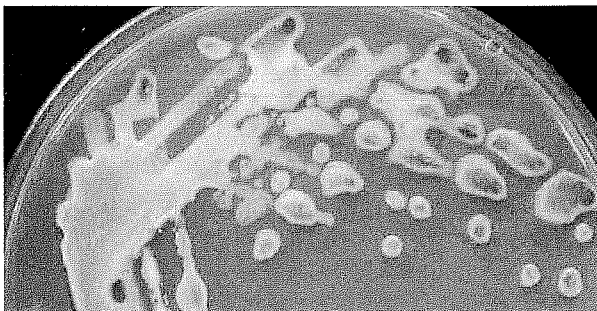


Figure 8. Colonies of *R. solanacearum* culture on TZC medium after incubating at 30 °C for 48 hours.

Recommendations

1. Choose a clean field

Field selection is a key step in managing this soil-borne disease. For bacterial wilt disease to occur, the pathogen must be in the field and environmental conditions must favor the development of the pathogen.

Plots that have no history of BW and have not been planted previously to other susceptible crops like pepper are less likely to have the pathogen. Regular rotation with paddy rice and other non-host plants (Table 1) will reduce the disease incidence.

Table 1. Non-host crops of *R. solanacearum* suited for rotation with tomato crops

Crop group	Crop name
Field crop	Maize, mungbean, rice sorghum
Vegetable	
- Root type	Carrot, yam, yam bean
- Bulb type	Chive, garlic, onion, spring onion
- Stem type	Asparagus, celery, lotus, taro
- Leaf type	Amaranth, cabbage, coriander, leafy brassica, lettuce, mustard, spinach
- Flower type	Broccoli, cauliflower
- Fruit type	Gourd, pea, pumpkin, yardlong bean
Green manure	Brassica, sesbania, sun hemp

Survey results indicated that farmers who rotated tomato with rice or other crops frequently suffered less yield loss from the disease (Table 2).

Table 2. Effect of cropping rotation on yield loss caused by tomato bacterial wilt

Rotation frequency	Mean yield loss (%)	No. of farmers
Every crop	4.8	33
Every year	11.1	38
Every 2 years	11.3	6
Every 3 years	24.4	5
Never	35.0	2
Total mean/ number	10.0	84

Data were collected interviewing 84 tomato farmers in Hsinchu and Tainan, Taiwan in 2002.



Rule of thumb:

Choose a clean field

- No history of BW in the production field and neighboring fields
- Previous crop is paddy rice or another non-host crop
- Flat topography and good drainage
- Free from water that flows within fields having the disease

2. Suppress the pathogen in infected fields

Once introduced into a field, soil-borne pathogens like *R. solanacearum* are difficult to eradicate—but they can be suppressed.

Recommended strategies include fumigation, rotation with non-host crops, flooding, and use of soil amendments. Fumigation with chemicals like methyl bromide is often used to control soil-borne diseases; however, it is highly toxic and not practical for small-scale farmers.

Rotation with paddy rice or flooding the field for 1 to 3 weeks will reduce the incidence of BW and other

soil-borne diseases such as Fusarium wilt and nematodes.

Growing a Brassica manure like Indian mustard (*Brassica juncea*) and incorporating the plants into soil at flowering stage can also suppress the BW pathogen. Urea and lime are also reported to suppress BW in the field (Figure 9).

Keep in mind that the effectiveness of these strategies will vary from field to field. Nevertheless, such practices are not only good for managing soil-borne diseases but also for promoting soil sustainability. Thus, farmers should be encouraged to implement these practices regularly.



Rule of thumb:

Suppress the disease in infected fields

- Rotate with non-host crops like paddy rice or green manures
- Flood the field 1 to 3 weeks before planting tomato
- Use soil amendments that suppress BW



Figure 9. Application of urea and lime in the field may suppress the disease.

3. Use resistant varieties and clean seedlings

Planting a variety with resistance to bacterial wilt is the simplest way to control the disease.

Commercial varieties with high and stable resistance as well as good fruit characteristics are not common. Examples of resistant or tolerant varieties include 'Arthaloika' in Indonesia, 'Delta' in Thailand, and 'Taichung AVRDC 4' in Taiwan.

The main purpose of integrated management is to provide an unfavorable environment for disease development and to stabilize performance of resistant plant materials. To be sure the resistant materials will perform well, they should be evaluated in local infested fields or with local predominant strains.

When resistant varieties are not available, grafting can be considered (Figures 10, 11). Tomato varieties with good resistance but poor horticultural traits can be used as rootstocks, such as 'Hawaii 7996' and 'BF Okitsu 101'. When flooding or excess soil moisture is a concern, resistant eggplant rootstocks should be used.



Figures 10, 11. Tomato transplants grafted onto BW-resistant rootstocks.

These include 'EG203' and 'EG219'. However, seedlings grafted on eggplant rootstock tend to have slower early development, produce smaller fruits but with higher solids, and have greater incidence of blossom end rot. The rootstock variety should be tested locally to confirm its resistance. For information on grafting, see AVRDC Publication "Grafting Tomatoes for Production in the Hot-Wet Season".

Seedlings can be symptomless carriers of the pathogen. Seedling nurseries should not be located in fields with a history of BW. Seedlings should be grown in soil mixtures that are sterilized by fumigation, solarization, or steaming.



Rule of thumb:

Use BW-resistant and disease-free planting materials

- Select BW-resistant tomato varieties, which have been tested locally
- If resistant varieties are not available, graft tomato to BW-resistant rootstocks
- Use healthy and disease-free seedlings



Figure 12. BW destroys plants (left row), but the same variety grafted onto a BW-resistant eggplant rootstock shows no symptoms (right).

4. Prevent the spread of disease in the field

BW-infected plants should be removed and destroyed right away. At the same time, reduce irrigation frequency and water amounts to shorten the period of high soil moisture. After rains, drain fields quickly.

If possible, isolate the infected section of the field by preventing water flow in or out of the section (Figure 13). Limit the traffic of people and machinery in the area. When pruning and harvesting, tools should be disinfected with 70% alcohol or a 4X dilution of household bleach.



Rule of thumb:

Prevent the spread of BW in fields

- Remove and destroy infected plants
- Reduce irrigation frequency and water amounts
- Drain the field quickly after rain
- Isolate diseased spots
- Disinfect pruning tools

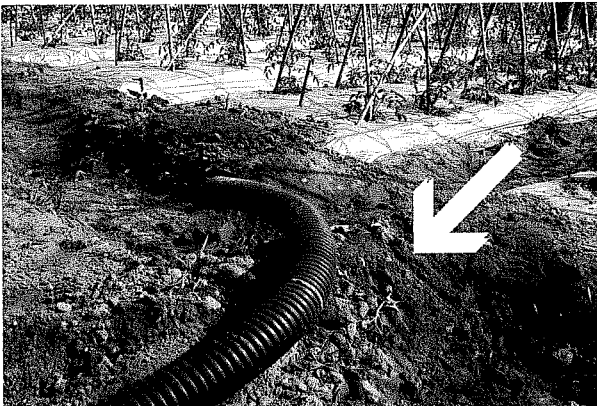


Figure 13. Isolate the diseased spot (lower right) with furrow (arrow).



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