Plant Virus Disease Management
Part II

General Approaches to Management:

- Prevention: remove or avoid sources of the pathogen
- Protect the plant from infection
- **Manage Vectors: control or avoidance**

Management: Vectors

- **Chemical management**
  - Systemic, contact and growth regulator insecticides/miticides /nematicides
  - Timing of application is important to success
  - Rotation of insecticides with different chemistries is important to manage insecticide resistance in the vector
  - Antifeedents – arrest feeding behavior very quickly (15 min) and prevent transmission
  - Repellents – oils with volatiles can be effective
  - Insecticidal soaps
  - Stylet oils – interfere with binding of virus to stylet, so can be effective with viruses transmitted in a non-persistent manner

Example: Effect of an antifeedent on virus transmission:

Treated with Fulfill (pymetrozine) before addition of whiteflies

Treated only with water

Both flats were inoculated with TYLCV (by whiteflies) 3 weeks before this picture was taken.

Why Fulfill® works to reduce virus transmission:

- Translocated in plants: translaminar and phloem mobile activity limited to Hemiptera (aphids, whiteflies, leafhoppers)
- Causes an inhibition of stylet penetration leading to dehydration and starvation
- Demonstrated to interfere with whitefly transmission of Begomoviruses (persistently transmitted)
- Demonstrated to interfere with aphid transmission:
    - semi-persistently transmitted virus (CaMV)
    - persistently transmitted virus (PLRV)

Management of Vectors: Use of insecticides

- Monitoring of vector populations is important for success. Chemical applications are most effective (for reducing virus incidence) when applied when vectors are at a low population in the crop
- Rotation of insecticides with different chemistries is important to prevent the selection of vectors that are tolerant or resistant to the insecticide
- Inappropriate insecticides or insecticides with sub-lethal doses can cause hyperactivity and bring dispersal or increased movement of viruliferous vectors leading to increased virus spread.

  ex. Imidacloprid doesn't kill thrips but does agitate them this results in increase in spread of TSWV
- For these reasons, growers use professional pest scouts who monitor vector (and pest/pathogen) populations and advise when and what to apply during crop production

Management: Vectors

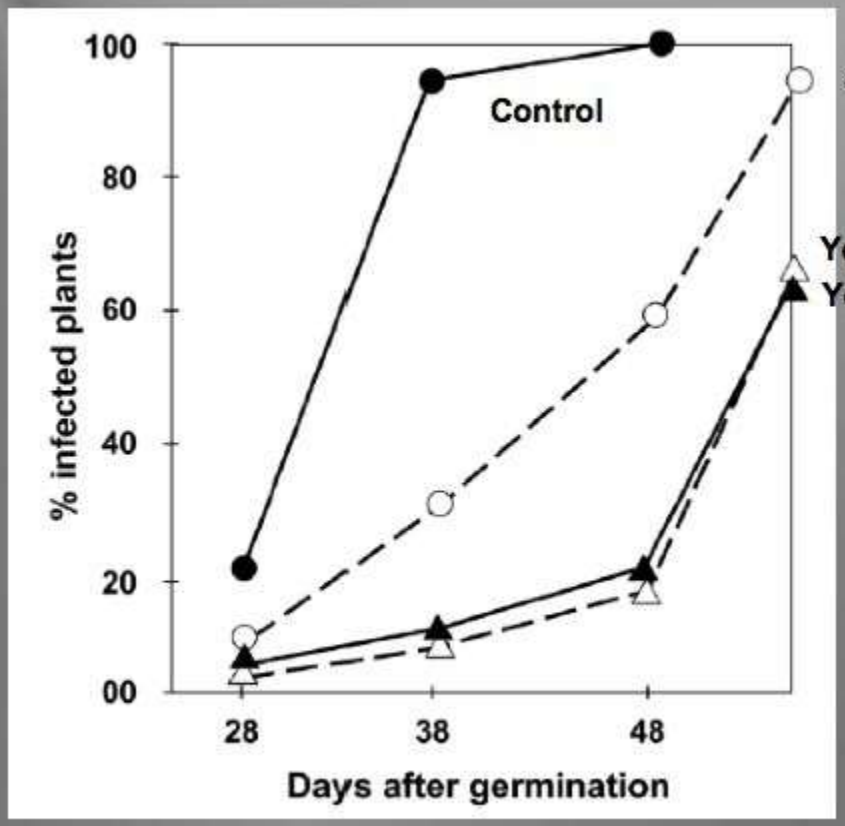
- **Regulatory**
  - prevent introduction of vectors on plant parts
- **Cultural**
  - Purchase transplants from locations unlikely to have vectors
  - Use sanitation to prevent movement of soil-borne vectors
  - Use reflective plastic mulches – can repel aerial vectors
  - Reflective screens to repel as well as protect plants
  - Use of UV absorbing screens/plastics to “blind” vectors
  - Select cultivars that repel vectors (sticky hairs, repellent or biocidal exudates) however, this is not a commonly available tactic

Management: Vectors

- **Cultural**
  - **Mulches that repel aerial vectors or interfere with landing of vectors in field**

Colored plastic mulches

The effect of different mulches on incidence of TYLCV



Results from Israel

Results were different in Florida – we found increases in whiteflies and virus-infected plants (higher than controls) with use of yellow mulches

Cohen and Melamed-Madjar 1978. Bull. Ent. Res. 68:465-470.

Reflective plastic mulches

Figure 1. Tomato planted on metalized vs. black plastic mulch (back - right).

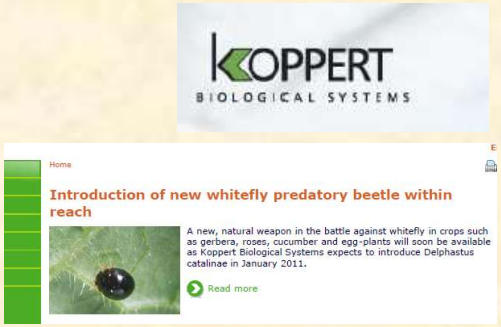
Reflective strips

Management: Vectors

- **Cultural Con't**

- Barrier crops surrounding a field can work to reduce movement of insect transmitted viruses (non-, semi- and persistently transmitted viruses)
  - Non-persistent: Barriers must be taller than the crop you are trying to protect and must be several meters deep
  - Semi- and Persistent: Barriers must be more attractive to the insect than the crop

* Biocontrols – not effective for virus management. Population reduction is too slow and does not reduce populations to a level that reduces transmission.



Management: Vectors

- **Cultural**
  - **Physical Barriers**

Row covers

Row covers protect plants from aerial vectors until pollination when cover must be removed

Wind breaks of grasses used to impede spread of non-persistently transmitted viruses

- Grass must not be a host of the virus and must be attractive to the vector

Management: Vectors

- **Cultural**
  - **Physical Barriers plus Repulsion**

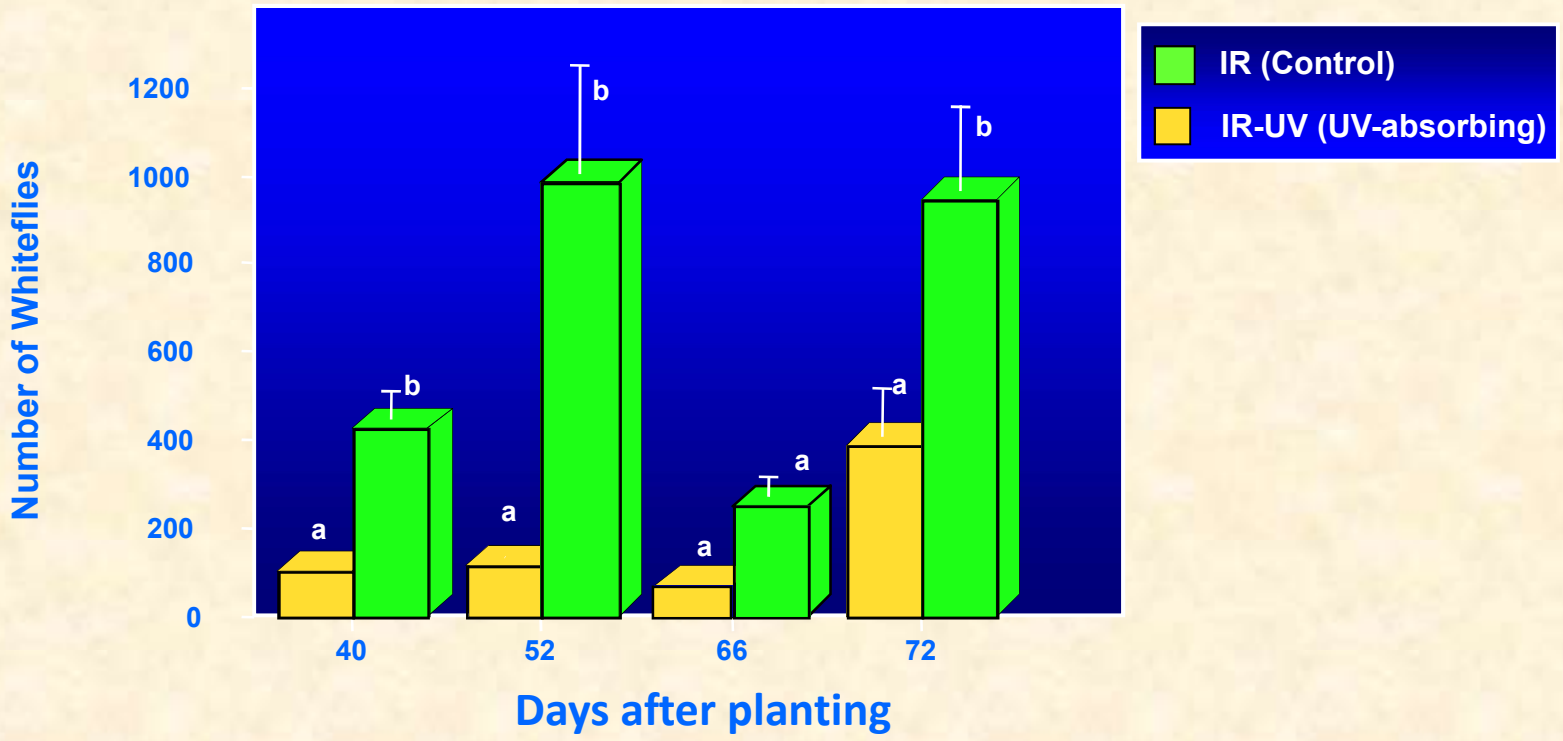
    UV-Absorptive row or tunnel covers: Lack of UV light interferes with vectors' ability to find plants, resulting in less movement and therefore lower rates of infected plants.

Insects Blinded by Science

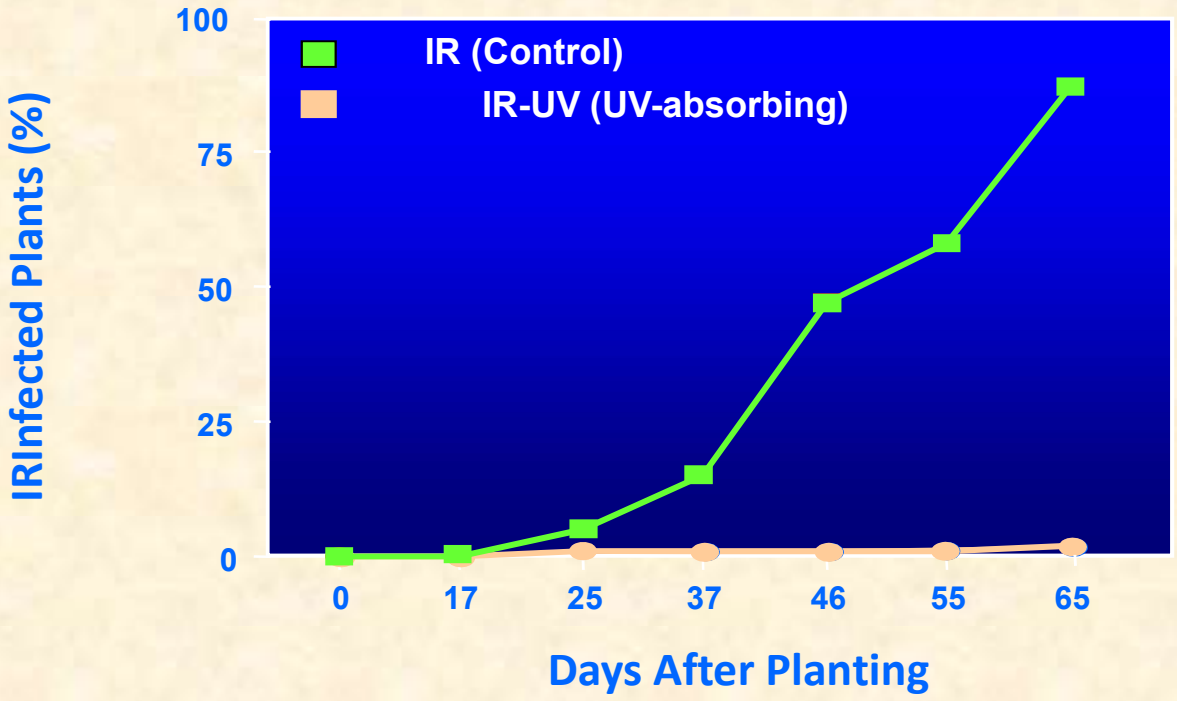
The eye of a whitefly is a sophisticated ultraviolet scanner, zeroing in on tasty crops. But it can be stymied by a cheap bit of camouflage: a simple layer of polyethylene film. > Yehezkel Antignus, a virologist at Israel's Agricultural Research Organization, stumbled across this countermeasure while studying ways to protect plants from disease. He was surprised to find that crops grown in greenhouses roofed with ultraviolet-absorbing polyethylene films had significantly fewer insect-borne viruses. Experimental trials confirmed that the films contributed to a steep decline in some of the worst agricultural pests–whiteflies, aphids, and leaf miners, along with their attendant diseases. Antignus infers that polyethylene obscures the ultraviolet markings pests use to find their host plants. > But there are some limitations to the technique. Polyethylene films can confuse bees, too. Antignus has had to adjust the lighting to keep them pollinating. And the films protect only plants grown inside greenhouses. Still, within the sizable world of greenhouse agriculture, farmers have a potent new weapon. Two Israeli companies are now manufacturing insect UV camouflage: Ginegar Plastic Productions makes films, while Meteor Ltd. sells ultraviolet-absorbent mesh. –*Anna Charny*

Walk-in tunnel (6 by 6 by 2.7 m) covered either with IR or IR-UV plastic sheets. The front and rear ends of each tunnel were covered with a 50-mesh screen (southern Israel)

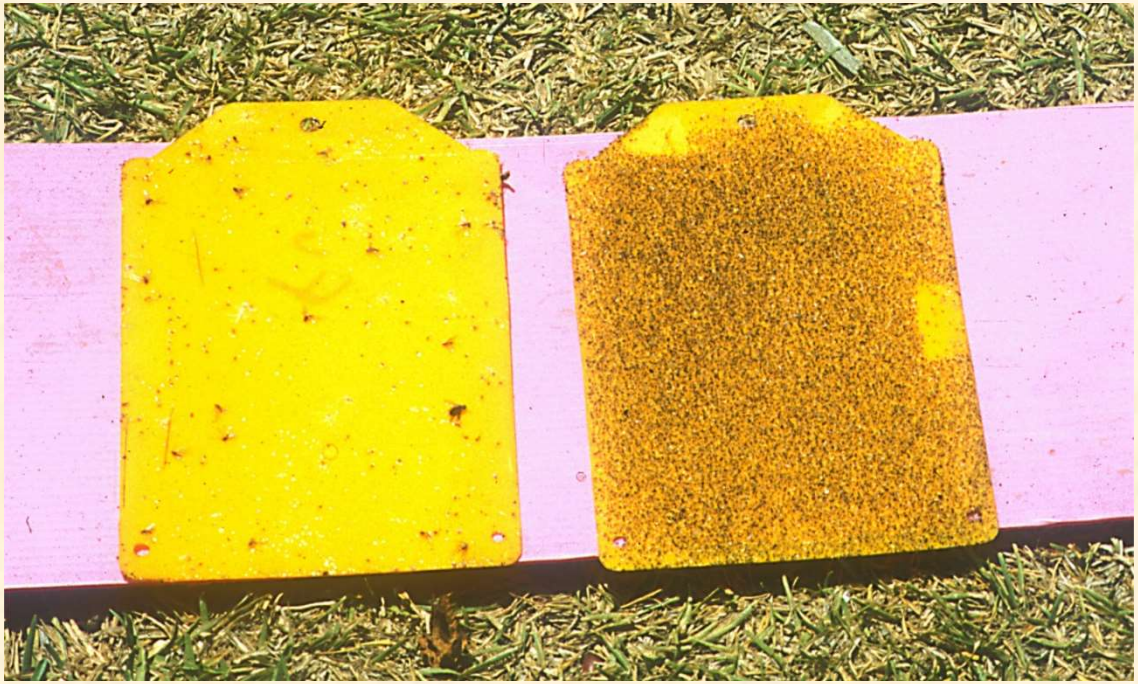
Trapping of Whiteflies Under UV-Absorbing Plastic Sheets



Disease Incidence of TYLCV Under UV-Absorbing Plastic Sheets



Aphids on Yellow Sticky Traps Taken From a Greenhouse Covered by Plastic Sheets:



UV-absorbing

Regular

Feeding by other insects/arachnids also reduced by use of UV-absorbing plastic:

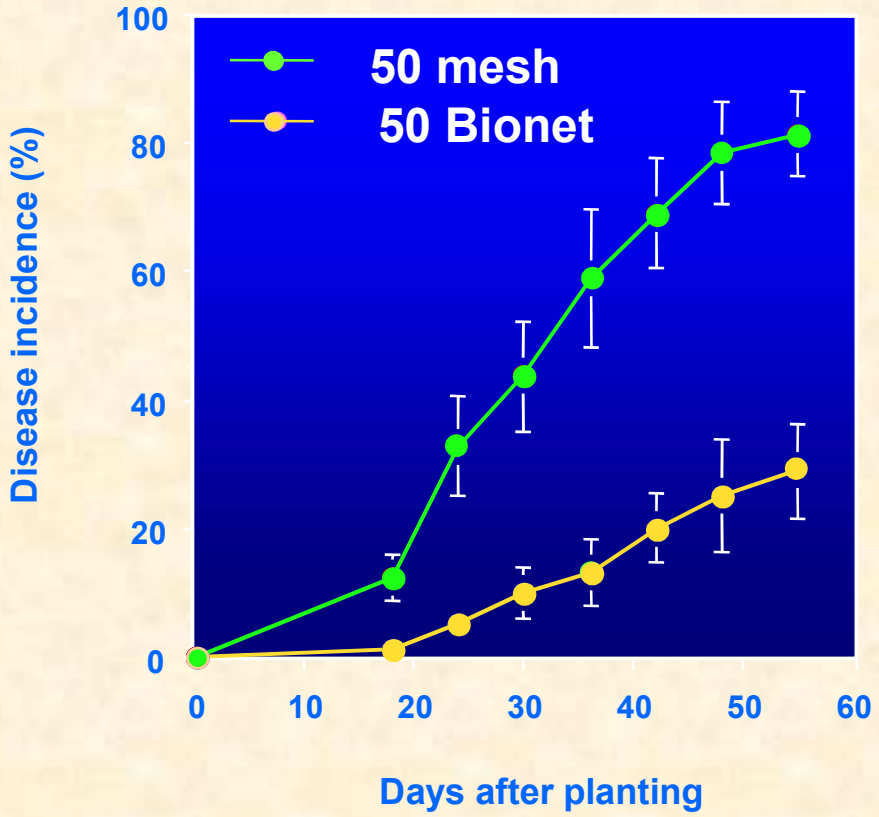
- Thrips (*Frankliniella occidentalis*)
- Leafminers (*Liriomyza trifolii* Burgess)
- Red mites (*Tetranychus telarius* L.)
- Nocturnal moths (*Spodoptera lituralis & Laphygma sp.*)

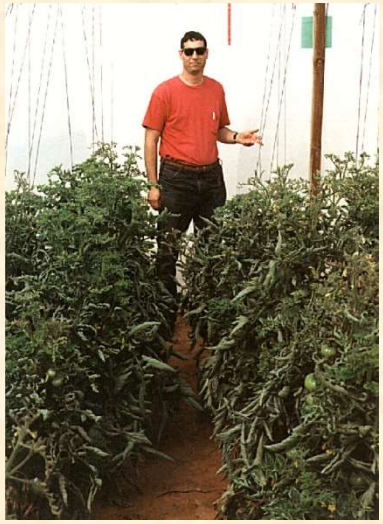
Effect of UV-absorbing plastic on feeding of Laphigma caterpillars on mint

Regular plastic sheets

UV-absorbing plastic sheets

TYLCV Disease Incidence Under UV-Absorbing Screens (ex. 50 Bionet)





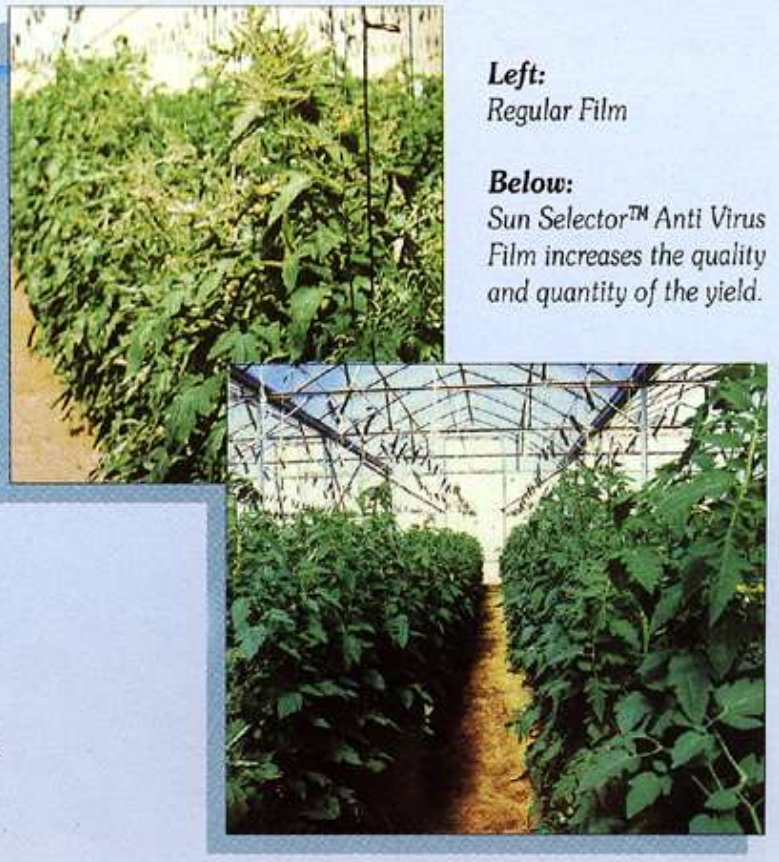
Regular 50-mesh nets

UV-absorbing 50-mesh nets

SUN SELECTOR™ ANTI VIRUS

Sun Selector™ Anti-Virus is the newest photoselectiv film from Ginegar Plastic Products. Due to its special optical properties, this film significantly reduces damage caused by insects (e.g. aphids, white flies, thrips, leaf miners) and by the viruses they transmit.
The film also reduces certain fungal diseases (e.g. Botrytis) and blackening of red roses and provides environmental - friendly solution to higher and better yields with reduced pesticide and fungicide use.
Sun Selector™ Anti-Virus is available in adjustable levels of light diffusion for maximum adaptation to specific local light conditions and crops requirements. Recommended: For most types of flower and vegetable crops in all climates.

Technical Specifications		
	Thickness:	150-200 microns
	Width:	Between 2 to 15 meters
	Film length:	Per customer specifications



Left:
Regular Film

Below:
Sun Selector™ Anti Virus Film increases the quality and quantity of the yield.

Mechanism:

The putative mechanism by which the UV filtration protects crops seems to be two-fold:

- UV filtration reduces the attraction of insects to plants. As a result fewer insects penetrate the greenhouses covered by UV-absorbing material

- An environment lacking UV seems to affect the whiteflies dispersal behavior. Thus, once inside a UV deficient environment, the insects ability to disperse is reduced and therefore fewer plants become infected.

Management of Vectors

- **Nematodes**

- Nematode-transmitted viruses persist for long periods in the soil and in their nematode hosts, and disperse slowly in fields.

- For these reasons, use of nematicides can be a very effective and practical method of control.

- Crop rotation with hosts that reduce nematode populations can also be an effective treatment

Management recommendations are often complicated with multiple approaches used in combination

Examples:

- **TSWV in north Florida**
- **TYLCV in Australia**
- **TYLCV in Florida**

TSWV in N. Florida

Figures showing the effect of different insecticides sprayed on plants with different mulches on incidence of TSWV symptoms

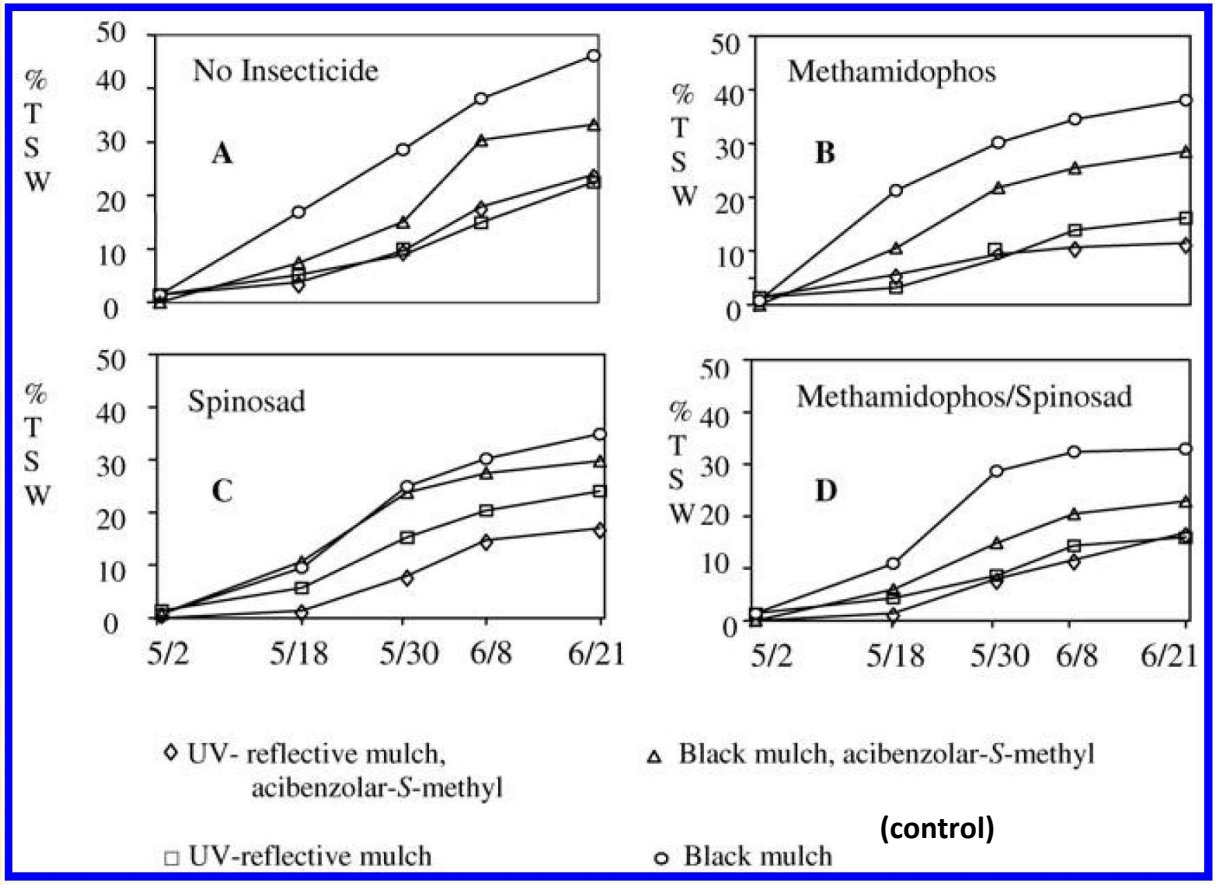


Fig. 1. Disease progress curves of tomato spotted wilt (TSW) as affected by mulch type, acibenzolar-*S*-methyl, and insecticides in the experiment conducted in 2000.

Momol et al 2004. Plant Dis. 88:882-890

TSWV in N. Florida

Table 2. Effect of mulch type, acibenzolar-*S*-methyl, and insecticides on final incidence of tomato spotted wilt in an experiment conducted in 2000

	Final percent incidence of tomato spotted wilt [±SEM][a]		
Treatments	**Acibenzolar-*S*-methyl**	**No acibenzolar-*S*-methyl**	**Mean**
Black mulch			
No insecticide	33.3 [7.8]	46.3 [7.1]	39.8 [5.5]
Methamidophos	28.6 [4.0]	38.2 [6.7]	33.4 [4.0]
Spinosad	29.8 [4.9]	34.9 [9.7]	32.3 [5.1]
Methamidophos/spinosad	23.0 [4.0]	33.0 [6.4]	28.0 [4.0]
Mean	28.7 [2.6]	38.1 [3.6]	33.4 [2.4]
UV-reflective mulch			
No insecticide	23.8 [7.3]	22.5 [6.2]	23.1 [4.4]
Methamidophos	11.4 [0.9]	16.2 [4.4]	13.8 [2.3]
Spinosad	17.1 [2.0]	24.1 [6.6]	20.6 [3.5]
Methamidophos/spinosad	16.9 [4.4]	16.0 [2.9]	16.4 [2.4]
Mean	17.3 [2.3]	19.7 [2.5]	18.5 [1.7]

[a] Figures in brackets indicate standard error of means [SEM].

Table showing the effect of different insecticides sprayed on plants with different mulches with and without Actigard on incidence of TSWV symptoms

Momol et al 2004. Plant Dis. 88:882-890

TSWV Management Recommendations for N. Florida:

- Use reflective mulches
- Use rotations of Monitor and Spinosad to control thrips populations
- Apply Actigard at 2 week intervals

Years later, a survey of growers' perceptions of TSWV management using these recommendations supported the effectiveness of the combined use of all 3 approaches.

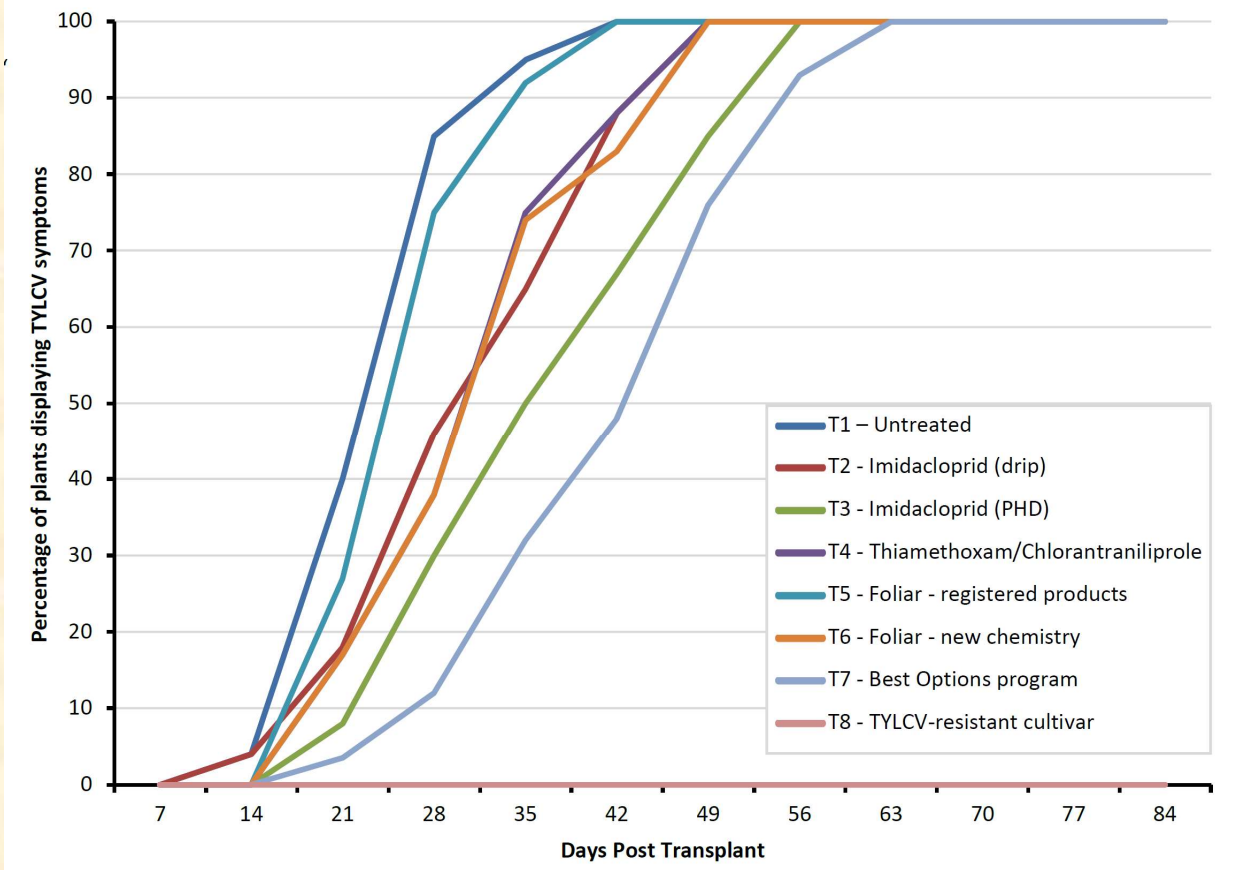
HORTICULTURAL ENTOMOLOGY

Effectiveness of Tomato-Spotted Wilt Virus Management Tactics

SEBASTAIN N. AWONDO,[1] ESENDUGUE G. FONSAH,[2] DAVID RILEY,[3] AND MARK ABNEY[4]

J. Econ. Entomol. 105(3): 943–948 (2012); DOI: http://dx.doi.org/10.1603/EC11272

Example – developing management recommendations for TYLCV in Australia



Effects of different practices on the incidence of TYLCV (based on symptom expression)

T7 Best Option: combination of plant hole drench of Imidacloprid (see T3), foliar sprays of registered chemicals (see T5) and new chemicals applied during flowering/fruit set (T6)

Campbell et al 2017. Towards area wide management of insect vectored viruses of tomatoes in the Bowen district. Virus Res.

Example – developing management recommendations for TYLCV in Australia

Table 3. Fruit yield for TYLCV-susceptible Pinnacle tomatoes treated with a range of management options compared to a TYLCV-resistant cultivar

	Treatment	Mean no. fruit per plant	Mean fruit weight (g)	Mean total yield per plant (kg)
T1	Untreated control	23.9 e	126.7	3.03 e
T2	Imidacloprid (drip)	32.5 cd	129.7	4.22 d
T3	Imidacloprid (PHD)	36.8 bc	129.0	4.75 c
T4	Thiamethoxam/Chlorantraniliprole (STD)	34.1 c	130.6	4.45 cd
T5	Foliar Imidacloprid	25.9 e	129.1	3.34 e
T6	Foliar - new chemicals	38.7 bc	132.1	5.11 b
T7	Best Options program	40.5 ab	133.1	5.39 b
T8	TYLCV-resistant cultivar	44.6 a	132.8	5.92 a
***P*-value**		0.0001	0.6962	0.0001
LSD (5% level)		4.79	N/A	0.59

Means within columns followed by the same letter are not significantly different at the 5% level according to least significant difference (LSD) test. N/A= Not Applicable due to a p-value > 0.05

Effect of different management practices on yield:

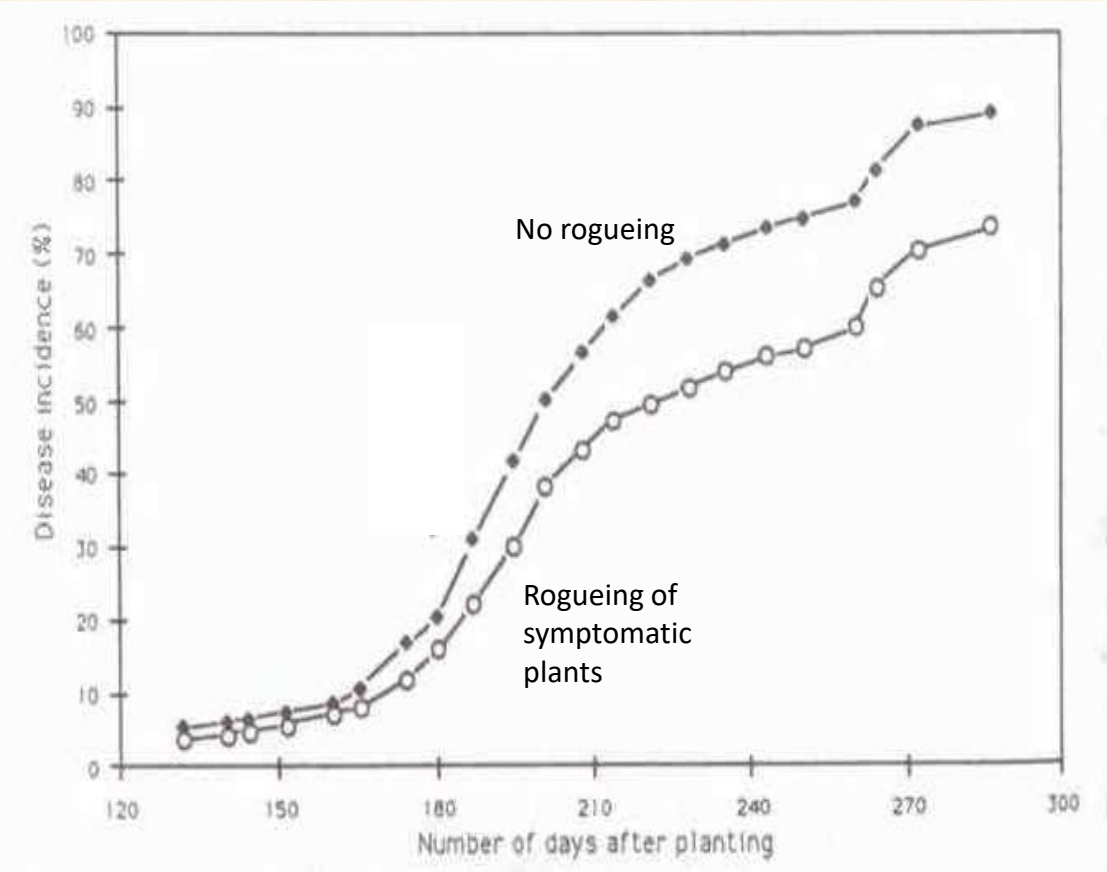
T7 Best Option: combination of plant hole drench of Imidacloprid (see T3), foliar sprays of registered chemicals (see T5) and new chemicals applied during flowering/fruit set (T6)

Management Recommendations for TYLCV in south/central Florida:

- Select TYLCV-resistant cultivars (tomato, pepper) for all crops or at the minimum use them when whitefly populations are traditionally high
- Use TYLCV-free transplants (tomato, pepper)
- Use care in selecting location of crops (tomato, pepper)
- Use reflective plastic mulches
- Rogue infected tomato plants before 1st tie
- Manage whitefly populations in tomato:
  - Nicotinoids: Soil drench at beginning of season
  - Pyridine-azomethines (Fulfill) - foliar spray
  - Insect Growth Regulators IGRs (Knack, Courier)
  - Foliar insecticides (Thiodan, pyrethroids, etc..)
- Remove tomato plants promptly at the end of the crop

Control of vector-borne virus diseases by rogueing

- Ex. African cassava mosaic virus, transmitted by whiteflies
  - Most spread from outside sources (primary spread)
  - Same management practices were employed (few)



Fargette et al., 1990

Summary

1. Incidences of virus-infected plants can be affected by production practices so select practices that suppress incidences of virus-infected plants
2. Diseases caused by viruses are rarely curable.
3. Diseases caused by viruses can only be managed through preventative means.
4. If you don’t prevent the virus from infecting the crop, see #2.