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SCREENING AS PART OF INSECT AND DISEASE MANAGEMENT IN THE GREENHOUSE

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Robb and Parrella (1988) described a greenhouse screening experiment in California in which they were able to grow a crop of chrysanthemums without a single application of pesticides. This article describes some of our efforts with screening materials for excluding greenhouse pests inspired by those workers. Most of our emphasis has been with the western flower thrips, a vector of the tomato spotted wilt virus. We also used the sweetpotato whitefly. These two relatively new pests are remarkably resistant to pesticides and cause considerable damage to greenhouse ornamentals.

Why Consider Screening?

Resistance to pesticides has made control of insect and mite pests increasingly difficult in the greenhouse. In the case of pesticide failure, changing to a pesticide in a different chemical group may help. However, with some pests, such as the western flower thrips, the number of pesticides which are effective and labeled for use in the greenhouse is uncomfortably small.

Loss of pesticides due to EPA regulations and industry concerns has made chemical control of greenhouse pests much more difficult now and threatens to force major changes in the way growers deal with pests in the near future. Costs of developing new pesticides have escalated as have the costs associated with reregistration. Thus pesticides are going to be more expensive than in the past. Although pesticides will remain an important tool for pest management in the greenhouse, other methods of control must be used to slow the build up of resistance in order to conserve the usefulness of the dwindling supply of legally registered pesticides.

Environmental and health problems

associated with pesticides has sensitized the public and greenhouse workers to pesticide issues. Because of both dermal and respiratory exposure to pesticides, greenhouse workers have greater risk associated with pesticides than any other group of agricultural workers. An obvious way of reducing risks is to make fewer applications of pesticides by using screening to reduce numbers of pests entering a greenhouse.

Tomato Spotted Wilt on Gloxinia

Our first demonstration compared the incidence of tomato spotted wilt virus on gloxinias in four types of cages covered with perforated polyethylene film (VisQueen Vispore insect screen) to plants with no cages in a heavily infested commercial greenhouse with a medium population of western flower thrips. The cages were installed 30 June and small gloxinia plants were transferred from the shipping container to six inch pots, watered in, and the cages were taped closed with two inch fabric tape (Fig. 1). There were about twenty-one plants per cage. In addition, the grower covered a set of gloxinia plants in an adjacent greenhouse with Reemay spunbonded polyester tobacco plant bed cover. (even while still in the shipping container). They were planted in six inch pots the following week (Fig. 2). The plants in the cages were irrigated and fertilized through drip tubes with occasional supplemental watering through the perforated film. In the what else can go wrong category, an opossum crawled in a vent and across the cages, tearing open the seams of the cages. Even with that, there was appreciably lower rate of infection in the caged plants. We were surprised at the length of time the plants under the spunbonded polyester were symptomless (Table 1). Plant quality under the spunbonded polyester was not good, but at least the plants were alive. By adjusting the light intensity and by suspending the material above the crop, plant quality could probably be improved greatly. Plants in the Vispore cages with frames were of higher quality than the frameless caged plants. We were encouraged by the degree of

Figure 1. Vispore covered cages at the end of the demonstration showing the difference in plant growth inside the cages (mostly without tomato spotted wilt virus) and outside the cages (most of the plants have the virus).

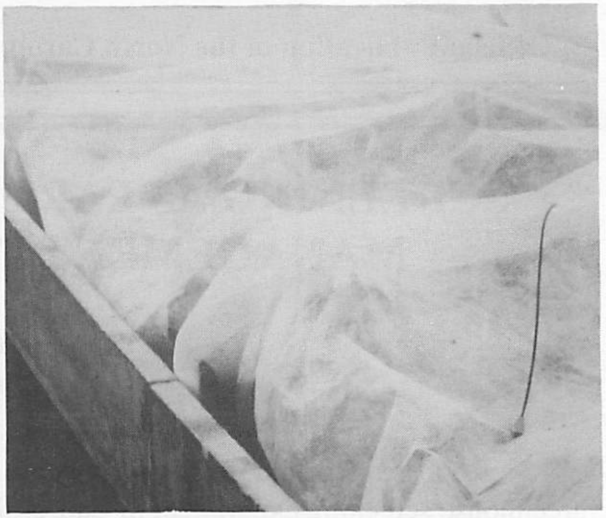

Figure 2. Spunbonded polyester draped over gloxinias.

Table 1. A comparison of types of Vispore covered cages for Tomato Spotted Wilt Suppression on Gloxinia, 1988.

Treatment	Incidence of Tomato Spotted Wilt Virus (Number of Plants Infected)				
	25JUL	4AUG	17AUG	8SEP	Total% TSWV
cage, no frame, no fan	1	1**	2	1	24
cage, no frame, fan	0*	1	0	2	14
cage, frame, no fan	1	0	2	0	14
cage, frame, fan	0	0***	0	1	5
spunbonded polyester	0	0	0	1****	low
no cage	high	high	high	high	high

* Two plants died possibly due to dehydration.
** One other plant died due to Phytophthora.
*** One plant died of unknown causes.
**** Only one plant verified, several more plants with symptoms noted.

protection from tomato spotted wilt virus afforded by the cages even though they could have been infested by thrips as the plants were placed in the cages and during the opossum tearing incident. This agrees with results reported by Dr. Ron Mau (personal communication) that a windbreak of trees between fields of lettuce retards the spread of tomato spotted wilt in Hawaii. In other words, some screening is better than none. However, if done poorly, the thrips can be trapped inside the screening with the plants.

Western Flower Thrips

In a demonstration on African violets in a commercial greenhouse with a low but chronic western flower thrips infestation, numbers of thrips on plants in four types of cages covered with Vispore were compared with the number of thrips on plants with no cages for the exclusion of western flower thrips. The cages were installed 6 July and young African violet plants in four inch pots were placed in the cages. The cages were then taped closed with two inch fabric tape. The plants were irrigated through drip tubes with occasional supplemental watering through the Vispore so that the cages did not have to be opened during the experiment. Counts were made of thrips per flower after the plants began to produce flowers by cutting open the cage and extracting the flowers and then taping the cages closed. The first plants were harvested for sale on 22 August from the cage with a frame and fan. The demonstration was discontinued 15 September.

Vispore is capable of at least partially excluding western flower thrips from a crop of African violets for more than two months (Table 2). Plants grown in the cages with frames appeared to be of higher quality. Some of the varieties were "stretched" in response to lowered light levels inside the cages. Because the house was covered with shading material, one could compensate for the reduced light intensity in the cages by using a less dense shade cover. Unfortunately, in this demonstration, the drip irrigation tubes were of such small diameter that the grower was forced to supplement the irrigation by watering directly through the perforated film. Watering through the Vispore was an unsatisfactory practice in the cages without fans as the excess water on the blossoms aggravated gray mold development which sometimes spread to the leaves because the grower could not remove dead blossoms inside the cages. (The fans provided positive air pressure to help exclude thrips and they increased air movement to reduce *Botrytis* blight.)No pesticides were applied to the plants inside the cages. Plants outside of the cages were treated with Avid and Mavrik at irregular intervals for western flower thrips control.

As it seemed unlikely growers would accept growing plants inside sealed cages as a conventional growing practice, we then tried comparing tightly sealed cages to cages with the screening material draped over the frame but not sealed down. Each cage was covered with either Vispore or spunbonded polyester. One cage of each fabric was tightly sealed and the other draped with the fabric to provide complete coverage of the frame. The cages were installed on 15 September and young African violet plants in 4 inch pots were placed in the cages (Fig. 3), on the bench adjacent to the cages, and elsewhere in the house. The sealed cages were taped closed

Table 2. A comparison of Vispore covered cages for Western Flower Thrips on African Violet, 1988.

Cage Treatment	**Avg Number of Thrips per Flower**		
	22AUG	31AUG	15SEP
No frame, no fan	0 (32 flowers)	0 (40 flowers)	0 (40 flowers)
No frame, fan	0 (6)	0.05 (19)	0.10 (52)
Frame, no fan	0.02 (41)	0.06 (48)	0.04 (77)
Frame, fan	0 (55)	0.02 (44)	0.02 (40)
No cage, next bench	0.15 (84)	0.42 (73)	0.5 (28)
No cage, same age plants across greenhouse	0.63 (78)	0.93 (45)	0.5 (44)

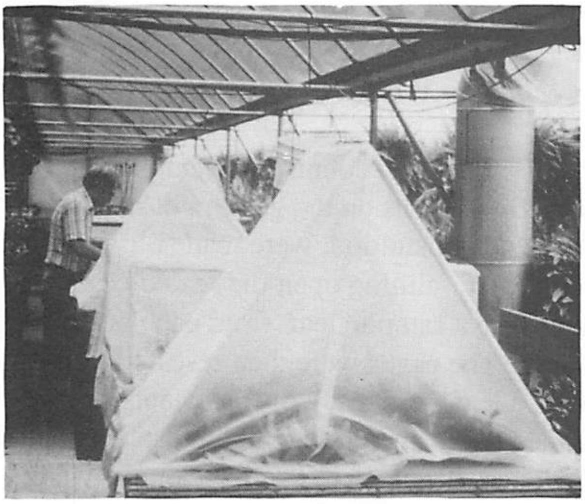

Figure 3. Thrips exclusion cages covered with draped and sealed screening materials.

using 2 inch fabric tape. The plants in and adjacent to the cages were irrigated through the larger diameter drip tubes. After the plants began to produce flowers, counts were made of thrips per flower by cutting the sealed cage fabric to extract the flowers, then taping the cut closed. The fabrics on the draped cages were lifted to extract flowers, then put back in place. Small external fans were directed toward the sealed cages to provide some additional ventilation. Embarrassingly enough, by the end of the test, there were more thrips inside some of the cages than on plants outside. However, the grower was spraying the plants outside with Mavrik and Avid, but not spraying the plants inside (nor the plants marked " No cage, adjacent" in Table 3). Spraying may have repelled the thrips outside the cages and encouraged the thrips to enter the cages. This points up a problem with screening for pest management: if you start with pests already inside the screening, the screening will keep them in. Obviously, if thrips are already on plants to be protected, those thrips must be treated to keep down the population.

We decided to run the next demonstration on screening in the entomology greenhouse because of its raging populations of western flower thrips and sweetpotato whiteflies. Exacum, gloxinia and gerbera daisies were grown in four cages covered with Vispore or spunbonded polyester. Plants were maintained in prism shaped cages on a bench

Table 3. A comparison of types of cages and screening materials for Western Flower Thrips on African Violets, 1988-89.

Cage Treatment	Avg No. of Thrips per Flower	
	December 20, 1988	January 18, 1989
Vispore (draped)	3.05 (75 flowers)	1.88 (82 flowers)
Vispore (sealed)	2.04 (75)	2.46 (57)
Spunbonded Polyester (draped)	0.48 (75)	1.90 (52)
No cage, adjacent	1.18 (45)	1.54 (26)
*No cage, across greenhouse	1.98 (45)	0.59 (39)

*Subjected to standard greenhouse spray program.

in a polyethylene greenhouse and irrigated by drip tubes so the cages would not have to be opened for hand irrigation. After the plants were placed in and sprayed with Avid at the 8 oz per 100 gallons rate, one of the Vispore cages and one of the spunbonded polyester cages were tightly sealed. The coverings of the other Vispore and spunbonded polyester cages were merely draped over the top bar of the cage frame after the plants were placed in and sprayed with Avid as above. Thus the plants in the draped cages could be accessed from both sides and each end. Uncaged control plants were placed on the same bench and irrigated by the same drip irrigation system. The plants were put into the cages on 13 September, 1988. On 3 January, 1989, the cages were opened and a quart of foliage from one exacum plant in each cage was put into a Berlese funnel to extract live thrips. Likewise, the flowers from the gloxinias were put into a Berlese funnel to separate the thrips for counting (Table 4). Even though all the plants were sprayed with Avid when put into the cages, the numbers of thrips from gloxinia flowers in the sealed cages were much higher than in the draped cages. This, again, points out an important limitation to screening for pest management: *You can screen pests in as well as out.*

Sweetpotato Whitefly

The first counts of sweetpotato whitefly nymphs on the gerbera dasies in the above demonstration, were made on 7 November by slitting open the sealed cages and removing a sample leaf from each of four plants. The cages were then resealed. Likewise, a leaf from each of four plants in the draped cages and each of the four plants on the open bench were taken. Counts were made of living whitefly nymphs per 2 square cm. Averages were analyzed by a one way analysis of variance. Plants outside the cages had significantly more whiteflies than those inside the cages (Table 5).

The Big Screen

A commercial flower grower gave us permission to use a quonset style, polyethylene house which would have gloxinias after crops of poinsettias and azaleas. The house had 140 sq ft of cooling pads and so we built an external screen with 700 sq ft of Vispore screening to test its efficacy against thrips (Fig. 4). (Tests made in Dr. Dan Willits' lab

Table 4. A comparison of screening materials and types of cages for Western Flower Thrips exclusion on gerbera daisy, 1988-89.

Treatment	**Exacum:** No. Thrips in 1 qt of foliage.	**Gloxinia:** No. Thrips per flower.
Draped Vispore Cage	0 (6 flowers)	0.6 (11 flowers)
Draped Spunbonded Cage	0 (16)	0.3 (10)
Sealed Vispore Cage	1 (0)	3.4 (10)
Sealed Spunbonded Cage	0 (0)	3.8 (10)
Not caged	10 (35)	3.7 (10)

Table 5. **A comparison of screening materials and types of cages for Sweetpotato whitefly control on gerbera daisy, 1988-89.**

Cage Treatment	**Avg No. Whitefly Nymphs/2 sq cm**	
	November 7*	January 3*
Sealed Vispore	0.75b	0.0b
Sealed Spunbonded	0.50b	1.0b
Draped Vispore	1.5b	3.75b
Draped Spunbonded	1.0b	22.0b
Check	5.0a	215.0a

*Means followed by the same letter are not significantly different (DMRT, P = 0.05).

in Biological and Agricultural Engineering at NCSU showed Vispore reduces air flow by a factor of five. Spunbonded polyester reduces air flow by a factor of two). Similar sized greenhouses next door or across the ally were used as unscreened check treatments. Crop composition in the check greenhouses were somewhat variable as the various crops were marketed. The crops in the screened house were primarily gloxinia with some exacum and occasional "returns" left by the truckers after hours (this is a horrible practice; truckers should have a separate house for returns or should discard the plants on a plastic covered dump or in a plastic covered bin). During the Mother's Day holiday, the doors of the greenhouses were propped open to facilitate the removal of plants.

Ten yellow sticky cards per greenhouse were used and counts were made of new thrips per card at roughly weekly intervals. Almost twice as many thrips entered the unscreened greenhouse compared to the screened one (FIg. 5). Tomato spotted wilt virus eventually occurred in the unscreened and then the screened houses. Losses due to tomato spotted wilt were greater in the unscreened houses although exact comparisons were not possible because marketing caused constant turnover of plants. In late spring the number of thrips caught on the cards was significantly correlated to temperature: the warmer the day the more thrips were flying. However, later in the summer, there was no correlation between any weather factors and

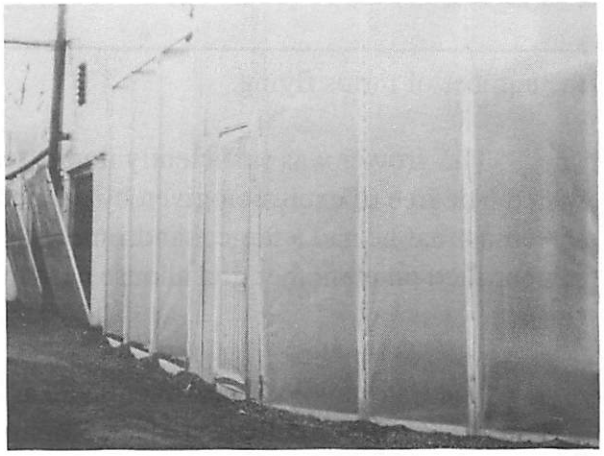

Figure 4. The large screen installed over the cooling pads of a commercial greenhouse. The screen was pleated on one end to increase the surface area.

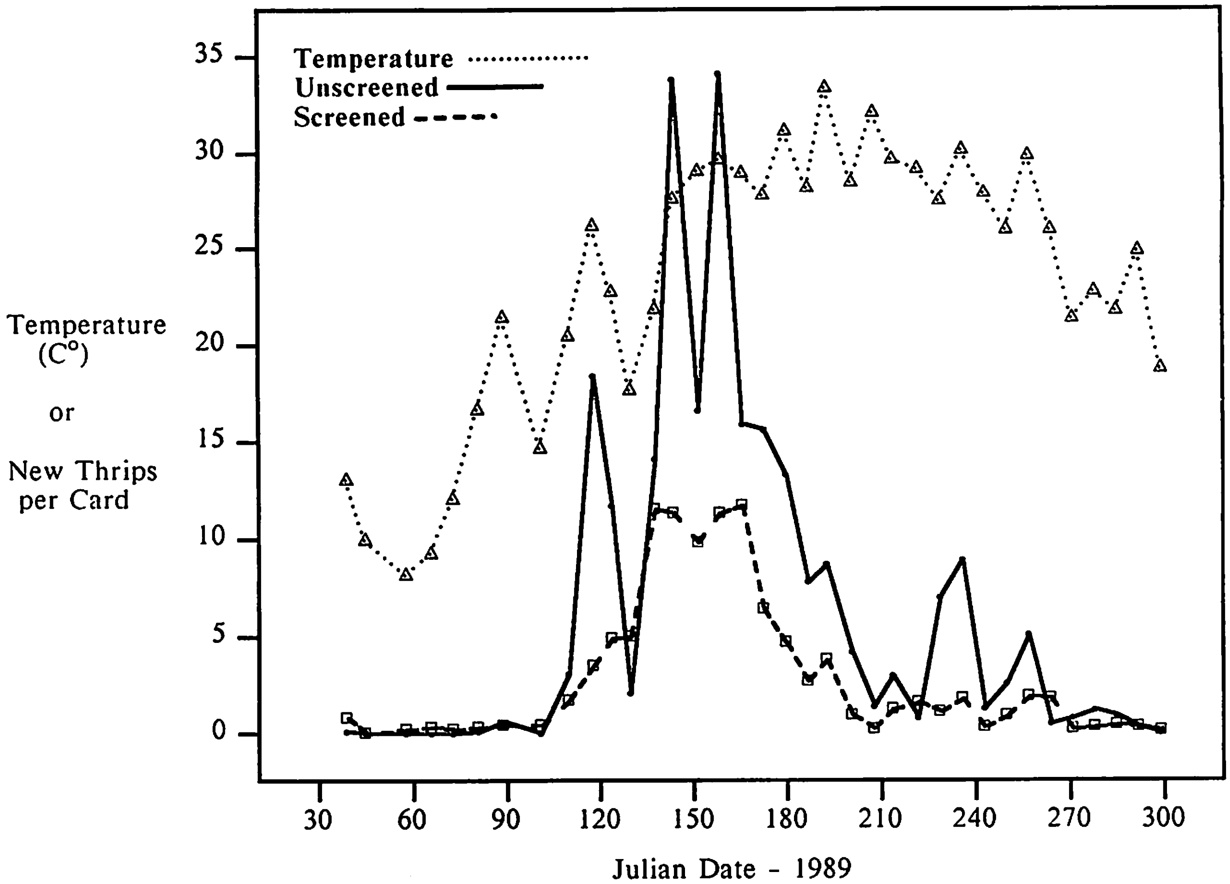

Figure 5. Numbers of thrips caught on sticky cards in the screened house (dashed line) and in unscreened houses (solid line). The upper dotted line is the average of the maximum daily temperature (°C) for the previous trapping period.

the number of thrips flying.

The grower was sufficiently impressed with the degree of exclusion given by the pore screening that he had a large, handsome screen fitted onto another greenhouse nearby (Fig. 6).

The Entomology Department here at NC State has a new graduate student, Kijong Cho, who arrived from Korea in August to study the biology of the western flower thrips and its role as a vector of the tomato spotted wilt virus, especially in field grown tomatoes. One of Mr. Cho's first experiments was to find out whether Vispore and other screening materials actually can exclude thrips. He set up a series of vials tightly covered with Vispore, Chicopee's woven synthetic fabric 52 x 52, and a few other types of screening. He then put a known number of thrips in the vials and sealed them closed. Mr. Cho found that as long as there was some plant material or even filter paper inside, many of the thrips would remain inside the vials. But if the thrips were placed in an empty vial, they would escape through most of the screening materials he tried. We then thought of looking at the stuff under the microscope and found the holes in Vispore and Remay and some of

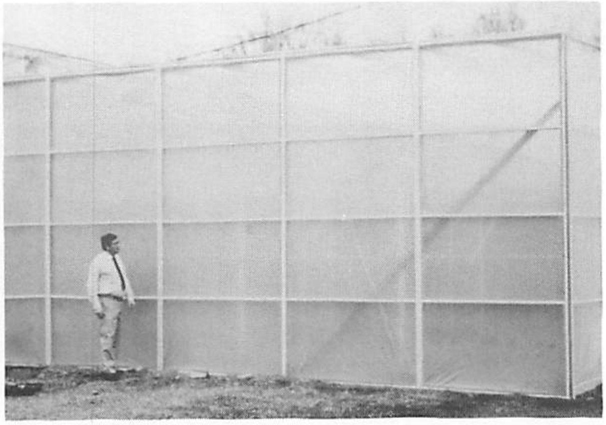

Figure 6. A large thrips exclusion screen installed by a grower.

the other screening materials are big enough that thrips should be able to squeeze through (Fig. 7, 8). The screening material which actually could contain the thrips was batiste, a relatively sheer fabric used for garments and draperies. The advice we received from Extension Home Economics was to use drapery batiste because it has ultraviolet inhibitors which prolong the life of the fabric in sunlight. We have not had time to test the reduction of air flow through the batiste, but it is probable significant. Mr. Cho's experiments bring up the question, "How does Vispore work so well if thrips can get through it?". Perhaps the answer is that screening materials are not recognized by thrips as a suitable substrate to feed on. Thrips often probe the surfaces they land on with their needlelike mouthparts. Apparently this is their method of finding suitable host plants. When the thrips probe the screening and discover it is not a plant, they may automatically resume flight searching for a suitable host plant.

We plan to continue these exclusion experiments in hopes of finding effective, convenient and affordable screening techniques to augment other pest management procedures for greenhouse ornamentals.

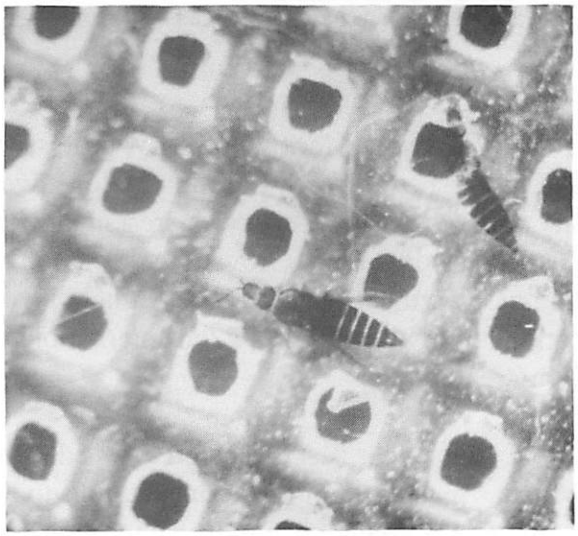

Figure 7. Close up of Vispore with a slide of a thrips the same size as the western flower thrips.

References

Robb, K. L. and M. P. Parrella. 1988. Chemical and non-chemical control of western flower thrips. Proc. Fourth Conf. on Insect and Disease Management on Ornamenatals. 94-103.

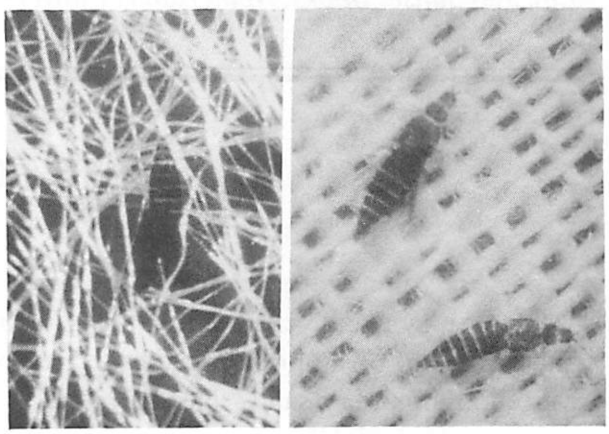

Figure 8. Close up of spunbonded polyester (left) and batiste (right) with a slide of a thrips the same size as the western flower thrips.