SCREENING AS PART OF INSECT AND DISEASE MANAGEMENT IN THE GREENHOUSE

James R. Baker, Michelle Bell Crouse and Edwin A. Shearin
Department of Entomology, NCSU

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 aphids or 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, restrictions on the uses of pesticide by OSHA, and industry concerns have made chemical control of greenhouse pests much more difficult. Growers may be forced soon to make major changes in the way they deal with pests. Costs of developing new pesticides have escalated as have the costs associated with reregistration. Thus pesticides may be more expensive than in the past. Although pesticides will remain important tools for pest management in the greenhouse, other methods of suppression must be used to slow the buildup of resistance and conserve the usefulness of the dwindling supply of legally registered pesticides.

Environmental and health problems associated with pesticides have sensitized the public and greenhouse workers to pesticide issues. Because of the frequent handling of floral crops and the nature of working in an enclosed structure, greenhouse workers have greater dermal and respiratory exposure to pesticides than any other group of agricultural workers. An obvious way of reducing pesticide exposure is to reduce the need for pesticides by reducing numbers of pests entering a greenhouse. However, a fundamental problem with screening for pest management exists: if you start with pests already inside the screening, the screening will keep them in. If pests are already on plants to be screened, those pests must be treated to keep down the population.

Research Results

In 1988, researchers at UC Davis reported being able to grow a crop of chrysanthemums without a single application of pesticides by screening the entire greenhouse (Robb and Parrella, 1988). The following summarizes NCSU's research efforts, inspired by Robb and Parrella, using screening materials for excluding greenhouse pests. Most of the emphasis has been with aphids, the western flower thrips and the sweetpotato whitefly. These pests are remarkably resistant to pesticides and cause considerable damage to greenhouse ornamentals. In addition, the western flower thrips is a vector of the tomato spotted wilt virus (impatiens necrotic spot virus).

The first demonstration compared the incidence of tomato spotted wilt virus (impatiens necrotic spot virus) on gloxinias in cages covered with perforated polyethylene film (Vispore insect screen, 400 holes per square inch [400 holes/in^2]) to the incidence on uncaged plants in a heavily infected commercial greenhouse with a medium population of western flower thrips (Baker and Jones, 1989). There was appreciably less infection in the caged plants. This is analogous to results reported by Mau (Baker, 1988) that a windbreak of trees between lettuce fields retards the spread of tomato spotted wilt in Hawaii. In other words, some screening is much better than none.

In a demonstration on African violets in a commercial greenhouse with a low but chronic western flower thrip infestation, plants in four types of cages covered with Vispore (400 holes/in^2) were compared with uncaged plants for the exclusion of western flower thrips. Vispore was capable of partially excluding western flower thrips from the caged crop for more than two months (Baker and Jones, 1989).

In another study, gerbera daisies were placed in sealed or "draped" cages screened with either Vispore (400 holes/in^2) or a spunbonded polyester fabric, Remay, in a greenhouse with a raging population of sweetpotato whiteflies (Baker and Jones, 1989). After two months, plants inside all of the cages had significantly fewer whiteflies than those outside the cages.

In 1989, a commercial Quonset style, polyethylene house containing mostly gloxinias was screened with 700 ft² of Vispore for its 140 ft² of cooling pads to test efficacy against thrips. (Tests made in Dr. Dan Willit's lab in Biological and Agricultural Engineering at NCSU showed Vispore reduces air flow by a factor of five; spunbounded polyester reduces airflow by a factor of two). Similar sized greenhouses containing various crops were used as unscreened check treatments. Crop losses due to tomato spotted wilt virus (impatiens necrotic spot virus) were greater in the unscreened houses although exact comparisons were not possible. Significantly more thrips were caught on sticky cards in the unscreened house than on those in the screened house. The grower was sufficiently impressed with the degree of exclusion given by the Visqueen screening that he had a large screen fitted onto another greenhouse nearby (Baker and Jones, 1989).

Prompted by initial studies by a graduate student in the Department of Entomology, NCSU, Mr. Kijong Cho, it was found that the holes in Vispore (400 holes/in²) spunbonded polyester (Remay) and some of the other screening materials are big enough that thrips should be able to squeeze through. Yet these materials effectively exclude thrips; how is this possible? 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 plants to feed on (about half of the complaints on thrips received by the NCSU Plant Disease and Insect Clinic are from people complaining of being bitten). When the thrips probe the screening they may automatically resume flight searching for a suitable host plant.

In 1990, in a comparative study, four small greenhouses were fitted with Vispore (400 and 1600 holes per square inch), Remay spunbonded polyester, and FlyBarr (reinforced spunbounded polyester) (Baker and Jones, 1990). Each house had an exhaust fan controlled by a thermostat so that as the days warmed up and the insects started flying, the houses would have static pressure drops. Chrysanthemums were grown as the "crop." Thrips and aphids were monitored inside the outside the small greenhouses. All of the screening materials were effective in excluding thrips and aphids.

In 1991 and '92, biological control demonstrations were set up at commercial greenhouses in Concord and Gatonia, NC. Air intake vents and doors were screened with Vispore 1600 holes/in2 and Remay spunbounded polyester as one management practice. Though the data are somewhat inconclusive, in 1992 it appears that number of whiteflies in the Remay-screened biocontrol greenhouse grew weekly in comparison to those outside and those in a nearby unscreened greenhouse in which the grower was using Tame plus Orthene regularly to control whiteflies. In this case, the screening may have been confining the whiteflies to the biocontrol greenhouse!

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

Types of Screening Materials

Various types of screening materials are available. They include:

·Films -- Perforated polyethylene film (Vispore insect screen) came in two configurations: 400 holes per sq. in. and 1600 holes per square inch. As far as we know, this screening material is no longer available.

·Spunbonded Materials -- FlyBarr is a spunbonded fabric with a plastic mesh that gives it strength. FlyBarr is available from Hydro-Gardens, PO Box 9707, Colorado Springs, CO 80932.

Typar is a spunbonded polypropylene material that is very resistant to ultra violet light degradation. It is also resistant to air, so growers using Typar must use a relatively large screen area. Typar and Remay are manufactured by Remay, Inc. represented in North Carolina by Jim Whitaker, 70 Old Hickory Blvd, Old Hickory, TN 37138. These fabrics are also sold in various greenhouse supply catalogs.

Remay is a spunbonded polyethylene material that breaks down in a matter of months outdoors. On the other hand, Remay has much less resistance to air, so for many greenhouses, Remay screens may function well with only twice as much screen area. Remay is used for tobacco plant bed shading (tobacco canvas), and is available from local farm supply stores in tobacco growing area.

Woven Materials -- Aluminum window screening is available at many hardware and building supply houses.

The Chicopee 32 and Chicopee 52 fabrics are available from various greenhouse supply catalogs and from Lumite, 6525 The Corners Pkwy, Suite 115, Norcross, GA 30092.

The Pak 32, 52 and 87 fabrics are also carried by various greenhouse suppliers and Pak Unlimited Inc, 3300 Holcomb Bridge Road, Suite 215, Norcross, GA 30092. The Pak 87 material is woven polyethylene coated with acrylic for ultraviolet light resistance.

Bed Bug 123 and 85 materials are available from the Green Thumb Group, 3390 Venard Road, Suite 2, Downers Grove, Illinois 60515.

How to Calculate the Area of Screening Material Needed

Static Pressure. When the exhaust fans are running, a noticeable pressure drop inside the greenhouse occurs. Growers then notice the doors are harder to open, and gusts of air whoosh through the door as the pressure equalizes with the pressure outdoors. The drop in air pressure inside a greenhouse is called static pressure. If one end of a U-shaped tube filled with liquid were inserted into the greenhouse, the level of the liquid inside the house would rise as the fans come on and static pressure drops. Static pressure is usually measured in inches of water.

If static pressure drop is too great, the fans will not be able to move enough air to properly ventilate the greenhouse and will use excessive power (NGMA, 1993) or the covering plastic film may pull loose from the staples. Johnson (1990) suggested not using screening materials that create a static pressure over 0.05 inches H_2O at 250 feet per minute air velocity. Sase and Christianson (1990) recommend 0.032 inches H_2O for clean screening materials and pressure drop should not exceed 0.1 inches with dirty screening. Since the pressure drop inside an unscreened greenhouse may approach 0.095" (Green Thumb Groups, no date), screening increases total pressure 0.145 to 0.195" as the screen gets dirty. The Green Thumb Group recommends a maximum of 0.15" total static pressure drop (screening and all) to avoid overloading the fans.

Three things are needed to calculate the area of screening materials needed: (1) the volume of air needed to adequately cool the greenhouse on the hottest days of summer in cubic feet per minute (ft^3/min or cfm); (2) the resistance coefficient (resistance constant or resistance factor), **R**, of the screening materials; and (3) the velocity or approach velocity of the air in feet per minute (ft/min or fpm) as it travels through the screening material.

Volume of Air Needed for Adequate Cooling. Nelson (1985) suggests 8 cubic feet per minute for each square foot of greenhouse space as the optimal minimal requirement for air exchange. Thus for a 30' by 100' greenhouse, the optimal minimal air exchange is 8 cfm times 3,000 square feet equals 24,000 cfm:

$8\ ft^3/min \times 30' \times 100' = 24{,}000\ ft^3/min$

Willits (1993) recommends 11 to 17 cubic feet per minute for each square foot of greenhouse space (one to one and one half air exchanges per minute). Thus for a 30' by 100' greenhouse, the optimal air exchange at 11 to 17 cfm times 3,000 square feet equals 33,000 to 51,000 ft^3/min.

Resistance Coefficient. The resistance constant (**R**) is usually different for each screening material. This constant may be given by the manufacturer of the material as a number of $H_2O\ min^2/ft^2$ units or more often is presented on a graphic chart as a function of pressure and velocity of air (Figure 1).

Velocity of Air. The maximum velocity of air movement through the screening material so that the chosen pressure drop is not exceeded can be calculated by taking the square root of the quotient of the maximum static pressure you wish to have divided by the resistance constant for the screening material. Suppose you decide to use 0.03" for the maximum static pressure and you know the resistance coefficient (**R**) for the screening material. In this example, the screening material has an **R** = $4.8 \times 10^{-7}\ H_2O\ min^2/ft^2$):

Another and simpler method of deriving the velocity of air is to read it from a "Velocity vs Static Pressure Resistance" chart supplied by the manufacturer of the screening material. A typical chart is shown in Figure 1. Start at 0.03 inches on the left axis of the chart and trace over to where that value intersects the curve. Trace straight down from that intersection and you have the velocity in ft/min. Velocity is usually given in feet per minute (ft/min) and static pressure is given in inches of water.

A third method of calculating the velocity of air needed to cool a greenhouse is given on the Green Thumb Group handout (Greenhouse Ventilation and Screening). Their method merely divides the total volume of the greenhouse by the area of the ventilating window to give an ideal air velocity. The Green Thumb Groups suggest one complete air exchange per minute (the minimum according to Willits, 1993). They by using the chart in Figure 1, select a screening material that does not add too much additional static pressure at the ideal velocity (i.e. more than 0.05" [Johnson, 1990} or 0.1" [Sase and Christianson, 1990]).

Calculation of Area of Screening Materials. The calculation of area of screening material to allow enough air to pass through the greenhouse to provide optimal minimal cooling is done by dividing the total volume of air needed for adequate cooling by the velocity of air needed for adequate cooling. For the 30' x 100' greenhouse example using Nelson's (1985) recommendations 24,000 cfm and Willits' (1993) recommendation 33,000 to 51,000 cfm:

area of screening needed = [volume in cfm] ÷ [velocity in fpm]

area (ft^2) = 24,000 cfm ÷ 250 fpm = 96 ft^2

Therefore, 96 ft^2 of screening would be needed using Nelson's suggestion or 132 ft^2 to 204 ft^2 using Willits' recommendations.

How to Retrofit Screening on a Greenhouse
If you don't know what the pressure drop inside a greenhouse is, let's assume it is about 0.095" (Green Thumb Group, no date). This gives us 0.055" of leeway in pressure drop before overloading the fans. We will stick with the 30' x 100' greenhouse example. The volume of air exchange needed to adequately cool the greenhouse in July and August is 33,000 to 51,000 cfm (Willits, 1993). Suppose that the ventilation window is 6' x 22' (132 ft^2). Then the velocity of air moving through the ventilation window is the quotient of total volume divided by the area of the window:

velocity = [volume (cfm)] ÷ [area (ft^2)]
So for the lower volume:
velocity = 33,000 cfm ÷ 132 ft^2 = 250 ft/min
For the higher volume:
velocity = 51,000 cfm ÷ 132 ft^2 = 386 ft/min

A greater volume of air has to pass through the same size opening at a greater velocity. First let's examine the lower volume of air needed (33,000 cfm). Examine the chart (Figure 1) and find the velocity 250 ft/min on the horizontal axis. Those fabrics whose curves do not exceed the 0.055" pressure drop level at 250 ft/min can be used directly over the ventilation window. If the resistance curve exceeds the 0.055" pressure drop level, then move to the left along the velocity axis until you reach a velocity at which the resistance does not exceed 0.055" pressured drop. Next, divide the velocity through the ventilation window by the lower velocity on the chart and the quotient is the number you must multiply the area of the screening material required. For example, if you decide to use Typar fabric, you have to move to the left on the velocity axis to about 100 ft/min divided by 100 ft/min times the size of the ventilation window (132 ft^2) or about 510 ft^2 of screening area.

References

Baker, J.R. 1988. Sixth ornamental workshop, October 1988. North Carolina Flower Growers' Bulletin 33(6):1-6.

Baker, J.R. and R.K. Jones. 1989. Screening as part of insect and disease management in the green house. North Carolina Flower Growers' Bulletin 34(6):1-9.

Baker, J.R. and R.K. Jones. 1990. An update on screening as part of insect and disease manage ment in the greenhouse. North Carolina Flower Growers' Bulletin. 35(6):1-3.

Green Thumb Group. no date. Greenhouse ventilation and screening. 2 pp. 3380 Venard Road, Suite 2, Downers Grove, Illinois 60515.

Johnson, G.B. 1990. Insect barrier. Amer. Coolair Bulletin. American Coolair Corp., Jacksonville, Florida 90-6.

National Greenhouse Manufacturers Association. 1993. Recommendations for using insect screens in greenhouse structures. An addendum to NGMA ventilation and cooling standards. 5 pp.

Nelson, P.V. 1985. Greenhouse operation and management. 3 ed. Reston Pub. Virginia. 598 pp.

Robb, K.L. and M.P. Parrella. 1988. Chemical and non-chemical control of western flower thrips. Proc. 4th Conf. on Insect and Disease Management on Ornamentals. 94-103.

Sase, S. and L.L. Christianson. 1990. Screening greenhouses - some engineering considerations. Paper No. NABEC 90-201. Northeast Agro./Bio. Eng. Conf. Penn. State Univ. July 29-Aug. 1, 1990. 13 pp.

Willits, D.H. 1993. Greenhouse cooling. North Carolina Flower Growers' Bulletin 38(2):15-18.

Reprinted from N.C. Flower Growers' Bulletin, August 1993, Vol. 38, No. 4.