AN UPDATE ON SCREENING FOR THE EXCLUSION OF INSECT PESTS

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Acquisition of resistance to pesticides has made control of insect and mite pests increasingly difficult in the greenhouse. The western flower thrips, a vector of the tomato spotted wilt virus, the silverleaf whitefly and aphids have become noticeably more resistant to pesticides over the past few years. Although pesticides will remain an important tool for pest management in the greenhouse, other methods of pest control must be used to slow the build up of pesticide resistance in order to conserve the usefulness of legally registered pesticides.

In addition, environmental and health problems associated with pesticides have 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, the numbers of pests entering a greenhouse can be reduced so fewer pesticide treatments are needed.

Tomato spotted wilt virus is a third problem confronting greenhouse operators. As tomato spotted wilt virus becomes established in field crops and perennial weeds outdoors, some thrips sucked into greenhouses in hot weather may carry the common or lettuce strain of tomato spotted wilt virus. It makes so much more sense to screen out thrips than it does to allow them in and then try to eradicate the thrips and tomato spotted wilt virus on tomatoes, peppers and other susceptible crops!

There is a basic problem with screening materials: screens with small hole sizes are better for excluding pests but they are also more resistant to airflow. Air resistance characteristics have been published for some but not all screening materials.

Screening Structures

Pest exclusion structures do not need to be constructed of heavy timbers nor are they necessarily elaborate. Screening fabrics are relatively light but strong, and they do not require much support. Most retrofitted screens are placed outside the ventilation windows and entry doors. It is a good idea to provide easy access to the inside of the screen so that it can be washed from the inside. Pest exclusion will be much more effective if greenhouse workers can be trained to keep the doors closed as much as practical especially during ventilation.

There is no need to screen exhaust fans that are fitted with shutters. Most insects that are pests of plants tend to fly in warm, bright conditions, the same conditions that require ventilation of greenhouses. Plant pests cannot fly against the air stream from an exhaust fan. As conditions cool off and ventilation is no longer required, the insects also become less active. In addition, most plant pests are attracted to the color of plants, not odor. Thus when the fans are not running and the shutters close, most plant pests will not be attracted to the shutters to try to squeeze into the greenhouse unless the shutters are painted white, yellow or green. Nevertheless, it is a good idea to keep the shutters in good repair so that they close reasonably tight.

Static Pressure

When exhaust fans are running, air pressure drops inside the greenhouse. Doors are harder to open, and gusts of air whoosh through opened doors as the pressure equalizes with the pressure outdoors. The air pressure inside a greenhouse is called static pressure. If one end of a U-shaped tube filled with liquid (manometer) were inserted into the greenhouse, the level of the liquid inside the house would rise as the fans come on and static pressure drops. For determining static pressure drop, the Dwyer® MarkII, Model 25 manometer is a remarkably good value at about $25.00, but you must make sure that the flexible tubes are free of any drops of liquid, that the tubes are not kinked and that the tube-to-manometer connections are tight. Also make sure the manometer is level. Otherwise, you may obtain inaccurate readings. The Mark II, model 25 is available from Dwyer® Instruments, Inc. P. O. Box 373, Michigan City, IN 46360. 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, the fans will use excessive power, and the greenhouse will overheat during hot, bright summer days. Johnson (1990) suggested not using screening materials that create a static pressure drop greater than 0.05" of water at 250 feet per minute air velocity. Sase and Christianson (1990) recommend 0.032" pressure drop for clean screening materials and total pressure drop should not exceed 0.1" with dirty screening. Certainly a pressure drop of 0.1" should be the maximum for a screened greenhouse with clean screening and the total pressure drop should not exceed 0.15" as the screens become dirty.

Adequate Ventilation

To check if a greenhouse is presently adequately ventilated, estimate the amount of air moving through the greenhouse with all the fans running and all unscreened doors and windows closed. Use a manometer to measure the difference in static pressure in the structure with the fans shut off and with the fans running. Use that pressure drop when consulting a fan specification chart given in various greenhouse supply catalogs. Look across the line from the model of each fan at the volume of air moved by that fan at that static pressure drop. You can interpolate between the 0.0", 0.05" and 0.1" volumes given for the various fans and motors. (For example, if your pressure drop is 0.025", that is half way between 0" and 0.05". Thus the volume of air moved by your fans would be about half way between the volumes given for 0" and 0.05"). Then add all the volumes of each fan together. By dividing the total volume by the number of square feet of the greenhouse, the quotient should equal an air exchange of 11 to 17 cubic feet per minute per square foot (recommended by Willits, 1993). This recommendation is higher than Nelson's (1985) recommendation of 8 cubic feet per minute per square foot. If the volume of air exchange is below 8 cubic feet per minute, the structure is likely to overheat during hot, bright weather. If your total volume of air exchange is well above 17 cubic feet per minute per square foot, the selection of screening fabrics may be limited and you may have excessive transpiration and evaporation.

Screening Materials

Screening materials with small hole sizes are better for excluding pests, but they are also more resistant to airflow. If a grower decides to apply a fabric with a very small hole size but under estimates the area of material needed, the resulting screen may cause a high static pressure drop, inadequate air exchange, higher energy consumption by the fans, excessive wear and tear on the fans, and high greenhouse temperatures.

Spunbonded fabrics are made of extruded fibers stuck together to form a fabric. Woven fabrics include ordinary window screening, available at many hardware and building supply houses as well polyethelene and coated polyethelene fabrics. Some of the woven fabrics have ultraviolet light inhibitors incorporated into the fibers or coated onto the fibers.

Sources of Screening Fabrics

The following are sources for fabrics we tested at North Carolina State University:

- Duragreen, 436 E. Fifth Ave., Mount Dora, FL 32757 (Durascreen)
- Green-Tek Inc., 407 N. Main St., Edgerton, WI 53534 (No-Thrip, Anti-virus Net)
- Green Thumb Groups Inc., 3380 Venard Rd. #2, Downers Grove, IL 60515 (Bug Bed)
- Hydro-Gardens, P. O. Box 9707, Colorado Springs, CO 80932 (Flybarr)
- LS Americas, 1813-E Associates Lane, Charlotte, NC 28219 (Econet L, M, T)
- Lumite, P. O. Box 977, Gainesville, GA 30503
- Naz-Dar Co., 1087 N. Branch St., Chicago, IL 60622
- Pak Unlimited Inc, 3300 Holcomb Bridge Rd, Suite 215, Norcross, GA 30092
- Reemay Inc., 70 Old Hickory Blvd,. Old Hickory, TN 37138 (Reemay, Typar)

Cleaning the Screen

When building an exclusion structure, be sure to incorporate easy access to the inside to facilitate cleaning of the screening material. Make it easy to clean as clean fabrics have less resistance to air flow. It is a good idea to have a manometer convenient to check static pressure in each screened greenhouse on a regular basis especially in hot, dusty weather when screening is likely to be fouled by dust. Do not clean the screening material while the ventilation fans are running! Wait until evening or clean the screens early in the morning. Water can fill the openings in the material by capillary action and completely stop air flow. On a sunny day, temperatures inside the greenhouse would rise swiftly and unscreened windows and doorways would have to be opened to prevent heat damage to plants before the water in the screen evaporates. Opening the windows and doors defeats the whole exclusion effort.

How to Retrofit Screening on a Greenhouse

Caution: Any screening retrofitted to a greenhouse without other changes will decrease airflow and increase greenhouse temperatures. The following procedure should help avoid serious ventilation problems. An additional consideration: if you start with pests already inside or bring pests in on plants or clothing, screening will keep them inside.

Step 1. Measure the pressure drop inside the greenhouse by using a manometer. *Pressure Drop*: ________ inches. (If the pressure drop is close to 0.1" without screening, consider enlarging the ventilation window. If the fans stay the same,

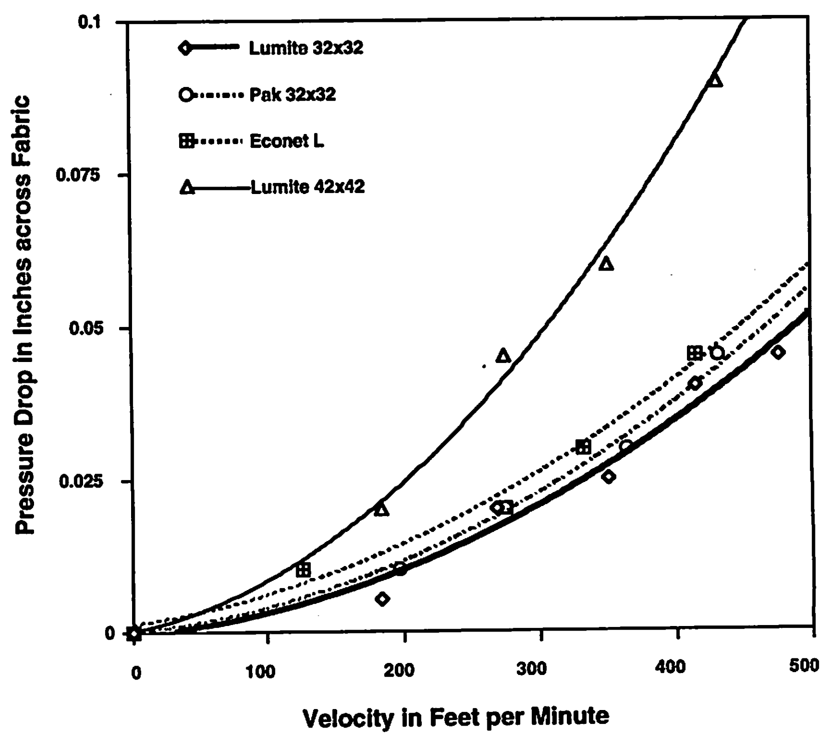

Figure 1. Resistance curves for 4 screening materials with relatively low resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

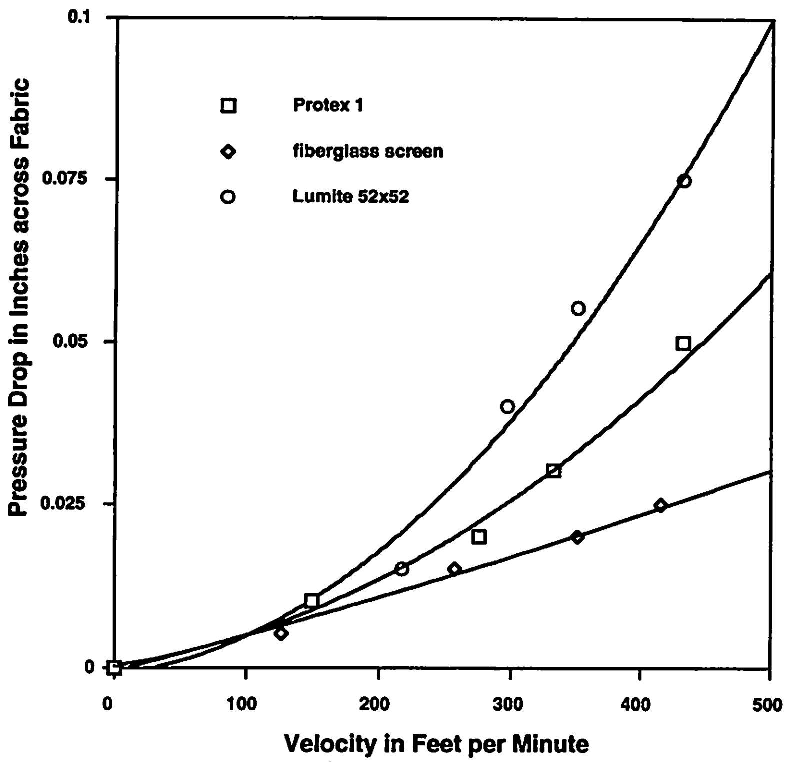

Figure 2. Resistance curves for 3 other screening materials with relatively low resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

add all the volumes of each fan together: *Total air exchange*: ________ cfm.

Now you can check if the volume of air that will move through the house after screening meets Nelson's (1985) or Willits' (1993) recommendations. If not, your houses may become too hot during July and August. Consider using larger motors on the fans or adding additional fans. *Suggested Air Exchange per minute*:

Nelson's: Area of greenhouse × 8 cfm = ______________ cfm.

Willits' Low: Area of greenhouse × 11 cfm = ______________ cfm.

Willits' High: Area of greenhouse × 17 cfm = ______________ cfm.

Step 4. Calculate the area of the ventilation windows. *Total*

enlarging the ventilation windows will reduce static pressure.)

Step 2. Subtract the pressure drop in Step 1 from 0.1". *0.1" – pressure drop*: ____________ inches. This difference is a guide to how much additional resistance to air movement can be tolerated. For example if your pressure drop in Step 1 is 0.025", then you can use a screen that adds up to an additional 0.075" of pressure drop without exceeding the maximum recommended pressure drop.

Step 3. Now calculate an estimated total air movement at 0.1" by consulting a fan specification chart given in various greenhouse supply catalogs. Look across the line from the model of each fan at the volume of air moved by that fan at that static pressure drop. Then

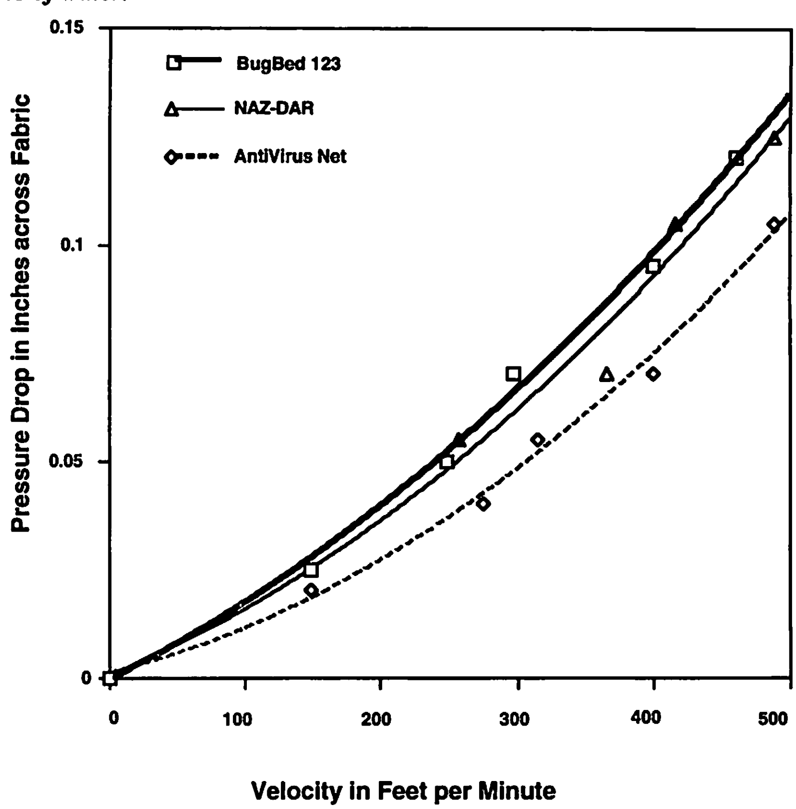

Figure 3. Resistance curves for 3 screening materials with moderate resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

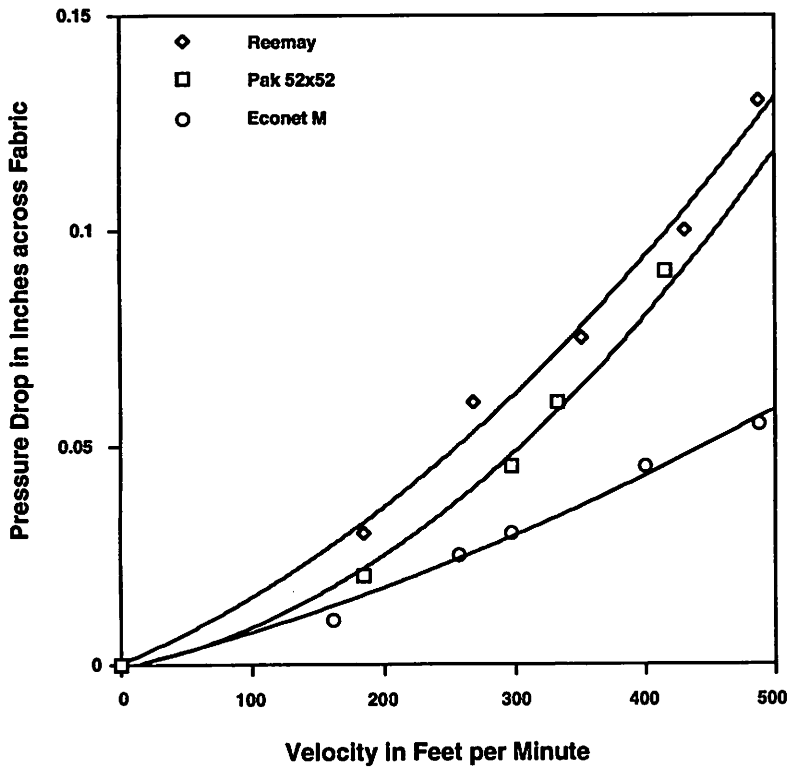

Figure 4. Resistance curves for 3 other screening materials with moderate resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

Ventilation Window Area (length × width): ________________ ft².

Step 5. Calculate the approach velocity of the air moving through the ventilation windows. *Approach velocity (Total air volume after screening from Step 3 divided by ventilation window area from Step 4)*: ____________ ft/min.

Step 6. Examine Figures 1 through 6 and find the approach velocity from Step 5 on the horizontal axis. Those fabrics whose curves <u>do not exceed</u> the pressure drop level calculated in Step 2 at the approach velocity from Step 6 <u>can be used</u> directly over the ventilation window. If the resistance curve for the fabric you wish to use <u>exceeds</u> the pressure drop level from Step 2, then move to the left along the velocity axis until you reach a velocity at which the resistance does not exceed Step 2 pressure drop. Then divide the velocity through the ventilation window in Step 5 by the lower velocity on the chart and the quotient is the number you must multiply the area of the ventilation window by to arrive at the area of the screening material. *Multiplication Factor (velocity in Step 5 ÷ velocity from Figure)*: ____________.

The curves for Figures 1 to 6 were generated in a small wind tunnel of 8" metal pipe. Air is sucked through the wind tunnel by a 0.75 hp squirrel cage fan. Velocity is measured with a Pitot tube using a Dwyer® Mark II, Model 25 manometer. A Dwyer® Durablock Model 102.5 manometer is used to measure the pressure drop across the fabric under test. The fabrics

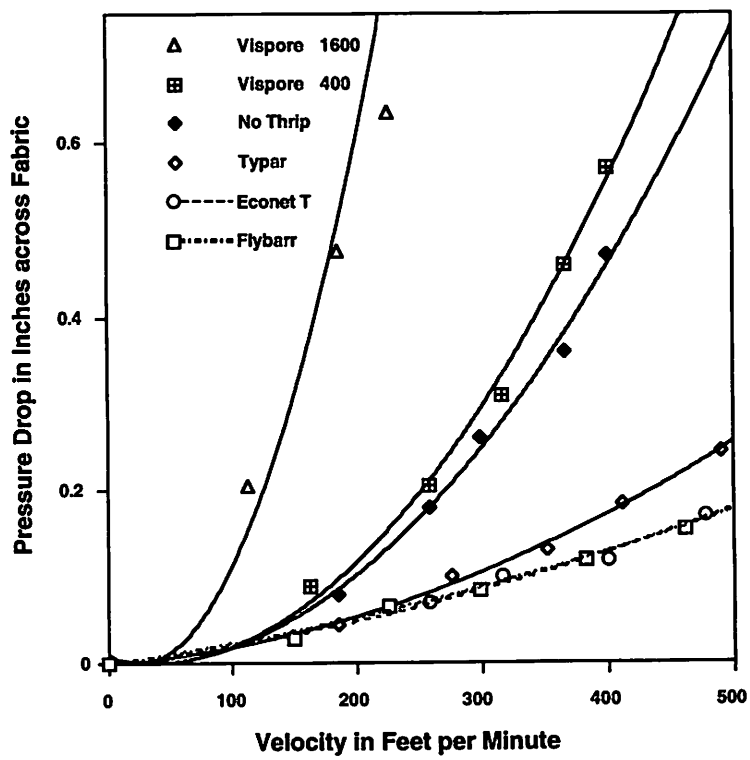

Figure 5. Resistance curves for 6 screening materials with relatively high resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

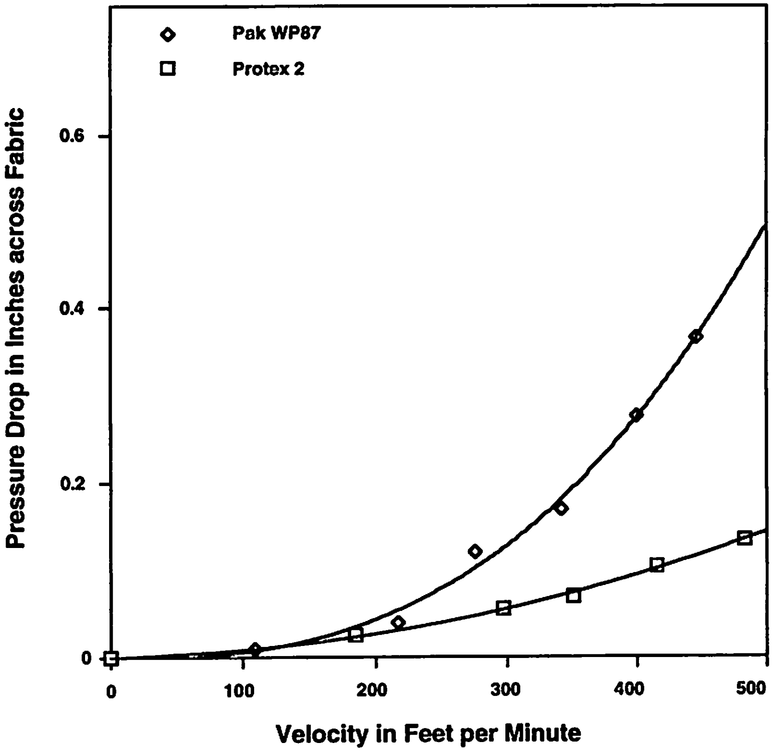

Figure 6. Resistance curves for 2 other screening materials with relatively high resistance to air flow shown as functions of velocity in feet per minute and static pressure in inches of water.

were stretched on stiff foam forms and introduced into the wind stream by bolting them between airtight flanges. Most of the fabrics we tested are shown in Figures 1 to 6. Each fabric was tested and retested at a number of pressure drops and velocities. The curves presented in these figures were obtained by fitting fabric pressure drop vs. air velocity data for each fabric to a second degree polynomial equation. Use of the second degree polynomial equation rather than the theoretically predicted $\Delta p = R(v)^2$ function provided a better fit both to our data and to data published for some of the fabrics. (For some reason, the Pak™ WP87 data points had to be fitted to a third degree polynomial equation.) Although our results do not agree perfectly with other published results, we believe these curves are within reasonable limits of error. It is very difficult for us to measure velocities between 0 and 100 feet per minute, but it is unlikely that most greenhouses can be properly ventilated at air exchange velocities of less than 100 feet per minute. Our advice is to "round up" when rounding off and slightly overbuild rather than have a screen that works well except in late July and August.

References

Johnson, G. B. 1990. Insect barrier. Amer. Coolair Bull. American Coolair Corp., Jacksonville, Fla. 90-6. 6 pp.

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

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

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