Choose a Greenhouse Screen Based on Its Pest Exclusion Efficiency

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(Dr. Michelle Bell recently completed her Ph.D. with a dual major in Entomology and Horticultural Science under the direction of Dr. Jim Baker and Dr. Doug Bailey. This article is taken from a portion of her thesis research. Michelle has taken a floriculture extension and research position with the University of Florida at Bradenton. We at NC State are very proud of her accomplishments and wish her the very best of luck in her continuing career in floriculture.)

Acquired resistance to pesticides by aphids, thrips and whiteflies has made management practices that rely on pesticides less effective and more costly in terms of economics and the environment. In an integrated pest management system, exclusion of pests should be one of the first tactics considered in order to reduce the need for pesticides and other control measures. An important part of exclusion involves screening the greenhouse.

Excluding pests using greenhouse screens is now more feasible than in the past due to the rising costs of registered pesticides and increased worker protection regulations. Reductions in pest population, lower incidence of insect-transmitted disease, and fewer needed pesticide applications have been documented when screening is used. Exclusion screens are proving a valuable addition to current management practices and may be especially important where greenhouse pests overwinter outside.

As use of exclusion screens has risen, some materials, such as Vispore products and Pak WP87, have become unavailable while many more have entered the market. Selection of the screen most beneficial to a particular greenhouse situation requires some basic information. A foremost consideration when designing or retrofitting a greenhouse for screen installation is the effect screening materials will have on the flow of air.

Airflow resistance, primarily a function of hole or mesh size, varies widely among available screening products. In our laboratory, we have investigated airflow resistance of screens and have developed "resistance curves" for each product. This airflow resistance data, along with greenhouse airflow recommendations, has been incorporated into a step-by-step guide for calculating the total screening area required for different materials. The guide walks the user through a short series of inputs, such as greenhouse and fan specifications and the measured pressure drop. For ease of use, the information has been developed as a computer program by Mr. Edwin Shearin and can be obtained from Dr. James Baker, Dept. of Entomology, North Carolina State University, Raleigh, NC 27695; (919) 515-8880.

Once a grower determines which screens can be used on his or her greenhouse, the cost of screening is often the next consideration (see Table 2). Costs vary depending not only on the price of the screening material, but also on the type and size of the frame required and screen longevity or replacement considerations. However, even though costs may differ, the next consideration after airflow should really be one of efficacy, that is, how well a screening material excludes pests.

The unfortunate fact is that many screens on the market do not effectively exclude common greenhouse pests at air approach velocities required for adequate summer ventilation of a well-designed greenhouse. Furthermore, choosing a screen with small holes and high resistance to airflow (if your greenhouse situation so allows) may not ensure adequate exclusion. This is a report of a three-year study to determine and compare efficacy of screens for excluding whiteflies and thrips under summer ventilation conditions resembling those of a commercial greenhouse.

Small (0.5 × 0.5 × 1 meter), wood-framed and polyethylene plastic-covered cages were used in these exclusion studies. Each cage was constructed with the front open to allow covering with the screening material to be tested. A squirrel cage blower was installed at the rear of each cage to pull air through the screening materials and into the cage. Resistance curves were used to equalize the velocity of air entering the cages through the screening materials being tested. The approach velocity used for each material was 300 ft/minute, an airflow velocity recommended for well-designed production greenhouses.

Yellow sticky cards were placed inside the cages before each installation of the screening materials and were used to sample the whiteflies and thrips entering the cages through the screens. Each commercial screening material was compared with ordinary fiberglass window screen to determine its degree of exclusion.

Screens exhibiting thrips exclusion equal to or greater than the window screen control are

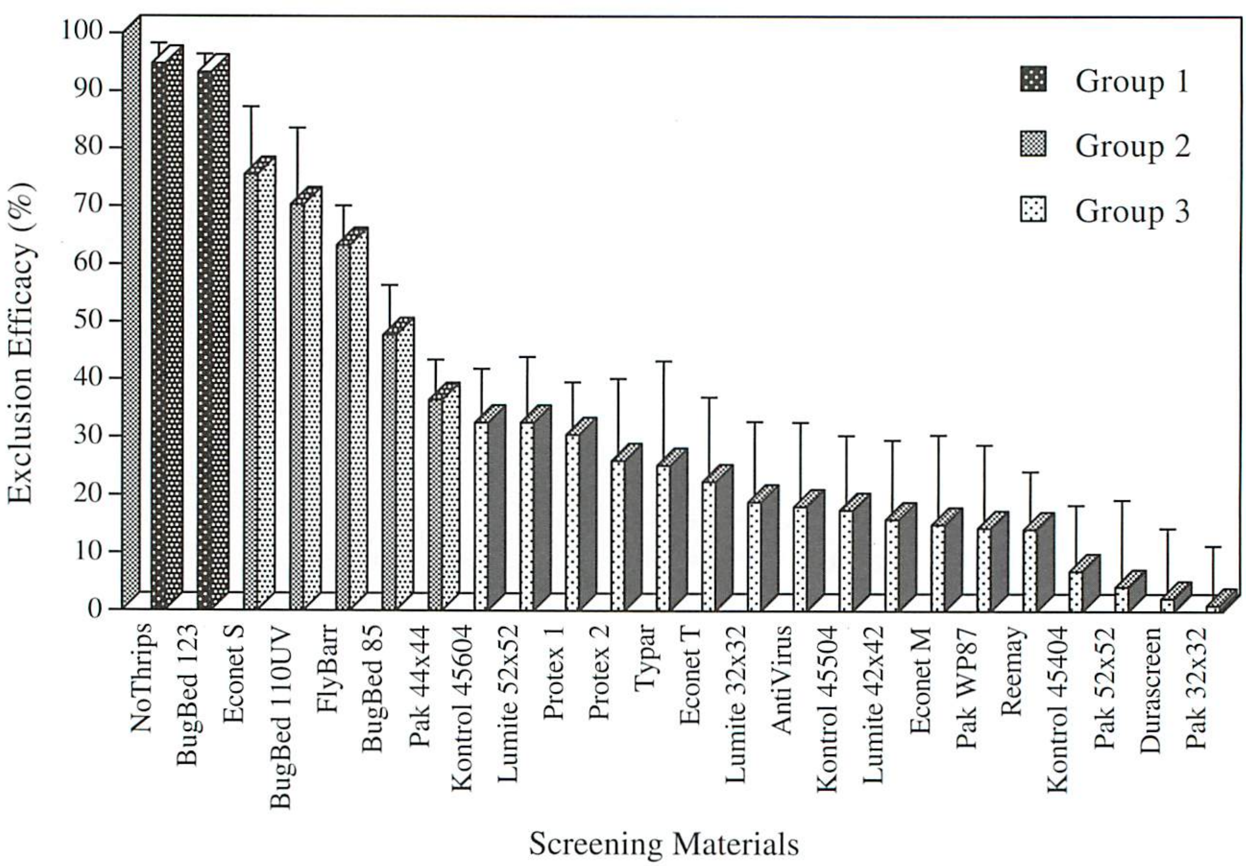

Figure 1. Thrips exclusion efficacy of commercial greenhouse screens as a percentage of the fiberglass window screen control (n = 8, commercial screens; n = 60, control screen). Screens shown gave exclusion equal to or greater than the control. Group 1 screens exclude more than the control and similar to No-Thrips, the screen with the highest percent efficacy, in pairwise comparisons. Group 2 screens exclude more than the control and less than No-Thrips. Group 3 screens exclude similar to the control.

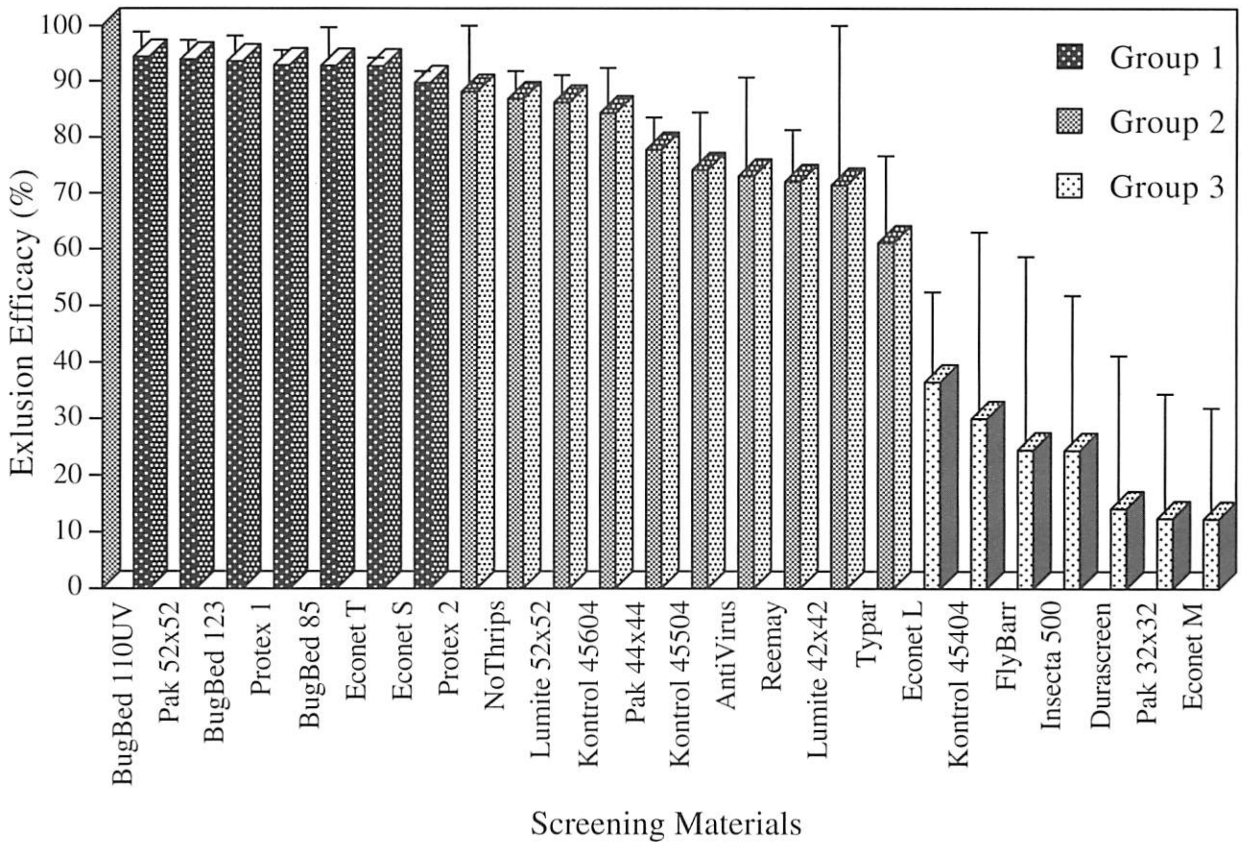

Figure 2. Silverleaf whitefly exclusion efficacy of commercial greenhouse screens as a percentage of the fiberglass window screen control (n = 8, commercial screens; n = 56, control screen). Screens shown gave exclusion equal to or greater than the control. Group 1 screens exclude more than the control and similar to BugBed 110UV, the screen with the highest percent efficacy, in pairwise comparisons. Group 2 screens exclude more than the control and less than BugBed 110UV. Group 3 screens exclude similar to the control.

shown in Figure 1. Seven screens gave greater exclusion than the control screen, and of these, the two Group 1 screens both can be considered the best screens for thrips exclusion.

Screens exhibiting whitefly exclusion equal to or greater than the window screen control are shown in Figure 2. Seventeen screens gave greater exclusion than the control screen, and of these, the seven Group 1 screens all can be considered the best screens for whitefly exclusion.

Screens with a lower percent exclusion than the window screen control do not appear in Figures 1 and 2. However, these screens were statistically similar to window screen in their exclusion capabilities and are included in Table 1 as Group 3 screens.

Only BugBed 123 was rated as a Group 1 screen in both studies, providing exclusion of both thrips and whiteflies at more than 93% compared with window screen. Being the only screen to be rated Group 1 for exclusion of both pests, BugBed 123 can be considered the best overall screen for thrips and whitefly exclusion.

No-Thrips was rated as a Group 1 screen for thrips exclusion and as a Group 2 screen for whitefly exclusion. Though only a Group 2 screen, No-Thrips gave whitefly exclusion at 87%, which was still very good.

Whenever exclusion of thrips and / or thrips-transmitted diseases is of paramount importance but where whiteflies may also be pests, BugBed 123 and No-Thrips should be strongly considered. An advantage of BugBed 123 over No-Thrips is that BugBed 123 is only moderately resistant to airflow whereas No-Thrips is very highly resistant to airflow (Table 1). The

Table 1. Grouping of screening materials for relative exclusion of whiteflies and thrips, characterization of relative air flow resistance and manufacturer or distributor.

Screening material	Exclusion rating[1] vs. Silverleaf whitefly	vs. Thrips	Static pressure[2] (inches of water)	Airflow resistance category	Source
BugBed 123	Group 1	Group 1	0.054	Moderate	Green Thumb Group, Inc.
No-Thrips	Group 2	Group 1	0.263	Very High	Green-Tek, Inc.
Econet S	Group 1	Group 2	0.095	High	LS Americas
BugBed	Group 1	Group 2	0.028	Low	Green Thumb Group, Inc.
BugBed 85	Group 1	Group 2	0.039	Moderate	Green Thumb Group, Inc.
Econet T	Group 1	Group 3	0.074	High	LS Americas
Pak 52x52	Group 1	Group 3	0.049	Moderate	Pak Unlimited, Inc.
Protex 1	Group 1	Group 3	0.023	Low	Rotogro Systems International Ltd.
Pak 44x44	Group 2	Group 2	0.051	Moderate	Pak Unlimited, Inc.
Protex 2	Group 2	Group 3	0.057	Moderate	Rotogro Systems International Ltd.
Kontrol 45604	Group 2	Group 3	0.044	Moderate	Baycor Products Group
Lumite 52x52	Group 2	Group 3	0.040	Moderate	Synthetic Industries
Lumite 42x42	Group 2	Group 3	0.042	Moderate	Synthetic Industries
Kontrol 45504	Group 2	Group 3	0.056	Moderate	Baycor Products Group
Antivirus	Group 2	Group 3	0.042	Moderate	Green-Tek, Inc.
Typar	Group 2	Group 3	0.271	Very High	Reemay, Inc.
Reemay	Group 2	Group 3	0.058	Moderate	Reemay, Inc.
FlyBarr	Group 3	Group 2	0.064	Moderate	Hydro-Gardens, Inc.
Pak WP87	Group 3	Group 3	0.152	High	(no longer available)
Kontrol 45404	Group 3	Group 3	0.022	Low	Baycor Products Group
Durascreen	Group 3	Group 3	0.024	Low	DuraGreen Marketing, Inc.
Insecta 500	Group 3	Group 3	0.024	Low	Green-Tek, Inc.
Econet L	Group 3	Group 3	0.020	Low	LS Americas
Econet M	Group 3	Group 3	0.022	Low	LS Americas
Lumite 32x32	Group 3	Group 3	0.022	Low	Synthetic Industries
Pak 32x32	Group 3	Group 3	0.022	Low	Pak Unlimited, Inc.
Kontrol 45304	Group 3	Group 3	0.010	Very Low	Baycor Products Group
Kontrol 45204	Group 3	Group 3	0.008	Very Low	Baycor Products Group

[1] Group 1 - screens that excluded more insects than the fiberglass window screen and about the same number of insets as the top-performing screen for that pest.
Group 2 - screens that excluded more insects than the fiberglass window screen but not as many insects as the top-performing screen for that pest.
Group 3 - screens that excluded no more insects than the fiberglass window screen.
[2]static pressures at an approach velocity of 300 ft./min. on which the designated relative airflow resistance category is based (Bell, Baker and Shearin, unpublished data).

two screens may also differ in longevity (expected life span). On a demonstration and research greenhouse at NCSU on which BugBed 123 was installed, the screen barely lasted one season before tearing occurred from weathering. No-Thrips lasts longer under similar conditions. Longevity studies of screening materials are currently underway in our lab.

BugBed 110UV, BugBed 85 and Econet S were rated as Group 1 screens for whitefly exclusion and as Group 2 screens for thrips exclusion. If whiteflies are the major pest problem in the greenhouse, these three screens will likely give excellent whitefly exclusion as well as provide the added benefit of good thrips exclusion.

BugBed 110UV, also called BugShield and the newest addition to the BugBed product line, exhibited the highest percent exclusion for whiteflies at 94%. Unique among greenhouse screens, BugBed 110UV is dark and, therefore, may be less attractive to pest insects that may happen upon the screen while in flight than would be lighter screens. Also, BugBed 110UV has enhanced protection from ultraviolet light degradation and thus may be longer-lived than BugBed 123 and other screens that lack UV protection. Another distinct advantage of BugBed 110UV is that its resistance to airflow is lower than BugBed 123; we characterize BugBed 110UV as a low resistance screen (Table 1).

Another new product, Econet S, provides excellent whitefly exclusion (90%) and, together with the other Econet products, is estimated by the manufacturer as offering the greatest longevity of available materials (5 to 8 years). Econet S has a smaller hole size--about one-half that of Econet T, formerly the most effective screen of the Econet line. Econet T very effectively excludes whiteflies but is rather ineffective in excluding thrips. Econet S excludes insects better than Econet T presumably due to the smaller hole size as well as a different hole geometry (holes of Econet S are square whereas those of Econet T are rectangular easily allowing thrips to pass through). Both Econet S and Econet T rank as high resistance screens based on our wind tunnel studies (Table 1).

Several screens that did not exclude thrips did exclude whiteflies. According to Bethke and Paine, investigators at the University of California at Riverside, greenhouse pests are likely to be excluded by screens with hole sizes smaller than the width of the insects' thorax, or midsection. They also noted that projecting body parts such as the wings of whiteflies further limit their ability to penetrate many screens. In general, species of thrips attacking greenhouse crops are narrower than species of whitefly pests, including the silverleaf whitefly. Our studies suggest that the holes of several screens allow differential passage of thrips over the silverleaf whitefly.

Though thrips are more difficult to exclude than the silverleaf whitefly, this whitefly is smaller in size than other whitefly pests such as the greenhouse whitefly. A screen which excludes the silverleaf whitefly should exclude other whitefly species equally well or better.

In general, the higher the airflow resistance of a screen, the smaller the mesh or hole size through which insects must pass. However, exclusion capability varied widely for the five screens exhibiting high or very high resistance (Table 1). As mentioned, No-Thrips and Econet S were rated as Group 1 screens for thrips and whitefly exclusion, respectively. The other three high resistance screens, Econet T, Typar and Pak WP87, failed to exclude thrips better than ordinary window screen. Moreover, Pak WP87 did not exclude whiteflies appreciably. In addition to hole size, Bethke and Paine found that hole geometry may play a role in insect penetration through screens. The holes of No-Thrips and Econet S are small and square. In contrast, Typar is a polyspun material and Pak WP87 is a woven material covered in acrylic lending high variability in hole size and shape to both screens. The rectangular holes of Econet T, as mentioned above, allow thrips to pass.

Four of the seven screens that exclude thrips are moderately resistant to airflow. In fact, a

Table 2. Percent shade as determined by manufacturer, size information and cost of greenhouse screening materials[1].

Material	Shade factor	Standard widths	Maximum lengths	Cost/ft^2
Kontrol 45204	20%	6 ft	300 ft	$0.34
Kontrol 45304	20%	6 ft	300 ft	$0.39
Kontrol 45404	27%	6 ft	300 ft	$0.63
Kontrol 45504	40%	6 ft	300 ft	$0.71
Kontrol 45604	40%	6 ft	300 ft	$0.89
Lumite 32x32	33%	6 ft (up to 24 ft with sewn seams)	min./max. 100 ft. Add $0.12/ft^2 for cutting roll	$0.64
Lumite 42x42	30%	6 ft (up to 24 ft with sewn seams)	min./max. 100 ft. Add $0.12/ft^2 for cutting roll	$0.58
Lumite 52x52	32%	6 ft (up to 24 ft with sewn seams)	min./max. 100 ft. Add $0.12/ft^2 for cutting roll	$0.80
Pak 32x32	–	6 ft	300 ft	$0.70
Pak 44x44	–	6 ft	300 ft	$0.95
Pak 52x52	–	6 ft	300 ft	$0.87
Econet L	15%	5.3 and 10.6 ft	no maximum	$0.46
Econet M	15%	5.3 and 10.6 ft	no maximum	$0.52
Econet T	15%	5.3 and 10.6 ft	no maximum	$0.74
Econet S	15%	5.5 and 11.1 ft	no maximum	$0.78
BugBed 85	32%	3.4 and 6.7 ft	102 ft	$0.95
BugBed 110UV	32%	5 and 6.7 ft	165 ft	$1.00
BugBed 123	32%	3.4, 5, 6.7 and 10 ft	165 ft	$1.00
No-Thrips	33%	3.3 and 6.5 ft	328 ft	$0.91
Antivirus	20%	3.6, 6.5, 9.8 and 11.8 ft	656 ft	$0.67
Insecta 500	35%	9.8 ft	1000 ft	$0.33
Durascreen	40%	9.8 and 16.4 ft	1,650 ft	$0.84
FlyBarr	60%	6 and 7 ft	62 and 100 ft rolls	$0.24
Reemay	25%	15.7 ft (up to 60 ft with sewn seams)	min. 300 ft, 500 ft and max. 10,500 ft rolls	$0.03-0.04
Typar	25%	15.7 ft (up to 60 ft with sewn seams)	min. 300 ft, 500 ft and max. 10,500 ft rolls	$0.03-0.04

[1]Where possible, reported cost reflects distributor pricing and is for minimum order; both may vary with distributor. Bulk discounts may apply. Special fabrication (addition of Velcro, zippers or fasteners; sewn caging, etc.) and custom sizing costs extra when available.

moderately resistant screen, BugBed 123, accounts for one of the two screens that were rated the best for thrips exclusion. Several moderately resistant screens exclude whiteflies. One low resistance screen, BugBed 110UV, excludes thrips; along with BugBed 110UV, the low resistance screen, Protex 1, excludes whiteflies.

Comparisons were made to window screen even though, certainly, any type of screening is better than none at all. Results of these studies may seem somewhat conservative since screening materials were compared with what is essentially another screen. However, one should consider that window screen has a mesh, or hole size, considerably larger than most greenhouse screening materials, and most greenhouse pests are very small and easily pass through window screen.

Reemay and Typar are marketed primarily as crop or turf blankets and not as greenhouse screens, though they are available as such. Pak WP87 is no longer available. Other than these three products, the screens reported from our studies are presently being sold for use as insect screens on commercial greenhouses. The fact that several performed poorly in our exclusion tests run at 300 ft/min air velocity points to the pressing need for continued, independent evaluation of screens for their pest exclusion properties.

In summary, of the 25 greenhouse screening products tested and presently available to growers, fewer than $^2/_3$ exclude whiteflies and fewer than $^1/_3$ exclude thrips better than ordinary window screen. Your selection of a screen can be narrowed considerably if you keep exclusion efficiency in mind. Also, though airflow is an important consideration, there are no strict rules when it comes to its effect on exclusion. High airflow resistance, often costly in terms of requiring greater screening area to maintain adequate airflow in a greenhouse, neither ensures nor is necessary for significant exclusion of whiteflies and thrips.

Most of the sources listed in Table 1 are product manufacturers. Contact these manufacturers for a list of distributors:

Baycor Products Group. 3500 Parkway Ln., Suite 500, Norcross, GA 30092; (404) 448-1518; fax 404-446-0696.

DuraGreen Marketing, Inc. P.O. Box 1486, 2600 Britt Rd., Mount Dora, FL 32757-1486; (904) 383-8811; fax 904-735-2688.

Green Thumb Group, Inc. 3380 Vernard Rd., Suite 2, Downer's Grove, IL 60515-1178; (1-800) 240-3371; fax 708-964-1963.

Green-Tek, Inc. 407 N. Main St., Edgerton, WI 53534; (1-800) 747-6440; fax 608-884-9459.

Hydro-Gardens. P.O. Box 9707, Colorado Springs, CO 80932; (1-800) 634-6362; fax 719-531-0506.

LS Americas. 1813-E Associates Ln., P.O. Box 19548, Charlotte, NC 28219; (704) 357-0457; fax 704-357-0460.

Pak Unlimited, Inc. 3300 Holcomb Bridge Rd., Suite 215, Norcross, GA 30092; (404) 448-1917 and (206) 845-9453.

Reemay, Inc. 70 Old Hickory Blvd., Old Hickory, TN 37138; (1-800) 284-2780; fax 615-847-7068.

Rotogro Systems International Limited. Churchfield, Station Rd., East Preston, West Sussex BN 16 3AJ, U.K.; phone: 9011 44 (1903) 785955. Note: At press-time, Protex products were not yet available to U.S. growers.

Synthetic Industries. 6525 The Corners Pkwy., Suite 115, Norcross, GA 30092; (404) 449-4960; fax 404-449-0054.