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Properly Recycled Perlite Saves Money, Does Not Reduce Greenhouse Tomato Yield, and Can Be Reused for Many Years

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SUMMARY. A study was conducted to determine if raising tomatoes (*Lycopersicon esculentum*) in cleaned and disinfected used perlite would be more economical than new perlite and have no negative impact on yield. Cleaning and disinfecting used perlite for recycling saved 56% of the cost to replace the media and reduced salt content to the optimum level recommended for raising container grown plants. Disinfecting used perlite with hot water raised media temperatures above limits necessary to kill several fungi and nematodes. Tomatoes

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planted in recycled perlite produced greater marketable yield and heavier fruit than those planted in new perlite. Season and year of planting also have significant effects on yield. Used perlite can be cleaned and disinfected as needed and recycled for many years because it is not organic in nature and physically and chemically stable.

Perlite is volcanic lava widely used as a growing medium for many horticultural crops, including greenhouse tomatoes (Szmids et al., 1988). The original rock found in nature is crushed to small pieces and heated to approximately 1832.0 °F (1000 °C) to force inside moisture to evaporate and expand the granules like popcorn (Papadopoulos, 1994). This lightweight medium is inert, pathogen free, easy to handle, and will not decompose.

Reusing perlite without processing to grow successive tomato crops is potentially risky because of media compaction, salt buildup, and pest contamination (Hanna and Smith, 2002). Replacing used perlite with new media to raise every tomato crop is costly, and recovering the expense by selling the fruit at a higher price may not work well in a competitive market.

Steam sterilization of used perlite before planting a new crop has been recommended to safeguard against pathogen contamination (Wilson, 1988). However, this treatment requires expensive steam generators and may not be adequate to restore perlite's loose structure and reduce media salt.

We developed a practical procedure to process used perlite for repeated use in greenhouse operations with

limited space. The procedure can be applied as needed after terminating the previous tomato crop and before planting a new one. This study was conducted to assess the economics of this procedure, evaluate its effect on reducing media salt, and determine the impact of the recycled perlite on tomato yield.

Materials and methods

Studies were conducted in a 30 × 96-ft (9.1 × 29.3 m) double-polyethylene greenhouse, typically used to raise 640 tomato plants in 320 polyethylene (poly) bags at Louisiana State University (LSU) AgCenter in Bossier City. A total of six studies were conducted in the spring (January–July) and fall (August–December) of 2000, 2001, and 2002. In every study, tomato plants were grown in 5-gal (18.9 L) poly bags filled with either new or recycled perlite. To recycle perlite, all vegetation of the previous tomato crop was removed from the greenhouse and the medium was sifted, cleaned, and disinfected using the procedure developed. To minimize labor input, a simple movable hopper was designed that can be built by growers. The hopper was equipped with a wire mesh screen for sifting used perlite to restore its loose structure and isolate most of the tomato roots (Fig. 1). The hopper was built on wheels and can be rolled between tomato rows in the greenhouse.

Used perlite mixed with tomato roots was poured out of the poly bags onto the hopper mesh screen and shaken well. The loose perlite was collected in same-size poly bags at the bottom, and the remaining roots were separated on the screen-top and then discarded. The perlite was then treated with hot water (Fig. 2) at temperatures reaching 200 °F (93.3 °C) to leach out excess salt and disinfect the medium. A Versa 4200 SS hot water pressure washer (MGM Sales & Service, Siloam Springs, Ark.) was used after replacing the pressure nozzle with a water breaker. Each bag was drenched with approximately 3.5 gal (13.25 L) hot water. Time for sifting and hot water treatment of used perlite in 320 poly bags was recorded and labor costs were calculated. New perlite sufficient to fill 320 poly bags was purchased (BWI, Texarkana, Texas) and labor wages to fill the bags with the new perlite were also calculated. The time to remove 320 poly bags filled with used perlite

Fig. 1. Movable hopper equipped with a wire mesh screen for sifting used perlite before planting the next tomato crop.

Fig. 2. Disinfecting and partial desalination of used perlite with hot water using a pressure washer that can be rented from local shops.

from the greenhouse and disposal was estimated.

Plots of four bags each filled with the new perlite and an equal number filled with the recycled perlite were arranged in a randomized complete-block design with three replications. The remaining greenhouse space was used to grow tomatoes for commercial production.

To determine the effectiveness of this procedure in reducing the salt level of the recycled media, a representative sample of perlite was collected from each replication before and after

processing using an AMS Soil Probe (Ben Meadows Co. Janesville, Wis.). Nutrient solution was squeezed out from each sample using the media press technique described by Scoggins et al. (2000). The electrical conductivity (EC) of the pressed solution was determined using an OakTon Conductivity Tester (Spectrum Technologies, Plainfield, Ill.). The solution nitrate-nitrogen ($\text{NO}_3\text{-N}$), potassium (K), and pH were also determined using Cardy Ion and pH Meters (Horiba Instruments, Irvine, Calif.).

'Trust' tomato seeds were sown in

No. 38 growing trays (Growing Systems, Milwaukee, Wis.) and transplants were raised in a soilless mix (Pro-Mix BX, Premier Brands, Yonkers, N.Y.) for 5 weeks before being planted in the poly bags. Two transplants spaced at 7 inches (17.8 cm) apart were planted in each bag at a 3-inch (7.6 cm) depth and bags were spaced at 30 inches (76.2 cm) apart within the row. Rows were arranged to allow each plant about 4 ft² (0.4 m²) of greenhouse space. Other cultural practices consisted of standard recommendations for growing greenhouse tomatoes for fresh market production in Louisiana (Hanna, 2003).

Tomatoes were harvested from each plot at the pink stage three times per week for 10 to 20 weeks. Fruit with blossom-end rot and other defects were removed, and the rest were graded by hand according to U.S. Dept. of Agriculture standards (U.S. Dept. of Agriculture, 1991). Marketable yield was determined by weighing fruit graded medium or larger in all harvests. Cull yield was the weight of all fruit with visible defects and small size. Mean fruit weight was determined on all marketable fruit. Data were subjected to analysis of variance (SAS Institute, 1990) considering seasons and years as variables because of different environmental conditions.

Results and discussion

Sifting and removing old tomato roots and refilling 320 poly bags with the sifted media required 24.89 person-hours. Cleaning and disinfecting the sifted media with hot water required 6.22 h and 1120 gal (4239.6 L) of municipal water priced at \$1.41 per 1000 gal (3785.4 L). The hot water pressure washer rent and fuel consumption cost was \$75. The sifter cost prorated over 5 years was \$40 per year. Assuming that wages were \$7.00/h, it would cost \$334.35 to process used perlite for recycling in a 30 × 96-ft greenhouse (Table 1).

The cost to replace the used media in 320 poly bags was \$540 to buy the new perlite, \$56 to dispose of the used perlite, and \$156.80 to fill the same old poly bags with new media, for a total of \$752.80 (Table 1).

Processing used perlite had a significant effect on reducing media salt (Table 2). In fact, perlite EC (a measure of total soluble salts in the media), $\text{NO}_3\text{-N}$ and K were reduced

Table 1. Time and expense needed to sift and disinfect used perlite vs. replacing the used media in 320 5-gal (18.9 L) polyethylene bags in a 30 × 96-ft (9.1 × 29.3 m) greenhouse at Louisiana State University Agricultural Center, Bossier City.

Action	Used perlite		New perlite	
	Time (person/h)	Expense (\$)	Time (person/h)	Expense (\$)
Sifting and filling the bags	24.89	174.23	---	---
Building a sifter ^z		40.00		
Disinfecting the media	6.22	43.54	---	---
Water cost ^y	1.58			
Pressure washer rental and fuel consumption	---	75.00	---	---
Buying new perlite	---	---	---	540.00
Disposing of used perlite	---	---	8.00	56.00
Filling the bags with new perlite	---	---	22.40	156.80
Total	31.11	334.35	30.40	752.80

^zBuilding a sifter would cost approximately \$200 and can be used for at least 5 years.

^yWashing and disinfecting used perlite in 320 bags required 1120 gal (4239.6 L) at \$1.41 per 1000 gal (3785.4 L).

by 43%, 50%, and 47% respectively. Media pH increased after the hot-water treatment because tap water had a higher pH than perlite. Season and year of planting had significant effects on media salt (Table 3). Media EC and NO₃-N were higher and K was lower in the fall than in the spring. Year effects and interactions between variables on media salt did not follow a specific trend (Table 2).

Tomatoes planted in the recycled perlite produced greater early and total marketable yields and heavier fruit than did those planted in the new perlite (Table 3). Cull yield was not affected

by the perlite treatment. Production of the early and total marketable yields and culls was greater in the spring than in the fall season. Fruit weight was not affected by the growing season. The spring season was 2 months longer and tomato plants continued to produce for a longer period of time than in the fall season. The year of planting had no significant effect on early marketable yield but total marketable and cull yields, and fruit weight were greater in 2001 and 2002 than in 2000 (Table 3). Season by year interactions

were significant for all studied traits (Table 3).

Most greenhouse tomato operations in the southern U.S. are small (Snyder, 1995). Growers in the region have to reduce production cost and increase plant yield or price to compete in a market dominated by more efficient large corporations. Yield reduction of greenhouse tomatoes planted in the same media year after year without processing is a serious problem. Contaminated perlite can impair the root system and lead to a weak and less productive plant. Most of the large greenhouse tomato operations in Ontario, Canada, replace the root media once a year to avoid yield reduction or crop failure [Canadian Greenhouse Conference and Tour (Oct. 2003), unpublished].

Results of this study indicate that replacing perlite at the onset of every tomato crop is expensive, and processing perlite for recycling can reduce the replacement cost by 56%. Most of the processing expense is labor related and smaller producers are more than willing to do the job themselves without considering it an added expense. The rent of a hot water pressure washer, fuel consumption, and water cost can

Table 2. Effects of processing used perlite, season, and year of planting tomatoes on medium electrical conductivity (EC), nitrate-nitrogen (NO₃-N), potassium (K) and pH in a 3-year study conducted at Louisiana State University Agricultural Center, Bossier City.

Variable	EC (mS·cm ⁻¹)	NO ₃ -N [ppm (mg·L ⁻¹)]	K (ppm)	pH
Used perlite ^z (P)				
Before processing	4.21	237	368	6.12
After processing	2.38	118	195	6.93
Significance	***	***	***	***
Season (S)				
Spring	2.67	168	318	6.5
Fall	3.93	187	245	6.5
Significance	***	**	***	NS
Year (Y)				
2000	2.83 b	185 b	323 a	6.51 b
2001	3.39 a	203 a	275 b	6.76 a
2002	3.67 a	146 c	246 b	6.31 c
Interactions				
P × S	*	**	NS	NS
P × Y	*	NS	NS	**
S × Y	NS	***	NS	*

^zNew perlite had an EC of 0.07 mS·cm⁻¹, NO₃-N of 25 ppm, K of 2 ppm, and pH of 6.1.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 3. Effects of recycled and new perlite, season, and year of planting on tomato yield in a 30 × 96-ft (9.1 × 29.3 m) greenhouse at Louisiana State University Agricultural Center, Bossier City.

Treatment	Marketable yield (lb/plant) ^z		Culls (lb/plant) ^z	Fruit wt (oz) ^y
	Early	Total		
Perlite (P)				
Recycled	3.6	12.0	0.8	7.4
New	3.0	10.9	0.9	7.1
Significance	**	*	NS	**
Season (S)				
Spring	3.9	14.5	1.4	7.2
Fall	2.8	8.4	0.3	7.3
Significance	***	***	***	NS
Year (Y)				
2000	3.2 a ^x	9.0 b	0.1 c	7.5 a
2001	3.3 a	12.8 a	0.9 b	7.1 b
2002	3.4 a	12.5 a	1.6 a	7.1 b
Interactions				
P × S	NS	NS	*	NS
P × Y	NS	NS	NS	NS
S × Y	***	***	**	***
P × S × Y	*	NS	NS	NS

^z1.0 lb = 0.45 kg.

^y1.0 oz = 28.35 g.

*Values followed by the same letter within columns are not significantly different according to the least significant test at $P \leq 0.05$.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

be the only out-of-pocket expense to do the job.

Salt buildup in the root media is undesirable. High soluble salts can cause root injury and impair root ability to take up water and nutrients. High soluble salts in the media can also result in reduced fruit size (Del Amor et al., 2001) and number (Chrétien et al., 2000). According to Schwarz and Kuchenbuch (1997), plants grown at an EC of $6.0 \text{ mS}\cdot\text{cm}^{-1}$ produced 64% less yield than those grown at an EC of $1 \text{ mS}\cdot\text{cm}^{-1}$. Rose (1998) indicated that the optimum EC for raising container-grown plants was 2.0 to $3.5 \text{ mS}\cdot\text{cm}^{-1}$ and the optimum $\text{NO}_3\text{-N}$ and K contents were 100–199 and 150–249 ppm ($\text{mg}\cdot\text{L}^{-1}$), respectively. Results of this investigation have indicated that media EC, $\text{NO}_3\text{-N}$, and K were higher before processing but dropped to within the optimum levels after processing.

In our study, perlite temperature measured at a depth of 8 inches (20.3 cm) in the poly bags with a long stem Traceable Thermometer (Daigger, Vernon Hills, Ill.) reached 160 and 185 °F (71.1 and 85.0 °C) after the hot water treatment in the spring and fall seasons, respectively. These temperatures exceeded the 122.0 °F (50 °C) temperature defined by Pullman et al. (1981) as lethal for several fungi, and the 113.0 °F (45 °C) temperature defined by Stapleton and DeVay (1983) as lethal for nematodes. The effect of these temperatures on virus diseases is not known, but we have not had any problems thus far.

We recycled perlite twice a year in four additional greenhouses mostly used for commercial tomato production since 1997. Sifting the used perlite through No. 8 and No. 16 mesh screens produced 55%, 41%, and 4% coarse, medium, and fine granules, respectively. New perlite sifted through the same mesh screens produced 69%, 29%, and 2% of the same size granules,

indicating that the physical condition of the recycled perlite has not changed considerably in 8 years.

The collective effect of salt reduction, media disinfection, and the presence of an optimum level of nutrients may have improved plant yield in the recycled perlite. It takes time to build nutrients to an optimum level in the new perlite.

The inverted gutter system equipped with side channels to collect the runoff for recycling is now popular in modern greenhouse operations to reduce pollution. The same system can be used to collect and reuse the already disinfected runoff resulting from treating used perlite with hot water.

In conclusion, cleaning and disinfecting used perlite for recycling can save the smaller grower a significant amount of money, does not reduce tomato yield, and can be repeated as needed for many years. Efficient management of limited-space greenhouse tomato operations by reducing production cost and improving plant yield should help smaller producers to survive a very competitive market.

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