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Developing a Method for Large Scale Solarization and Recycling of Used Potting Soil

S.T. Steed*

University of Florida, IFAS, Hillsborough County Extension, 5339 CR 579, Seffner, FL 33584

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Used potting soil from the environmental horticulture industry is a problematic waste. In conversations with growers, it is estimated that about 10% of plants with potting soil are culled and disposed of in the industry. These culled plants and soil are typically dumped on site and generally not reused. In an effort to recycle this waste, a series of methods were tested to solarize the used potting media. Solarization is a sustainable, inexpensive, and effective method to reduce pathogens, nematodes and weeds. Soil moisture, plastic thickness, bed depth, and covering configurations were manipulated to generate best outcomes. Successful methods were achieved using a small (one cubic yard) and larger scale (3.65 cubic yards) approach. Highest temperatures in the study reached a maximum of 159 °F in the large scale experiment. Solarization reduced nematode populations compared to untreated soil. Weed seed germination at 14 days was reduced about 91% compared to untreated soil.

Research has shown the effectiveness of soil solarization of previously used container media (Zinati et al., 2002). Gamiel et al. (1989) found that high sterilizing temperatures could be reached to a depth of 15 cm and improved growth of greenhouse tomatoes compared to fresh media. If container media is held at temperatures of 158 °F or higher for 30 min or 140 °F or higher for one hour, solarization can completely eliminate pests (Stapleton et. al., 2008). It was also shown that soil temperatures in potting soil could be reached in as little as a day when media was incorporated in small bags. A "double tent" method has been effective at eliminating nematodes in potting soils in California reaching temperatures of 158 °F (Stapleton et al., 2000)

This research has been done on a small-scale with satisfactory results. Wide-scale adoption of these practices has not been implemented in the container grown, woody ornamental nursery industry. Florida has ample, free solar radiation that can provide an energy source for sterilizing soil by solarization.

Materials and Methods

Mid-Scale Solarization

Commercial black polypropylene groundcover was used as the base of the solarization pad. This was laid over soil previously treated with glyphosate to eliminate weeds. A layer of 4.0-mil polyethylene clear plastic was placed over the ground cover to prevent contamination from untreated soil below. A frame box was constructed with 2 inch x 4 inch boards measuring 12 ft x 7.5 ft x 0.33 ft to yield a treatment area of one yd^3. Untreated used potting soil (approximately 70% pine bark, 25% peat, and 5% sand) was then filled to the top of the wood frame and smoothed with a rake. Large plant debris and weeds were removed by hand. The soil was irrigated by hand to visual wetness. A layer of 4.0-mil clear plastic was laid over the top of the frame and tucked under the frame edges. Another layer of 4.0-mil clear plastic was suspended over the entire frame with 1.5-inch PVC pipes approximately 2 inches above the soil surface and sealed with wooden posts laid horizontally upon the ground outside the frame. A HOBO Micro Station (S-TMB-M006) logged temperatures with three Smart Temp Sensor 12-bit with six meter cables. Sensors were places at the top just under the surface, two inches deep, and at the bottom of the area, at a four inch depth randomly located within the treatment area. The solarization started on 24 June 2013. On 26 June 2013, the outermost plastic was raised to approximately one foot to create a more tent like configuration. On 28 June 2013, the soil moisture level was increased to field capacity and outermost plastic layer configuration was changed to facilitate runoff of rainwater. On 8 July 2013, the outermost layer of plastic was removed. The solarization ended on 15 July 2013. Soil was collected and placed in seedling trays measuring 1 ft x 1.5 ft x 2.5 inches. Three trays were filled with one inch of solarized soil. Three trays were filled with one inch of untreated soil for a weed growth comparison. Trays were placed in a high tunnel with 30% shade. Trays were watered daily with overhead irrigation and grown for two weeks. Weed seedling numbers were counted after two weeks of growth.

A second trial was run in a similar fashion with the exception of using 0.5 mil plastic as the soil covering and 1.0 mil plastic as the top sheet. This experiment was started on 17 July 2013 and run for 2 d and stopped due to low temperatures within the pile and collapsing plastic. The top sheet was replaced with 4.0 mil plastic and ran for 14 d. A third trial was run in the same manner using 1.0 mil plastic as the soil covering sheet and 4.0 mil was used as the top sheet. This experiment was started on 31 July 2014, and stopped 15 d later.

Large Scale Solarization

A large scale solarization project was begun on 17 July 2014. Ground cover was laid down on bare ground. A sheet of 4.0 mil plastic measuring 24 ft x 24 ft was placed on top of this layer. A frontend loader dumped 3.56 cubic yards of the same used potting soil onto the plastic and spread by rakes and shovels to a depth of

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*Corresponding author; phone: (813) 744-5519; email:ststeed@ufl.edu

two inches. Large roots, weeds, and plant debris were removed by hand. Moisture was added to the soil by hand. A temperature probe was placed at one inch, and two were placed at two inches in the soil depth and randomly located in the soil pile. The soil was covered with two layers of 4.0 mil plastic. The bottom layer lay directly on the top of the surface of the soil. The top layer was suspended above the soil with three-inch galvanized pipes averaging six inches in height. Both top layers of soil were tucked below the bottom layer of plastic and held in place with wooden posts placed horizontally on the ground. The experiment ran for 14 d. All costs and time expenditures to solarize the used potting soil were tracked.

The solarized soil was sampled for weeds in the same manner as previously mentioned with the addition of three trays of a fresh commercial potting soil check. Weed germination numbers were counted after 15 d. This experiment was repeated on 20 Aug. 2014, and ran for 14 d. A sample of solarized soil and untreated soil was sent for chemical and physical analysis to University of North Carolina Horticulture Substrates Lab.

Results and Discussion

The first mid-scale test run temperatures reached 134 °F at the top of the soil pile and 116 °F at the bottom after 2 d. The volume of airspace was increased slightly to trap more heat. This had no effect on the temperatures. Soil moisture was increased to field capacity. This slowed the heat movement to the bottom of the pile. After removing the top layer of plastic more heat reached the deepest layers of soil however maximum temperatures were reduced to about 117 °F. This soil was used to test weed seed germination rates compared to untreated soil. Weed germination after 14 d show an average of 14.7 weeds per tray in solarized soil compared to 240 weeds per tray in untreated soil. Solarization reduced germinating weeds by 94%.

The second mid-scale experiment used a 0.5-mil covering sheet and a 1.0-mil top sheet in the thought that this would allow more sunlight in to heat the soil. This may have been the case but the gauge of plastic was too thin to trap the heat. The uppermost temperatures reached 135 °F but the bottom of the pile at a four-inch depth only reached 100 °F. The top sheet also did not have enough resilience to shed rain water. After changing the top sheet to 4.0 mil, temperatures reached 135 °F. However the bottom of the pile didn't exceed 100 °F. At night the heat dissipated completely and returned to ambient air temperatures. This also may have been due to too much water in the soil mix. It would be advisable to measure water content to determine optimal levels for this type of solarization.

The third mid-scale experiment used a 1.0-mil soil covering sheet and a 4.0-mil top sheet. A rain event collapsed the experiment on day two. On day seven, the plastic was adjusted and upper soil temperatures reached 153.79 °F as a high and 118.83 °F at the bottom of the pile. The middle of the pile (two-inch depth) reached 122.23 °F.

In the large scale experiment soil depth was kept to about two inches. The average height of the tent was about 6 inches above the soil surface. Highest temperatures were reached at the surface of the soil at 140.78 °F. The two bottom probe temperatures reached 130.9 and 138.25 °F. The average of the soil over the study was about 100 °F. Soil from this experiment was sent to the soil testing lab for a physical and chemical comparison.

The second large scale experiment yielded much higher temperatures. The top most temperature probe measured a high of 159.23 °F, the middle probe 147.32 °F, and the bottom probe 144.31 °F. This soil was used to run a second weed seed germination trial. After two weeks in a greenhouse, three trays of newly purchased soil had zero weeds germinate. The solarized soil averaged 10.6 and the non-solarized soil was 89.0 weeds germinating. Solarization reduced weeds by 88% compared to untreated used soil.

Further research is being conducted comparing solarized soil with untreated used soil in growing out container plants.

If solarization is going to be used by growers, careful attention should be made to the topmost layer of plastic and removing water from rain events. Strong rains will collapse plastic sheets together minimizing temperature gain in the soil.

Costs for the large scale set up were $233.62 in materials that would be used for the entire solarizing season. Labor costs ran $16.63 per solarization run, which included removing finished soil from the solarization pad. Total costs per yard of soil was about $4.67 to treat used potting soil. This is a savings of about $30.33 per cubic yard of soil or about $107.97 per solarizing run. Material costs would break even in about 2.16 solarizing turns.

Physical (total porosity, container capacity, air space, bulk density), and chemical comparison of solarized and un-solarized had little differences (EC, P, K, CA, Mg). Solarized soil did have more available NO_3-N (51.52 ppm) than untreated soil (29.98 ppm) and a lower pH (5.6 versus 6.3). This may be from breakdown of organic compounds or residual polymer coated fertilizer remaining in used soil.

Nematode counts were compared by Florida Department of Agriculture and Consumer Services, Department of Plant Industry. Nematodes were found in the treated soil, however numbers were greatly reduced (untreated 73 nematodes, treated 10.3 nematodes) and no live nematodes were found in solarized soil. Assays determined that they were heat killed by solarization.

To improve the efficacy of the solarization on weed control it would be beneficial to wet the soil prior to covering with plastic sheets to allow for weed seeds to germinate for a few days. High temperatures achieved with solarization would eliminate these germinating seeds.

It was confirmed with these series of experiments that soil moisture, depth of soil, plastic thickness, and tenting configuration can impact results of solarizing soil. However excellent results can be achieved to eliminate nematodes, nearly eliminate weed seeds, and recycle old potting soils for reuse with minimal cost.

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