SOLAR PASTEURIZATION OF POTTING MEDIA

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ABSTRACT

The maximum thickness of potting media that can be pasteurized (66 °C for > 30 min) with solar energy was determined. In field tests, a media thickness of about 5.1 cm was successfully pasteurized using a box type solarization unit that passively heated only the top surface of the media. A prototype unit that heated both the top (with solar rays) and bottom (with hot air) surfaces of the media successfully pasteurized 50% greater media depth (7.6 cm thickness layer). The moisture content of the media was about 72% (dry basis) and the maximum solar irradiation during the tests was approximately 1050 W/m².

KEYWORDS: Pasteurization, solar energy, potting media

INTRODUCTION

Commercial nurseries in Hawaii producing ornamental potted plants and/ or hydroponics vegetables generate large quantities of used potting media. Most nurseries do not reuse the media unless it is free of potentially harmful pathogens, insects and weeds. Potentially harmful organisms are controlled by fumigation with chemicals or by heating with steam. However such treatments require expensive equipment and trained operators which are usually beyond the economic capability of most small nurseries. Furthermore, recycling of spent potting media is becoming an important issue due to the reduced availability and increasing cost of imported media.

Treating used media with mild heat [< 70 °C (pasteurization)] to control plant pathogens and weeds is a viable alternative to sterilization using steam with temperature of about 100 °C or fumigation with methyl bromide and chloropicrin. In addition, methyl bromide is an ozone-depleting fumigant, and the Environmental Protection Agency under the Clean Air Act has initiated action to phase methyl bromide out of production by the year 2000 (USDA 1993). Extensive studies by many researchers have demonstrated that exposure to moist heat at about 66 °C for 30 minutes will destroy the important plant pathogens, insects and weeds (Baker, 1972). This moderate time-temperature regime should be easily attained with a well-designed passive solar heating unit given ample solar irradiation. The use of solar irradiation to heat soil (solarization), by covering moist soil with a clear polyethylene tarp, has been a very effective method in controlling certain diseases and weed seeds in many field grown agricultural crops (Katan, 1981; Ashworth and Gaona, 1982; Pullman et al., 1984). Furuta (1982) recorded temperatures of more than 49 °C in soils placed in small black containers or nursery cans sealed in clear plastic bags and placed in sunlight. Utilization of solar irradiation to pasteurize greenhouse media is a very practical option for Hawaii nurseries since they are typically situated in areas receiving high amount of solar irradiation. The purpose of this study was to investigate the feasibility of using solar irradiation to pasteurize greenhouse media. A successful pasteurization treatment requires that the entire volume of media reaches the desired temperature for a prescribed length of time. In a passively heated system using solar irradiation, media temperatures in the
deeper layers will be lower unless the media thickness is limited or very long exposure to sunlight is possible. Hence the specific objectives of the study were:

- Determine the maximum thickness of potting media that can be passively heated to pasteurization temperature with solar energy.
- Design, construct and evaluate a low cost portable solar pasteurization unit.

MATERIALS AND METHODS:

Media Thickness Tests

Six solar test chambers (box pasteurizer, Fig. 1) were constructed from 2.5 cm thick styrofoam stock sheeting. The styrofoam pieces were glued together with a waterproof sealant (Lexel, Sasco, Commerce City, CO 80022) to create an airtight seam at all edges. The inside dimensions of the test chambers were 60 x 60 cm (L x W) with 3 depths of 2.5, 5.1 and 7.6 cm. Two units were fabricated for each depth. A plywood frame cover was designed and constructed to fit tightly over the top and sides of each chamber. The inner sides of the cover were insulated with 2.5 cm thick styrofoam material. Clear polyethylene (PE) film (6 mil thick), commonly used for greenhouse glazing, was stretched taut and fastened onto the top of each cover. PE was chosen as the glazing material based on previous work done by Furutani and Tsang (1996). They compared different types of glazing materials for solarizing potting media and demonstrated that clear PE film was as effective as glass. PE also has the advantage of low cost and being easy to install.

Media thicknesses and densities used for the box pasteurizers are shown in Table 1. The desired amount of a commercial potting media (Pro Mix BX, Ontario, Canada), moistened to 72.0 ± 0.5% moisture content (dry weight basis) was weighed on a scale and compacted into each pasteurization unit so as to completely fill the chamber. A sheet black PE film (6 mil thick) was stretched on top of the media before the cover was placed on the chamber. A 4 cm thick air space existed between the two PE surfaces. The units were then placed in an open field and elevated to a 30° angle in the southward direction to take maximum advantage of the incoming solar radiation (Figure 1). Media temperatures were recorded every 5 minutes using a datalogger (CR21X, Campbell Scientific, Inc, Logan, Utah) equipped with thermocouple probes. The probes were placed at about 0.6 cm below the surface, 0.6 cm above the bottom and at the center of the media layer. Solar radiation (watts/m²) was measured with a radiometer (model no. LI-185B, LICOR, Lincoln, Nebraska) fitted with a pyranometer light sensor which was placed at the same angle as the pasteurization units.

Fresh media were replaced in the test chambers after each treatment. The experiment was repeated on 3 separate days.

Description of prototype solar pasteurization unit

Based on the results of the thickness tests, the prototype pasteurization unit was designed for two-directional heating of the media. Besides heat conduction from the top layers, the bottom of the media was also heated by rising hot air from an adjoining solar collector.

The prototype unit (collector assisted pasteurizer) consisted of a media holding chamber and a collector plate located below the chamber to generate the hot air for heating the bottom surface of the media (Figure 2). The unit was fabricated from 1.9 cm thick lumber and internally insulated with 2.5 cm thick styrofoam. The bottom of the media chamber (60 x 60 x 10 cm inside dimensions) was made from 2.5 cm meshed wire cloth and the top was sealed with a hinged door lined with 6 mil clear PE glazing material. The collector (60 x 60 cm) was fabricated from corrugated iron roofing, which was wedged between the styrofoam linings glued to the sides on the chamber. The surface of the collector was sprayed with low luster black enamel paint and the collector chamber was sealed at the top with 6 mil PE glazing to form about a 5 cm air space between the two surfaces. For each test, the media was placed inside a sealed plastic bag (60
x 60 x 7.6 cm) made from 6 mil thick black PE which was then placed in the holding chamber. The unit was mounted on wooden legs at a 30° angle.

The collector assisted pasteurizer was compared with the box type pasteurizer unit used in the thickness tests. Each unit was loaded with 10.6 kg of potting media (72% moisture content) to form a layer about 7.6 cm thick. Three thermocouple probes were then inserted at the top, middle and bottom of the media through pre-drilled holes on one side of the chambers. Media temperatures were recorded at 5 minutes interval using a datalogger (CR21X, Campbell Scientific Inc, Logan, Utah) as described above.

RESULTS AND DISCUSSION

Effect of media thickness and density

Since the media was heated mainly by conduction heat transfer from the surface to the bottom, successful treatment was attained only when the bottom of the media reached 66°C for >30 min. Temperature rise curves at the bottom of the media layers are shown in Figure 4. The media in all of the heat chambers, with the exception of the unit containing the thickest layer and greatest quantity of media (7.6 cm thick layer, 10.9 kg), attained pasteurization requirements (66°C, >30 min) under the test conditions. The temperature curves reveal some interesting but perhaps not unexpected trends. As expected, the media heated progressively slower with increasing thickness and packing density. For the same amount of media, more efficient heat transfer was obtained by packing the media more densely within a given volume, thus reducing the insulating effect of air spaces within the media mass as illustrated in Figure 4; curves 1H and 2L, 2H and 3L (different thicknesses but same amount of media).

Covering the moist media in the heat chamber with the black PE prevented condensation of water on the underside of the glazing which was a major problem encountered in previous experiments (Furutani and Tsang, 1996). Also by trapping all the moisture and steam within the enclosed volume probably helped in a more effective pasteurization of the media. The maximum amount of media that was successfully pasteurized was about 256 kg/m² in a 7.6 cm thick layer or 395 kg/m² in a 5.1 cm thick layer. The tests were conducted under clear sky in June, with a maximum solar irradiation measured at 1050 watts/m² at noon (Fig. 3).

Performance of Prototype Pasteurization Unit

Temperature rise at the top and bottom of the media for both solarization units are plotted in Figure 6. The incoming solar irradiation is plotted in Figure 5. As in the previous tests, this amount of media in the box type unit (one-directional heating) did not attained pasteurization conditions. In contrast, because of the additional heat input from the collector, the media in the prototype unit attained pasteurization conditions after about 6 hours of heating although the top layer heated at a faster rate than the bottom layer (Fig. 6). Hence using a two-directional heat flow increased the quantity of media (about 50%) that can be pasteurized as compared to a one-directional heating system.

An efficacy test-using an amount of media (7 kg in a 5.1 cm thick layer) that was successfully heated to pasteurization temperature in the styrofoam test chamber was conducted using both units. One gram of fresh mustard (> 80% germination) seeds (about 500 seeds) was mixed with the potting media before they were placed in each heat chamber. Mustard seed (Brassica juncea var. rugosa) was chosen because of their persistence in the soil for a very long period. After it was ascertained that the media attained pasteurization conditions in both units, they were removed and spread in four 1 cm x 1 cm trays and observed for any seed germination. After two weeks, no seed germinated in the media pasteurized in the prototype unit while about 2% (9 seeds) of the seeds germinated in the media pasteurized in the box type unit. The results indicate the importance of uniform heating throughout the media mass so that complete pasteurization is attained. This
was achieved with the prototype unit. Leaving the media in the test chambers or bags at the end of the treatment allowing the residual heat to spread may also help in achieving pasteurization uniformity.

CONCLUSIONS

A system for pasteurizing potting media without using a great deal of fossil fuel or the need to purchase complicated and expensive equipment is possible with solar energy. Potting media at 72% moisture content was successfully heated to pasteurization temperature (66 °C) within a few hours for solar irradiation of approximately 1050 W/m². The maximum media thickness that can be heated using a box type pasteurizer providing only a one-directional heat flow was about 5.1 cm. A prototype solarization unit that heated both the top and bottom layers of potting media contained in a black PE bag pasteurized media up to 7.6 cm thick layer. The method is relatively inexpensive and simple to use and provides an alternative energy resource for small growers and nurseries for media pasteurization in areas where the climate is suitable.

LITERATURE CITED


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Figure 1. Test of media layer thickness that can be heated in a solar box pasteurizer

Figure 2. Collector assisted solar pasteurization unit
Fig 3. Incoming solar radiation

Fig. 4. Effect of layer thickness and density on media temperature.
Fig. 5. Incoming solar radiation

Fig. 6. Effect of collector design on temperature rise

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