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Pit Greenhouse Construction and Operation

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INTRODUCTION

Older greenhouse concepts from many decades ago or even past centuries seem new today and the benefits are many. Previous generations of nurserymen and estate gardeners embraced the concept of earth shelter structures and used them with great success (Figure 1). With increasingly common and complex energy crises in recent memory, there should be greater energy awareness.

In addition to the environmental stewardship, savings on energy costs can translate into greater profitability. Using new double-wall glazing materials, the energy benefits of being up to 6-ft below grade can be quite significant. This project was not a scientific study of energy efficiency, but an example of how common-sense principles can be applied simply and economically, resulting in a successful propagation program that is scalable to any size nursery.

Figure 1. Earth shelter structure at Summer Hill Nursery.

MATERIALS AND METHODS

Timing

If the timing of construction is in the fall, there may be an opportunity to effectively use nursery staff as nursery activities decrease and the skill levels required are modest if the plans are well conceived and there is competent construction leadership. It is important to close in the structure before the onset of winter. Much of the interior work can continue regardless of weather and at very comfortable indoor temperatures. It is likely that there can be active propagation the first winter of construction with the first crop after only 4 months.

Depth of the pit excavation

A pit greenhouse is a structure that is earth sheltered either by digging a deep pit (Figure 2A) or a shallower pit with soil used for berms. If the site is nearly level, then the shallower pit is quite practical because the excavated soil does not need to be removed but can be used to berm the walls thus creating the benefits of a deeper pit.

Wall construction

Once level footings are in place, 8-in. concrete blocks are stacked dry without mortar joints (Figure 2B). A surface bonding cement specified for this method of wall construction is applied to both sides of the wall and used for bedding the first course of concrete block. This type of cement builds a very strong wall and is also quite effective at waterproofing. The concrete blocks can be strengthened further by filling some of the cores with cement and rebar though this was not done in this construction project. Polystyrene panels 2-in. thick were applied exteriorly for insulation to a depth of 4-ft from sill to below grade.

Figure 2. (A) Pit greenhouse is a structure that is earth sheltered, (B) Once level footings are in place, 8-in. concrete blocks are stacked dry without mortar joints.

Subfloor stone heat storage bed for increased efficiency

Efficiency can be increased further if air is circulated through perforated 4-inch ducts in a subfloor stone bed of 3-in. stones (Figure 3A). Even on cloudy days there can be a “greenhouse effect” and the extra energy can be stored. A thermostat turns on a fan when there is extra heat and stores it under the floor and the same fan releases the heat at night. Because of the constant heat from being below grade, it may even be possible to skip an alarm system as freezing temperatures are not likely to occur with good construction. General guidelines from the passive solar building industry for subterranean heating recommends a total length of perforated pipe ducting to be half of the floor area. The sizing of the fan should allow about five air exchanges per hour. For this project, a cage fan used for inflating double-wall poly film greenhouses has worked well as they were designed for continuous operation.

Supplemental heating

This project included 4 independent zones of hydronic heating pipe from a manually controlled manifold supplying warm water for radiant heat in the floor and under the propagation bench (Figure 3B). A small 30-gal electric hot water heater with a thermostatically controlled circulating pump provides adequate root zone heating at any level desired. Heating only the plant root zone and not the air adds to energy efficiency.

Figure 3. (A) Efficiency can be increased further if air is circulated through perforated ducts in a subfloor (left), (B) project included 4 independent zones of hydronic heating pipe (right).

DISCUSSION

Because of excavation and greater material expense, pit greenhouses are more expensive than simple hoop-house construction. It comes down to: "You can pay a little more now or a lot more later." Energy costs are always increasing and only a few feet below ground the earth remains a constant temperature year-round of 55-58 ^{o}F in the Mid-Atlantic region. If the structure is used for propagation of seed and cuttings and not growing, the greater cost of construction is offset by the high value of the propagules. The density of plants per square foot is very high. As an example, standard Anderson deep flats may hold over 100 cuttings. The calculation to estimate the number of years to recoup the cost of construction can be quite simple based on unit cost to purchase propagules versus on site pit propagation. In the project used in this article; the payback is estimated to be less than 3 years.

This modest 12 ft ×28 ft pit greenhouse example has about 300 sq. ft. of growing space (Figure 4A). Results from the first year of production has shown that the number of cuttings per sq. ft. can range from 25–50 resulting in the potential of 7,500–15,000 propagules (Figure 4B). The cost of construction in this example was under $10,000 due to the free labor associated with owner equity. In this modest example, the cost of construction may be recovered in 2–3 years.

In addition to the cost savings of not having to purchase plants propagated from other sources, nursery production can be nimbler with availability and sales. Having control of propagation can allow nurseries to specialize in a niche markets by producing plants that are often unavailable.

Figure 4. (A) Finished pit greenhouse, (B) propagules rooting.

SUMMARY

Although this was not a scientific study, the success of the construction design can be determined by successful plant propagation. Every situation is unique and success in propagation is largely dependent on the propagator and attentive administration. The improved economy of energy efficiency is universal and quite remarkable. There is not a single month throughout the year that plants cannot be propagated. Working in the pit greenhouse in the depths of winter sheltered by the warmth of the earth and sun is a special pleasure for the propagator.

CONCLUSION

Older greenhouse designs have stood the test of time. If the pit greenhouse is used primarily for seed and cutting propagation rather than production growing, the return or profitability of construction costs can be recouped in a very short period of time. A simple calculation of the density of cuttings per unit area times the cost per propagule if purchased and the math become apparent. Pit greenhouses are scalable and may be ideal for many different types of nurseries. Due to the low-tech concepts, pit greenhouses may be a good fit for small or startup nurseries.