SOME BIOLOGICAL AND ENGINEERING DESIGN ASPECTS OF A COATED CLAY CONTAINER1/

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Abstract.--A wax coated clay container is being developed for machine planting tree seedlings. The rigid container is impervious to moisture in the greenhouse but is allowed to soften by absorbing water from rainfall after outplanting. The container appears to be a viable alternative and is superior in many respects to other container systems.

INTRODUCTION

It has been estimated that the demand for wood products from the Southern forests of the United States would double between 1968 and the year 2000 (SFRAC, 1969). The use of containerized seedlings may play a significant role in helping to meet this demand.

A conference on containerized seedlings sponsored by the U.S. Forest Service in Louisiana in 1971 pointed out some of the needs and problem areas with containerized systems for reforestation in the Southeastern United States.3/ A goal of primary importance is a biologically sound container system with which the entire process, from seedling rearing through outplanting, can be completely mechanized. A container which appears to have the potential of attaining this goal is a coated clay container (CCC) currently being developed by the Mississippi Agricultural and Forestry Experiment Station at Mississippi State University.

This paper gives preliminary observations on some of the biological and design aspects being considered in developing the container.

The general design concept is to produce a seedling with automated procedures in a container that can last for an indefinite period under greenhouse conditions and then be machine planted. The purpose of the container then changes at outplanting from a passive containment role in the greenhouse to a beneficial role in the field. The container should not be restrictive in any way on the seedling and ideally, should be an asset to its survival and growth.

Foot establishment and growth is paramount to the success of a containerized plant when outplanted, and coated clay containers have the potential for being an asset at this critical period. It is possible to include additives in the body of the tube which can be released at planting and for a period thereafter. This should enhance conditions conducive to rapid root growth in an area immediately surrounding the seedling.

The types and amounts of additives have a wide range because of the material formulation and the fabrication techniques used for the container. For instance, nutrients, phytohormones and even pesticides may be incorporated. This offers the opportunity to formulate containers for specific areas, species and other purposes. The coating prevents the release of the additives in the greenhouse but after outplanting they can be made available for utilization by the plant.

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3/Minutes, Containerized Seedling Workshop, Alexandria, Louisiana, September 8-9, 1971. USDA Forest Service, State and Private Forestry, Southeastern Area.

BIOLOGICAL AND DESIGN ASPECTS

Material and Methods

Two of the commercially most valuable southern species, loblolly pine (Pinus taeda L.) and slash pine (Pinus elliottii Engelm.) seedlings are being used for testing. They are grown for a period of eight to twelve weeks in the greenhouse and then outplanted by hand. The Walters 3/4" x 4 1/2" bullet and the BC-CFS Styroblock 2" containers are being used for comparison with the CCC. The media is U.C. Soil Mix D, 3:1 peat moss and fine sand, (Baker, 1957). Irrigation in the greenhouse is by overhead sprinklers and fertilization is with Rapid-Gro (23-19-17).

Several configurations of the clay container have been tried. The container presently being used is a round tube 4" x 1" O.D. with 1/8" walls and two longitudinal ribs along the inside surface (fig. 1) .

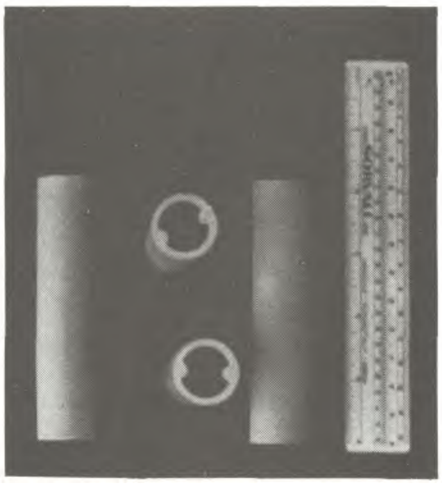


Figure 1.--Uncoated clay containers showing configuration.

The ribs serve a dual purpose. They help prevent root spiraling by orienting roots downward and also facilitate the failure of the inside coating of the tube after outplanting. The tubes are placed in racks which have bottoms of hardware cloth and the roots of the plants air prune.

The base material chosen for the container was a mixture of clay, sand and water. The clay is a readily available Kaolinite called Parkes Ball Clay which has good extrudibility and good green strength. Good extrusion characteristics allow the container tube to be extruded with thin wall sections and good green strength will allow the container to be mechanically handled in the unfired state without breakage either in the greenhouse or during mechanical outplanting.

The coating used was a Ceresin wax with a melting point of 73-78° C. The higher melting point waxes are probably necessary to prevent excessive softening that can occur due to high temperatures in the greenhouse.

The CCC was fabricated with a laboratory model extrusion machine by commonly used extrusion techniques. Coatings were applied by submerging the clay container in a bath of Ceresin wax for various times and temperatures, depending on the desired thickness.

The weight of the CCC is from 45 to 50 grams or about 4 times the weight of the Walter plastic bullet. A possible reduction in weight can be achieved by reducing the wall thickness and also incorporating lighter materials into the extrusion material mix. It is estimated from the cost of the base and coating materials and the low cost fabrication techniques that the cost of the CCC will be from 1-2 cents per container in large quantities.

Results and Discussion

In greenhouse tests to date, the coated container has been satisfactory. It maintains its shape and rigidity, a necessary requirement to facilitate automatic machine planting. Germination and growth in the CCC compares very favorably with the other containers. The wax coatings tried have not been detrimental to seedling development.

Field trials have been initiated but results at this time are inconclusive. In late May a limited number of CCC 12-week-old slash pine were outplanted by hand with a soil auger. A portion of the outer coating of the tube was removed at planting to enable the wall material to absorb water, expand and become soft. Plants in uncoated clay containers were used as controls.

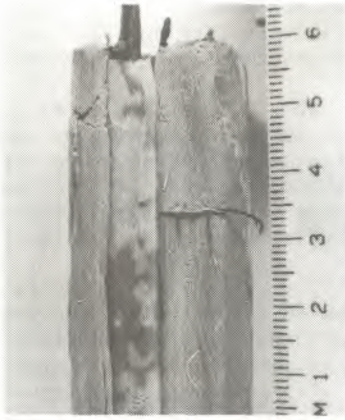
After 3 weeks in the field, roots were well established out of the bottom of the tube. Lateral roots which had grown through the container walls were beginning to appear (fig. 2).

After 4 weeks, survival is 97% for all plants, and lateral roots have grown through the walls of many of the coated containers (fig. 3B,C).

Examination showed roots escape the inner coating, the area of main concern, in three different ways: 1) They can grow through cracks. 2) Root tips can mechanically penetrate the coating material, and 3) Roots can chemically penetrate the coating material. The third type of penetration appears to be the result of a reaction between root exudates and the wax.

In the uncoated containers, lateral roots were well developed through the walls indicating the base clay material is easily penetrated (fig. 3A). The clay material may even be of

Figure 2.--Container with portion of outer coating and wall removed showing lateral root development.



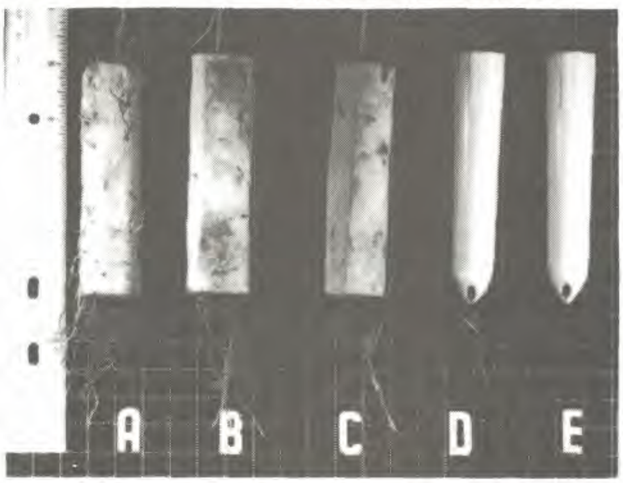


Figure 3.--Slash pine root development 4 weeks after outplanting: A, Uncoated container; B,C, coated clay container - laterals beginning to appear; D,E, 4-1/2" Bullets.

benefit to the plant by improving the cation exchange capacity of the soil surrounding the roots.

Results indicate that water uptake by the clay is important for lateral root escape from the CCC. After the first moderate rainfall the tubes absorb enough water to expand and become soft. This allows the inner coating to crack, usually along the ribs, allowing root escape. Also, the inner coating is no longer backed up by the hard clay enabling root tips to force their way through the walls of the container (fig. 4). This method of root escape can be of considerable importance with the CCC system if most plants are capable of this, since it allows a more normal root development pattern.

The type of wax appears to be a significant factor for root escape. It is apparent that root tips more easily penetrate some waxes than others. Also, there is no chemical reaction between roots and some types of wax.

Figure 4.--Inner coating of container showing slash pine root tips which have forceably penetrated the wax (X3.5).

As stated previously, for a container system to work most advantageously, from the biological standpoint, the container should not present a handicap to root development. The coated clay container allows lateral root growth and the open bottom allows unimpeded downward root growth thus the container does not appear to be unduly restrictive in this respect.

In the biological and engineering areas of the design studied thus far, the CCC shows promise for a complete container regeneration system that has many advantages with respect to other container systems.

LITERATURE CITED

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Question: What prevents the clay containers from disintegrating and roots escaping while still in the greenhouse?

Elam: The wax coating is on both inner and outer surfaces.