GROWING CONTAINERIZED SOUTHERN PINES1/

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Abstract.--Containerized seedling systems for southern conditions lag behind those developed in the Pacific Northwest and Canada, however, the criteria necessary for south-wide acceptance are now beginning to be met. It is possible to markedly extend the planting season, to achieve better early seedling growth, and to develop automated planting equipment.

INTRODUCTION

Development of containerized planting in the South has lagged behind the Pacific Northwest and Canada primarily because planting nursery stock is both reliable and economical, Since there is little likelihood of reducing reforestation cost with container-grown seedlings, there is little incentive to plant them during the dormant winter period. Other advantages must be proven if this new technique is to gain a foothold in the South.

Three criteria are generally considered essential for acceptance: (1) extension of the planting season, (2) better survival and growth than with bare-root stock, and (3) adaptability to mechanical planting to eliminate the man on the planting machine.

It is doubtful if one specific container system will be adequate for the broad southern pine region, where four pines are planted extensively and two others on a lesser scale. Varying growth habits, nutritional requirements, cold and drouth hardiness, and other factors may necessitate developing different systems for species groups alone.

In addition to species differences, environmental and climatic conditions vary widely, especially as the planting season is expanded. Soils are diverse, ranging from deep sands to silt and clay loans, with differing moisture regimes. Coupled with the inherent tendency of some soils to be drouthy, summer rainfall varies greatly and prolonged dry periods are common. Temperatures fluctuate from below freezing in the winter to 90 to 100° F. in the summer--and continuous heat may persist for 3 to 4 months.

Forest Service research on containerization at Alexandria, Louisiana, has been underway for less than 3 years. This paper summarizes progress during that time.

CONTAINERS

A wide range of containers is being evaluated for suitability under southern conditions. Approximately 20 different products have been tested. Among these are a number still under development and not available commercially. The products can be divided into three general types: (1) tubes, (2) plugs, and (3) blocks.

Included in the tube category are plastic bullets, kraft-paper tubes, Japanese Paperpots 3/, and plastic nondegradable, biodegradable, and Conwed mesh-like tubes. This type of container is filled with a growing medium and generally has a wall that restricts root egress when outplanted. However, the rigidity of a wall is often considered beneficial in planting operations, especially if the task is to be mechanized.

Plugs are grown in containers like BC/CFS styroblocks, Spencer-Lemaire fold-up trays, Swedish multipots, and Weyerhaeuser test tubes. Biologically, these are ideal since they are planted with no root constraint. Applying this type of system to southern conditions may be limited because roots will not firmly bind the media together in the 8 to 12 weeks we anticipate to be optimum for the culture period.

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3/Mention of trade names is solely to identify materials and does not imply endorsement by the U. S. Department of Agriculture.

Blocks refer to such products as Gro-blocks (BR-8), Agritec Polyloam, Keyes Peat Sticks, Dow Water Foam, RCA Peat Sausage, and extruded soil media containers. Generally, they have some of the advantages of both the tube and plug. Most are fairly rigid and require no filling; they also allow rapid root egress upon outplanting.

The relative merits of each container product will not be discussed here. However, some materials not generally available show considerable potential and they will be described. The greatest effort to develop new containers for southern conditions has been with block- and tube-type products. The reason is probably because they seem more likely to fit southern conditions and specifications.

A new tube material having great potential is a biodegradable plastic (caprolactone polyester) developed by Union Carbide Corporation. It is broken down by soil microorganisms and the rate of degradation can be controlled by fillers incorporated in the plastic. Our tests show that it can be made to deteriorate in as little as 2 months or it can remain intact for a year or more. The desirable properties of this plastic could well be combined with other products to develop superior containers. For example, biodegradable plastic could be used to make bullets or mesh-like tubes and thereby overcome some of the constraint objections of styrene plastic. We are now evaluating blow-molded, hex-shaped tubes made from caprolactone polyester. This is a unique and very promising material for container applications.

Several new block-type containers are being tested. They have been compared with products previously available, such as Famco Gro-blocks (BR-8) and RCA Peat Sausage. Although not yet commercially available, Keyes Fibre Company's Peat Stick has great potential. This is a molded product consisting of peat and vermiculite with nutrients incorporated. Excellent survival and growth, even during midsummer plantings, have been obtained. The Peat Stick is now being redesigned and may soon become available for widespread testing and use.

Two polyurethane foam blocks have been evaluated--Agritec's Polyloam and Dow Chemical Company's Water Foam. Polyloam has properties like cation and anion exchange capacity, increased water-holding ability, and nutrients in a balanced formulation. Water Foam, used primarily in floral arrangements, is essentially inert and requires addition of nutrients. Althougth Polyloam reportedly has some moisture retention capability, low retention has been a problem with both types of foam blocks when planted in relatively dry soil.

At present a tube that will rapidly degrade or a block seems to most nearly meet the criteria for a container suitable under southern conditions. Japanese Paperpots and Gro-blocks have been the products most widely accepted to date, because they meet our criteria well and have been available in sufficient quantities for testing. We do need full development of some of the other products and possibly new materials to provide new approach to container planting.

CONTAINER DIMENSIONS

There appears to be no clearcut optimum container size for all conditions. Studies show that factors such as species, soil type, site preparation, and seedling age may affect this determination. A study with three species and two seedbed treatments on a dry site demonstrates the individuality of southern pines.

Longleaf pine seedlings, which exhibit stem dormancy but make rapid root growth, survived better on both seedbeds in 8-inch tubes than containers 6 or 4 inches long. In contrast, slash pine survival and growth were not affected by tube length. Loblolly seedlings were more sensitive to variations in tube length, which interacted with site preparation. Average midsummer survival for 4-, 6-, and 8-inch tubes was 32, 21, and 14 percent on disked soil and 32, 26, and 38 percent on unprepared sites. Although survival was low because of drouthy conditions, this did result in a discriminating test. Growth of loblolly followed the same trend; increases in tube length were beneficial in the rough, and had no effect on disked sites. Of the three species evaluated in midsummer on a dry site, longleaf survived much better than slash pine and loblolly ranked last.

A length of about 5 inches is generally considered satisfactory for tubes under southern conditions. However, slightly shorter tubes have proved to be advantageous on moist, prepared sites and longer ones superior on dry or unprepared sites. Block-type containers may not need to be quite as large as tubes because roots are not impeded and make quick contact with the soil.

Although container diameters have not been fully evaluated, 1- to 1-1/4-inch widths seem most suitable. Growth in 3/4-inch tubes was found to be less than in the slightly larger Ones and there has been no growth advantage in tube diameters greater than 1-1/4 inch with loblolly pine. The rapid increase in volume with slight increases in diameter also economically limits increasing diameters to any appreciable degree.

SEEDLING CULTURE

Growing Facilities

As we all realize, the environment under which seedlings are grown and the cultural treatments they receive can have a marked influence on field survival and growth. Generally, in contrast to northern conditions, high temperatures in the South are more of a problem than low ones in growing containerized seedlings in greenhouses. Particularly during midsummer, cooling is a major problem in closed greenhouses. Shadehouses may provide a better environment for growing containerized seedlings. Because high temperatures can adversely affect seed germination, a cooled germination facility would be ideal to obtain seedling establishment. Such a facility is also needed to provide heat during the winter months.

Supplemental light which increases the photoperiod to about 16 hours and heat that raises day temperatures to about 70° F. is necessary for rapid midwinter growth.

Potting Medium

At the Southern Forest Experiment Station, we have worked with a number of potting mixtures and all seem acceptable if they are properly handled. One of the most suitable for growing seedlings in containers is a 1:1 mixture, by volume, of peat moss and vermiculite. It is lightweight and has good water-holding capacity. Our tests show that such an artificial mix produces better growth than those with considerable amounts of soil, even though some soil may provide microorganisms antagonistic to pathogenic fungi. Finely ground bark is a possible substitute for peat moss, but supplemental nitrogen is needed when breakdown of the bark begins.

Although several commercial potting mixes based on Cornell-type artificial blends are available, they should be selected with care since the pH is usually adjusted to meet horti cultural needs. Southern pines do best at a pH of 5.0 to 5.5 and most commercial media have a pH of about 6.5.

Mycorrhizae

Cooperative work with Dr. D. H. Marx of the Southeastern Forest Experiment Station at Athens, Georgia, shows that inoculation of containerized southern pine with vegetative mycelium or basidiospores of effective strains of mycorrhizal fungi is feasible and may increase survival and early growth The effectiveness of such inoculation seems directly related to the nutrient status of the seedlings. Mycorrhizae are most beneficial to containerized seedlings when they are grown under conditions of low fertility. However, even under high fertility regimes certain strains of mycorrhizae may be particularly effective and increase field performance. Inoculations should also be very effective when plantings are to be made in soils that have low mycorrhizal fungi populations. Evaluations of mycorrhizae inoculations in container planting will continue.

Seed

High quality seed is essential for container production, and empty seeds must be removed before planting. Unless viability is very high, it may be desirable to sow two seeds in each container so that complete blanks will be kept to a minimum. However, double sowing requires a time-consuming operation to thin back to one seedling. Studies are underway to evaluate the effects of multiple seedlings in a container on subsequent survival and growth. At this time, the decision on rate of sowing depends largely on the availability and cost of labor to thin versus the losses due to containers without seedlings.

Double seeding without thinning is risky with longleaf pine because the characteristic growth pattern results in no epicotyl elongation for lengthy periods and this contributes to the rapid development and spread of disease organisms. Dr. William Pawuk, with State and Private Forestry of the U. S. Forest Service, who has cooperated in our work on seedling diseases, has shown that the seedcoat is a significant source of infection from pathogenic fungi. Soaks in hydrogen peroxide or sodium hypochlorite (clorox) will effectively surface sterilize seedcoats. Fungicides may also be used to coat the seeds, and this procedure may be more desirable than sterilization since some microorganisms antagonistic to pathogenic fungi will probably survive.

Greenhouse conditions resulting in surface media temperatures above 85° F. become detrimental to germination. Weak and abnormal germination occurs, particularly in longleaf pine, the most heat sensitive of the major southern pines. On the other hand, germination is slow and erratic with all species except longleaf at temperatures below 70° F. Longleaf will germinate at tempera tures in the 40's although speed is reduced as temperatures are reduced.

Watering

Maintaining good moisture conditions in the potting medium during the germination and culture period requires constant attention. The need for water varies with types of medium, environmental conditions, and the stage of seedling development. During germination, the uppermost portion of the media should be kept wet at all times. This results in a moist condition of the entire media. Gradual reduction of watering after establishment results in more cold and drouth hardy seedlings. Other than these general guides, it is impossible to prescribe an optimum watering schedule. The experience of the grower is the most important determinant of this aspect of seedling culture.

Disease Control

A preventative program of fungicide appli cations is necessary under southern conditions of high temperatures and relative humidities. Fusarium, Pythium, and Rhizoctonia are pathogenic fungi that have caused heavy losses of seedlings grown in closed greenhouses. In fact, Fusarium has been a serious problem in large-scale production of containerized seedlings by the Kisatchie National Forest. This is one of the biggest obstacles encountered so far. To prevent outbreaks of these disease organisms, fungicide application programs are being developed. Standard fungicides, such as Captan and Busan, do not give the control that is essential. New formulations that will check all of the major root diseases are under development. It is obvious from Forest Service research that frequent applications of fungicides or combinations of products with a broad spectrum of control will be required to prevent outbreaks of pathogenic fungi.

Disease problems have been most acute in warm weather--perhaps because spores are more prevalent and spread is faster. It may be possible to reduce the incidence of disease development during seasons of hot temperatures by moving seedlings out of closed greenhouses after germination and establishment into lath or shadehouses. This is possible during much of the year. Such a facility is also needed to harden off seedlings. A shadehouse should be constructed so that the degree of light can be controlled, since requirements vary from season to season.

Fertilization

Development of a well-balanced nutritional regime will undoubtedly result in containerized seedlings that will outgrow nursery stock in the field. In some Southern Station field plantings, 1-year-old container-grown seedlings exceeded 30 inches in height or almost double the size of bare-root stock. Differences increased into the third year, probably because of better root systems of containerized stock rather than an appreciable carryover of nutrients.

Despite some encouraging results, we have purposely delayed the start of intensive fertilization studies until other aspects of the containerization problem were well underway. Many of the media and blocks we were testing already had substantial quantities of nutrients. Moreover, manufacturers have frequently changed their formulations, making it difficult to conduct series of integrated tests. Fertility and fungicide trials now have the highest, priority in our research.

It is apparent that, except with blocks where penetration into the container may be slow, nutrients do not need to be incorporated into the media. Balanced fertilizers are easily applied to the seedlings through the watering system.

Seedling Age

Although seedling ages of 8 to 12 weeks are generally considered sufficient under our conditions, age alone should not be the criteria for determining if seedlings are plantable. Morphological and physiological indices of seedling quality and resulting field performance are greatly needed. Many cultural treatments can influence the rate at which seedlings reach a certain development stage, but at present we do not know what the ideal seedling should be. Particularly in spring and summer plantings, a rapidly growing, vigorous seedling which quickly extends its roots into the surrounding soil seems to perform best.

Hardening Off

Seedlings can be moved directly from greenhouses to the planting site with good success in spring and summer. Some type of acclimatization may improve the performance of these seedlings, and hardening off will be essential for most species in the winter months. This conditioning can be achieved by water, nutrient, photoperiod, and temperature regimes. The amount of conditioning will vary with species, site, development of seedlings, and time of outplanting. Longleaf seedlings, for example, are cold tolerant, but loblolly pine is very sensitive to low temperatures.

PLANTING

Season of Planting

In Louisiana, we have outplanted in every month during the last couple of years. Survival from these plantings has been high with our better container materials. However, some precautions are needed if year-round success is to be obtained. Seedlings of most species must be preconditioned to withstand low temperatures in winter months. Midsummer plantings should be made when there is enough soil moisture to keep seedlings alive. Very dry soils must be avoided because seedlings are quickly desiccated by high temperatures. Generally it is possible to hold containerized seedlings until rains replenish soil moisture. Although survival has been excellent, growth of seedlings planted in early winter has been slower than those planted later in the following spring. This slow growth may reflect poor initial root egress and development. It is important that seedlings for these plantings be grown in plug- or block-type systems so that roots grow into the soil as quickly as possible. This should result in better height growth.

Planting Techniques

Whether the planting tool punches a hole or removes a soil plug for the seedling may affect survival on certain soils. Studies show that plugged holes result in better survival on heavy, poorly drained soils. Apparently compacting the soil from punching reduces ability of the root system to penetrate the sides of the hole and slows seedling establishment. On some very heavy soils punched holes have resulted in root spiraling within the holes several months after planting.

Although use of some conventional planting equipment is possible, development of equipment specifically for containers is necessary to meet our goals. Ideally, a machine should provide for automated planting, eliminating the man on the planter, and reducing the power requirements necessary to make a continuous slit in the soil. Jerry Edwards of the Southern Region of the Forest Service has led in developing equipment in the South. A prototype of a containerized seedling planter is being constructed and other equipment will become available as more of the biological problems of containerization are overcome.

OUTLOOK

Additional research will provide solutions to many remaining problems in the utilization of container planting in the South. It must also stimulate the development of new container materials that will meet the specific needs of the area. These special needs relate to the criteria we think necessary for adoption of containerization: an extension of the planting season, an automated planting system, and improved survival and growth.

I believe that containerized planting is feasible for 9 or 10 months of the year, particularly if summer rains are frequent. Winter planting of loblolly and shortleaf pine will require preconditioning to prevent losses due to subfreezing temperatures and it is likely that nursery-grown seedlings will continue to be planted during this period.

Since it is doubtful that the initial cost of containerized seedlings can ever compete directly with that of southern nursery stock, superior growth will be necessary to overcome the economic advantage of bare-root seedlings. This better performance is expected, especially when specific nutritional balances for pines are developed.

The development of automated planting equipment is another necessity, if the intensification of our regeneration effort is to meet the goals for full development of the South's Third Forest. Not only will such equipment reduce the labor requirement for planting, but it will also result in developing a stable labor force which can be maintained throughout the year. Containerization will allow permanent employment rather than the highly seasonal requirement for bare-root plantings.

Planting of containers probably should be adapted first to wet sites that cannot be easily planted with nursery stock during the winter months. The technique can then be adapted to dry sites as well. Growers must gain experience in handling containerized seedlings under southern environments before large-scale operations begin. Organizations interested in developing programs should begin on a small scale until this expertise can be developed. Container planting is not a panacea, but it should become a valuable additional regeneration technique in the South.

Question: What are the main features of a successful mechanical planting system?

Barnett: Our objective is to eliminate the second man on the planting job. We would have someone driving the machine, but the planting would be automatic. Edwards 1/ describes a prototype machine Region 8 hopes to test this fall.

1/Edwards, Jerry L.
1974. Methods and machines for planting containerized trees. p,269-274, In North A. Containerized For. Tree Seedling Symp. Proc. Great Plains Agric. Publ. 68.

Question: When you reuse a container such as the styroblock, how important is cleaning for disease control? Is a good washing sufficient, or should steam or a disinfectant be employed?

Barnett: Cleaning the container is important, especially under our conditions, because we have been plagued by a multitude of disease problems. A good cleansing would probably suffice, but sterilization would be safer.