SURVIVAL, GROWTH, AND ROOT FORM OF CONTAINERIZED JEFFREY PINES TEN YEARS AFTER OUTPLANTING

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ABSTRACT: To evaluate the effect of various containers on survival and growth, trials established in 1973 were remeasured in 1983. In addition, 20 seedlings were excavated in order to determine the effect of container type on root development. After 10 years, the container type had a significant effect on survival arid height growth. Root form and the number of lateral roots were also influenced by container type.

INTRODUCTION

Since the early 1970's, containerized seedling systems have been developed and tested throughout the United States. The early work was concerned largely with the development of an acceptable and suitable container. Early experimental container types were available in various sizes, shapes and materials. These containers were either planted with the seedling or removed just prior to planting. Over the past decade, evaluation of the various containers has been based on early field performance, production cots, and technical problems.

The rapid evolution of container planting systems both in Canada and the U.S. resulted in a tremendous need to transmit research findings. Fortunately, much of the information has been made available through conference proceedings. In 1971, the Canadian Forestry Service sponsored a workshop on container planting (Waldron 1972). The first international conference held in Denver brought together much of the knowledge and expertise available on containerized seedlings (Tines and others 1974). Two symposia held in 1981, the Southern Containerized Forest Tree Seedling Conference (Guldin and Barnett 1982) and the Canadian Containerized Tree Seedling Symposium (Scarratt and others 1982), updated much of the available information on containerized seedling systems.

Although information has rapidly accumulated since the early 1970's, long term studies on growth arid development are lacking. The development and evolution of containerized systems will be influenced by biological performance under field conditions. Considerable discussion has dealt with the potential problem of root deformation resulting from container designs. Although a symposium was devoted to the root form of bareroot and containerized seedlings (Van Eerden and Kinghorn 1978), the overall effect of root configuration on field performance is still riot well documented. The primary objective of this paper is to report on ten year survival, growth, and root form of containerized seedlings outplanted on adverse sites.

METHODOLOGY

The materials and methods used in establishing the original trial in 1973 are discussed in the North American Containerized Forest Tree Seedling Symposium (Miller and Budy 1974). Survival, height, and root collar diameter were measured in June 1983. Five seedlings of each container type were excavated by hand in order to recover the root system extending 30cm from the container. No attempt was made to recover the entire root system. After excavation, the number of lateral roots extending from the container sidewalls was recorded and the diameter of the tap root at the bottom of the container was measured. The seedling was severed at the root collar, and shoot and root green weights were determined.

Containers

The container types included in the 1973 trial and reevaluated in 1983 are described in Table 1. The Japanese paperpot is designated FH520.
The Conwed is an open-mesh, nonbiodegradable polypropylene plastic material. The Conwed designated as 9+3 in this paper contained 9-inches of potting mix with 3-inches of the plastic mesh left exposed above the soil surface when planted. The Zeiset containers are made of a polyethelene coated board stock paper, similar to that used in milk cartons. The polyetheylene coating (.0005 inch) is intended to keep plants divided while in the greenhouse, but not thick enough to girdle plants when outplanted in the field.

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Table 1.--Description of containers evaluated.

Container Type	Dimensions Dia. (in)	Depth (in)	Dia. (cm)	Depth (cm)	Material	Rooting (in^3)	Volume (cm^3)
8-Paperpot	2.0	7.9	5.0	20.0	Treated paper	25.1	392.7
9+3-Conwed	2.0	9.0	5.0	22.9	Plastic mesh	28.3	463.3
12-Conwed	2.0	12.0	5.0	30.5	Plastic mesh	37.7	617.8
12-Zeiset	2.5[1]	12.0	6.4[1]	30.5	Polyethylene covered cardboard	75.0	1229.0

[1]Side of square.

RESULTS

Survival and Growth

After 10 years, the survival was very similar to the first year survival (Table 2). Compared to the losses encountered during the first year, subsequent mortality was relatively low. The highest survival and best growth after 10 years were evident with the Conwed containers. The results indicated a highly significant difference ($P < .01$) in survival between the Conwed containers and the paper and cardboard containers. After nine years the difference in heights was apparent, but not significant. The significant difference ($P < .05$) in height growth was not revealed until after ten years. The seedlings in Zeiset containers showed the lowest height and diameter growth. The poor field performance of the Zeiset seedlings appears to be related to the root form and is discussed in the following section.

Root Form

Excavation of the containerized seedlings revealed that field performance may be largely affected by the design and shape of the container. Representative root systems after excavation are shown for the 12-Conwed (Fig. 1), 9+3-Conwed (Fig. 2), 12-Zeiset (Fig. 3), and 8-Paperpot (Fig. 4). The most obvious difference between the four container types is the lack of lateral roots penetrating from the Zeiset container.

The only container type which showed any signs of breaking down was the Paperpot. The Zeiset containers were still very much intact and it appeared that the plastic coating was very effective in preventing lateral root development. The Conwed containers were not expected to break down; however, as the lateral roots developed they were able to break apart the plastic mesh (Fig. 5). Although the roots showed signs of constriction (Fig. 6), the developing lateral roots can apparently overcome the obstruction.

Table 2.--Mean survival, diameter and height of Jeffrey pine seedlings outplanted in 1973.

Container Type	Survival[1] 1974	Survival[1] 1983	Diameter[2] 1983	Height[1] 1983
	(%)	(%)	(cm)	(cm)
9+3-Conwed	80[a]	63[a]	3.3	77[a]
12-Conwed	76[a]	61[a]	3.1	70[ab]
12-Zeiset	59[b]	39[b]	2.3	51[b]
8-Paperpot	50[b]	34[b]	2.5	57[ab]

[1]Means with the same superscript are not significantly different.
[2]Diameter at root collar.

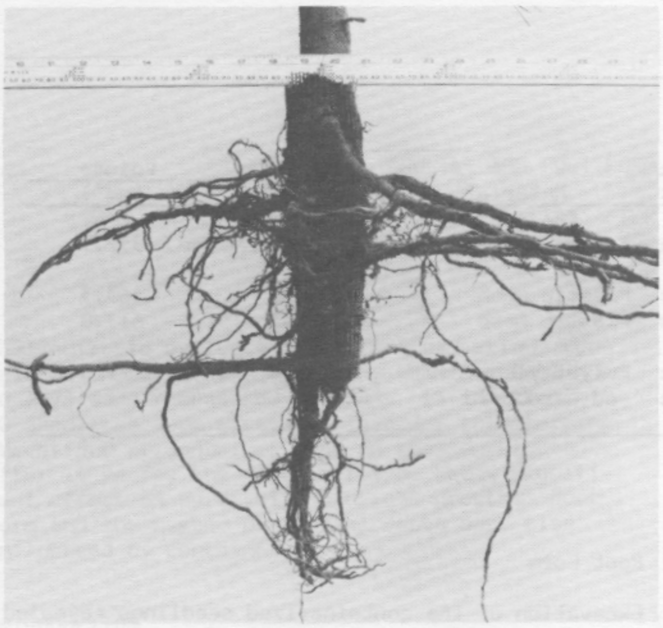

Figure 1.--Root penetration of a Jeffrey pine through a 12-Conwed ten years after outplanting.

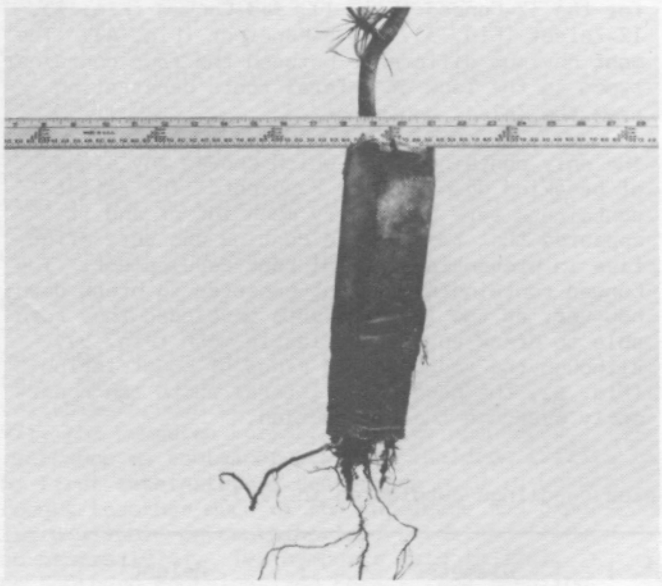

Figure 2.--Root Penetration of a Jeffrey pine through a 9+3-Conwed ten years after outplanting.

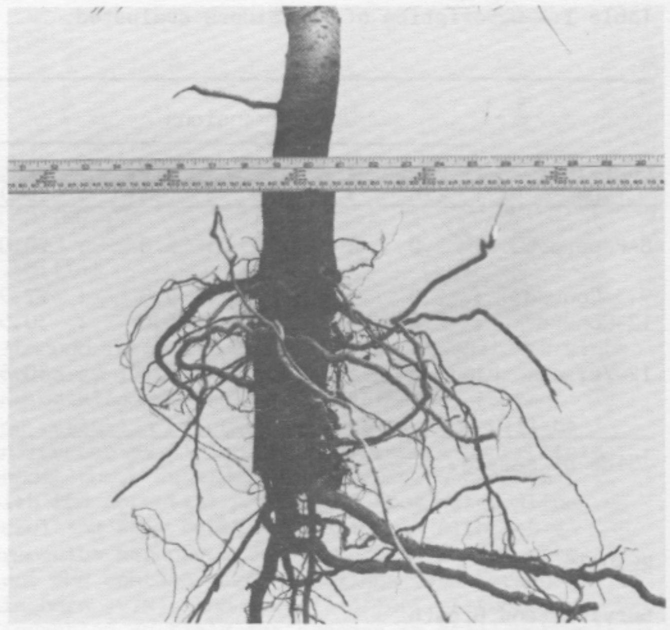

Figure 3.--Root penetration of a Jeffrey pine through a 12-Zeiset ten years after outplanting.

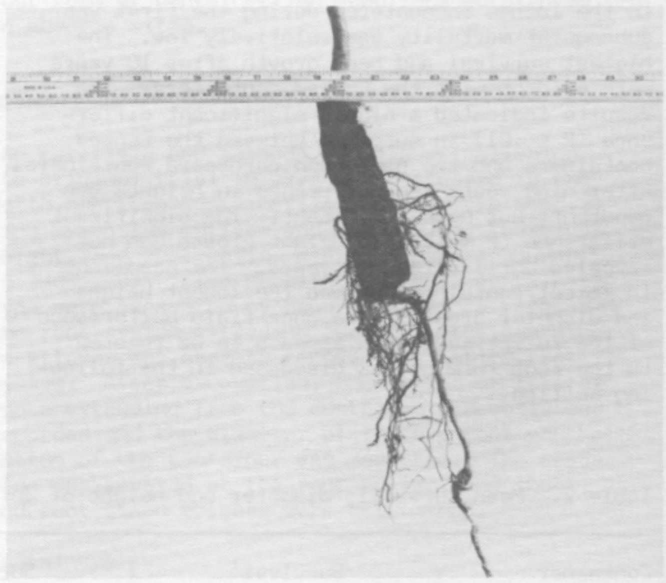

Figure 4.--Root penetration of a Jeffrey pine through a 8-Paperpot ten years after outplanting.

Characteristics of the excavated seedlings are shown in Table 3. The Conwed seedlings had a greater number of lateral roots penetrating through the container sidewalls, a larger tap root emerging from the bottom of the container, and a greater biomass than the Zeiset and Paperpot seedlings. There was a highly significant difference ($P < .01$) in the mean number of lateral roots between the Conwed and both the Zeiset and Paperpot seedlings (Table 3). Also, the Paperpot seedlings had significantly ($P < .01$) greater root penetration through the sidewalls than the Zeiset seedlings. The lack of lateral root penetration for the Zeiset seedlings may account for the poor field performance. In addition, after the containers were removed from the excavated seedlings (Fig. 7-10), root problems were most evident on the Zeiset seedlings. Although the Zeiset seedlings developed lateral roots (fig. 11), the laterals were confined within the container and became quite deformed after ten years of restricted growth (Figure 12).

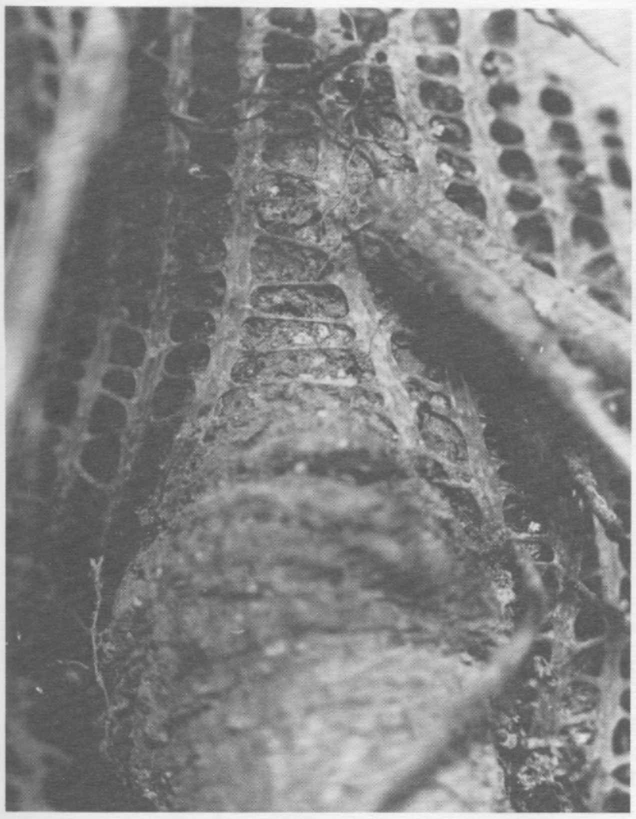

Figure 5.--Close-up view of a lateral root breaking apart the plastic mesh of a Conwed Container.

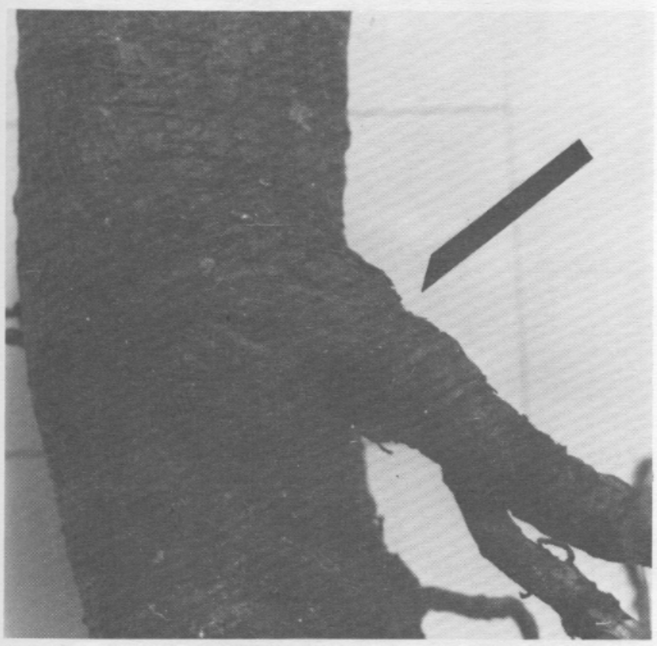

Figure 6.--Lateral Root of a Jeffrey pine showing constriction resulting from the plastic mesh of a Conwed container ten years after outplanting.

Table 3.--Mean root and shoot characteristics of excavated Jeffrey pines ten years after outplanting in four container types (5 samples per container type).

Container Type	Lateral Roots[1]	Tap Root Diameter	Green Weight Root	Green Weight Shoot
	(no.)	(cm)	(kg)	(kg)
9+3-Conwed	19.6[a]	2.12	.381	1.39
12-Conwed	19.6[a]	2.24	.406	1.60
12-Zeiset	.6[b]	.99	.227	.73
8-Paperpot	11.0[c]	1.26	.112	.42

[1]Means with the same superscript are not significantly different.

DISCUSSION

The results of this study indicate some interesting, as well as significant, findings regarding the relationship between container type and field performance. The highest survival and best growth occurred on those seedlings outplanted in Conwed containers while the poorest survival and growth occurred on the Zeiset and Paperpot containers. The most significant finding was the lack of lateral root penetration through the Zeiset containers. Although the manufacturer's intention with the plastic coating is to keep the plant roots divided during the rearing stages in the greenhouse, the thin coating apparently prevents lateral roots from penetrating through the sidewalls, even Len years after outplanting. The manufacturer does recommend punched holes for quicker lateral root extension on containers longer than four inches. The results of this study support the recommendation.

More importantly, and perhaps of significance in the development and evolution of an acceptable container, was the relationship between growth and lateral root development. In this study, the best growth was obtained on seedlings outplanted in containers where lateral root development was unrestricted. The poorest growth resulted where lateral root development was restricted. Owston and Stein (1978) reported the poorest growth after seven years on Douglas-fir and noble-fir outplanted in one-quart milk cartons. Although their studies were conducted on favorable sites, the milk cartons remained intact and the main laterals were almost entirely contained within the carton. They also reported greater height growth on seedlings outplanted in Conweds than in either milk cartons or cardboard tubes. Tinus (1978) has suggested that holes or slits be incorporated into the upper sides of solid wall containers to increase surface laterals for wind firmness; however, the results of this study indicated that better growth and development resulted where lateral root development was unrestricted.

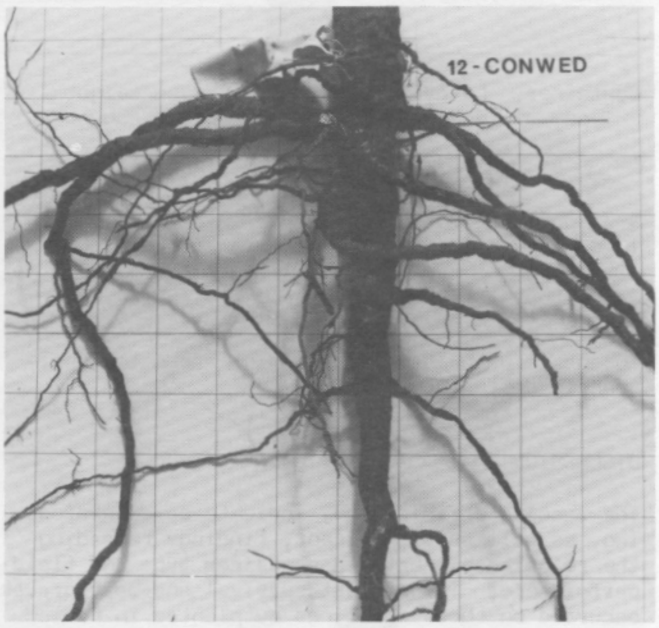

Figure 7.--Root system of a Jeffrey pine with the 12-Conwed container removed ten years after outplanting (grid = 4x4cm).

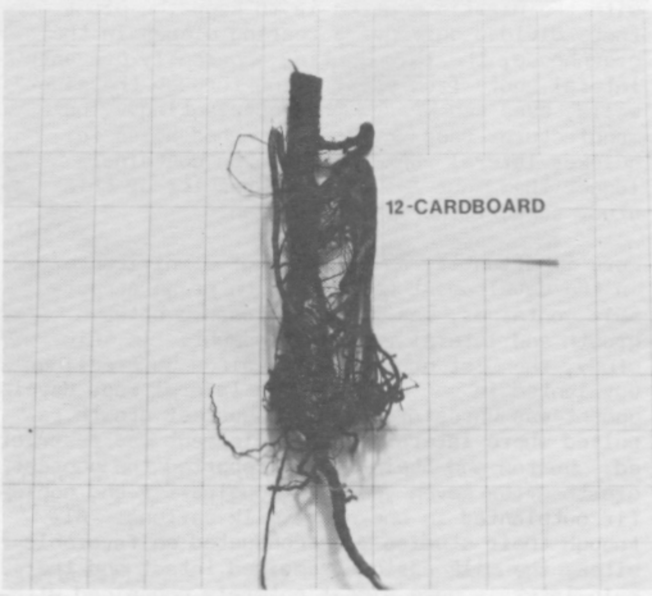

Figure 8.--Root system of a Jeffrey pine with the 9+3-Conwed container removed ten yers after outplating (grid = 4x4cm).

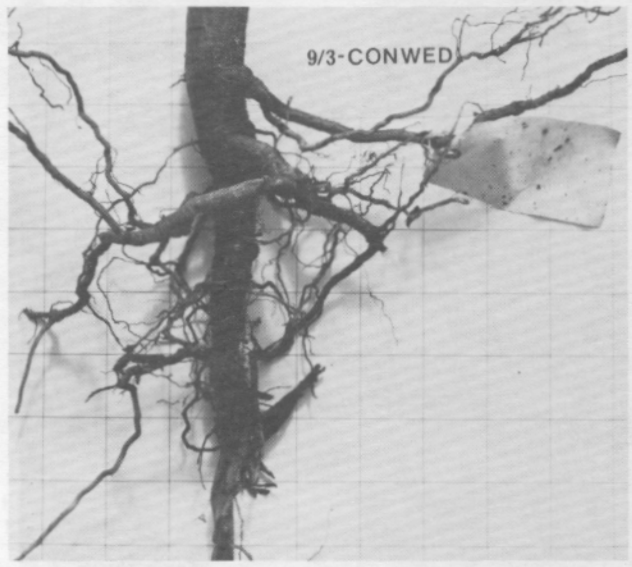

Figure 9.--Root system of a Jeffrey pine with the 12-Zeiset container removed ten years after outplanting (grid = 4x4cm).

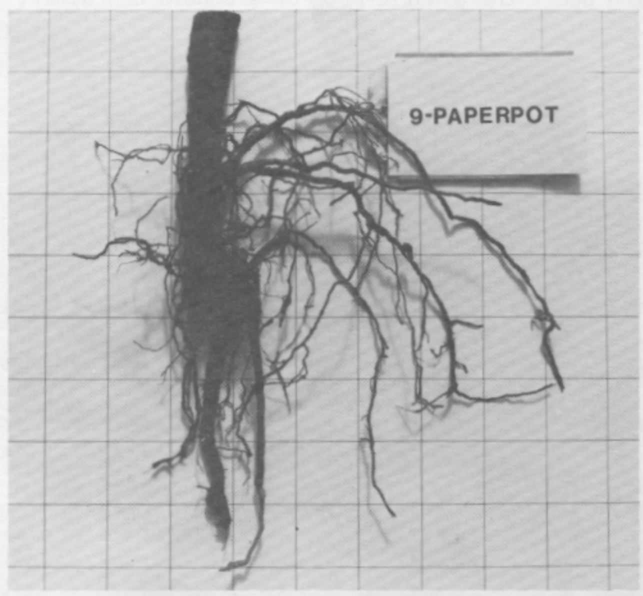

Figure 10.--Root system of a Jeffrey pine with the 8-Paperpot container removed ten years after outplanting (grid = 4x4cm).

The growth and development of seedlings outplanted in Conwed containers also dispel some of the early fears of root constriction problems associated with the plastic mesh type of container. Although Barnett (1982) reported that loblolly pine roots can become severly constricted by the plastic mesh three years after outplanting, the results of this study indicated that the lateral roots can break apart the plastic mesh. The Conwed material has been manufactured in various degrees of flexibility, and the material used in Barnett's study was less flexible than the material used in this study. Owston and Stein (1978) tested the same Conwed material as used in this study and reported girdling on the lateral roots. They found that the lateral roots penetrating the plastic mesh were smaller in diameter than those penetrating peat-fiber pots. The root constriction problem associated with plastic mesh containers may reduce growth somewhat; however the problem appears to be relatively minor and apparently short-lived compared to the root restriction problem associated with solid wall containers.

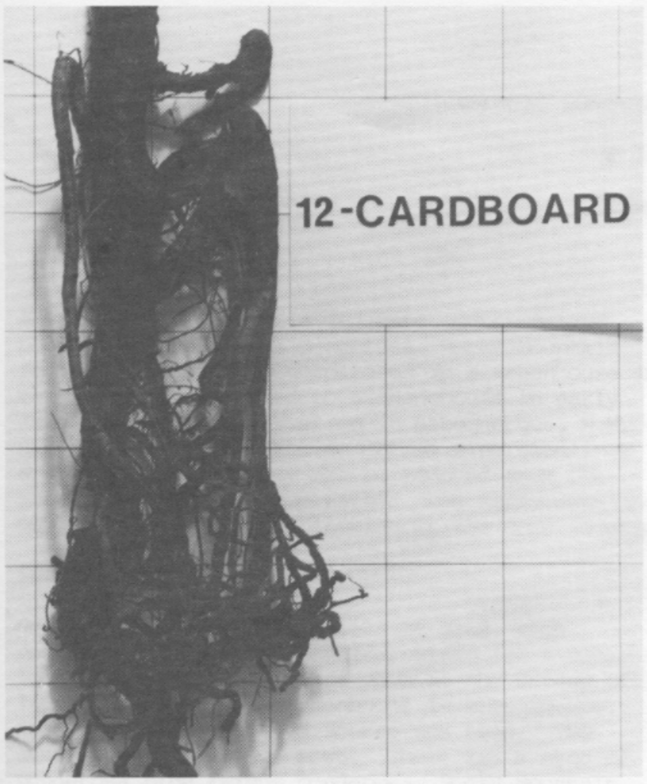

Figure 11.--Jeffrey pine root system showing the restriction of lateral root development after ten years in a 12-Zeiset container (grid = 4x4cm).

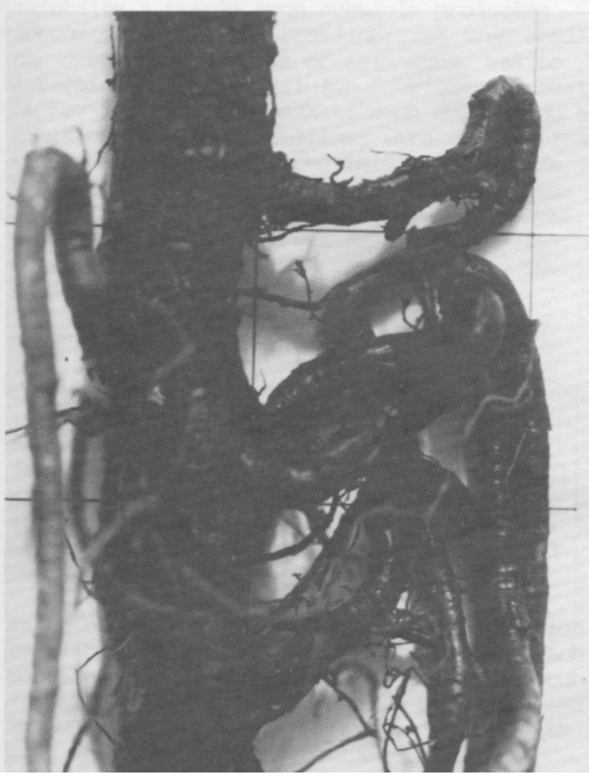

Figure 12.--Close-up view of a Jeffrey pine root system showing deformation after ten years in a 12-Zeiset container (grid = 4x4cm).

CONCLUSIONS

The acceptance of a container type for any system will depend on a number of variables. The field performance of outplanted seedlings will help evaluate the containers presently available and will aid the development of future containers. The higher survival and better overall growth obtained with the plastic mesh containers suggest the importance of unrestricted lateral root development. The root constrictions which did appear on the laterals due to the plastic mesh did not appear to adversely affect the seedling growth and development compared to the effect of restricted lateral root development found on the cardboard containers. Although a biodegradable plastic mesh container would appear promising, the relatively high cost of biodegradable plastic has discouraged further development (Barnett 1982; Barnett and McGilvroy 1981).

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