ROOT GROWTH OF CONTAINER-GROWN STOCK AFTER PLANTING 1/

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Abstract.--Describes root growth of bullet, tube and plug seedlings planted experimentally throughout British Columbia from 1967-73. Container design of bullets and tubes caused asymetric root development. Root growth of styro-plugs did not show a similar container effect.

INTRODUCTION

The morphology of root systems of planted container-grown stock has long been of interest to foresters concerned with development and application of container seedling planting techniques. Frequently, reluctance to accept this planting method as a viable alternative to bareroot planting stemmed from fears of potential constriction of roots by seedling containers. The "plug" concept, whereby seedlings are container-grown but are removed from the container prior to planting and planted free of any container restraint, has, however, found wide acceptance.

Although our observations indicate that planting seedlings free of any container restraint results in a relatively symmetrical root form, we have also noted that factors other than the presence or absence of the container after planting leave their imprint on root system development. In addition to the effects of planting method, soil and site conditions, and genetic/ecological factors, the ultimate form of the root system of planted container stock is dependent upon the initial shape and size of the root system, as determined by design and size of the container and by nursery practice.

This presentation outlines some of our preliminary observations and impressions of root development for seedlings in Walters' bullets, bullet-plugs, Ontario tubelings, bareroot stock and styro-plugs.

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INFLUENCE OF CONTAINER DESIGN

As discussed elsewhere in this symposium, the design of Walters' bullets and BC/CFS styroblocks permits air-pruning of roots. Thus, roots which have reached the drainage hole, and in the case of Walters' 4½-inch plastic bullets, the side-slit, are dried off and form what we have termed root buds. Therefore, pot-binding of seedlings raised in these containers is essentially prevented and root growth subsequent to planting is initiated from the growing points at the root buds. To date, we have found no evidence to suggest that tap-root development has been impeded as a result of air-root pruning.

The typical pattern of root development of seedlings raised and planted in Walters' bullets shows roots egressing from the side-slit(s) and the drainage hole at the base of the container (fig. 1; Tables 1 and 2). Although removal of bullet-seedlings from their containers and planting the seedlings as bullet-plugs results in more uniform distribution of roots around the entire "root plug" (fig. 2), the original imprint of the bullet container may still result in a relatively asymmetric root form, with much of the developing root system emerging from the line formerly occupied by the vertical slit of the bullet (Table 1).

Observations of root development of Ontario tubes and bareroot stock show roots of the former egressing from the container bottom and lower portion of the vertical slit (fig. 3; Tables 1 and 2), while for the latter, root growth is oriented in the direction of the planting slit (Tables 1 and 2).

Figure 1.--Root development of bullet-planted western hemlock seedling, six years after planting on Southwestern Vancouver Island at 500 feet A.S.L.

Figure 2.--Root development of bullet-plug of western hemlock, six years after planting on Southwestern Vancouver Island at 500 feet A.S.L.

Table 1.--Distribution of main roots[1/] of container and bareroot coastal Douglas-fir seedlings, five years after planting.

Quadrant	Seedling Categories				
	6-cm Bullet	11-cm Bullet	11-cm Bullet-plug	Ontario tube	2-0 Bareroot
	Main Roots (%)				
1[2/]	36	40	33	39	33
2	24	21	20	21	26
3	20	21	28	23	23
4	20	18	19	17	18
No. Seedlings Sampled	37	37	24	30	33

[1/] All roots with a diameter of 3mm or more

[2/] For container stock, the open slit was located in first quadrant while for bareroot seedlings the same quadrant coincided with the direction of the planting slit.

Table 2.--Distribution of main roots[1] of container and bareroot white spruce, lodgepole pine, and interior Douglas-fir seedlings, five years after planting.

Quadrant	Seedling Categories											
	6-cm Bullet			11-cm Bullet			Ontario tube			Bareroot[3]		
	Ws[4]	Lp	Df	Ws	Lp	Df	Ws	Lp	Df	Ws	Lp	Df
	Main Roots (%)											
1[2]	53	40	24	36	41	43	32	40	22	72	55	51
2	15	21	21	16	18	19	24	20	19	12	23	13
3	12	23	22	20	15	16	26	20	34	10	12	20
4	20	16	33	28	26	22	18	20	25	6	10	16
No. Seedlings Sampled	20	20	20	20	20	20	20	20	20	12	12	12

1/See Table 1.
2/See Table 1.
3/White spruce: 2+1+1   Lodgepole Pine: 2+1   Douglas-fir: 2+1
4/Ws - White spruce   Lp - Lodgepole Pine   Df - Douglas-fir

Figure 3.--Root development of white spruce in Ontario tube, three years after planting in the North Central Interior of British Columbia at 3,000 feet A.S.L.

Preliminary observations indicate that root growth of styro-plugs after planting is highly symmetrical. Two or three years after planting, the root system of styro-plugs typically shows a large mass of fibrous roots which are evenly distributed around and along the original root plug (fig. 4 and 5).

Figure 4.--Root development of styro-plug 2 of lodgepole pine, three years after planting on South Central Vancouver Island at 2,000 feet A.S.L.

Figure 5.--Root development of styro-plug 8 of Sitka spruce, two years after planting on the West Coast of Vancouver Island at 800 feet A.S.L.

Figure 6.--Grafting of roots of bullet-planted white spruce seedling, four years after planting in the North Central Interior of British Columbia at 3,000 feet A.S.L.

Smooth-walled and cylindrical containers are conducive to spiralling of primary laterals around the tap root. Therefore, present styroblock cavities are manufactured with vertical ribs, raised ridges which guide lateral roots down to the drainage hole in a relatively straight line after they hit the container wall. This modification of the original styroblock design has substantially reduced spiralling of root systems in the nursery. To date, development of outplanted seedlings raised in ribbed styroblocks has not been evaluated. However, like Jansson (1971), we have found no direct evidence to date to suggest that circling of roots of container-grown stock has contributed to seedling mortality and/or reduced growth. In our opinion, most of the original root mass will fuse through grafting, whether spiralled or not, thus rendering it unlikely that trees would die from strangulation of circled roots.

Grafting of roots within the original root plug of planted container stock may commence within two years after planting. The main lateral roots, especially on high sites, are forced together soon after planting, causing the formation of root grafts. As root growth proceeds, individual roots fuse to form one root within the cambium (fig. 6). Although much of the outer bark is sloughed off, some bark and growing medium may be incorporated within the fused root portion. However, to date, no pathogenic infections have been found as a result of these inclusions.

INFLUENCE OF NURSERY PRACTICE

The size of the root system for a given container volume is primarily a function of nursery practice. Strengths or weaknesses of cultural regimes, the nurseryman's experience, and the intensity of care will all have their impact on the size and growth potential of the root system at time of outplanting.

Failure to provide for adequate pruning may necessitate removal of a portion of the root system at a time when the potential for new root growth is low or, in the absence of further pruning, result in serious kinking of roots after planting (Harris, 1967; Harris et al., 1973). Insufficient protection from low temperatures during overwintering may result in root dieback and significantly reduce, if not eliminate, the potential for root extension after outplanting. For coastal Douglas-fir, this type of root damage will occur at 16°F (Parker, 1973)3/ We also have evidence to suggest that root growth potential may be affected by the amount of lime in the growing medium and we suspect that inadequate levels of phosphorus in our earlier nutritional schedules may have precluded optimum initial

3/Personal communication

root growth after planting in our first plantations.

The probability of the occurrence of moribund roots of trees raised in Walters' bullets or styroblocks is small because container design together with cultural practices essentially prevents pot-binding of root systems in these containers. Nonetheless, an excessive and overly compacted root mass may result from undue extension of the growing period. The size of root system, which is to be contained in a given container without pot-binding, must be conducive to optimum tree survival and growth and permit high planting rates with minimum disturbance of the root system. For styro-plugs 2 of most British Columbia conifers, a root mass of .30 to .50 gm (dry weight) appears to be sufficient to satisfy the stated criteria. At weights less than .30 gm the integrity of the plug is jeopardized, planting rates decline, disturbance to the root system during planting is increased, and root growth after planting may be insufficient to sustain optimum tree growth.

INFLUENCE OF SOIL AND ENVIRONMENTAL CONDITIONS

In addition to the effects of stony and heavy soils on root system development, other environmental conditions may result in deformation and/or limited root growth. The effects of a hard pan on root development of container-grown stock are similar to those reported for bareroot stock by Schultz (1973). Root development on such sites is restricted and frequently the taproot is severely kinked.

On some sites, and under certain weather conditions, repeated frost heaving of bullet and tube seedlings may limit root growth and severely bend the root system. Frost heaving of plugs has not been a problem to date.

On stony soils and, occasionally, on heavy soils during droughty conditions, gun-planting of bullets may result in extensive damage to seedling root systems. On such sites, using the contained seedling as an integral part of the planting tool is, therefore, not recommended. The question as to whether dibble planting on heavy clay soils inhibits root development after planting, as a result of a relatively impenetrable clay barrier, still needs investigating.

CONCLUSION

In this report, we presented preliminary evidence that root development of plugs, especially styro-plugs, was more symmetrical than that of bareroot stock and seedlings raised and/or planted in Walters bullets and Ontario tubes. Our observations also indicate that strangling of roots of styro-plugs, as a result of spiralling of primary laterals around the tap root, is probably prevented container design, cultural practice, and grafting of roots within the plug. Nonetheless and because of the well-founded concern of others over potential root problems that may arise from seedling cultural in containers, present our conclusions with guarded optimism. Finally, we emphasize the need for thorough and continued study of root development of planted trees, whether established by conventional techniques or other methods still in developmental stages.

LITERATURE CTTATIONS

Harris, R.W.
1967. Factors influencing root development of container-grown trees. In Proceeding of forty-third international shade tree conference. p. 304-312.

Harris, R.W., Davis, W.B., N.W. Stice and D.W. Long.
1973. Effects of root-pruning and transplanting in liner production. American Nurseryman. Vol. CXXXIII, No. 9:10-11, 89-91.

Jansson, Karl-Ake.
1971. En orienterande studie av rotade tallplantor avseende rotdeformation (A pilot study on rooted pine-plants concerning root deformation). Institutionen for Skogsforyngring, Skogshogskolan. Rapporter och Uppsater. Nr 31, 25 p.

Schultz, R.P.
1973. Site treatment and planting method alter root development of slash pine. USDA, Forest Service, Southeastern Forest Expt. Station. Research paper SE-109, 11 p.