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16. Abstract

A five-year study was initiated in 1972 to study propogation procedures, artificial soil mixes and season of planting for two types of tubeling containers. A cost comparison, based on plant survival was also made between plant materials grown in the two types of tubeling containers.

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FINAL REPORT

(1972 - 1977)

NATIVE VEGETATION

DEVELOPMENT

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

in cooperation with the

FEDERAL HIGHWAY ADMINISTRATION

October 1977

CONTENTS

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SUMMARY

Planting newly constructed areas adjacent to highways not only adds to the aesthetic qualities of the highway right-of-way but also helps control wind and water erosion and provides wildlife habitat. In recent years reforestation planting methods have switched from the use of plants grown bare root to tube container grown plant materials. The use of tubeling grown plant materials by both private and public forestry agencies has been successful in increasing the survivability of timber tree plantings. Hodder, 1971, found that plant materials from 2 1/2" x 24" paper tubes had higher rates of survival than those from conventional sources. Colby, 1973, concluded that plant materials could be produced more economically in tube containers than conventional types of containers.

This study was begun in 1972, to study propagation procedures, artificial soil mixes and season of planting for two types of tubeling container. The tube containers studied had 7.7 (126.1cc) and 3.4 cubic inch (55.7cc) holding capacities.

During the propogation phase of the study it was observed that tube containers had to be elevated above solid surfaces to stimulate root pruning.

Air pruning of the main root promotes the growth of secondary roots which retards the development of a root bound condition.

The water reservoir at the top of both of the tube containers studied was considerably smaller than conventional containers. This can prevent the irrigation system from delivering adequate water into the tube to completely moisten all the artificial soil mix. Irrigation schedules have to be adjusted to compensate for the small water reservoir of the tube container.

Poor root growth occurred in artificial soil mix which contained a high percentage of giant arborvitae sawdust.

During the field planting phase of the study it was observed that tubeling plant survival was highest for early spring planting than fall planting. Plantings of tubeling grown snowberry and rose survived better on west facing slopes than east facing slopes. Frost heaving was extensive with fall planted material in mountainous areas with low snowfall.

Plants grown in the 7.7 cubic inch (126.1cc) tube had better survival than those grown in the 3.4 cubic inch (55.7cc) tube. This was reflected in lower cost per plant for those grown in the 7.7 cubic inch (126.1cc) tube.

CONCLUSIONS AND RECOMMENDATIONS

The study was divided into two phases: (1) Propagation and (2) Field Planting. These phases are covered in detail in the DISCUSSION portion of the report. Conclusions are listed by Study Section, and overall recommendations are presented.

CONCLUSIONS

Propagation Phase

The propagation phase of the study involved growing various types of plant materials in two types of tube containers. Root growth and root tube integrity were evaluated for 100 soil mixes. The following conclusions were reached:

1. Tube containers must be elevated above a solid surface to allow air pruning of roots.
2. The duration and frequency of irrigation must take into account the limited water reservoir at the top of the tube and the affect of plant foliage forming a canopy over the tube.
3. Poor root growth occurred in soil mixes which contained high percentages of giant arborvitae sawdust. This appeared to be due to a low pH because poor root growth was corrected by adding dolomite to the soil mix.
4. A higher percentage of Lowfact cotoneaster and English ivy root tubes remained intact when grown in 7.7 cubic inch (125.1cc) than when grown in the 3.4 cubic inch (55.7cc) tubes.

Field Planting Phase

The field planting phase of the study consisted of planting various types of plant materials at different planting dates at six locations. In each of those area's, percent survival, height and root growth of the plants were recorded. The following conclusions were reached:

1. At Brady, English ivy, lowfast cotoneaster and Oregon grape survival was highest when grown in the 7.7 cubic inch (126.1cc) container. Douglas spirea had the highest survival when grown in the 3.4 cubic inch (55.7cc) tube.
2. In the Olympia vicinity survival rates for spring planted rose and snowberry was superior to fall planting. Root development was most extensive for spring planted snowberry.
3. For Snoqualmie, Swauk and Satus Passes, spring planted snowberry had higher survival rates than fall plantings. Highest survival rates were obtained in areas where highest precipitation rates occurred. In areas with lower precipitation rates, tubeling frost-heaving was more extensive.
4. For Rosalia vicinity plantings, rose on west-facing slopes had higher survival rates than on east-facing slopes regardless of season of planting. Those plant materials that did survive on east-facing slopes had more extensively developed root systems than plant materials on west-facing slopes.

Cost Comparison Phase

Cost comparison between the 7.7 cubic inch (126.1cc) and the 3.4 cubic inch (55.7cc) tubes showed that English ivy, cotoneaster 'lowfast' and Oregon grape were less expensive, based on cost per thousand surviving plants, when grown in the larger tube. The reverse was true for Douglas spirea.

RECOMMENDATIONS

During propagation, tube containers must be elevated above solid surfaces to enable air root pruning to occur. Tube soil mix moisture should be checked periodically to ensure that the irrigation schedule is adequate. Giant arborvitae sawdust should not be used as a soil mix component. When feasible, planting should be done during early spring.

The 7.7 cubic inch (126.1cc) tubelings should be used instead of the 3.4 cubic inch (55.7cc) tubelings because the larger tubelings are less expensive when compared on the basis of cost per number surviving.

IMPLEMENTATION

During the course of this study the Washington State DOT Division of Highways has incorporated the use of tubelings into its landscape program. To date 30,000 tubelings have been used. From this experience it appears that tubelings are of benefit for areas where there are short growing seasons, like mountainous areas because the normal period for fall planting in these area's does not coincide with the normal period of digging bare root grown plant materials. When field grown plant materials are dug too early in the fall they have not been hardened off sufficiently to withstand the early frost that occur in mountainous areas. Under these conditions the Department intends to continue to use tubeling grown plant materials.

NOTE:

Field data obtained during the conduct of this study is on file at Washington State Department of Transportation Headquarters in Olympia, Washington. Inquiries should be directed to Dr. Russell Rosenthal at Phone 206-753-0854.

INTRODUCTION

Planting newly constructed areas adjacent to highways not only adds to the aesthetic qualities of the highway right-of-way but also helps control wind and water erosion and provides wildlife habitat.

Planting of constructed areas adjacent to highways is an accepted procedure to reduce maintenance and add to the aesthetic qualities of highway right-of-way areas. In the past small plant materials have been planted bare root or from shallow depth containers (4 inches - 10cm or less).

In recent years reforestation planting methods have switched from the use of bare root grown to tube container grown plant materials. The use of tubeling grown plant materials by both private and public forestry agencies has been successful in increasing the survivability of timber tree plantings. The reason for this appears to be that air drying of root systems is decreased when the root system is enclosed in a soil mix during the planting process.

Investigation into the use of tube containers for plant materials other than timber species has been limited.

During 1972 the Washington State Nurserymen's Association (WSNA) expressed an interest in participating in a joint research effort on tubeling grown plant materials between themselves and the Washington State Department of Transportation.

Research project number 523 was initiated in 1972 as a joint effort with the Washington State Nurserymen's Association. Plant materials were propagated and donated for use in the study by WSNA members.

STUDY OBJECTIVES

The objectives of the study were:

1. To evaluate procedures for propagation of native plant materials in tube containers.
2. To evaluate various types of artificial soil mixes.
3. To evaluate methods and season of planting.

METHODS AND PROCEDURES

Investigation began in the spring of 1972 and was composed of two phases.

Propagation Phase

The propagation phase of the study consisted of growing the plant materials in tube containers by members of the WSNA. Two types of tube container were used. Examples of these containers are shown in Figure 1. The black plastic block contained one hundred cavities, each measuring 1" x 6" (2.5cm x 15cm), top diameter and depth respectively with a 3.4 cubic inch (55.7cc) capacity. The white styrofoam block contained eighty cavities, each measuring 1.5" x 6.25" (3.75cm x 15.62cm), top diameter and depth respectively with a 7.7 cubic inch (126.1cc) capacity.

Both types of container blocks had drain holes at the bottom of each tube cavity. The tube is constructed in such a way that when the tube blocks are placed on wire screen, the plant roots are air pruned when they grow out the drain hole. This process can prolong or, in some cases, prevent a root bound condition from developing.

To evaluate media mixes, perennial rye grass was planted in 100 different mixes composed of varying ratios of peat, Douglas-fir bark, Douglas-fir sawdust, giant arborvitae sawdust, vermiculite, sand and perlite. Both the 1 (2.5cm) and 1.5 (3.75cm) inch diameter tubes were used. After one month of growth in the greenhouse, plants were pulled from the cavities and root tube integrity was rated on a visual scale from one to ten, with ten being best and one poorest.

The following species were used in this study to evaluate method and season of planting:

Cotoneaster, lowfast	Mockorange, Lewis
Cotoneaster, willowleaf	Ninebark, mallow
Holly, Japanese (Howard)	Oregon grape
Holly, Japanese (Highland)	Rose, Nootka
Ivy, English	Snowberry, common
Maple, vine	Spirea, Douglas

The vine maple and paper birch were propagated from seed. The rest of the material was started directly from cuttings in tubes.

To obtain maximum growth all plant materials were grown in the greenhouse using artificial soil mixes. Plants were watered daily and fertilized periodically. Seedlings and cuttings were planted out in the test areas when root development had progressed to the point of holding the soil mix intact when removed from the tube and the field conditions were condusive for good plant survival.

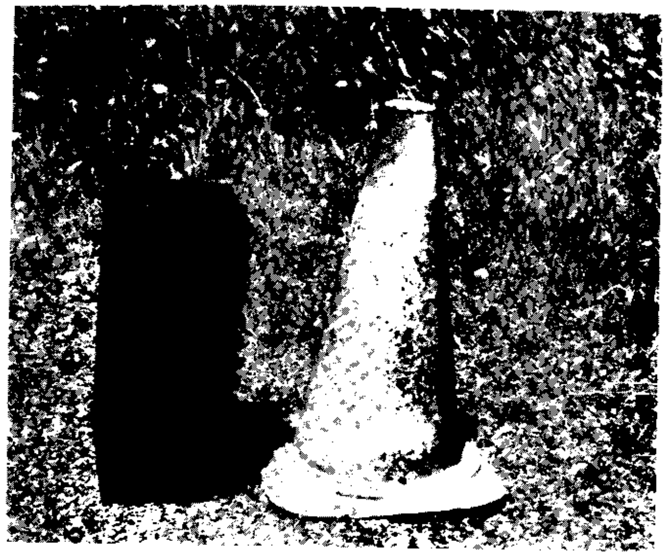
During plant propagation observations were made as to the advantages and disadvantages of the tube containers.

Field Planting Phase

The field planting phase of the study consisted of planting the plant materials out along the highway and collecting the following data:

1. Percent survival.
2. Amount of top growth after planting.
3. Amount of root growth after planting (number of roots per plant longer than 4" and the length of the longest root).

Plants were put out at six locations, Figure 3: Olympia, Brady, between Rosalia and Colfax, and Snoqualmie, Satus and Swauk Passes.



A

B

FIGURE 1

Examples of tube containers used in study.

A. Plastic block containing 100 cavities, each measuring 1" x 6" (2.5cm x 15cm), top diameter and depth respectively with 3.4 cubic inch (55.7cc) capacity.

B. Styrofoam block containing eighty cavities, each measuring 1.5" x 6.25" (2.75cm x 15.63cm), top diameter and depth respectively with 7.7 cubic inch (126.1cc) capacity.

Planting was accomplished with a dibble which had the same dimension as the tube container. An example of the dibble toll is shown in Figure 2. The cross-bar of the dibble was to prevent making a deeper hole than the length of the tubeling plant, thus preventing an air space from occurring at the bottom of the planting hole. The cross-bar also served as a foot lever to force the dibble into the soil.

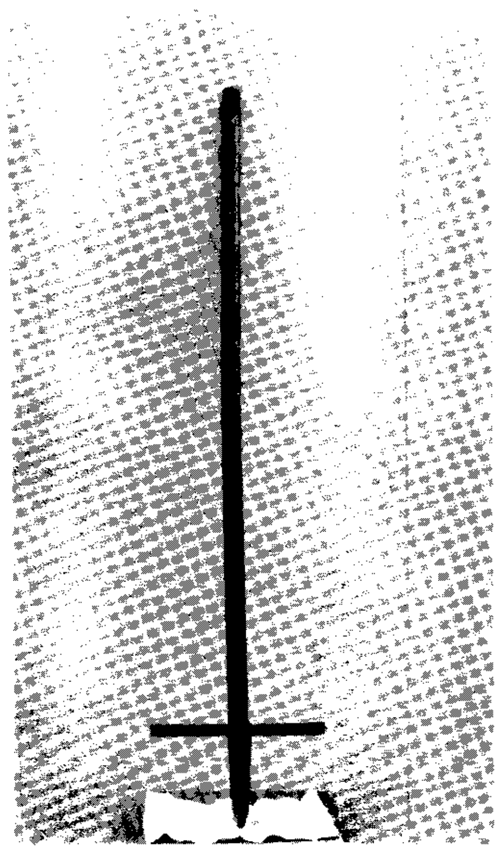


FIGURE 2

Example of planting dibble tool used in study.

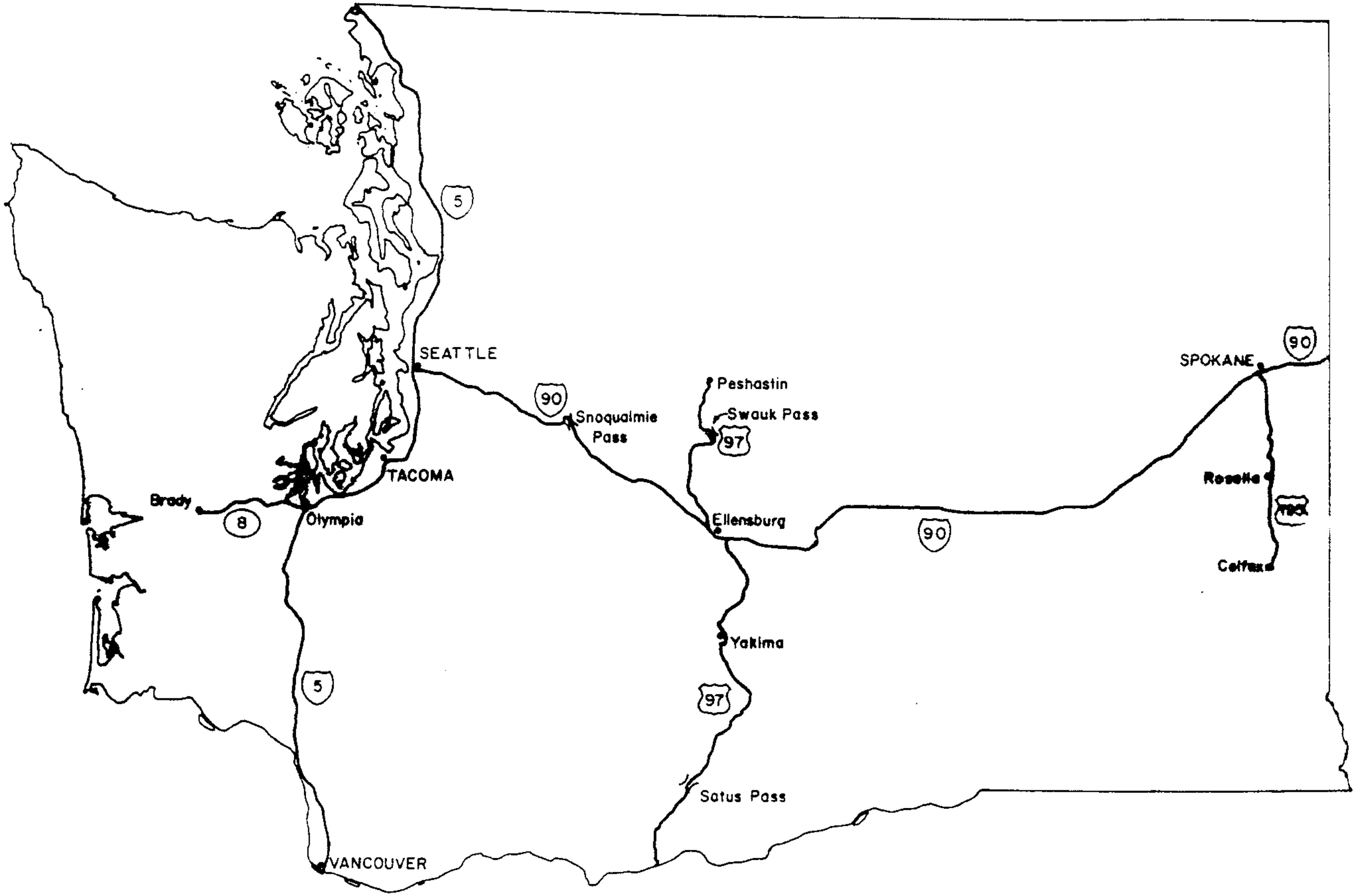


Figure 3-Test site locations (Brady, Olympia, Rosalia to Colfax and Snoqualmie, Satus and Swauk Passes)

Cost Comparison Phase

In a study by Colby and Lewis (1973) the following comparative equation was developed to evaluate propagation methods:

$$x = \frac{Pr + T + P}{S}$$

Where

x = Total cost per thousand surviving plants.

Pr = Production cost per thousand plantable seedlings, including depreciation and overhead. To account for length of holding period, compound annual costs incurred prior to the planting year at an appropriate interest rate.

T = Transportation cost per thousand plantable seedlings from production site to planting life.

P = Site preparation and planting cost per thousand plants.

S = Survival rate of plants planted, preferably at the time plants are considered established.

By assuming equal cost for Pr + T + P between the 3.4 cubic inch (55.7cc) and 7.7 cubic inch (126.1cc) containers and using the cost figures developed by Colby and Lewis for a greenhouse system cost per thousand based on survival where compared. In the Colby and Lewis study Pr - $145.81, T = $35.50 and P = $170.00.

Propagation Phase - Conclusion

During the propagation phase of the study, it was observed that tube containers have the following advantages over conventional types of containers:

1. A larger number of plant materials can be grown in a small area.
2. Plant materials from tube containers have a deeper root system than materials from conventional containers with comparable soil holding capacities.
3. Plant materials do not become root bound as easy as with conventional containers (due to air pruning).
4. Both types of tubes studied were found to be reusable. The styrofoam block remained intact through two complete propagation phases. After the second crop the blocks had structurally deteriorated to a point of being unusable. The black plastic blocks after a second propagation phase showed no noticeable deterioration.

The initial cost of the styrofoam tubes were lower than the black plastic tubes; $0.325 versus $.045. However, since the black plastic tubes can be **reused** for more crops than the styrofoam tubes their cost per crop would be less than the styrofoam tube.

The following disadvantages were observed:

1. Tube containers cost more than comparable sized conventional types, on a per plant basis with a single use concept.
2. Plant materials in tube containers are more difficult to irrigate because of a smaller water reservoir at the top of the container.
3. Plant materials with relatively large leaves, like English ivy, can prevent irrigation water from reaching soil.

To take full advantage of the air root pruning quality of tube containers propagation bench tops should be constructed of wire mesh. This converting of bench tops from wood to wire could be an initial disadvantage because of cost.

Plant materials which were grown in blocks which had been placed directly on wood bench tops or plastic had roots growing out of the drain holes (Figure 4). Many of these plants could only be pulled from the tube cavities when the roots were cut flush with the drain holes. In some cases this resulted in the loss, of over half the plant root system.

Table 1 shows the degree of root tube integrity from different ratio's of soil mix components.

Root tube ratings showed that generally ratings were higher for the smaller cavities regardless of the soil mix. This was probably due to the difference in soil-holding capacities. The smaller the cavity the sooner plant roots can penetrate the entire tube.

With the larger cavities, those mixes which had a higher percentage of giant arborvitae sawdust had the lower ratings. When Douglas fir sawdust replaced giant arborvitae sawdust as a soil mix component, root tube ratings increased. This appeared to be caused by a low pH from the arborvitae sawdust because the poor root growth could be corrected by adding dolomite to the soil mix.

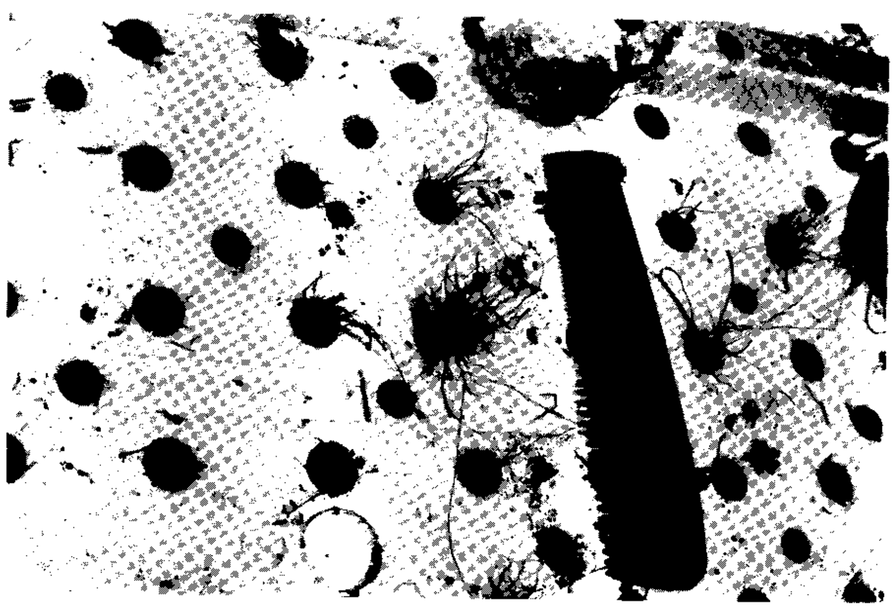


FIGURE 4

Example of plant roots growing out of the drain holes of tube containers.

Generally, a soil mix composed of around 60% organic matter and 40% sand when the organic matter content was peat, Douglas-fir bark or Douglas-fir sawdust, worked well. A complete list of soil mixes that were evaluated is included in the Appendix.

TABLE 1

AFFECT OF SOIL MIX COMPONENTS ON ROOT TUBE INTEGRITY

SOIL MIX COMPONENT (%)					AVERAGE ROOT TUBE READING [y]	
PEAT	DOUGLAS FIR SAWDUST	GIANT ARBORVITAE SAWDUST	SAND	PERLITE	7.7 cu. in. (126.1cc)	3.4 cu. in. (55.7cc)
25	50	—	12.5	12.5	7.0 bcd [z]	8.2 abc
25	50	—	5.0	20.0	8.8 ab	8.9 ab
25	50	—	20.0	5.0	9.8 a	9.7 a
25	—	50	12.5	12.5	2.0 i	5.3 def
25	—	50	5.0	20.0	3.2 hi	5.3 def
25	—	50	20.0	5.0	3.6 fghi	6.3 cde
15	60	—	25.0	—	8.0 abc	8.8 ab
15	—	60	25.0	—	7.4 bc	7.9 abc
15	60	—	12.5	12.5	7.8 abc	8.6 ab
15	60	—	20.0	5.0	8.0 abc	8.5 ab
15	—	60	12.5	12.5	3.6 fghi	4.6 efgh
15		60	5.0	20.0	3.8 fgh	5.0 efg
15	—	60	20.0	5.0	3.4 ghi	4.5 efgh

y 10 = Best, 1 = Poorest

z Any two comparable means not followed by the same letter are significantly different at the 1% level according to Duncan's multiple range test.

Root cuttings of 'Lowfast' contoneaster and English ivy were planted directly into tube containers. Three months after planting, a higher percentage of root tubes remained intact for both the cotoneaster and ivy in the 7.7 cubic inch (126.1cc) tube than the 3.4 cubic inch (55.7cc) tube.

The difference in root tube integrity was attributed to a difference in the ability to irrigate the two types of tubes. The smaller tubes were placed 1/8 inch (0.3cm) apart while the larger tubes were 3/8 inch (0.9cm) apart. This difference in spacing plus the difference in tube diameter, one inch vs. one and one-half inches, enables species such as English ivy, in the small tube, to form a canopy above the tubes which prevented direct water movement into the tubes. The larger tubes were spaced far enough apart to allow better water movement into the tubes.

TABLE 2
PERCENTAGE OF ROOT TUBES THAT REMAINED INTACT AFTER BEING PULLED FROM TWO CONTAINER TYPES

SPECIES	3.4 cu. in. (55.7cc) CAPACITY CONTAINER	7.7 cu. in. (126.1cc) CAPACITY CONTAINER
Cotoneaster 'Lowfast'	60	73
English ivy	74	98

1. Tube containers must be elevated above solid surfaces to allow air pruning of roots.
2. The duration and frequency of irrigation must take into account the limited water reservoir at the top of the cavity, tube volume and the affect of plant foliage from forming a canopy over the tube.
3. Poor root growth occurred in soil mix's which contained high percentages of arborvitae sawdust.
4. A higher percentage of Lowfast cotoneaster and English ivy root tubes remained intact when grown in the 7.7 cubic inch (126.1cc) tube than the 3.4 cubic inch (55.7cc) tube.

Field Planting Phase – Conclusion

Station II of the study included recording percent survival, height and root length for plant material planted around the State.

Table 3 shows the results of a planting at Brady. Ivy and Lowfast cotoneaster survival was highest with those plants grown in 7.7 cubic inch (126.1cc) tube.

Oregon grape survival for 7.7 cubic inch (126.1cc) container grown plants was higher than for 3.4 cubic inch (55.7cc) container grown plants. The reverse was true for the Douglas spirea.

Of the four species the highest survival was obtained by Douglas spirea followed by Oregon grape, lowfast cotoneaster and English ivy. Paper birch survival was nil.

TABLE 3
SUMMER 1976 PERCENT SURVIVAL, HEIGHT AND ROOT LENGTH
FOR PLANT MATERIALS PLANTED AT BRADY

SPACING	PLANTING DATE AND CONTAINER TYPE	NUMBER PLANTED	PERCENT SURVIVED	HEIGHT AVERAGE INCHES	HEIGHT AVERAGE CENTI-METERS	NUMBER OF ROOTS OVER 4 INCHES (10-16cm)	LONGEST ROOT AVERAGE INCHES	LONGEST ROOT AVERAGE CENTI-METERS
English ivy	Spring 1971 3.4 cu. in. (55.7cc)	258	2.7	21.8	54.1	4.4	9.3	23.6
English ivy	Spring 1973 7.7 cu. in. (126.1cc)	323	16.4	22.5	57.2	1.5	5.6	14.2
Lowfast Cotoneaster	Spring 1973 3.4 cu. in. (55.7cc)	166	13.1	11.6	34.5	5.1	6.4	16.3
Lowfast Cotoneaster	Spring 1973 7.7 cu. in. (126.1cc)	342	19.1	19.0	49.3	8.1	13.7	14.8
Oregon grape	Fall 1973 3.4 cu. in. (55.7cc)	45	17.8	—	--	--	0.6	1.5
Oregon grape	Fall 1973 7.7 cu. in. (126.1cc)	74	31.1	14.0	35.6	2.3	4.1	10.4
Douglas spirea	Fall 1971 3.4 cu. in. (55.7cc)	166	24.1	12.3	31.2	4.2	3.9	9.7
Douglas spirea	Fall 1973 7.7 cu. in. (126.1cc)	210	17.0			1.1	6.6	16.8
Douglas spirea	Spring 1974 3.4 cu. in. (55.7cc)	132	44.7	14.6	17.1	1.9	6.8	15.24
Douglas spirea	Spring 1974 7.7 cu. in. (126.1cc)	134	38.0	13.2	33.5	1.9	5.5	11.97

Table 4 shows the results of planting for the Olympia area. All plants were grown in the 7.7 cubic inch (126.1cc) tube. Spring planting of rose and snowberry was superior to fall planting. Rose survival was highest followed by snowberry, willow leaf cotoneaster, vine maple and Douglas spirea. Spring planted snowberry root development was most extensive followed by willow leaf cotoneaster, rose and Douglas spirea.

Although Japanese Holly 'Highland' survival was 100 percent it is felt that they had not been in the ground long enough for a valid comparison to the other species tested.

TABLE 4
SUMMER 1976 PERCENT SURVIVAL, HEIGHT AND ROOT LENGTH FOR PLANT MATERIALS PLANTED IN THE OLYMPIA AREA

SPECIES	PLANTING DATE	NUMBER PLANTED	PERCENT SURVIVED	HEIGHT AVERAGE INCHES	AVERAGE CENTI-METERS	NUMBER OF ROOTS OVER 4 INCHES (10-16cm)	LONGEST ROOT AVERAGE INCHES	LONGEST ROOT AVERAGE CENTI-METERS
Snowberry	Fall 1974	40	47.5	5.7	14.5	5.3	7.5	19.1
Snowberry	Spring 1975	60	76.7	6.0	15.2	3.0	6.3	16.0
Rose	Fall 1974	100	53.0	10.3	26.2	6.0	8.0	22.6
Rose	Spring 1975	55	89.1	12.3	31.2	4.0	5.9	15.0
Douglas spirea	Spring 1975	40	20.0	9.1	23.1	0.5	4.0	10.2
Vine maple	Spring 1975	20	25.0	11.0	28.0	0.5	4.5	11.4
Willow leaf Cotoneaster	Spring 1975	40	62.5	13.0	33.0	5.2	9.2	23.4
Japanese 'Highland'	Fall 1975	40	100.0	–	–	–	–	Holly
Japanese 'Howard'	Fall 1975	40	30.0	–	–	–	–	Holly

The results of the mountain pass plantings are listed in Table 5. Spring planted snowberry had higher survival rates than fall planted on Snoqualmie, Swauk and Satus Passes.

The three passes represent a wide range of annual precipitation rates: Snoqualmie, 145 inches; Swauk, 40 inches; and Satus, 29 inches. (Taken from the Climalogical Records of Columbia Basin States 1976. U. S. Weather Service.)

These differences are reflected by the survival rates observed with Snoqualmie having the highest followed by Swauk and Satus. This trend was also the same with the spring planted snowberry. Frost heaving of the root tubes was severe for fall plantings on Satus Pass. This did not occur with the other two passes' planting because they were covered with snow during the winter months.

TABLE 5
SUMMER 1976 PERCENT SURVIVAL, HEIGHT AND ROOT LENGTH FOR MATERIALS PLANTED AT SNOQUALMIE, SWAUK AND SATUS PASSES

Location	Species	Planting Date	Number Planted	Percent Survival	Height Average Inches	Height Average Centi-meters	Number Of Roots Over 4 Inches (10-16cm)	Longest Root Average Inches	Longest Root Average Centi-meters
Snoqualmie	Snowberry	Fall 1974	40	77.5	9.8	24.9	5.2	9.0	22.9
Snoqualmie	Snowberry	Spring 1975	19	84.2	6.3	16.9	2.5	4.5	11.4
Snoqualmie	Rose	Fall 1974	40	80.0	7.6	19.8	2.5	4.4	11.2
Swauk	Snowberry	Fall 1974	80	22.5	10.4	26.4	3.6	8.3	21.1
Swauk	Snowberry	Spring 1975	60	51.7	9.1	23.1	3.1	5.1	13.0
Swauk	Rose	Fall 1974	80	48.8	7.3	18.5	2.8	5.3	13.5
Satus	Snowberry	Fall 1974	50	0.0			--		
Satus	Snowberry	Spring 1975	50	34.0	6.4	16.3	2.4	3.9	9.9
Satus	Rose	Fall 1974	50	10.0	13.5	14.3	0.7	2.0	5.1
Satus	Rose	Spring 1975	50	13.3	8.8	22.4	3.0	8.0	20.1

Snowberry, rose, mockorange and golden ninebark were planted during the fall and spring on east and west facing slopes between Rosalia and Colfax; all species except golden ninebark had higher survival rated when spring planted than fall planted. West facing slope plantings had better survival than plantings on east facing slopes regardless of planting season. Snowberry and rose plantings on east facing slopes had more extensively developed root systems than plantings on west facing slopes. Survival percentages, height and root length are listed in Table 6.

TABLE 6
SUMMER 1976 PERCENT SURVIVAL, HEIGHT AND ROOT LENGTH FOR PLANT MATERIALS PLANTED BETWEEN ROSALIA AND COLFAX

Species	Slope Exposure	Planting Date	Number Planted	Percent Survival	Height Average Inches	Height Average Centi-meters (10-16cm)	Number Of Roots Over 4 Inches	Longest Root Average Inches	Longest Root Average Centi-meters
Snowberry	West facing	Fall 1974	110	55.5	7.0	17.8	3.5	5.8	13.5
Snowberry	West facing	Spring 1975	60	70.0	6.8	17.3	2.3	3.9	9.9
Snowberry	East facing	Fall 1974	110	25.4	5.3	13.5	4.4	7.2	18.3
Snowberry	East facing	Spring 1975	60	60.0	5.9	15.0	3.5	5.2	13.2
Rose	West facing	Fall 1974	110	51.8	10.2	26.0	3.5	4.8	12.2
Rose	West facing	Spring 1975	43	60.4	14.9	37.9	2.4	6.3	16.0
Rose	East facing	Fall 1974	110	32.7	6.8	17.3	4.7	9.2	23.4
Rose	East facing	Spring 1975	43	17.2	10.4	26.4	1.8	3.1	7.9
Golden ninebark	West facing	Fall 1975	60	11.6	13.8	35.0	7.0	8.1	20.3
Golden ninebark	West facing	Spring 1976	31	19.3	14.0	35.6	3.2	3.0	7.6
Golden ninebark	East facing	Fall 1975	60	10.0	15.8	40.1	1.4	2.8	7.1
Golden ninebark	East facing	Spring 1976	31	12.9	7.6	19.3	1.5	2.8	7.1
Mockorange	West facing	Fall 1975	80	26.2	14.9	37.8	7.8	8.2	20.8
Mockorange	West facing	Spring 1976	39	20.5	6.8	17.3	1.0	1.4	3.6
Mockorange	East facing	Fall 1975	80	17.5	9.8	24.9	2.6	4.3	10.9
Mockorange	East facing	Spring 1976	39	15.3	13.0	33.0	3.0	3.5	8.9

1. At Brady English ivy, Lowfast cotoneaster and Oregon grape survival was highest when grown in the 7.7 cubin inch (126.1cc) container. Douglas spirea was highest with the 3.4 cubin inch (55.7cc) tubes.
2. Olympia vicinity survival rates for spring planted rose and snowberry was superior to fall planting. Root development was most extensive for spring planted snowberry.
3. Spring planted snowberry had higher survival rates than fall planting on Snoqualmie, Swauk and Satus Passes. Highest survival rates were obtained in areas where highest precipitation rates occurred. In areas with lowest precipitation rates tubeling frost heaving was most extensive.
4. Rosalia vicinity plantings of snowberry and rose on west facing slopes had higher survival rates than on east facing slopes regardless of season of planting. Those plant materials that did survive on east facing slopes had more extensively developed root systems than plant materials on west facing slopes.

Table 7 shows the results of comparing cost of three plant species and two container types based on survival. Oregon grape, cotoneaster and English ivy were all less expensive when grown in the 7.7 cubic inch (126.1cc) container than when grown in the 3.4 cubic inch (55.7cc) container. The largest difference was with the English ivy.

TABLE 7
COST COMPARISON PER PLANT BASED ON SURVIVAL FOR THREE SPECIES AND TWO CONTAINER TYPES

SPECIES	CONTAINER TYPE	NUMBER PLANTED	DOLLAR COST PER PLANT
English ivy	7.7 cu. in. (126.1cc)	323	2.21
English ivy	3.4 cu. in. (55.7cc)	258	11.78
Cotoneaster 'Lowfast'	7.7 cu. in. (126.1cc)	342	1.86
Cotoneaster 'Lowfast'	3.4 cu. in. (55.7cc)	366	2.72
Oregon grape	7.7 cu. in. (126.1cc)	74	1.14
Oregon grape	3.4 cu. in. (55.7cc)	45	1.96
Douglas spirea	7.7 cu. in. (126.1cc)	134	0.93
Douglas spirea	3.4 cu. in. (55.7cc)	132	0.79

APPENDIX A

COMMON AND BOTANICAL NAMES OF SPECIES MENTIONED *

COMMON NAME	BOTANICAL NAME
Arborvitae, giant	Thuja plicata
Birch, paper	Betula papyrifera
Cotoneaster, Lowfast	Cotoneaster 'Lowfast'
Cotoneaster, willowleaf	Cotoneaster salicifolia
Douglas-fir, common	Pseudotsuga menziessii
Holly, Japanese (Howardi)	Ilex crenata 'Howardi'
Holly, Japanese (Highland)	Ilex crenata 'Highland'
Ivy, English	Hedera helix
Maple, vine	Acer circinatum
Mockorange, Lewis	Philadelphus lewisii
Ninebark, mallow	Physocarpus malvaceus
Oregon grape	Mahonia aquifolium
Rose, Nootka	Rosa nutkana
Ryegrass, perennial	Lolium perenne
Snowberry, common	Symphoricarpos albus
Spirea, Douglas	Spirea douglasii

* Kelsey, H. P. and Dayton, W. A., 1942, Standardized Plant Names. J. Horace McFarland Co. 675 pp.

APPENDIX B
SOIL MIX COMPONENTS AND ROOT TUBE INTEGRITY READING FOR TWO CONTAINER TYPES

	SOIL MIX (Percent Component)							ROOT TUBE READING AVERAGE	
Soil Mix No.	Peat	Douglas Fir Bark	Douglas Fir Sawdust	Giant Arborvitae Sawdust	Vermiculite	Sand	Perlite	7.7 cu. in. (126.1cc)	3.4 cu. in. 55.7cc)
1	50		—	—	—	50		8.4	10.0
2	60					40	—	8.8	9.0
3	70					30		10.0	9.6
4	80			—	—	20	—	9.4	
5	90			—	—	10	—	7.2	
6	100						—	8.0	
7	50		—	—	50	—	—	8.8	10.0
8	30	—		—	—	—	70	9.6	9.0
9	30	70	—	—	—	—	—	4.4	8.8
10	25	—	50	—	—	25		9.8	
11	25		—	50	—	25		6.4	
12	25		25	25	—	25		8.2	
13	25		35	15	—	25		9.2	9.6
14	25		45	5	—	25	—	9.6	9.4
15	25	—	50		—	25	—	8.6	9.8
16	25	—	50	—	—	12½	12½	7.0	9.4
17	25	—	50	—	—	5	20	8.8	9.0
18	25	—	50	—	—	20	5	9.8	9.6
19	25	—		50	—	12½	12½	2.0	8.6
20	25	—	—	50	—	5	20	1.2	7.4
21	25	—		50	—	20	5	3.6	8.0
22		—	25	25	—	12½	12½	-	
23			25	25	—	5	20	2.8	
24			25	25	—	20	5	4.4	
25			35	15	—	12½	12½	5.2	9.8
26			35	15	—	5	20		9.2
27		—	35	15	—	20	5		10.0
28	25	—	45	5	—	12½	12½		8.4
29	25		45	5		5	20	8.2	9.2
30	25		45	5	—	20	5	7.6	
31	25	50		—		25		9.4	9.4
32	25	25	25	—		25		9.2	
33	25	25		25		25		7.2	
34	25	35	15			25		10.0	8.0
35	25	35	—	15	—	25		7.6	7.2
36	25	45	5		—	25	—	10.0	8.0
37	25	45		5	—	25	—	7.6	10.0
38	25	50	—	—	—	12½	12½	5.6	8.8
39	25	25	25	—	—	12½	12½	9.4	9.6
40	25	25		25	-	12½	12½	8.8	
41	25	35	15	—	—	12½	12½	7.8	
42	25	35	—	15	—	12½	12½	7.0	
43	25	45	5	—	—	12½	12½	7.0	8.6
44	25	45		5	—	12½	12½	7.0	9.2
45	15		60	—	—	25		8.0	9.6
46	15			50	—	25	—	7.4	8.4
47	15		15	25	—	25	—	8.4	8.4
48	15		25	15	—	25	—	3.8	7.8
49	15		45	15	—	25	—	8.6	9.6
50	15		5	55	—	25	—	7.8	9.2
51	15		55	5	—	25	-	9.8	9.8
52	15		15	45	-	25	-	10.0	10.0
53	15		60		—	12½	12½	7.8	9.4

APPENDIX B
(Continued)
SOIL MIX COMPONENTS AND ROOT TUBE INTEGRITY READING FOR TWO CONTAINER TYPES

SOIL MIX (Percent Component)								ROOT TUBE READING AVERAGE	
Soil Mix No.	Peat	Douglas Fir Bark	Douglas Fir Sawdust	Giant Arborvitae Sawdust	Vermiculite	Sand	Perlite	7.7 cu. in. (126.1cc)	3.4 cu. in. 55.7cc)
54	15	45	15	–	–	25	–	8.6	8.2
55	15	35	25	–	–	25	–	8.0	8.2
56	15	45	–	15	–	25	–	7.8	8.0
57	15	35	–	25	–	25	–	8.4	8.0
58	15	55	5	–	–	25	–	8.0	7.0
59	15	45	15	–	–	25	–	8.4	8.2
60	15	55	–	5	–	25	–	9.0	8.4
61	15	45	–	15	–	25	–	9.0	8.8
62	15	60	–	–	–	12½	12½	8.0	8.2
63	15	35	25	–	–	12½	12½	8.0	9.4
64	15	25	35	–	–	12½	12½	10.0	9.4
65	15	35	–	25	–	12½	12½	8.0	6.8
66	15	25	–	35	–	12½	12½	7.8	6.0
67	15	45	15	–	–	12½	12½	7.6	8.8
68	15	35	25	–	–	12½	12½	8.0	8.2
69	15	45	–	15	–	12½	12½	9.2	5.6
70	15	35	–	25	–	12½	12½	7.6	–
71	15	55	5	–	–	12½	12½	8.8	–
72	15	45	7½	7½	–	12½	12½	7.0	–
73	15	55	–	5	–	12½	12½	8.8	9.2
74	15	45	10	5	–	12½	12½	9.2	8.8
75	15	–	60	–	–	12½	12½	8.8	8.8
76	15	–	60	–	–	5	20	8.4	8.8
77	15	–	60	–	–	20	5	8.0	9.0
78	15	–	–	60	–	12½	12½	3.6	5.6
79	15	–	–	60	–	5	20	3.8	6.2
80	15	–	–	60	–	20	5	3.4	5.6
81	15	–	35	25	–	12½	12½	6.8	9.2
82	15	–	25	35	–	12½	12½	6.6	8.4
83	15	–	35	25	–	5	20	8.2	8.4
84	15	–	25	35	–	5	20	6.6	8.0
85	15	–	35	25	–	20	5	8.0	9.0
86	15	–	25	35	–	20	5	7.0	10.0
87	15	–	45	15	–	12½	12½	7.6	–
88	15	–	45	15	–	5	20	7.8	7.4
89	15	–	45	15	–	20	5	8.2	8.6
90	15	–	55	5	–	12½	12½	7.4	8.4
91	15	–	45	15	–	12½	12½	8.8	9.2
92	15	–	55	5	–	5	20	7.8	10.0
93	15	–	45	15	–	5	20	7.6	7.4
94	15	–	55	5	–	20	5	8.2	9.8
95	15	–	45	15	–	20	5	8.0	8.6
96	15	60	–	–	–	25	–	9.2	9.6
97	15	35	25	–	–	25	–	6.6	10.0
98	15	25	15	–	–	25	–	9.4	9.4
99	15	35	–	25	–	25	–	7.2	–
100	15	25	–	35	–	25	–	9.0	–

* *Average for 10 readings.* ** *1 = Poorest, 10 = Best.*

APPENDIX C

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