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REPORT

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Effect of Planting Methods on Field Performance of Black Spruce Five Years After Planting

Introduction

Planting of cutover lands has been a major component of forest management practices in Nova Scotia for many years averaging 18 million seedlings planted annually between 1990-1994. Black spruce (*Picea mariana* (Mill.) B.S.P.) has accounted for approximately 30% of these plantings.

Many factors can affect the success or failure of planted trees in their new environment including nursery stock quality, weather, handling and shipping, storage, species-site selection, microsite, and planting methods. Planters must grapple with variable site conditions, weather and production quotas all of which can lead to improper tree planting or planting faults.

Planting faults considered in this study include shallow planting, deep planting, root deformation, inadequate soil contact by loose planting, angle planting, and planting on bare mineral soil (BMS). Deep planting has been found to: increase survival and decrease height growth in red pine (Mullin, 1964); increase survival, stability, and root development (Stroempl,1990, Paterson, 1993); and increase height growth in jack pine (Paterson and Maki, 1994). Stroempl (1990) reported that shallow planting was one of the leading causes of seedling mortality. Root deformities have had diverse effects on planted trees according to Sutton (1969) and Segaran *et al* (1978). Paterson and Maki (1994) reported that planting trees on an angle and with balled roots did not seriously affect survival and growth, but could affect stability.

This report summarizes the results of a study designed to determine whether planting faults negatively affect the survival and early growth of bareroot and container black spruce. Included are the effects of planting faults on the production of multiple stems, early stem-form and root-form development.

Methods

The experiment was located on Crown land leased to Stora Forest Industries near the MacQuarrie Lake Road, Pictou County. The site was clearcut in 1986-87, brushraked and burned in 1987-88, and planted in May of 1989. Competing vegetation was controlled by applying Vision at a rate of 4.7 litres per hectare in the summer of 1989. Treatment blocks were located on a slight knoll underlain by a moderately well-drained, gravelly, sandy loam.

The trial consisted of 3 replications (blocks), 17 treatments and 30 seedlings per treatment within each block (Table 1). Blocks were located side by side and treatments were assigned to lines within each block. Spacing between trees was 1.8 x 1.8 metres.

Two stocktypes were planted: bareroot 2+1 transplant black spruce and Multipot 67 black spruce containers. Trees were graded to Nova Scotia planting stock standards and planted by NSDNR Research staff on May 9, and 10, 1989. A total of 1,530 trees were planted on 0.55 hectares.

In the fall of 1993, 5 years after planting, all planted trees were assessed for survival, and every third live tree was measured for total height and leader growth. Survival (after an arcsine transformation) and mean total height were subjected to analysis of variance ($P \leq 0.05$) separately for the bareroot and container seedlings. A Student-Newman-Keuls means separation test was used to indicate significant treatment differences after five years.

A destructive sample was undertaken in December, 1994 to measure shoot and root growth. One tree of average height for every treatment and block was carefully excavated (51 trees). All soil within a 60cm radius was excavated to a depth ensuring complete removal of the root mass. Trees were immediately transported to the Tree Breeding Center, Debert, N.S. and measured for total height, internodal growth, multiple stems, stem diameter 5cm above root collar, and fresh weights of shoots and roots. Three photograghs were taken of all excavated trees: (i) total tree, (ii) side view lower stem and roots, (iii) Top view root system.

In February, 1995, five trees per treatment per replication were measured for multiple stems and stem heights.

Table 1. Description of planting fault treatments.

Stock Type	Treatment Description	Description of Planting Method
Black Spruce Bareroot (2+1)	Too Deep	Planted, root collar 2" below ground
	Too Loose	Planted too loose, soil not tamped
	Too Shallow	Planted, root collar 2" above ground
	Curved Roots	Planted with roots curved upwards
	Rolled Roots	Planted with roots rolled into ball
	BMS[1], Scalped	Planted in 1 ft^2 exposed mineral soil
	Scalped & Replaced	Planted in exposed mineral soil, then soil covered with humus
	45° Angle	Planted at 45° angle
	Control[2]	Correctly planted
Black Spruce Container (Multipot)	Too Deep	Planted, root collar 2" below ground
	Too Loose	Planted too loose, soil not tamped
	Too Shallow	Planted, root collar 2" above ground
	Plug Flush	Planted, top of plug flush with ground
	BMS[1], Scalped	Planted in 1 ft^2 exposed mineral soil
	Scalped & Replaced	Planted in exposed mineral soil, then soil covered with humus
	45° Angle	Planted at 45° angle
	Control[2]	Correctly planted

1 BMS = Bare mineral soil
2 Guidelines used for "correct planting" (Control) are shown in Appendix I

Results and Discussion

Survival

No significant differences in 5 year survival were found among bareroot treatments (Table 2). Survival averaged 91 percent and ranged from 87 to 95 percent. Highest survival was recorded in the control, 45° angle and deep plantings, whereas the curved root, loose, and rolled root plantings had the lowest survival. Similar results were found with jack pine in Ontario (Paterson and Maki, 1994). English (1995) reported that deep planting black spruce 2+1 seedlings did not affect survival until 80% of the tree was buried.

Container stock planted too deep (71%) and too loose (74%) had survival rates at least 15% lower than controls (90%)(Table 2). However, only survival of deep planted containers was significantly different at the 0.05 confidence level. Paterson and Maki (1994) found no difference in survival with deep planted or loose planted container jack pine. Weather conditions following planting were dryer than 30 year normals during July and August. However, this does not explain the lower survival of deep planted trees, but could have affected trees planted too loose. Seedlings planted correctly (controls) and 45° angle planting had the highest survival of all the container treatments (Table 2).

Table 2. Black spruce 5th year survival and mean height.

Stock Type	Treatment Description	Survival (%)[1]	Mean Height (cm)[1]
Bareroot	45° Angle	95a	130ab
	Too Deep	93a	118ab
	Control	**93a**	**135a**
	Scalped & Replaced	92a	127ab
	BMS, Scalped	91a	129ab
	Too Shallow	90a	129ab
	Rolled Roots	89a	111b
	Too Loose	88a	118ab
	Curved Roots	87a	120ab
Container	**Control**	**90a**	**140a**
	45° Angle	87ab	141a
	Scalped & Replaced	84ab	137ab
	Too Shallow	82ab	116b
	BMS, Scalped	82ab	128ab
	Plug Flush	82ab	132ab
	Too Loose	74ab	124ab
	Too Deep	71b	130ab

[1] Means followed by same letter within stock type are not significantly different (Student-Newman-Keuls means separation test, $P \leq 0.05$)

Height Growth

Height growth differences were evident in both bareroot and container stock five years after planting. Bareroot trees planted with rolled roots (111cm) suffered significant reductions in height growth compared to controls (135cm) (Table 2). Height reductions exceeding 10 percent were also noted with deep, loose and curved-root planted bareroot trees (Table 2). Controls, 45° angle, BMS scalped, and shallow planted bareroot trees were tallest (135 - 129cm).

Shallow planted containers were significantly shorter (116cm) than controls (140cm) and trees planted on a 45° angle (141cm) after five years. Height reductions were also evident with loose planted containers and trees planted on bare mineral soil (BMS Scalped) (Table 2).

Multiple Stems

The highest number of trees with multiple stems (stems originating at the root collar) were found with deep planted bareroot stock. Sixty percent had more than one stem and averaged 1.7 stems per tree (Figure 1). Bareroot seedlings that were shallow planted or planted on a 45° angle had the lowest number of multiple stems (Figure 1).

Container trees that were deep planted and 45° angle planted had the highest number of multiple stems (26%) while loose and shallow planted trees had no multiple stems.

Deep planting, particularly with black spruce, has been found to cause the development of new shoots from the root collar area of the stem (Stroempl, 1990). This trial supports these findings for bareroot and to a lesser extent with container stock.

A major difference in multiple stems was found between bareroot and container stock. Thirty-seven percent of all bareroot trees had multiple stems compared to 14 percent of containers (Figure 1).

The difference in length between the dominant and second longest leader of multiple-stem trees averaged 38.6 cm. A leader height difference of greater than 20 cm occurred in

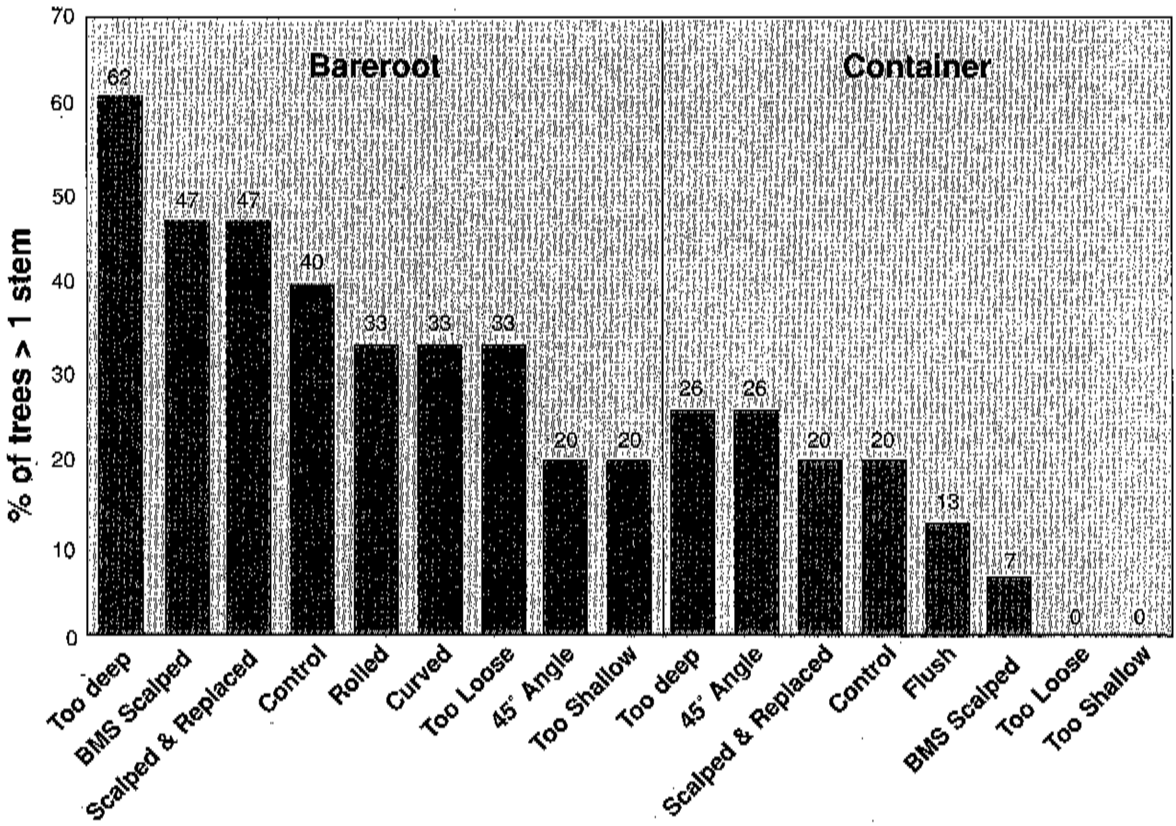

Figure 1. Percent of black spruce trees with multiple - stems five years after planting by treatment and stock type.

66 percent of all multiple stem trees measured.

A study by Gross (1985) has indicated that many black spruce with multiple stems become single stemmed and those that initially have single stems develop multiple stems during their early years of growth. Gross (1985) also reports that 77 percent of trees with multiple stems had established a dominant leader, 5 years after planting.

Biomass Production

The biomass of sampled bareroot trees showed marked differences by treatment. Trees planted with rolled and curved roots had 62 and 49 percent less total biomass than controls (Figure 2). Wagg (1967) reported that initial root system recovery and establishment from severe mistreatment such as rolling or curving roots at time of planting can negatively affect trunk growth and thus total biomass. In contrast, Sutton (1969) and Paterson and Maki (1994) have reported a general lack of effects, or diverse effects caused by root deformations.

Three container treatments; BMS scalped, too shallow, and too loose, resulted in 33 to 47 percent less biomass than controls (Figure 3). These results combined with lower height growth for shallow, loose and BMS planting could be caused by:

1. initial root mortality due to poor plug-soil

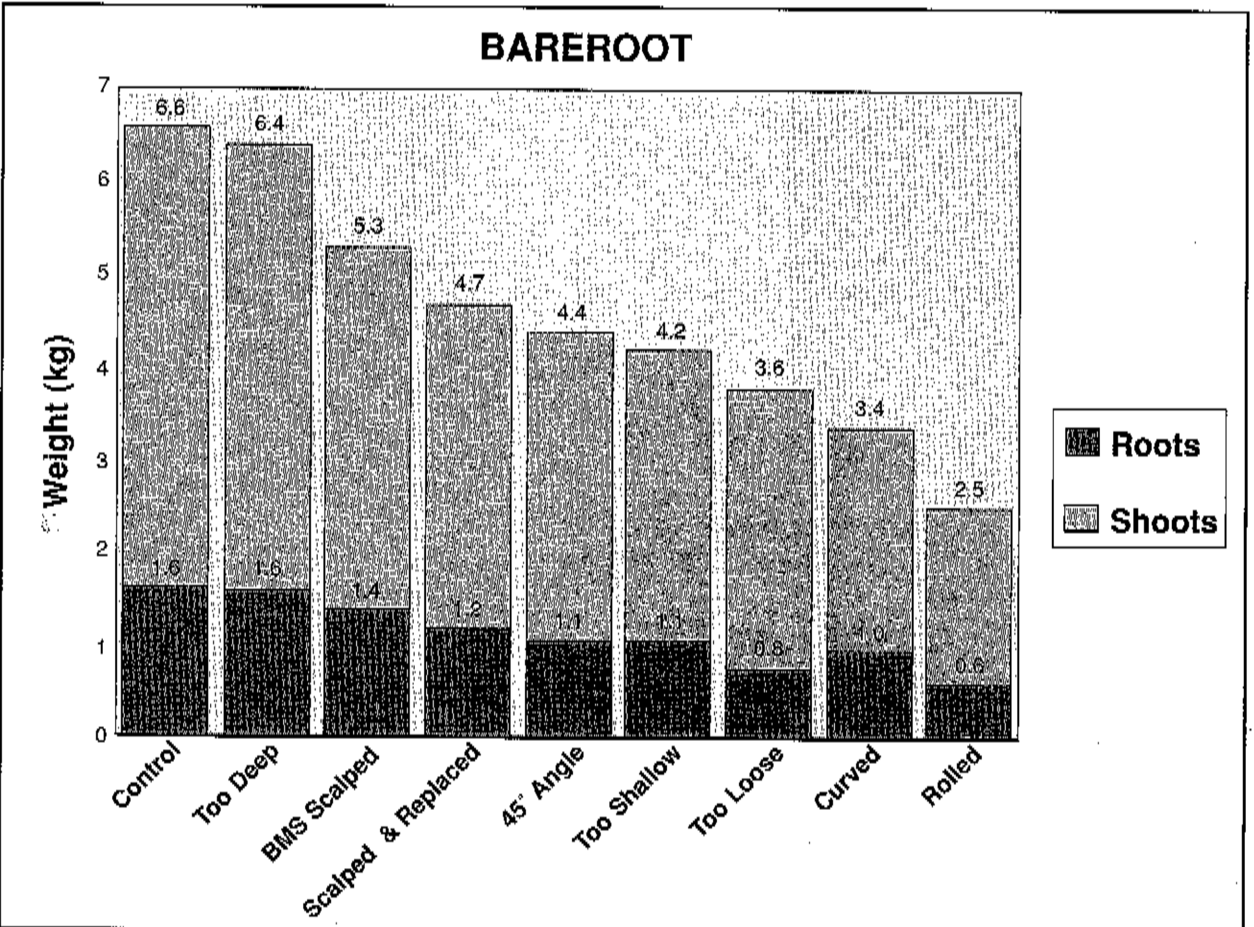

Figure 2. Mean fresh weights of six year old bareroot shoots and roots.

contact affecting root establishment.

2. frost-heaving on BMS sites resulting in root mortality and consequently slowing the establishment process.

Biomass production following 45° angle and deep planting was similar to controls with the 45° angle treatment having the highest mean total biomass of all container treatments (Figure 3).

Stemform and Rootform

Excavated sample trees for each treatment were examined for stem deformities and general rootform and distribution. Examples of some of the better and poorer shoots and roots are shown in Appendices II and III.

Crooked or bent stems were noted with the shallow and 45° angle treatments in both container and bareroot stock. Crooked stems were confined to the root collar area and in all cases stems grew straight beyond that point. Bent stems, particularly with 45° angle trees, did not affect height or biomass growth. The long term effects on growth or wood quality are uncertain at this point and should be investigated further.

Trends in rootform according to planting method were difficult to determine. Two treatments, bareroot planted with rolled roots and containers planted too loose, had the smallest root systems (Figures 2 and 3). Root distribution by treatment was too variable to draw meaningful conclusions.

3. Planting at a 45° angle had no effect on survival, height growth, and biomass; but caused stem deformations at the root collar.

Management Recommendations

Based on the results of this planting trial the following recommendations are made:

1. Planters should be instructed on the importance of maintaining proper planting depth, ensuring good root-soil contact, avoiding root deformation with bareroot stock and to avoid planting container stock on bare mineral soil.
2. Planting at a 45° angle should be avoided due to increased possibility of stem defects and juvenile instability.
3. Existing monitoring procedures should be maintained, since improper planting methods can have significant negative effects on survival and early growth.

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Appendix I. Guidelines for Proper Planting of Container and Bareroot Seedlings (Anon. , 1994).

Container

- Plug must be placed in tight contact with the soil.
- Only one tree/plug.
- Plug must be placed so that the top is covered.
- At least 1/2 of the plug must be in contact with the mineral soil.
- Plug must not be crushed or jammed.
- Plug must not be planted on bare mineral soil.
- Stem angle must not be more than 30 degrees from the vertical.
- Tree must not be planted in a depression.
- Tree should be planted so that ground contact is at the root collar. Under no condition is the tree to be planted with green foliage buried, or the root collar exposed.
- Roots and/or stem must not be damaged as a result of planting.
- Planted seedlings must not be planted closer to each other than 1/2 the allowable spacing.

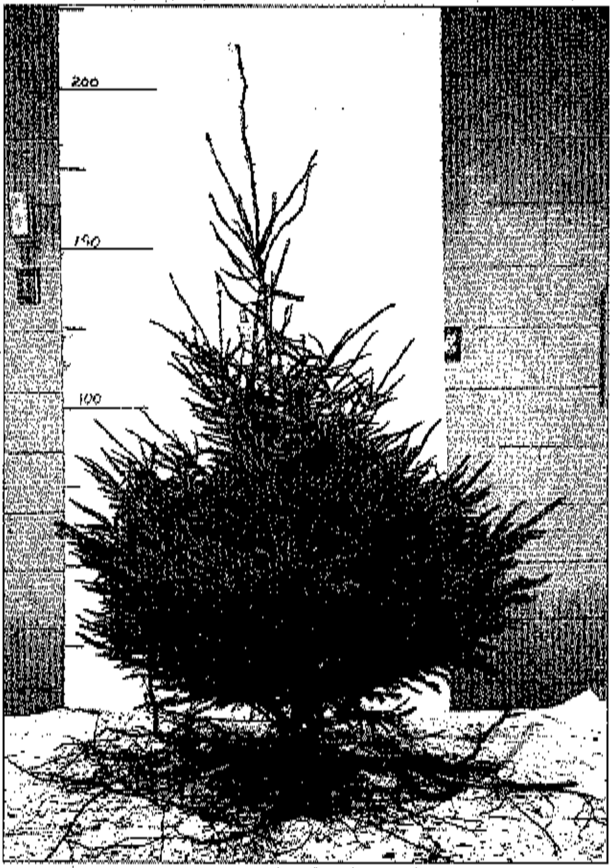
Bareroot

- Tree must be in tight contact with the soil.
- Seedlings must not be planted closer to each other then 1/2 the allowable spacing.
- Roots must not be curved or rolled.
- Roots must not be exposed to air after planting.
- Stem angle must not be more than 30 degrees from the vertical.
- Tree should be planted so that ground contact is at the root collar. Under no conditions is the tree to be planted with green foliage buried or the root collar exposed.
- Tree must not be planted on bare mineral soil.
- A minimum of 2/3 of the root mass must be in contact with the mineral soil.
- Trees must not be planted in depressions.
- Roots and/or stem must not be damaged as a result of planting.
- Planting hole must be closed such that no air pockets exist.

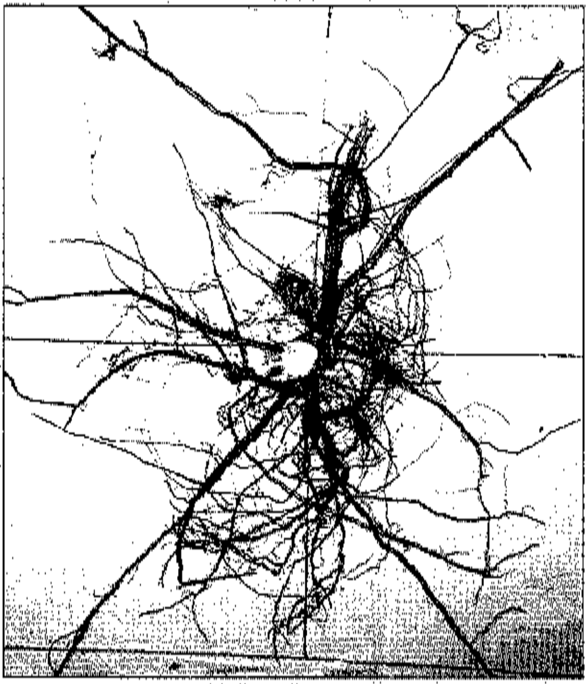
Appendix II. Examples of a 6 year old Black Spruce with *good* morphological growth characteristics.

1. Black Spruce Container, Scalp and Replace

Side View



Top View



Morphological Data

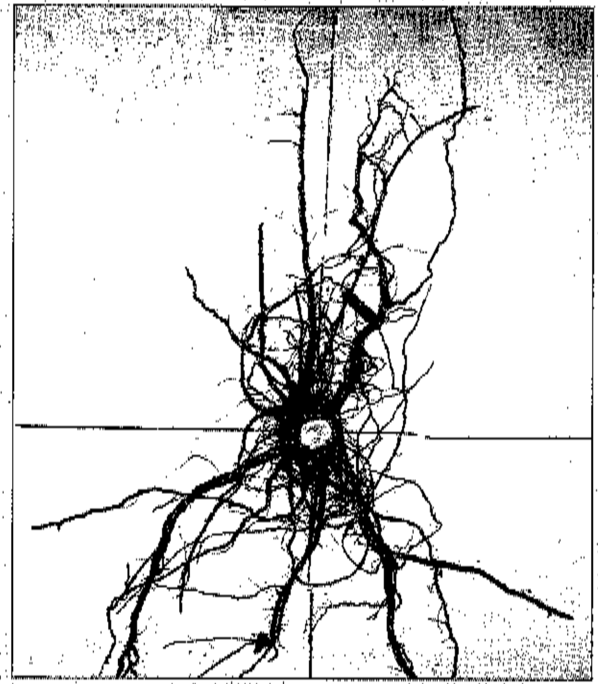
Height (m):	2.01
Root Collar Diameter (cm)	5.4
Top Fresh Weight (kg)	5.76
Root Fresh Weight (kg)	2.09
Root Area Dot Count	105

Appendix II. (Cont.) Examples of 6 year old Black Spruce with *good* morphological growth characteristics.

2. Black Spruce Bareroot, Control

Side View

Top View



Morphological Data

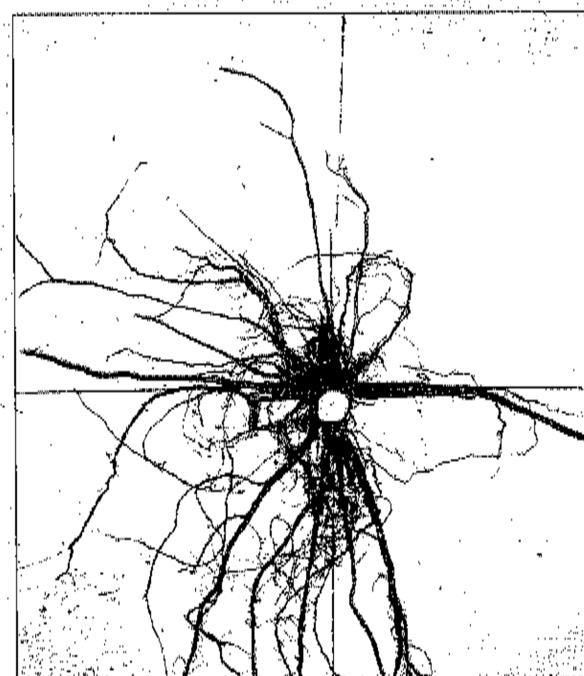
Height (m):	1.85
Root Collar Diameter (cm)	4.8
Top Fresh Weight (kg)	5.14
Root Fresh Weight (kg)	1.41
Root Area Dot Count	72

Appendix II. (Cont.) Examples of 6 year old Black Spruce with *good* morphological growth characteristics.

3. Black Spruce Container, Control

Side View

Top View



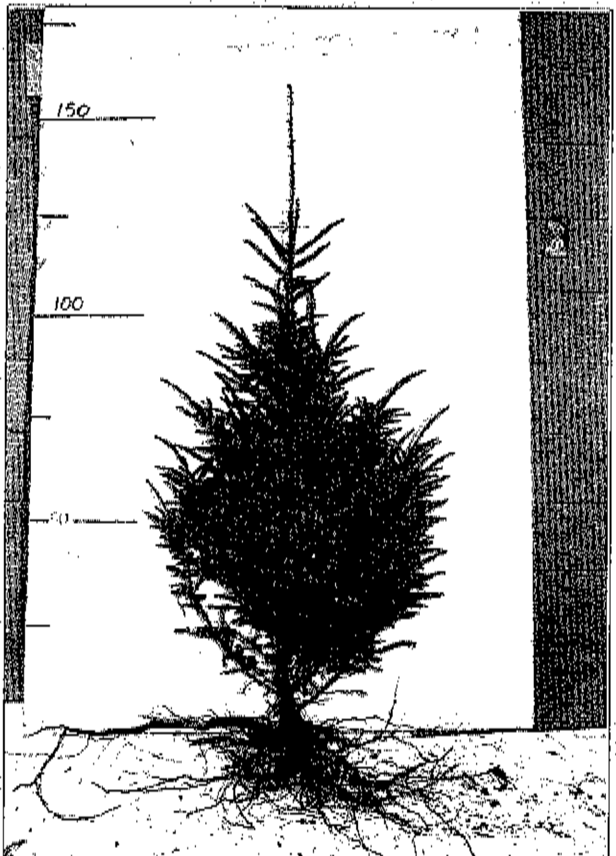
Morphological Data

Height (m):	1.98
Root Collar Diameter (cm)	6.1
Top Fresh Weight (kg)	6.50
Root Fresh Weight (kg)	1.39
Root Area Dot Count	77

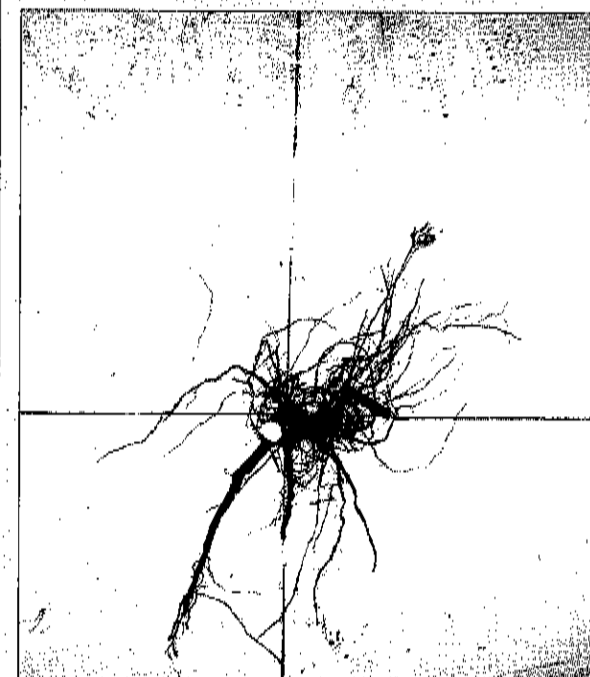
Appendix III. Examples of 6 year old Black Spruce with *poor* morphological growth characteristics.

1. Black Spruce Bareroot, Rolled Roots

Side View



Top View



Morphological Data

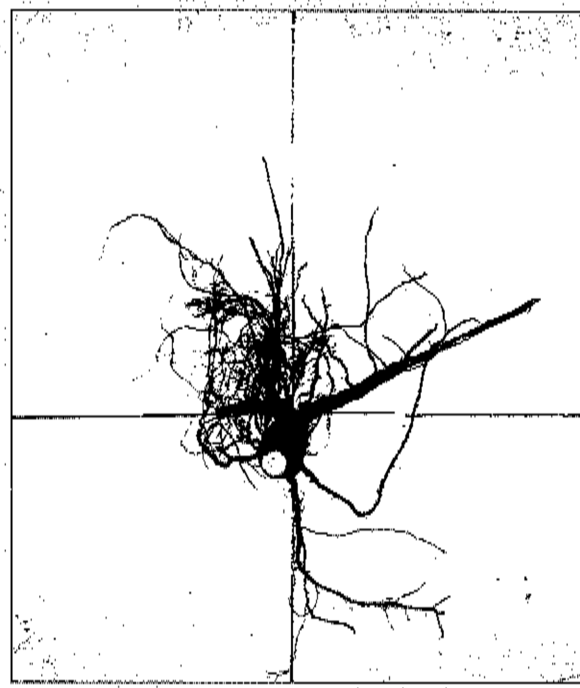
Height (m):	1.42
Root Collar Diameter (cm)	3.4
Top Fresh Weight (kg)	1.60
Root Fresh Weight (kg)	0.46
Root Area Dot Count	41

Appendix III. (Cont.) Examples of 6 year old Black Spruce with *poor* morphological growth characteristics.

2. Black Spruce Container, Too Loose

Side View

Top View



Morphological Data

Height (m):	1.56
Root Collar Diameter (cm)	3.9
Top Fresh Weight (kg)	2.50
Root Fresh Weight (kg)	0.67
Root Area Dot Count	39

Appendix III. (Cont.) Examples of 6 year old Black Spruce with *poor* morphological growth characteristics.

3. Black Spruce Bareroot, Too Shallow

Side View

Top View

Morphological Data

Height (m):	1.72
Root Collar Diameter (cm)	3.9
Top Fresh Weight (kg)	3.07
Root Fresh Weight (kg)	0.78
Root Area Dot Count	56

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