NURSERY PRACTICE IN THE FERTILIZING AND PROPAGATION OF SEEDLINGS

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E. D. CLIFFORD

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THESIS

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Nursery Practice in the Fertilizing and Propagation of Seedlings

The major part of this thesis deals with the effects of fertilizers upon young seedlings; the purpose being to determine as nearly as possible the best fertilizer or fertilizers to use on the seed beds at the Michigan State College forest nursery. Also, to determine the relative effect different fertilizers have on different species of trees.

Experiments of this nature have been carried on at various tree nurseries in different parts of the country with varying results. Different soils require different kinds of fertilizers as well as do various kinds of plants. It has of late been proven that the effect of fertilizers on the same soil give different results, varying with the condition of the soil, how the soil was prepared, and the time of year the fertilizer was applied. These factors have a marked effect on the growth of the plants. It is not advisable to go to a dealer and tell him you want a corn fertilizer, wheat fertilizer or tree fertilizer. It is necessary to know the nature of the soil and the conditions under which the fertilizer is to be used. Almost any fertilizer will help any crop, on any type of soil, but that fertilizer may not be the best to use. This study has been carried out to determine the best

fertilizer to use under the special conditions found in the seed beds at the Michigan State College forest nursery where the beds are prepared in a very uniform way upon a rather uniform soil. The soil is a gravelly loam, with some tendency towards a clay.

In 1924 Professor Herbert carried on an experiment with a large number of fertilizers at various strengths. A few of those that gave the best results were used in this experiment on other seedlings. The fertilizers used were horse manure, poultry manure, ammonium sulphate and muck. Fifty seedlings dug in various locations in the seed beds were measured in order to obtain an average seedling grown under average conditions. The trees were carefully washed to remove all dirt possible without destroying the roots. They were then measured and weighed in the fall of the first and second year.

Most of the experiments were conducted upon white and Norway spruce, but white pine, yellow pine, Austrian pine and European larch were treated with one or two different fertilizers.

The tables give the results of the experiment. The trees are arranged according to the best development which did not always happen to be the largest seedling, for it is not necessarily length that is wanted, but a compact, bushy root system with many fibrous roots and a good healthy top.

WHITE PINE

Seedlings from four beds were weighed and measured. The first batch of seedlings were from beds that had been fall sown and did not receive any fertilizer. The second seedlings were from beds that had been sown in the following spring and treated with "Dip Dust". The third batch of seedlings were from beds sown the following spring and treated with poultry manure. The seedlings from the last bed were spring sown and were not fertilized.

The results of the first year showed that plants from the beds sown in the fall had the best root systems. The beds were uniform in height, color and density. (Plate 1 and 2). This condition remained the same in the fall of the second year. (Plate 3). There was a very much higher per cent of survival and germination in the fall sown beds than in the spring sown beds. The beds treated with "Dip Dust" produced plants with compact root systems and healthy plants with good color. (Plate 4). They were not as dense as in the fall sown beds. They were more evenly distributed and more uniform in height than those in the beds treated with poultry manure and in the spring sown beds that were not fertilized. These seedlings continued to develop during the second year better than the beds that were not fertilized or fertilized with poultry manure. (Plate 5 and 6). The beds treated with poultry manure made a very unsatisfactory growth during the first year, in that the trees did not have a healthy color, nor were they very thick in the bed. (Plate 2). The seedlings improved greatly the second year,

but only about one-tenth as many seedlings could be obtained from that bed as from the fall sown beds. The roots at the end of the second year were compact and the seedlings in much better condition than they were in the fall before. The spring sown bed that did not receive any treatment gave very marked results as compared with the fall sown bed that received the same treatment. The seedlings were sparse, uneven and not as well colored as the fall sown. The root systems were not compact. (Plate 6).

The results of this series of experiments show very plainly that white pine should be sown in the fall to get a full stand and that it does very well when fall sown without any fertilizer treatment. However, the seedlings could be improved by a light application of Dip Dust or poultry manure. Dip Dust apparently has some fertilizing value or else protected the plants from damping off, thus producing healthier plants. While poultry manure did not have much effect upon the seedlings the first year, it would undoubtedly improve the fall-sown plants. Spring sowing of white pine is poor practice owing to the delayed germination resulting in a poor stand of uneven seedlings, all of which goes to make them costly.

WHITE PINE

First Year

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.0907	5.565	.0566	2.386	.1473	7.951	No fertilizer roots compact	Fall sown, healthy
.0881	4.904	.1156	2.48	.2046	7.384	Dip dust	Healthy compact root seedlings evenly distributed
.067	4.7472	.063	2.038	.130	6.7852	Poultry manure Spring sown	Compact roots, thin in bed, not a healthy color
.0651	4.25	.0432	2.1942	.1083	6.442	No fertilizer Spring sown	Trees poor color, very poor germination

Second Year

.534	10.07	.635	3.96	1.169	14.03	No fertilizer Fall sown	Healthy color Compact roots, full crop
.672	11.15	.8624	3.83	1.5344	14.98	Poultry manure Spring sown	Healthy compact roots, poor stand

WHITE PINE

Second Year (Con't)

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.3784	9.7	.617	3.49	.9954	13.19	Dip Dust	Compact roots Good color Fair stand
.4264	9.91	.4864	3.50	.9128	13.41	No fertilizer Spring sown	Not many fibrous roots Very poor stand

WHITE SPRUCE

Beds of white spruce were treated with poultry manure, ammonium sulphate and horse manure and one bed was not fertilized.

The bed treated with poultry manure produced slightly the best seedlings the first year and the second year the seedlings were much better than those from the other beds. The roots were compact and well covered with fibrous roots. The seedlings made a very uniform growth and had a good healthy color. (Plate 7 and 8).

The bed treated with ammonium sulphate produced seedlings the first year almost as good as those from the beds treated with poultry manure and at the end of the second year the seedlings were well developed with compact root systems, but the roots were coarser and the fibrous roots not as well developed, nor was the growth as uniform as those in the above bed. (Plate 7 and 9).

The first year the bed treated with horse manure produced fairly good seedlings, but the development was not maintained during the second year. The beds were uneven and the tops did not have as good a color as in the above two beds. They were somewhat better than the seedlings from the bed that was not fertilized. The roots were fairly uniform but were somewhat lacking in fibrous roots. (Plate 7 and 10).

The bed that was not fertilized produced seedlings which varied greatly in size and root development. The beds were uneven and thin. The fact that the beds were thin accounts for a large amount of the root development of these seedlings as each plant had more room to develop than the seedlings in

the other beds. (Plate 7 and 11).

The results of these experiments on white spruce show that poultry manure and ammonium sulphate can be used on seed beds to produce a good stand of seedlings with well developed root systems, and larger seedlings in a shorter time than from untreated beds.

The use of horse manure will improve the seedlings somewhat over those not fertilized, but the improvement is hardly great enough to justify the expense.

Beds that are not fertilized tend to produce fewer seedlings of uneven growth and having a spreading root system that is apt to be injured greatly in transplanting.

WHITE SPRUCE

First Year

Roots Weight Gms.	Roots Length Inches	Tops Weight Gms.	Tops Length Inches	Total Weight Gms.	Total Length Inches	Treatment	Remarks
.0481	5.282	.0615	1.2014	.1096	6.4834	Poultry manure	Compact roots Good color
.067	5.6068	.1552	1.3374	.2222	6.944	Ammonium sulphate	Compact roots Good color
.0605	5.192	.1473	1.2754	.2079	6.4674	Horse manure	Compact numerous roots
.0316	4.7924	.06	1.148	.0916	5.9404	No fertilizer	No branches on roots and very few fibrous roots

Second Year

.504	8.56	.8762	5.17	1.3802	13.73	Poultry manure	Compact roots Good color
.4134	8.39	.676	4.53	1.0894	12.92	Ammonium sulphate	Roots coarser
.211	8.3	.381	4.12	.582	12.42	Horse manure	Not much better than those not fertilized
.3934	9.44	.6028	4.02	.9962	13.46	No fertilizer	Very long roots, uneven growth

NORWAY SPRUCE

During the first year of the experiment some of the beds of Norway spruce were boxed and some were not. Part of these beds were transplanted last spring so comparative results cannot be given for the second year. However, at the end of the first year all of the beds that were not boxed produced better seedlings than the framed beds, (Plate 12), for they were more even in size over the entire bed, whereas in the framed bed the seedlings were tallest along the edges, decreasing to the center of the bed. (Plate 13). This is due to the fact that those along the edge had more room being able to send their roots into the path. Also, the frame shelters the seedlings along the edge and thus they grow in a moister situation.

The beds of Norway spruce were treated with the same fertilizers as the white spruce, except one of the framed beds which was treated with a mixture of horse and poultry manure.

In the open beds treated with horse manure and poultry manure, the results were very similar to the beds treated with poultry manure, giving a more even stand and better colored tops than those in the beds treated with horse manure which were uneven and had a yellowish cast. (Plates 12, 15, 16).

The seedlings from the beds treated with ammonium sulphate were larger and heavier than those from the above two beds, but the roots were not as divided and the root hairs were in bunches. Perhaps the seedlings were every bit as good as those from the above beds. The results were very close. (Plates 12 and 14).

The bed that was not fertilized produced seedlings with long roots, well divided, but lacking many fibrous roots. The seedlings made an uneven growth and had a yellowish cast. (Plates 12 and 17).

The bed that was treated with both horse and poultry manure (one year results) produced the best seedlings of any of the beds.

Norway spruce seed beds can be treated with horse manure, poultry manure or ammonium sulphate with equally good results and with a stand of enough better quality seedlings to pay for the extra cost.

NORWAY SPRUCE

First Year, (open beds)

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.0535	5.303	.0483	.7332	.1018	6.0362	Poultry manure	Foliage dark green, roots branched and fibrous
.0434	5.362	.0421	.6852	.0855	6.0474	Horse manure	Long, bushy fibrous roots
.0466	5.417	.0555	.5248	.1021	5.9418	Ammonium sulphate	Long, not as bushy, dark green foliage
.0323	5.288	.028	.56	.0605	5.848	No fertilizer	Not bushy, few fibrous roots, foliage yellowish
			Framed Beds				
.0649	6.291	.0754	1.784	.1403	8.075	Poultry and Horse manure	Long, bushy roots with many fibrous roots. Good color
.0643	5.737	.0653	.9354	.1296	6.6724	Poultry manure	Compact roots
.1045	5.87	.1096	1.056	.2141	6.926	No fertilizer	Roots long and very few fibrous roots

Con't

NORWAY SPRUCE

Second Year, (open beds)

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.4558	9.42	.7774	4.61	1.2332	14.03	Ammonium sulphate	Compact fibrous roots in bunches Good color Even g rowth
.415	9.26	.7194	2.505	1.1344	11.765	Poultry manure	Compact roots
.408	9.3	.686	3.66	1.094	12.96	Horse manure	Compact roots, not as even growth as above
.3658	9.15	.5864	4-	.9522	13.15		Growth uneven and not as heavy a stand

AUSTRIAN PINE

Only two beds of Austrian pine were treated; one with poultry manure and the other with muck. Throughout the two years the beds treated with poultry manure produced the best seedlings. The seedlings from the beds treated with poultry manure had well divided root systems with numerous fibrous roots, while those from the bed treated with muck were more even in growth. Both beds were of good color.

It would be better to transplant Austrian pine at the end of the first year because of the long root system which by the end of the second year is hard to handle without severe damage.

There is very little choice in the two fertilizers and the one that is most readily available could be used. The seedlings in both beds were very scattered, owing either to poor germination or not heavy enough sowing of the seed. (Plates 18, 19, 20).

AUSTRIAN PINE

First Year

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.1121	8.701	.2313	1.668	.3434	10.369	Poultry manure	Roots long, bushy, tops good color
.0651	6.6226	.1346	1.3374	.1997	7.96	Muck	Long roots but not bushy

Second Year

.533	9.39	1.143	5.781	1.676	15.171	Poultry manure	Long roots Good color
.4388	8.565	.6968	4.745	1.1356	13.310	Muck	

YELLOW PINE

(One year's results)

Only two beds of yellow pine were treated; one with horse manure and the other with muck. The best seedlings came from the bed treated with horse manure, but with muck a very close second. These seedlings have a long root system as in the Austrian pine and were transplanted at the end of the first year. (Plate 21).

YELLOW PINE

Roots		Tops		Total		Treatment	Remarks
Weight Gms.	Length Inches	Weight Gms.	Length Inches	Weight Gms.	Length Inches		
.2087	9.076	.5148	2.533	.7235	11.609	Horse manure	Roots long with many side roots
.4718	9.085	1.2099	3.0053	1.6817	12.0903	Muck	Roots and top longer but not as well branched

JAPANESE LARCH

Only two beds of Japanese larch were used in the experiment; one was treated with horse manure and the other, as a check, not being fertilized. (Plates 22,23,24). There was a very pronounced difference between the bed treated with horse manure and the check bed. The seedlings were larger, had better developed root systems and color than in the check bed. There was a pronounced difference in the seedlings at the edge of the bed and in the center with both the treated and untreated seedlings, those at the outer edge being very much larger with better developed root systems.

Measurements were not made on the larch the second year owing to the difficulty of getting the entire root system and also because the needles were falling off. It was still evident, however, that the bed treated with horse manure was producing the best seedlings. The difference between the outer edge and center of the beds was even more marked than in the first year. There was almost one foot difference in the height. There were several spots in the center of the bed where all the seedlings were dead, due to lack of moisture and crowded conditions. This crowded condition forced the roots to go deeper for water and food with the result that it was impossible to dig the seedlings without destroying some of the roots.

The Japanese larch should be sown only about a third as heavy as it was sown in these beds unless this resulted from an exceptionally high per cent of germination.

The larch should not be carried over the second year in the seed beds, but used for field planting at the end of the first year.

JAPANESE LARCH

Roots Weight Gms.	Roots Length Inches	Tops Weight Gms.	Tops Length Inches	Total Weight Gms.	Total Length Inches	Treatment	Remarks
.2375	7.555	.4098	4.5306	.6473	12.0856	Horse manure (edge)	Roots long bushy, foliage good color
.1112	6.975	.1098	2.1408	.2210	9.1158	Horse manure (center)	Roots bushy, long, color not as good
.1723	7.30	.2637	4.4856	.4360	11.7856	No fertilizer (edge)	Roots long not as bushy, color good
.0679	6.09	.0606	1.6674	.1285	7.7574	No fertilizer (center)	Roots not as bushy and color very poor

PROPAGATION OF BASSWOOD BY SEED

Considerable difficulty has been experienced at the College nursery in getting basswood seeds to germinate within a year. A series of experiments were conducted upon basswood seed in an effort to find some way to speed up germination.

First the seeds were treated in various ways to soften the seed cases. The seed was treated with nitric, sulphuric and hydrochloric acids, some were soaked in hot water, others in cold. Some were placed in hot water and the water allowed to cool and freeze, then reheated and refrozen several times, but with no results as the seed coats were not softened except in cases where the seed was treated for a prolonged time in the acids in which cases the embryo was injured. After the treatment the seed was planted in a greenhouse, but after a period of four months no germination had taken place and in a cutting test the seed was either dead or dormant.

The fall seed was picked from two trees and promptly planted in a greenhouse flat and placed under the bench where the temperature was around 50°. The soil was kept moist. A cutting test of the seed was made at the time of planting to see if the seed was fertile and to determine whether or not the outer and inner seed coat was hard as is the case in stored seeds. A cutting test was conducted on five seeds from each tree and both gave 80 per cent, or four seeds were fertile. In no case was the inner seed coat so hard that it could not be cut with ease with a jack knife. After two weeks a cutting test was made on five seeds from each tree to determine, first, if the seed coats had hardened and second, to note any change in

the kernel itself. These cutting tests were made every two weeks as long as any of the seed remained. In no case had the seed coats hardened and the kernel remained as it was when planted for a few weeks, then it gradually begun to swell and the endosperm started to develop. At the last cutting test several of the endosperms had broken through the inner seed coats. In no case had the seed coats hardened and all the good seed had started to germinate. In the mean time, Professor Laurie of the Horticultural Department was carrying on experiments on the rest period of seed and found that by storing basswood seed at 70° for 3 months and then planting it no trouble was experienced with the germination being delayed. Professor Chittenden of the Forestry Department found that by burying the seed for one year a rapid germination was obtained with a very small loss from moldy seed.

PROPAGATION OF BASSWOOD BY CUTTINGS

Owing to the difficulty of getting basswood seed to germinate, an experiment was carried on to see if it is possible to produce basswoods from cuttings. In 1927 Professor McLaughlin conducted some experiments with basswood cuttings, placing the cuttings in sand. The results were negative, and the cuttings seemed to decay in the soil although some of them developed leaves. This year the experiment was repeated, using three different soils for the experiment, namely; sand, fifty per cent sand and peat, and acid peat. Along with the basswood cuttings,

cuttings of purple willow and poplar were used, as these last two strike root very easily from cuttings, they were used to show the effect, if any, of the different soils upon the rooting of the cuttings. Twenty-five cuttings from last year's wood of basswood, willow, and poplar were placed in each soil bed. Those in the sand were placed erect with at least one bud beneath the soil. Those in the sand-peat and peat were placed horizontal and covered with the soil. These cuttings were placed in the beds on January twenty-first. In three weeks the willow and poplar in the sand-peat and peat showed signs of root development. Also a few had indications of callouses. The basswood were unchanged except for some decay at the ends. In another week the willow and poplar in sand-peat and peat had several roots, and small shoots were developing. Those in the pure sand in a few instances showed indications of root development. The basswood remained unchanged except for decay. On March twentieth most of the willow and poplar cuttings in the sand-peat and peat had well developed roots and shoots as plates A and B show. Only about half of the cuttings in the sand had developed roots, and these were not so well developed as in the sand-peat and the peat. All the basswood cuttings in pure sand were decayed at the end that was in the soil, while those in the sand-peat were decayed somewhat. No roots had developed on any of these cuttings, and only a few in the pure peat showed any indication of a callous. The results were negative as far as obtaining sprouts from basswood cuttings was concerned, but the power of acid peat in stimulating growth of roots on cuttings was well demonstrated on the willow and poplar.

RESULTS OF CUTTINGS OF BASSWOOD, POPLAR, WILLOW

Basswood

Propagation Soil	Third Week	Fifth Week	Seventh Week
Peat	No development	No development	Few calloused
Peat and sand	No development	No development	No development
Sand	No development	No development	No development

Poplar

Peat	Few callouses, roots starting on a few	Several roots and good callouses	All but 2 cuttings developed roots
Peat and sand	Few callouses, roots starting on a few	Several roots, good callouses	All but 5 cuttings developed roots
Sand	Few callouses,	Roots starting	12 had started roots

Willow

Peat	Few roots started, few are calloused	Good callouses, several roots	All but 3 cuttings developed roots
Peat and sand	Few calloused, and indication of roots	Roots started	All but 5 cuttings developed roots
Sand	Some have started to callous	Indications of roots	50% developed roots

Plates 25, 26 and 27 show the effect of peat on root production. From the effect on willow and poplar it would seem that if basswood will sprout it would do so in the peat. It may possibly be that older wood should be used. It does not seem probable that a tree such as the basswood that reproduced from sprouts so freely should not reproduce from cuttings.

PLATE I
First Year Seedlings

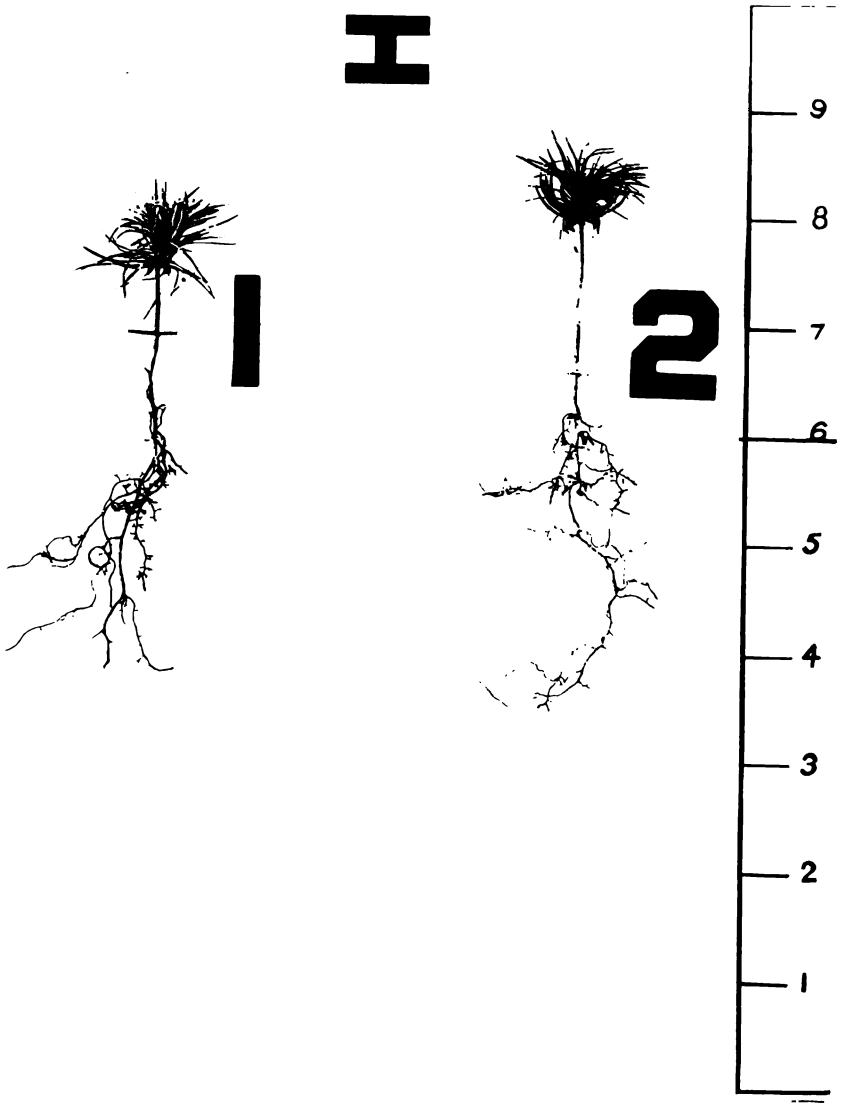


Figure 1. White Pine treated with Dip Dust.
Figure 2. White Pine spring sown, fertilized with poultry manure.

PLATE II
First Year Seedlings

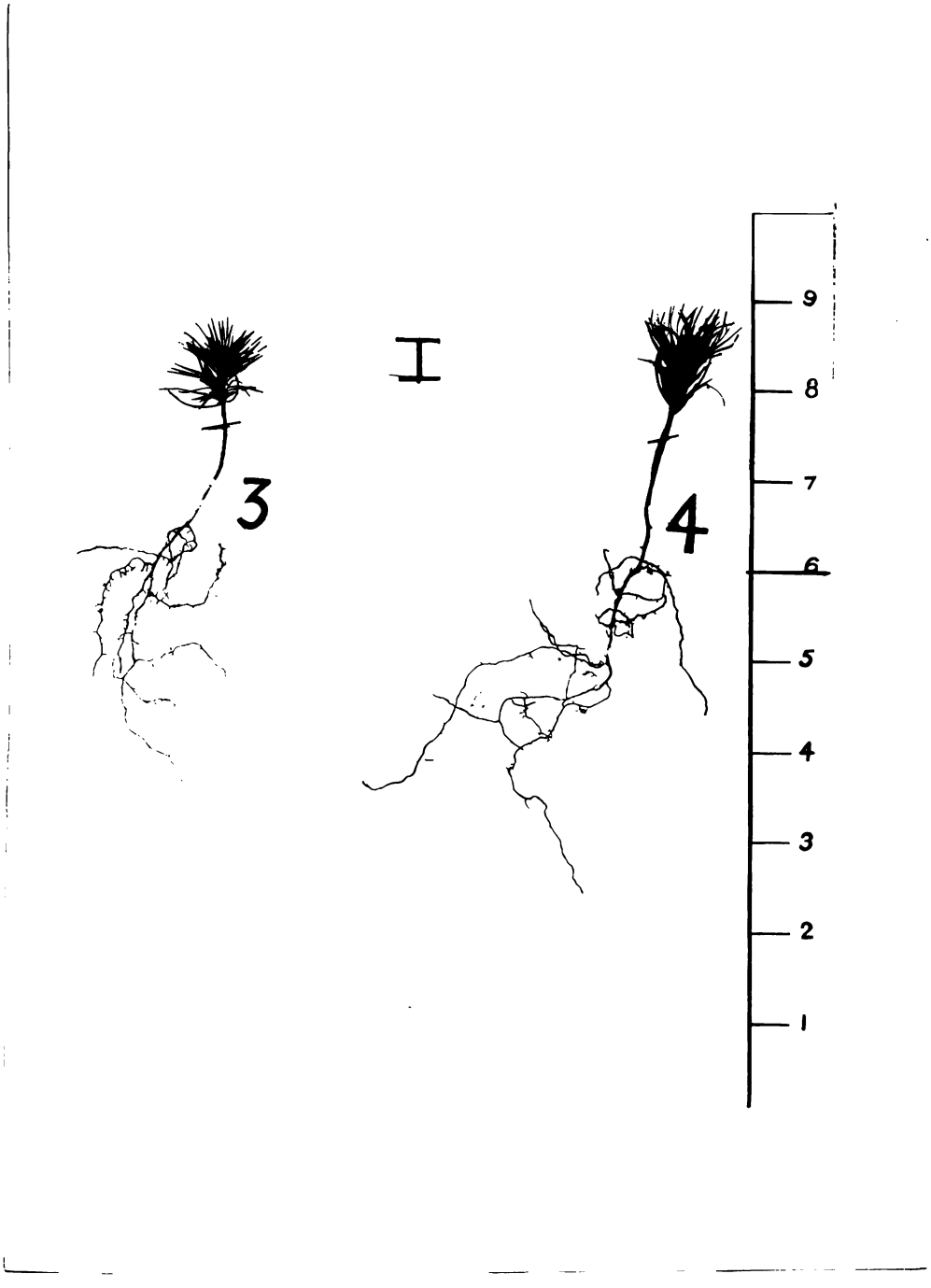


Figure 3. White Pine spring sown, not fertilized.
Figure 4. White Pine fall sown, not fertilized.

PLATE III
Second Year Seedlings

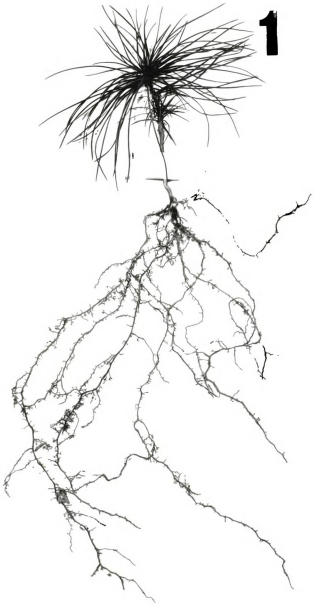


Figure 1. White Pine fall sown, not fertilized.

PLATE IV
Second Year Seedlings

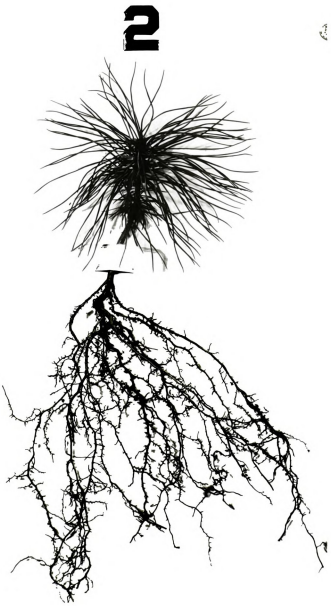


Figure 2. White Pine treated with Dip Dust.

PLATE V
Second Year Seedlings

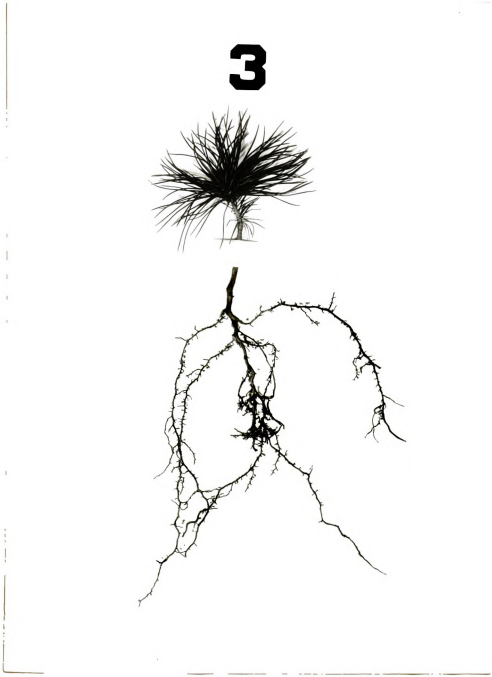


Figure 3. White Pine spring sown, fertilized with poultry manure.

PLATE VI
Second Year Seedlings

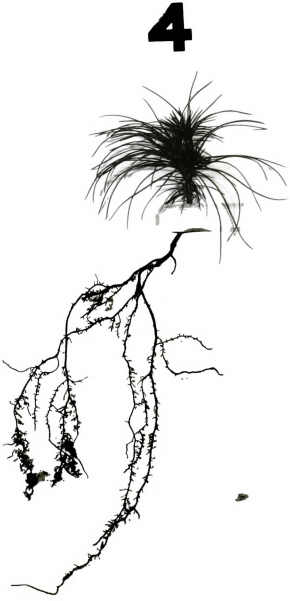


Figure 4. White Pine spring sown, not fertilized.

PLATE VII
First Year Seedlings

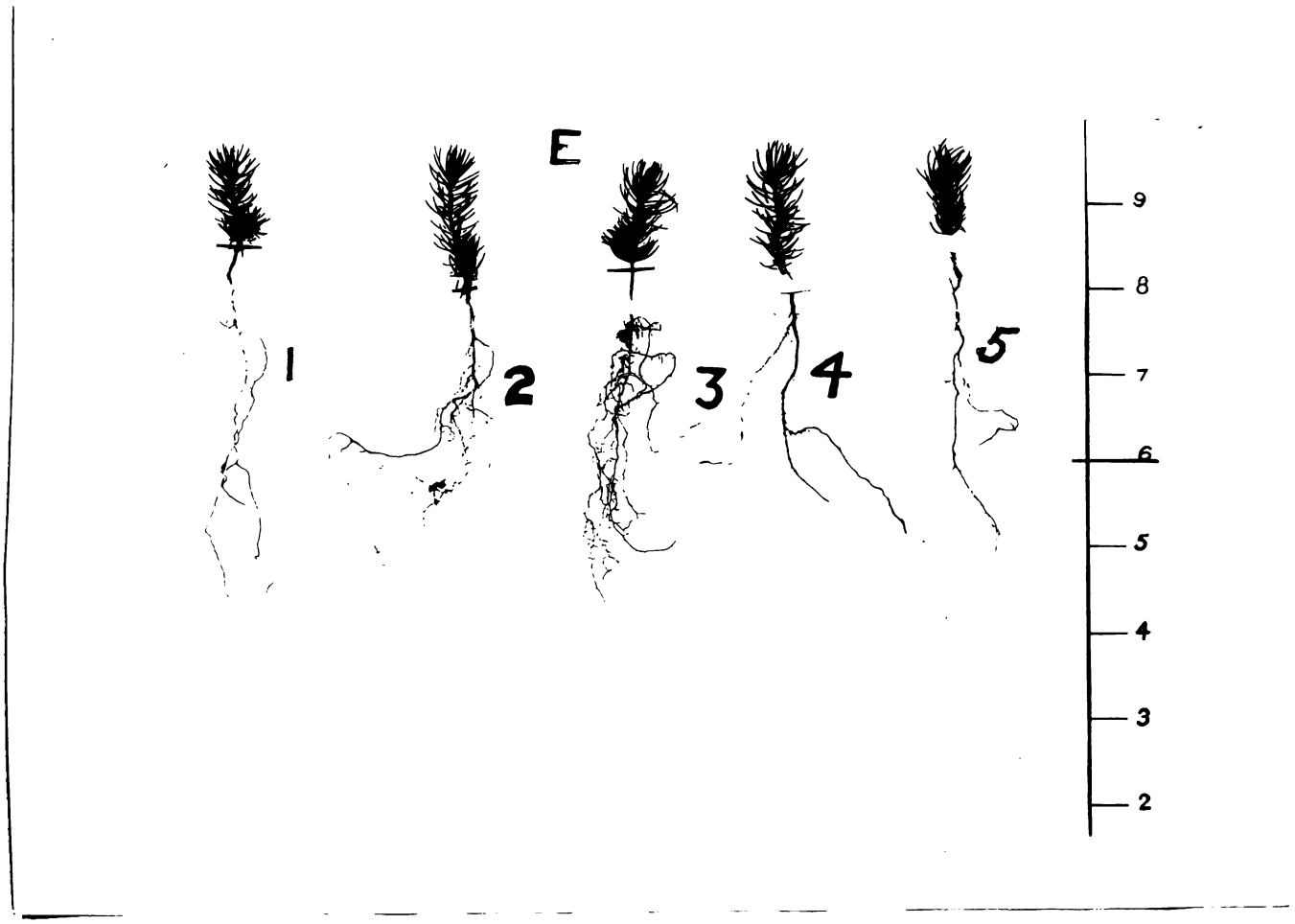


Figure 1. White Spruce fertilized with horse manure.
Figure 2. White Spruce fertilized with ammonium sulphate.
Figure 3. White Spruce fertilized with poultry manure.
Figure 4. White Spruce not fertilized.
Figure 5. White Spruce not fertilized.

PLATE VIII
Second Year Seedlings

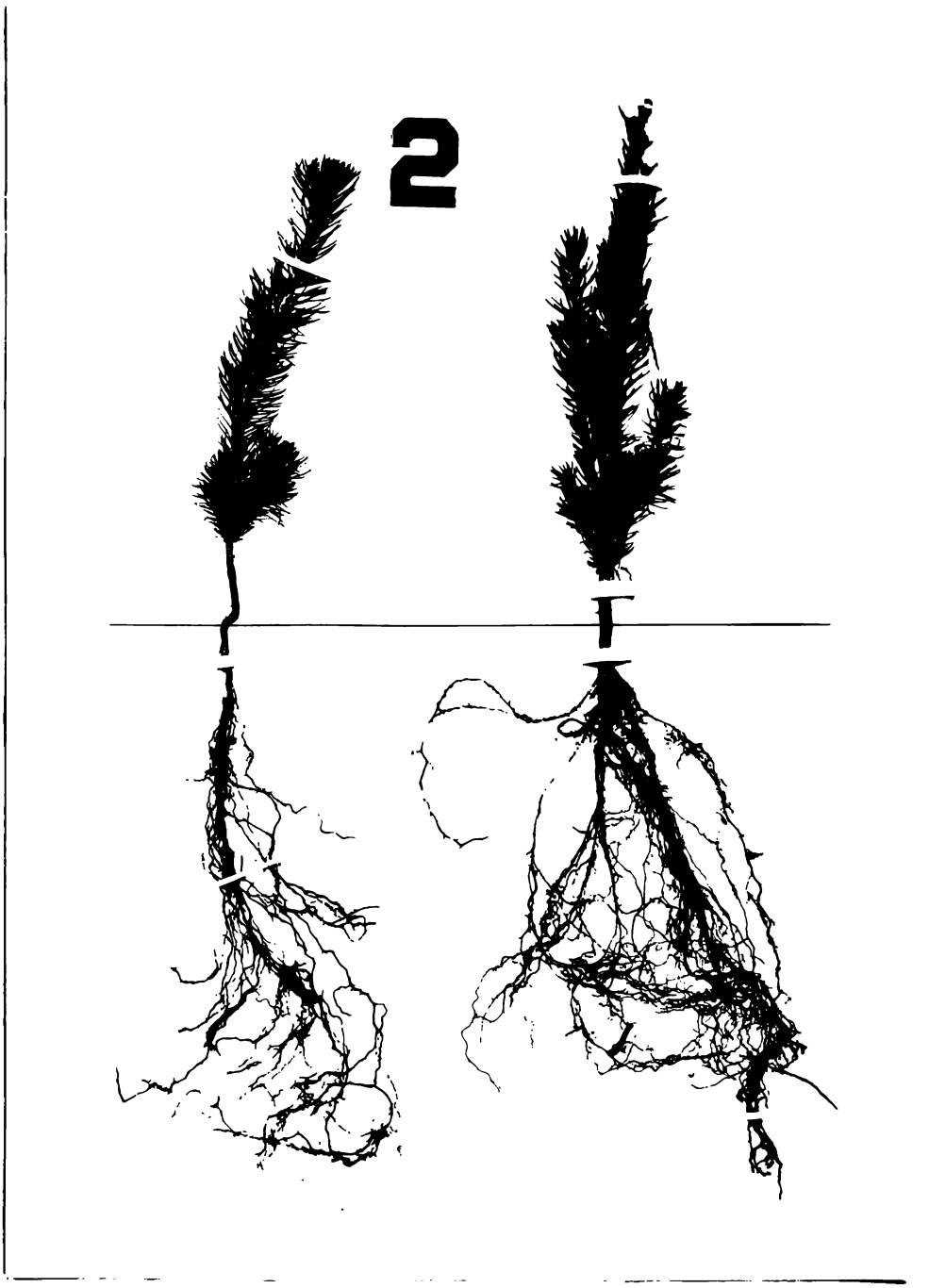


Figure 2. White Spruce fertilized with poultry manure.

PLATE IX
Second Year Seedlings

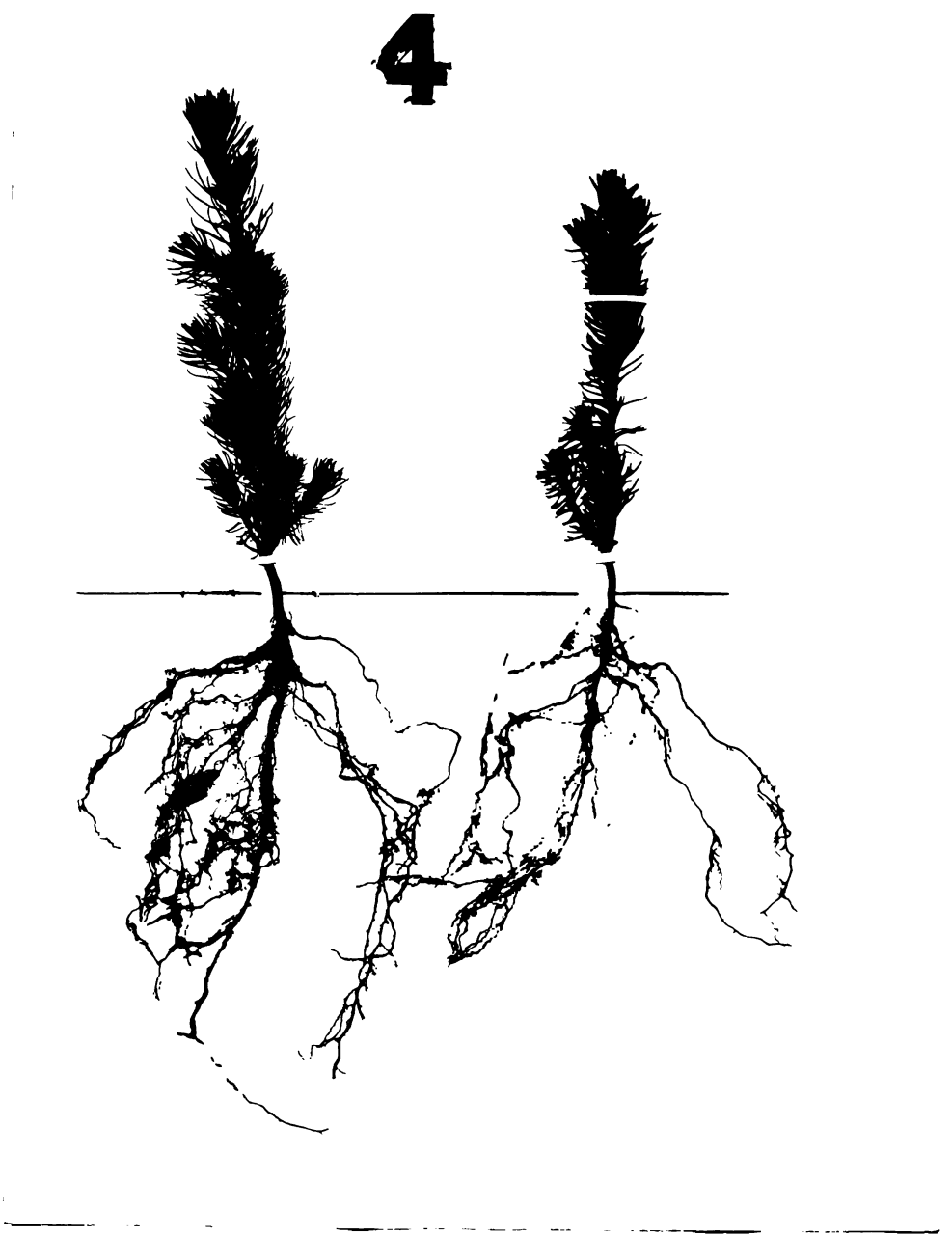


Figure 4. White Spruce fertilized with ammonium sulphate.

PLATE X
Second Year Seedlings

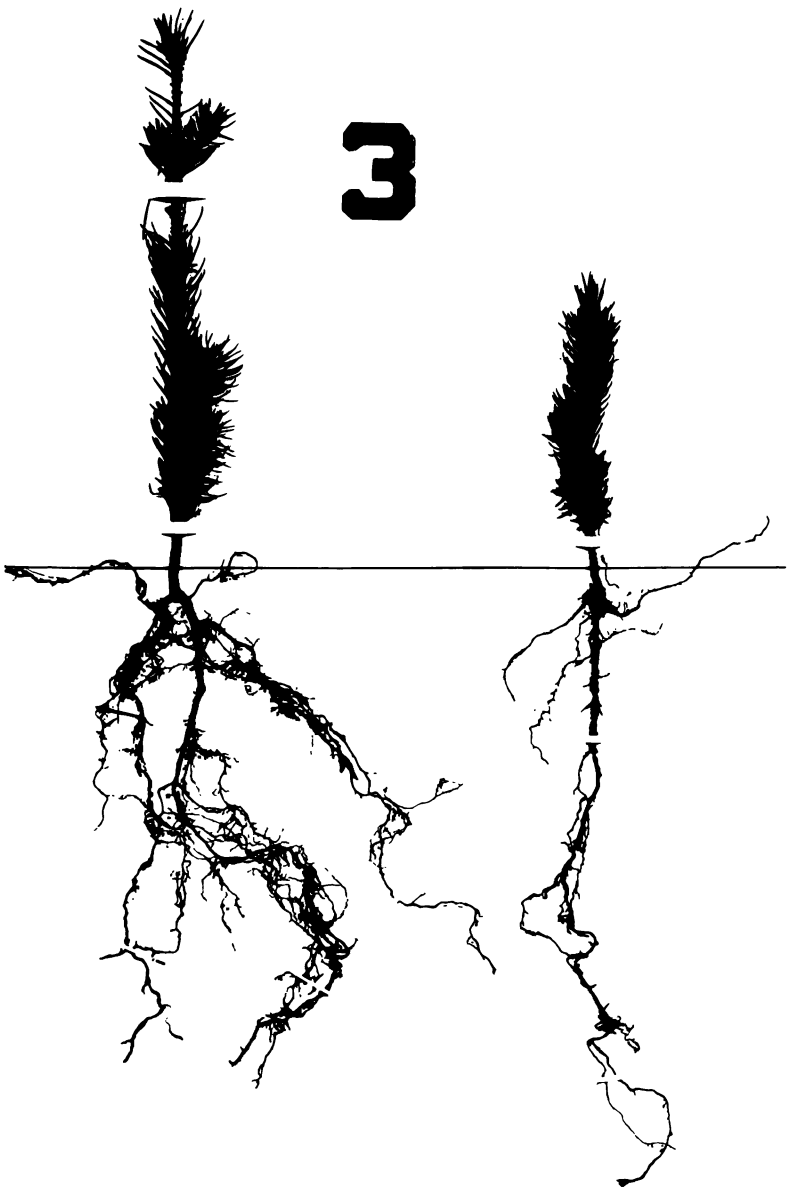
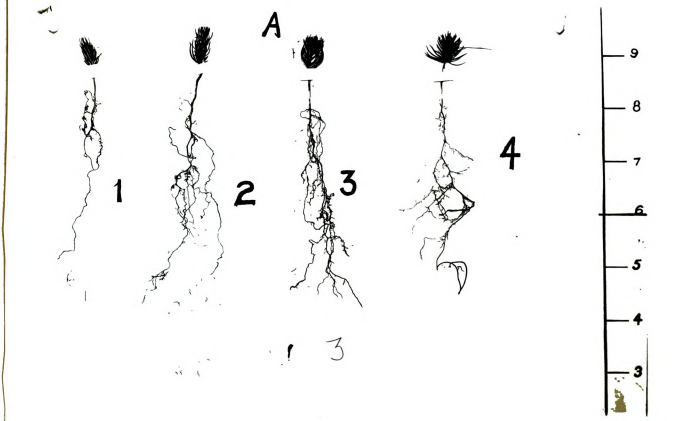


Figure 3. White Spruce fertilized with horse manure.

PLATE XI
Second Year Seedlings

Figure 1. White Spruce not fertilized.

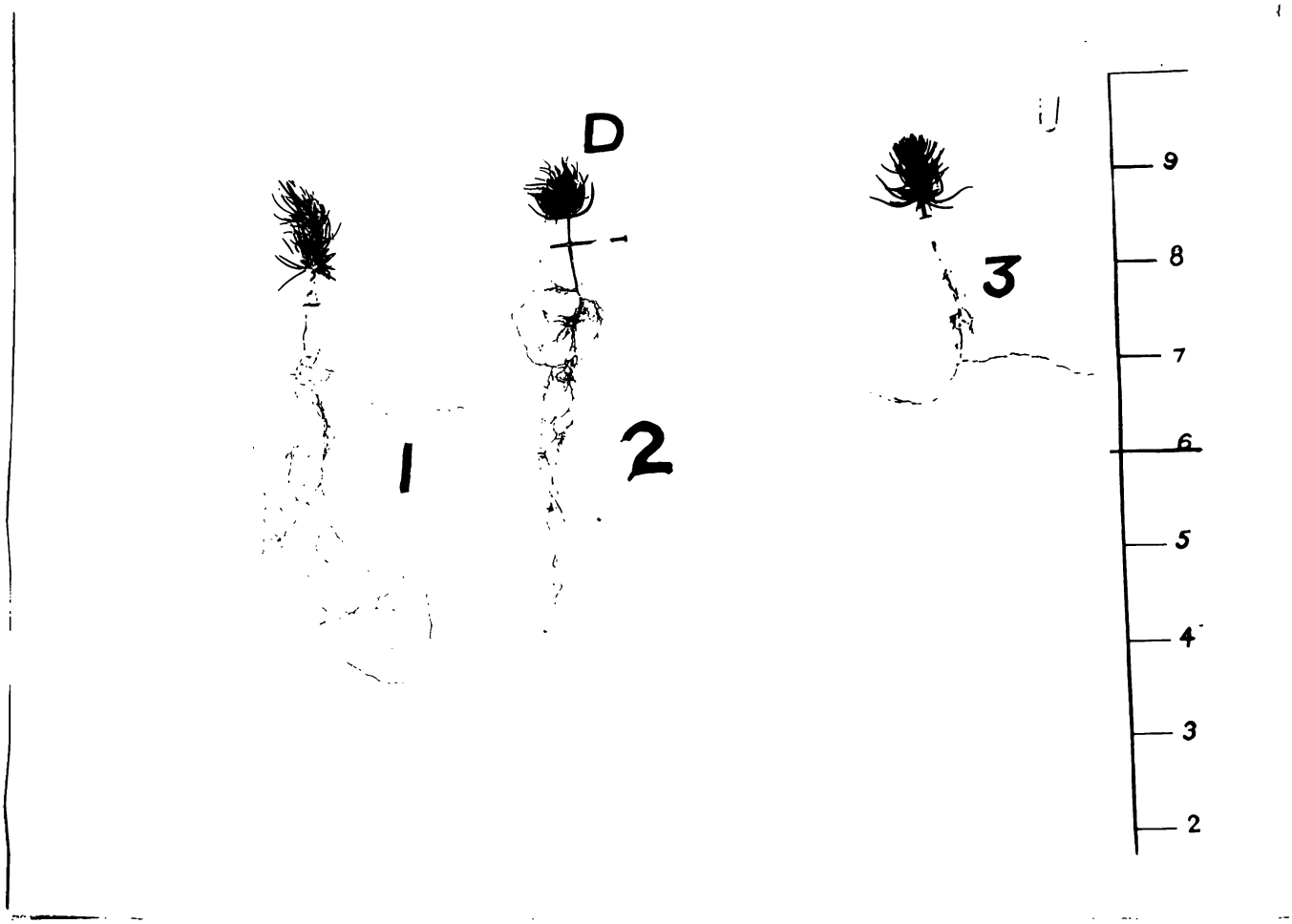
PLATE XII
First Year Seedlings



Open Beds

Figure 1. Norway Spruce not fertilized.
Figure 2. Norway Spruce fertilized with poultry manure.
Figure 3. Norway Spruce fertilized with ammonium sulphate.
Figure 4. Norway Spruce fertilized with horse manure.

PLATE XIII
First Year Seedlings



Framed Beds

Figure 1. Norway Spruce fertilized with horse and poultry manure.
Figure 2. Norway Spruce fertilized with poultry manure.
Figure 3. Norway Spruce not fertilized.

PLATE XIV
Second Year Seedlings

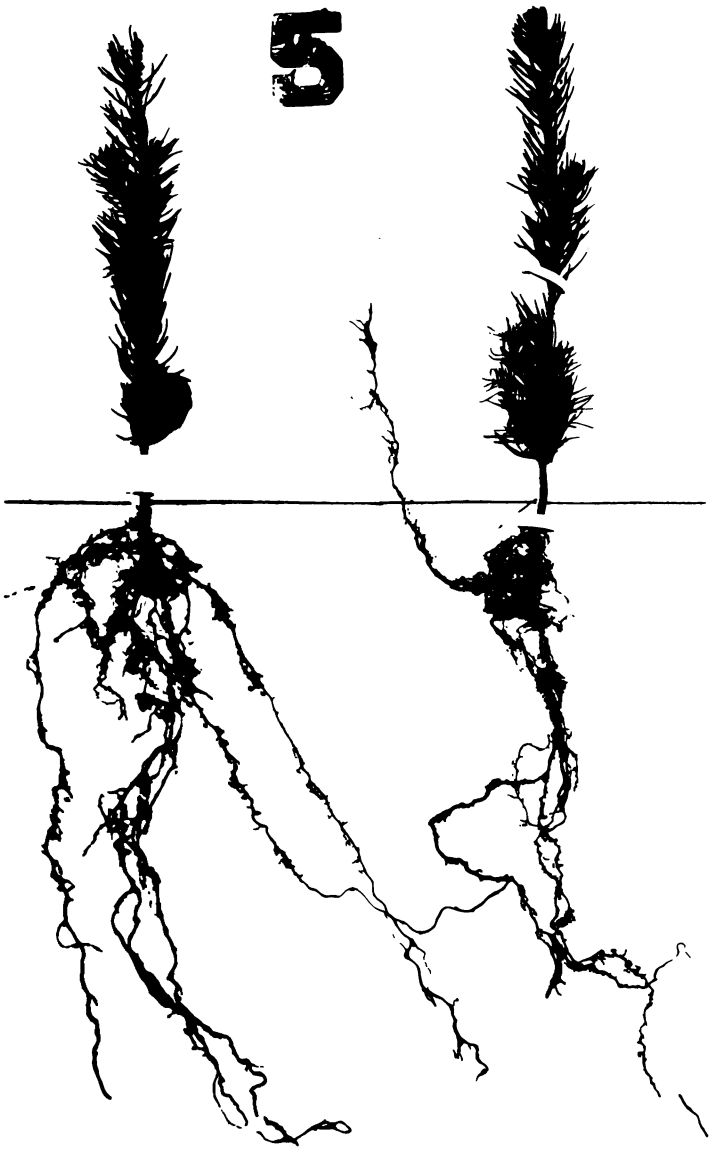


Figure 1. Norway Spruce fertilized with ammonium sulphate.

PLATE XV
Second Year Seedlings

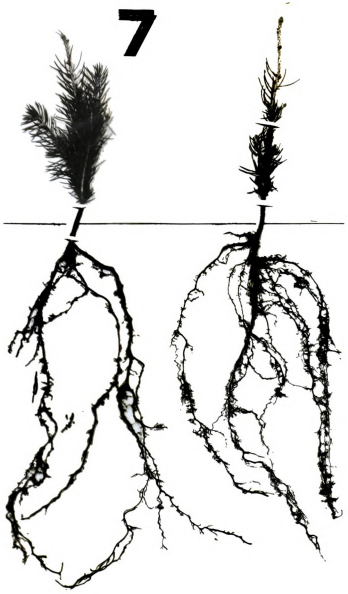


Figure 1. Norway Spruce fertilized with horse manure.

PLATE XVI
Second Year Seedlings

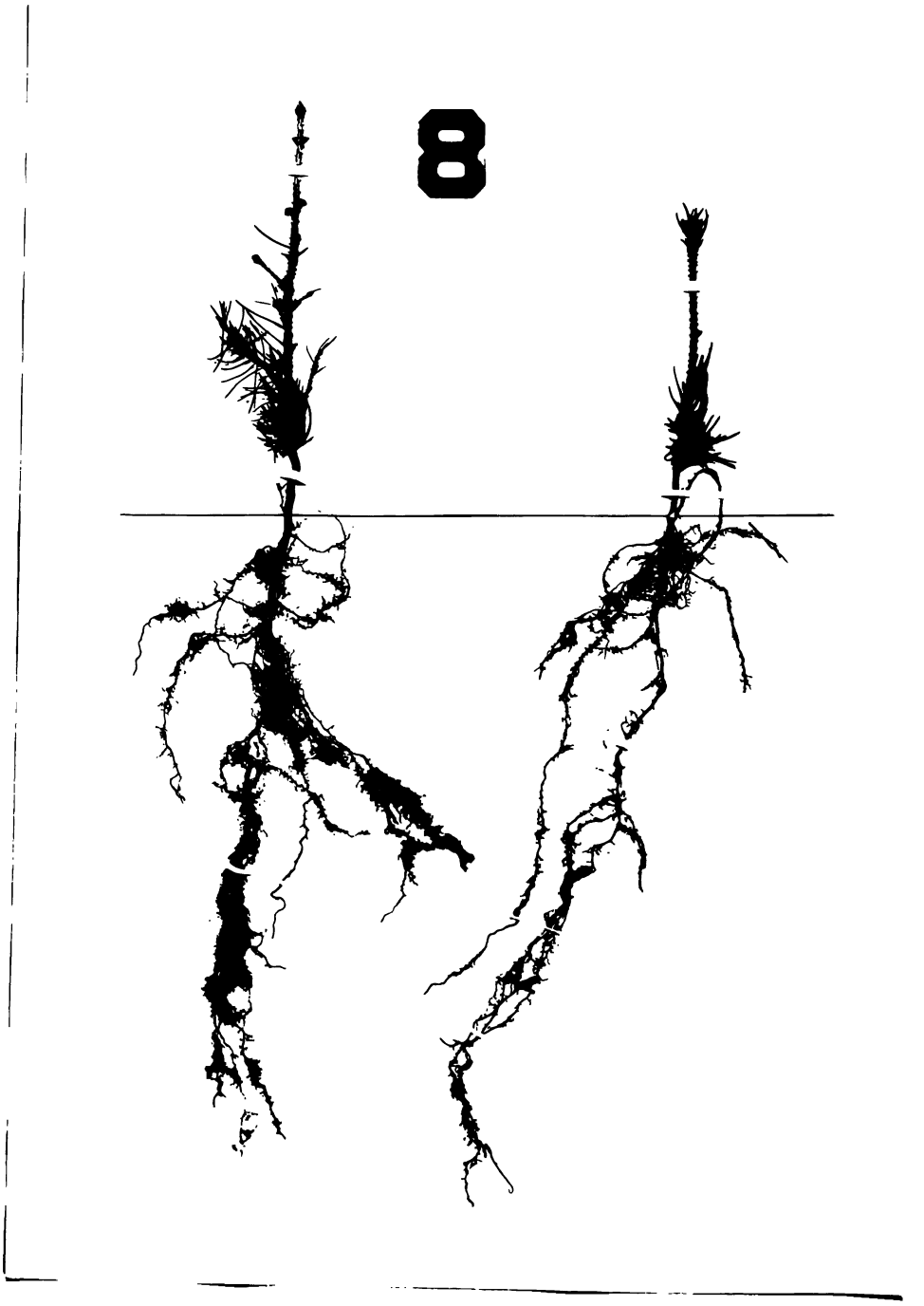


Figure 1. Norway Spruce fertilized with poultry manure.

PLATE XVII
Second Year Seedlings

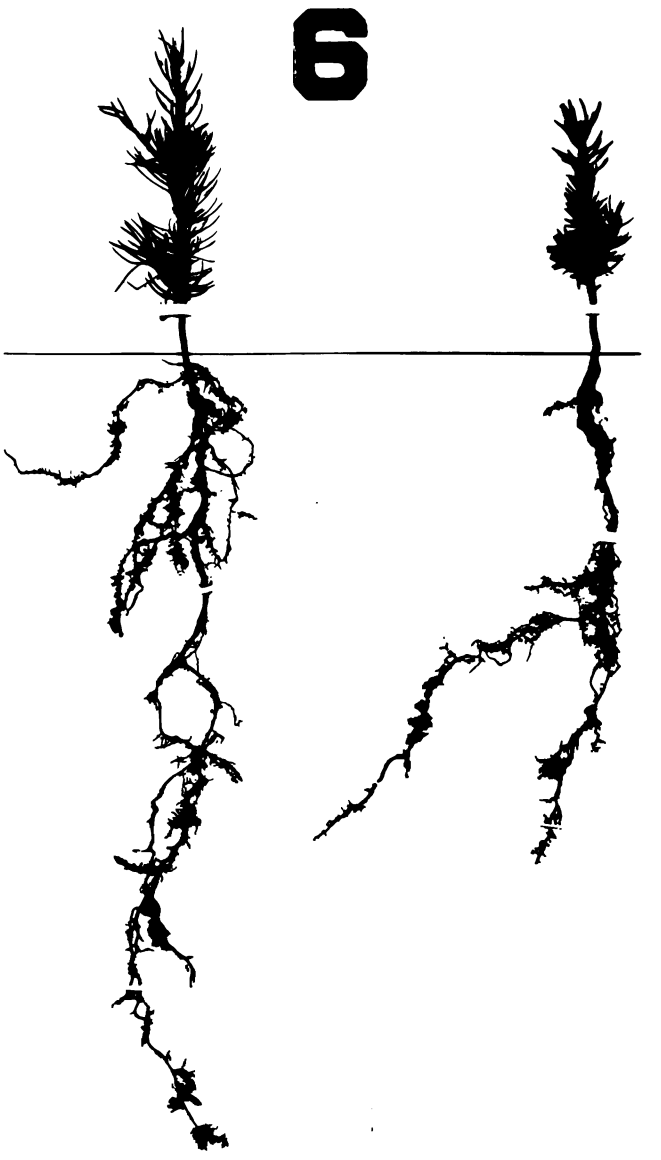


Figure 1. Norway Spruce not fertilized.

PLATE XVIII
First Year Seedlings

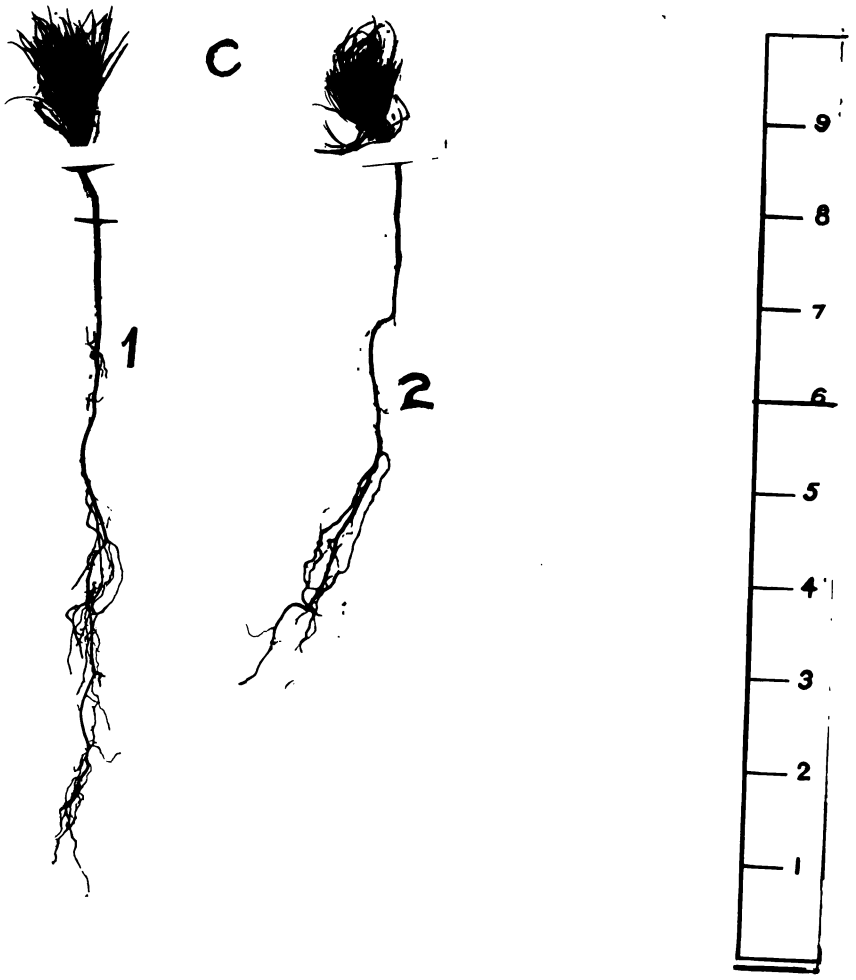


Figure 1. Austrian Pine fertilized with poultry manure.
Figure 2. Austrian Pine fertilized with muck.

PLATE XIX
Second Year Seedlings

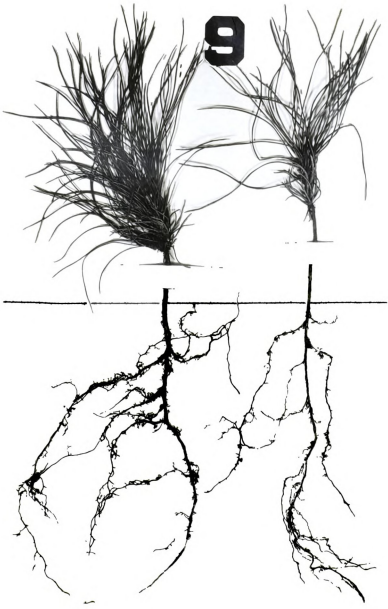


Figure 1. Austrian Pine fertilized with poultry manure..

PLATE XX
Second Year Seedlings

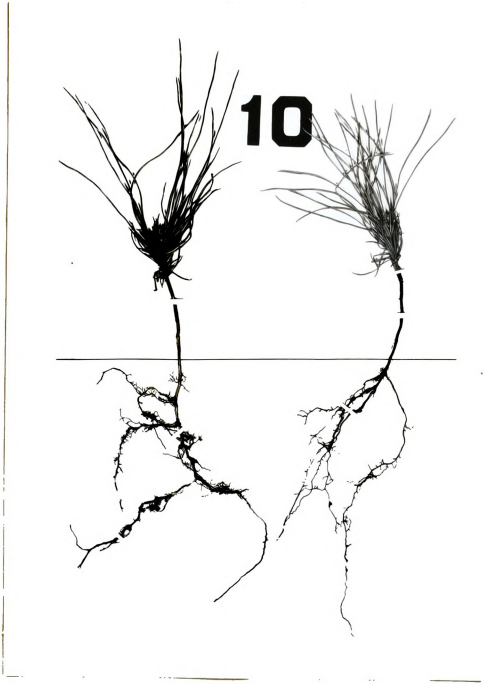


Figure 1. Austrian Pine fertilized with muck.

PLATE XXI
First Year Seedlings

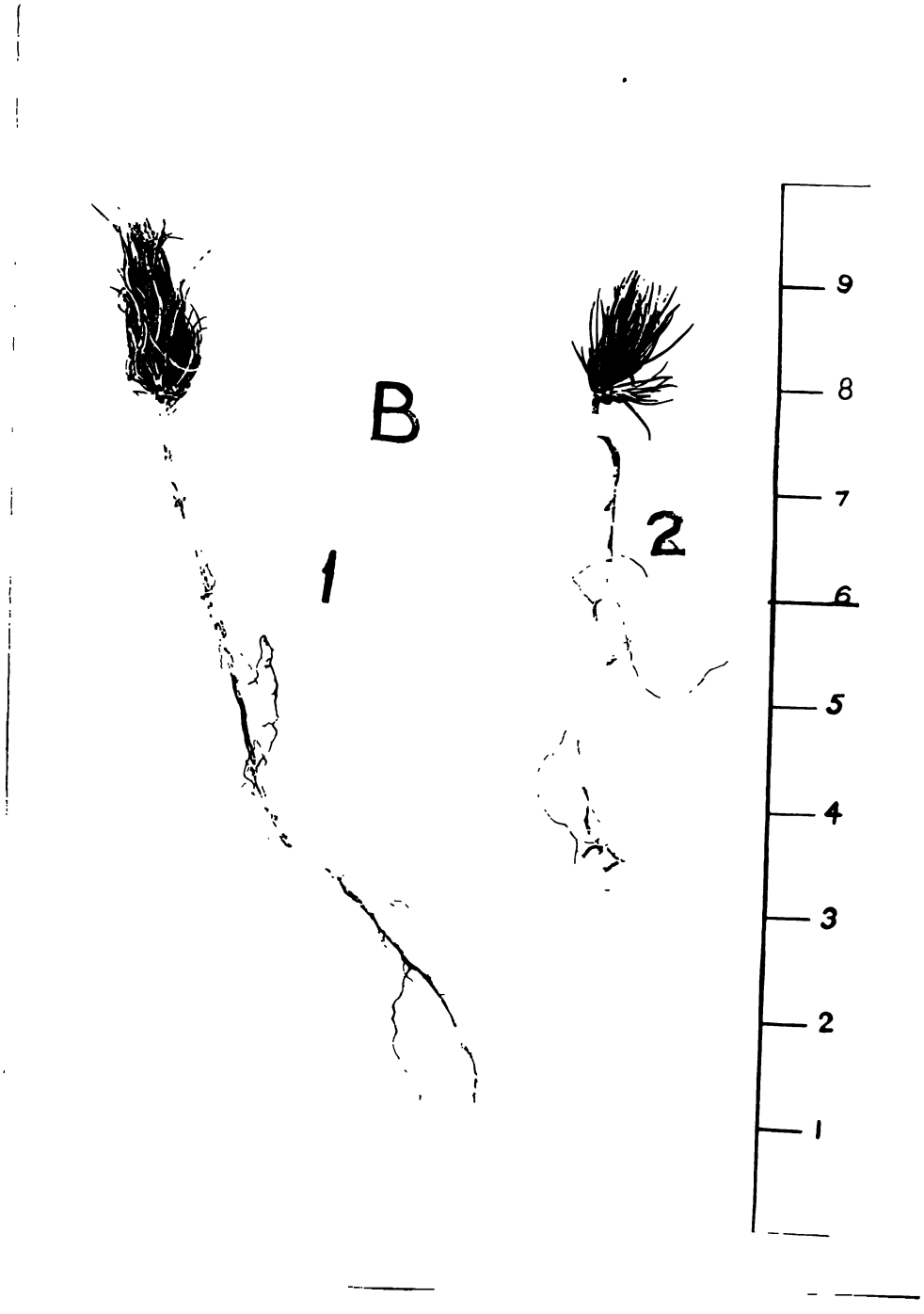


Figure 1. Yellow Pine fertilized with horse manure.
Figure 2. Yellow Pine fertilized with muck.

PLATE XXII
First Year Seedlings

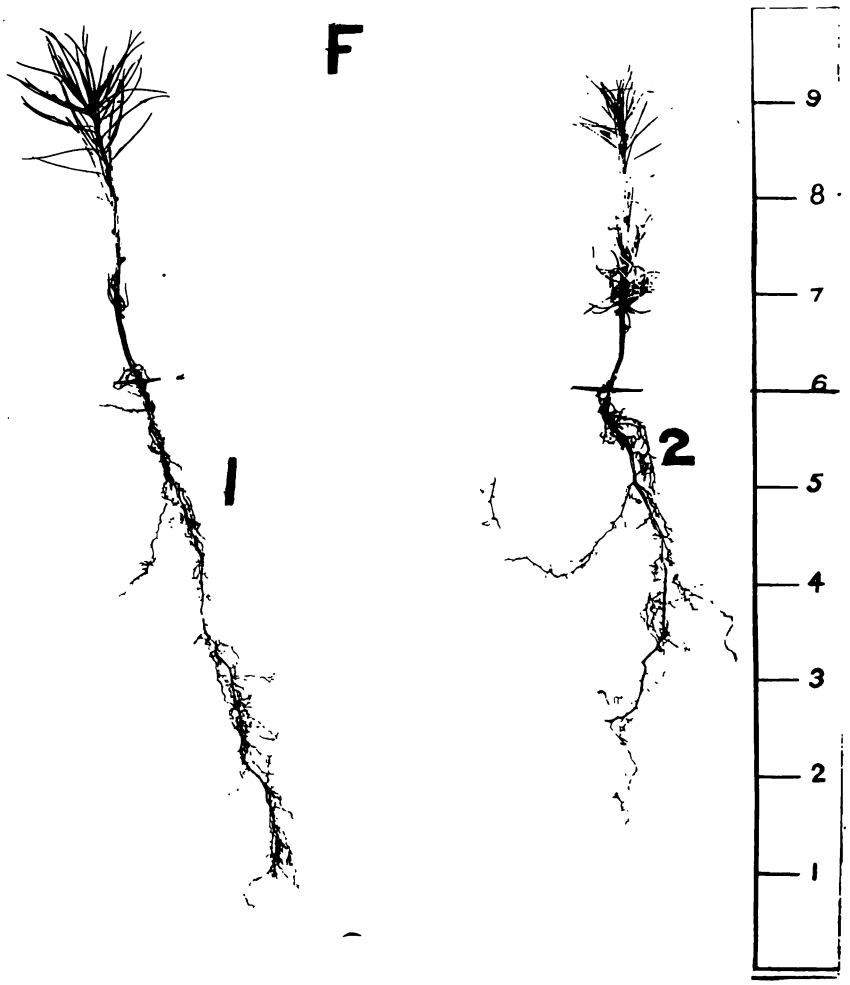


Figure 1. Japanese Larch fertilized with horse manure.
Figure 2. Japanese Larch not fertilized.

PLATE XXIII
First Year Seedlings

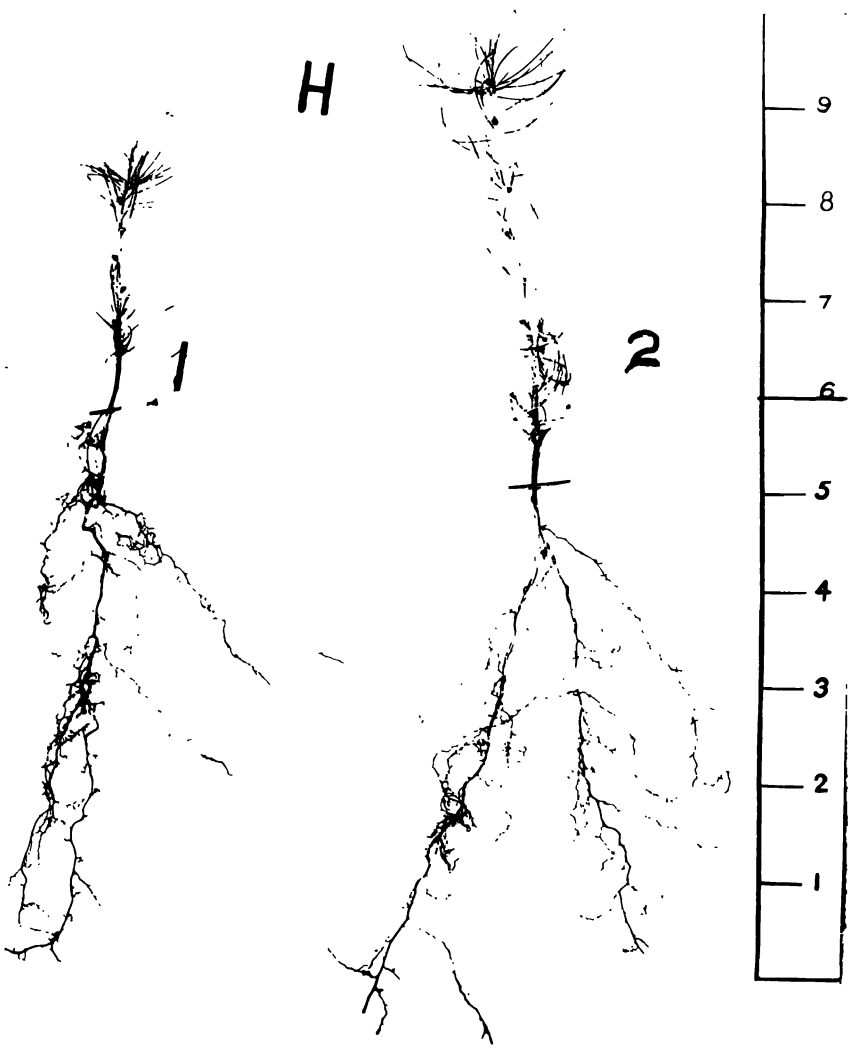


Figure 1. Japanese Larch fertilized with horse manure, edge of bed.
Figure 2. Japanese Larch fertilized with horse manure, center of bed.

PLATE XXIV
First Year Seedlings

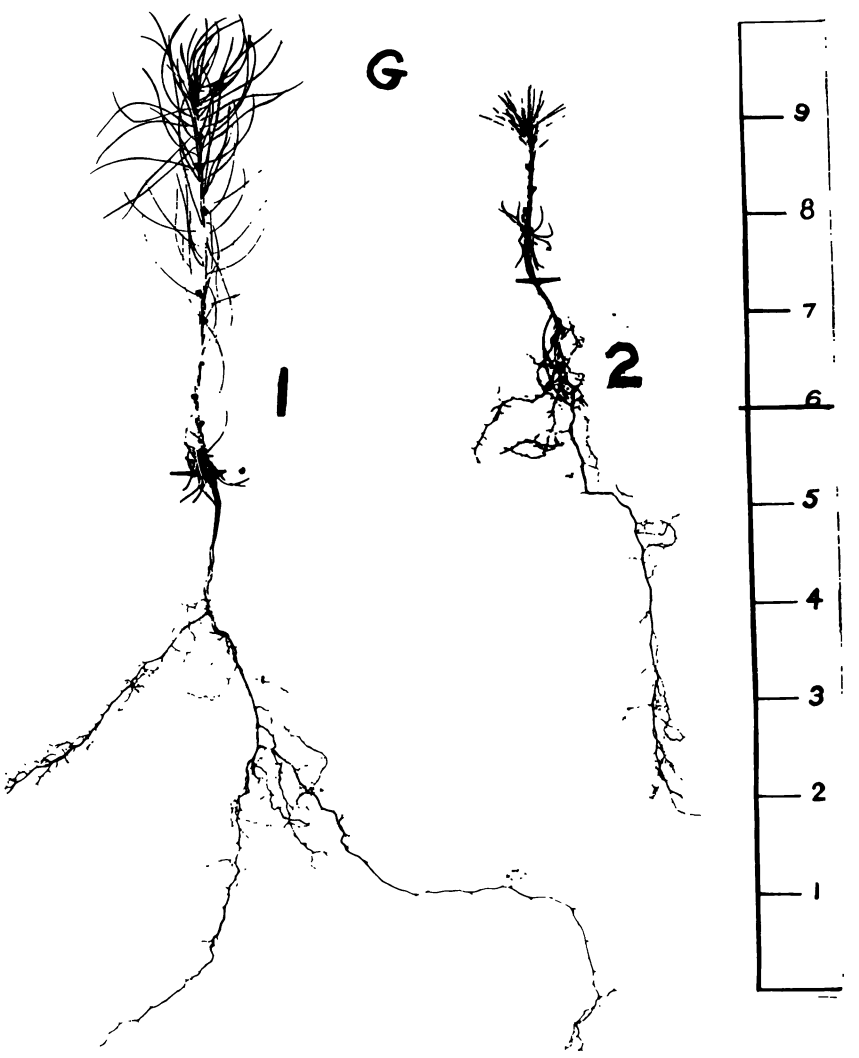


Figure 1. Japanese Larch not fertilized, edge of bed.
Figure 2. Japanese Larch not fertilized, center of bed.

Figure 1. Poplar cuttings propagated in pure sand.
Figure 2. Poplar cuttings propagated in sand and peat.
Figure 3. Poplar cuttings propagated in acid peat.

Figure 1. Willow cuttings propagated in pure sand.
Figure 2. Willow cuttings propagated in sand and peat.
Figure 3. Willow cuttings propagated in acid peat.

Figure 1. Basswood cuttings propagated in pure sand.
Figure 2. Basswood cuttings propagated in sand and peat.
Figure 3. Basswood cuttings propagated in acid peat.