The propagation of Sciadopitys verticillata Sieb. + Zucc

THE PROPAGATION OF

SCIADOPITYS VERTICILLATA. SIEB. + ZUCC.

LOWRY - 1932

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of

Sciadopitys verticillata. Sieb. + Zucc.

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Outline of Thesis

A. Statement of the problem

B. Literature available
   I. History and origin
   II. Methods of propagation

C. Vegetative methods tried and results
   I. Review of literature
   II. Properties of media and chemical reagents used
   III. Cutting experiments
      a. Trials at various times in the year
      b. Use of sand, sand and peat, and peat as rooting media
      c. Treatment of cuttings with $Kmno_4$ and Acetic acid
   IV. Grafting experiments
      a. Cryptomeria japonica elegans as an understock
         1. Various methods of making grafts
      b. Cryptomeria japonica as an understock

D. Sexual method tried and results
   I. Review of literature
   II. Properties of treatments used
   III. Seeding experiments
      a. 1930 crop of seeds
         1. Various periods of stratification in sand and peat media
         2. Various periods of storage on ice
         3. Treatments with H_2O, H_2O_2, ether and chloroform
      b. 1931 crop of seeds
         1. Check lots of stratification and storage on ice

E. Study of graft unions, callus, and root development

F. Discussion of results

G. Summary and conclusions.

Statement of the Problem

It seems to be generally accepted that propagation by seed is at present the most practical method of increase for the Umbrella Pine. The purpose of this study is to learn more about the propagation of the Umbrella Pine and, if possible, to determine some practical method of more rapid increase. The problem of the commercial man is not just propagation but growing the plant to some size in a reasonable length of time. Vegetative methods are much quicker and so have an advantage if they can be carried out economically. If time were not a limiting factor then seeds would certainly be the logical method for the nurserymen to use because they germinate as readily as the seed of many other plants.

Introduction

The Japanese Umbrella Pine (Sciadopitys verticillata Sieb. + Zucc.) is a coniferous evergreen tree grown for its handsome foliage and pyramidal habit. The form varies with the individual specimen from very narrowly pyramidal to broadly conical in shape. It takes its name from the rather unusual whorled arrangement of leaves at the tips of the season's growth.

It is hardy as far north as Portland, Maine and is of rather slow growth. It thrives well in a moderately and constantly moist loamy, and also clayey soil. In dry soil or in soil which periodically becomes dry, it grows poorly. It thrives well in acid soil conditions.

It is native to a restricted locality on Mount Kojasnin, in the island of Nipon, of Japan, where it is a tree 80 to 100 feet high. It is a rare tree in this country largely because of its slow habit of growth and difficult propagation. It has been known and cultivated for a number of years in this country and much earlier in Europe.

The first trees came into the United States about 1877 so that there are quite a number of large sized trees especially in the Eastern section of the country. At Massachusetts State College there are two specimens of the very first importation which without doubt are two of the finest in the country. They are very narrowly pyramidal in form and about 35 feet in height. The Arnold Arboretum have several of the early specimens but they are much broader and shorter in form. There are several other specimens in the vicinity of Boston which are of good size. The Forest Hills Cemetery of Jamaica Plain and the Mt. Auburn Cemetery of Cambridge each have trees. There is a large one in Leschi Park in Seattle, Washington which is quite well known. Most of the larger Botanic gardens have specimens but not all are of a very large size. Several of the well known conifer collections on Long Island also have trees which were of the early importations.

<u>Literature on the Propagation of Sciadopitys verticillata</u>

Bailey's Nursery Manual states that half ripened shoots, taken in summer and inserted in sand, in heat, root readily. Seeds, if obtainable, give best results.

Hottes (Plant Propagation) (14). Cuttings are more rapid than seeds but plants are not apt to be symmetrical.

Gardeners Chronicle (2) gives the following advice as to the propagation of the Umbrella Pine: "The usual method of increasing Sciadopitys verticillata is by means of seed, and this is the only one usually mentioned in garden literature; but seeds are comparatively dear, and they vegetate less freely than those of most coniferous plants, besides taking a long period of time and much attention. Grafting is much to be preferred to seed growing, grafted plants growing readily and making in four months plants equal in size to three year old seedlings. Early in March the terminal shoots are taken and grafted on to pieces of the roots of the same species and bound round with oiled cotton wool, planted in small pots; and placed in a close house or frame having a temperature of 63 to 68 degrees Fahr. When growth is completed, the plants should be hardened off and by the beginning of the month of July the majority will be fit for planting in the nursery. The usual coating of the graft and root with grafting-wax or placing in an air-tight case are not required. Under this treatment the percentage of failures is very small".

Mr. Hermann Herbst, (3) of Richmond gives the following advice: "Early in January bring plants into strong heat, root the young, succulent shoots as soon as they are large enough to handle. At this time they root very readily."

Revue Horticole (11) gives the following: "This very curious species which by nature, the form of the leaves themselves, and even by their arrangement rather recall to mind certain araliacees, have just fruited in France at Versailles. It is even probable that this is the first time that this has produced fruit in Europe. The cones have attained less than normal size and the subjects which bore them have produced for the first time male catkins. It is very probable that the seeds will be fertile and that soon one may collect regularly the seed of this species which now comes from Japan.

"A particularly curious thing which appeared on some of the cones in question was to see the central axil terminated by two or by three leaves. This peculiarity occurs frequently on certain species of conifers, notably upon the Cryptomeria and may be compared to a prolification. It demonstrated throughout that the axil of flowers and even with those of fruits, are merely a modification of branches which bear them, which shows itself very frequently in many of the rosaceae either by the flowers as in certain roses or even the fruits as they develop, notably in those of pears where one sees at times the leaves and even the young fruits to come forth from the axil in the calyx cavity.

"Sometimes also we have noticed another peculiarity produced by the leaves. It is a sort of budding which has shown for a long time that the leaves are equivalent to branches to which they revert at times, this is assumed to be the case in Sciadopitys.

"In admitting the fact of their equivalence, one may ask of oneself if one could multiply Sciadopitys verticillata by means of leaves."

Cutting Experiments

Review of literature on media and chemical treatments.

Potassium permanganate -

Winkler (23) in working with vine cuttings found that oxidizing reagents hasten both callus and root formation and improved the rooting of cuttings which rooted with difficulty.

Curtis (13) found that the use of potassium permanganate resulted in a very marked increase in root growth of various woody cuttings. The principal reason was the increase of respiratory activity by cayalytically hastening oxidation. He worked with the following plants: Ligustrum ovalifolium, Cydonia oblonga, Berberis thunbergi, Euonymus europaea, and Kerria japonica.

Chadwick (12) found stimulation of rooting with the use of potassium permanganate on Taxus cuspidata, Taxus cuspidata nana, Juniperus horizontalis, Thuja occidentalis lutea, and others.

Acetic Acid -

Small (20) reported that the watering of cuttings with a weak solution of acetic acid increased the rooting of Ligustrum, Rose, Veronica, and others.

Peat and sand media -

Esper (14) found that a mixture of peat and sand as well as a mixture of peat and agricultural slag rooted a larger percentage of evergreen cuttings than pure sand. He worked with Juniperus sabina, Thuja occidentalis, Juniperus chinensis pfitzeriana, Taxus cuspidata, and Chamaecyparis pisifera plumosa.

Hitchcock (17) reported a mixture of peat and sand as superior for the rooting of a good many plants.

Chadwick (12) found sand and peat mixture superior to peat and pure sand for several conifers, mainly, Thuja plicata, Thuja occidentalis wareana, Juniperus excelsa stricta, Juniperus virginiana tripartita, and Juniperus horizontalis plumosa.

Properties of Media and Chemical Reagents

Kmno4 is an oxidizing agent which has been found quite generally to stimulate root action in cuttings. The presence of oxygen in certain amounts is believed to induce root formation.

Acetic Acid gives an acid condition which is believed to favor root formation.

Sand has long been used generally as a rooting medium because of its good aeration and freedom from organic matter.

German Spaghnum Peat is a fibrous organic material having a pH of 4.0. It is light in weight and unless water-soaked gives reasonable aeration. It takes up water very rapidly so that care must be taken in applying water so that it may not become water-logged.

Peat and Sand ($\frac{1}{4}$ peat and $\frac{3}{4}$ sand) combines the characteristics of good drainage and aeration of the sand with the acidity and water-holding capacity of the peat. The problem of watering is not as troublesome as in the pure peat, yet it has the advantages of the influence of peat on rooting.

Results of Cutting Experiments

Work was begun in June, 1930, by starting a group of cuttings and continued through the first of May, 1932. Cutting and grafting work was done in the Upper Range of greenhouses on the campus. Cuttings were given bottom heat during the season when heat was necessary in the house, which was from about the middle of October to the first of May. Cutting material was obtained from the two specimen trees growing in the Rhododendron Garden.

Groups of cuttings were taken at various times in the year to determine, if possible, the best season for rooting cuttings. They consisted of one year wood and the cuts were made at the nodes in all cases except for one check lot of internode cuttings.

Three different media and two chemical treatments were used on the cuttings. The media used were sand, $\frac{1}{4}$ peat and $\frac{3}{4}$ sand, and peat. The two chemical treatments were potassium permanganate .1%

molar solution and acetic acid .1% solution. The cuttings in all cases were treated by soaking the bases for a period of 24 hours before inserting in the rooting media.

In general lots of 15 cuttings each were used for each treatment.

The following is a description of experiments and the results. The table on page 18 gives a summary of experiments on cuttings.

June 1, 1930 a group of cuttings were placed in a closed case in the greenhouse. Growth had developed one-fourth inch in length.

The cuttings made no further growth and by January 22, 1931, were dead.

August 1, 1930 a group of cuttings were put in three media and one chemical treatment. Season's growth was by this time completed and wood was practically matured.

Jan. 22, 1931.

Sand

$KMnO_4$ group all alive and callused

Check group 4 dead and remaining callused

$\frac{1}{4}$p.$\frac{3}{4}$s.

$KMnO_4$ - 2 poorly rooted and rest callused

Check 1 rooted and 3 dead

Peat - all cuttings were dead. Peat was kept too moist.

May 23, 1931

Sand - none rooted

$\frac{1}{4}$p.$\frac{3}{4}$s.

$KMnO_4$ - 2 well rooted

Check - 1 rooted

Mar. 23, 1932

Sand - all dead

$\frac{1}{4}$p.$\frac{3}{4}$s.

$KMnO_4$ - 2 rooted

Check - 1 rooted.

<u>October</u> <u>5</u>, <u>1930</u> a group of cuttings were placed in a closed case in which three media and two chemical treatments were used.

July 8, 1931

Sand - all cuttings dead

$\frac{1}{4}$p.$\frac{3}{4}$s.

$KMnO_4$ - 2 callused, rest dead

Check - all dead

$HC_2H_3O_2$ - 2 callused, rest dead

Peat

Check - all dead

$KMnO_4$ - 1 callused, rest dead

$HC_2H_3O_2$ - all dead

Mar. 23,1932
$\frac{1}{4}$p.$\frac{3}{4}$s.
$HC_2H_3O_2$ - 1 rooted, rest dead.

November 20, 1931 another group of cuttings were placed in a closed case using three media and two chemical treatments.

July 8, 1931
Sand
Check - all dead
$Kmno_4$ - all dead
$HC_2H_3O_2$ - 1 callused, rest dead

$\frac{1}{4}$p.$\frac{3}{4}$s.
Check - all dead
$Kmno_4$ - 3 callused, rest dead
$HC_2H_3O_2$ - 1 callused, rest dead

Peat
Check - 1 callused, rest dead
$Kmno_4$ - 2 callused, rest dead
$HC_2H_3O_2$ - all dead

August 1, 1931 -- all cuttings dead.

July 11, 1931 a group of cuttings were placed in the case. Material was still in a soft condition and by August 5, 1931, quite a number of the cuttings had damped off especially in the sand medium. By August 24, all the cuttings were dead.

July 24, 1931 another group of cuttings were placed under treatment. New growth was just beginning to color up from the bottom of the stems. By August 15, the acetic acid treatments in sand, and sand and peat mixture were dead.

March 23, 1931

Sand
Check - 3 callused, rest dead
$KmnO_4$ - 6 callused, rest dead

$\frac{1}{4}$p.$\frac{3}{4}$s.
Check - 1 callused, rest dead
$KmnO_4$ - 8 callused, rest dead

Peat - all cuttings dead

May 1, 1932

Sand
Check - 3 callused, rest dead
$KmnO_4$ - 5 callused, rest dead

$\frac{1}{4}$p.$\frac{3}{4}$s.
Check - 1 callused, rest dead
$KmnO_4$ - 7 callused, rest dead

August 9, 1931 a group of cuttings was placed in a case using three media and two chemical treatments. Also a group taken at the internode.

March 23, 1932

Sand

Check - 10 callused, rest dead

$KMnO_4$ - 12 callused, rest dead

$\frac{1}{4}$p.$\frac{3}{4}$s.

Check - 1 rooted, 9 callused, rest dead

$KMnO_4$ - 3 rooted, 10 callused, rest dead

$HC_2H_3O_2$ - 1 callused, rest dead

Peat - all dead.

Internode - 3 callused, rest dead

May 1, 1932

Sand

Check - 8 callused, rest dead

$KMnO_4$ - 12 callused, rest dead

$\frac{1}{4}$p.$\frac{3}{4}$s.

Check - 1 rooted, 9 callused, rest dead

$KMnO_4$ - 3 rooted, 10 callused, rest dead

$HC_2H_3O_2$ - 1 callused, rest dead

Internode - 3 callused, rest dead

<u>August 25, 1932</u>. Check lots were placed in the three media with chemical treatments in sand.

March 23, 1932 - 3 cuttings in the sand check plot callused, the remainder were dead.

May 1, 1932 - all cuttings dead.

Table giving number of cuttings rooted out of 15

Medium	Treatment \ Date	6/1/30	8/1/30	10/5/30	11/30/30	7/11/31	7/24/31	8/9/31	8/25/31
Sand	Check	0	0	0	0	0	0*	0	0
	$KMnO_4$	0	0	0	0		0*	0*	0
	Acetic Acid	0		0	0		0	0	0
Sand and Peat	Check	0	3	0	0	0	0	1*	0
	$KMnO_4$	0	6	0	0		0*	3*	
	Acetic Acid	0		0	1		0	0	
Peat	Check	0	0	0	0	0	0	0	0
	$KMnO_4$	0	0	0	0		0	0	
	Acetic Acid	0		0	0		0	0	

* No. of cuttings rooted at end of 9 months. Cuttings not rooted still alive

Comparative Groups of Cuttings at the End of 9 Months.

1. $KMnO_4$ treatment in peat and sand medium.
   3 rooted and 10 living out of 15.

2. Check in sand and peat medium.
   1 rooted and 10 living out of 15.

3. Check lot in sand.
   None rooted and 8 living out of 15.

4. $KMnO_4$ treatment in sand.
   None rooted and 12 living.

Left. - Rooted cuttings 24 months from the time of taking cutting.

Right.- Seedlings at the end of the third growing season.

Grafting Experiments

Through an anonymous source it was recommended that scions of Sciadopitys could be grafted onto stock of Cryptomeria japonica. With this information in mind the grafting work was started. By mistake the first stocks used were Cryptomeria japonica elegans and after trying three different grafting methods at different seasons of the year with no success stocks were obtained of Cryptomeria japonica and the veneer and side grafts completed with apparent success.

The stocks of Cryptomeria japonica and the Sciadopitys seedlings were obtained from F. M. Ellis of Griffin, Georgia, and the stocks of Cryptomeria japonica were obtained from Verkades Nursery of New London, Connecticut.

Grafting was also tried using several other conifers as stocks.

<u>Approach Grafting</u> - Feb. 14, 1931 approach grafts were made using three year old Sciadopitys seedlings on Cryptomeria japonica elegans as stock. The grafts were tied with raffia and placed in a closed case at a temperature of 70 degrees F. By July 6, the wounds on stock and scion had well callused over but no union had taken place.

<u>Veneer Grafting</u> - Feb. 14, 1931, 26 grafts were made using Cryptomeria japonica elegans as stock and one year wood of Sciadopitys as scions. The grafts were tied with raffia and placed in a closed case. By April 4, most of the scions showed bud action but growth seemed to stop and scions were all dead by July 3, 1931.

March 6, 1931, grafts were made using Thuja occidentalis, Chamaceyparis pisifera as stocks. Six grafts were made of each and placed in a case. No growth had started and by July 3, all scions were dead.

April 6, 1931, 6 grafts of each were made using as stocks Cryptomeria japonica elegans, Thuja occidentalis, and Chamaecyparis pisifera. By July 10, all scions were dead.

July 11, 1931, veneer grafts were made using Cryptomeria japonica elegans as stock and placed in closed case. By September 21, all grafts were dead.

August 25, 1931, veneer grafts were made using Cryptomeria japonica elegans as stock. By November 11, all scions were dead.

January 15, 1932, 12 veneer grafts were made using Cryptomeria japonica as stock. Grafts were placed in a closed case. By March 23, all had made considerable growth and apparently stock and scion had united. May 1, growth had slowed up but scions still living.

March 12, 1932, a group of side grafts were made using Cryptomeria japonica as stocks. The scions started almost immediately into growth. May 1, growth had apparently stopped but grafts were apparently in good condition.

Cutting Grafting - February 14, 1931, three groups of cutting grafts were made using Cryptomeria japonica elegans as stock.

Group I was made on rooted cuttings using the veneer method and immediately pottdd in sandy soil.

Group II was made on callused cuttings and carried in sand three weeks and potted in a sandy soil.

Group III was made on callused cuttings and left in sand media.

By July 3, all scions were dead.

Experiments on Seed Germination

Review of Literature

Stratification.

Barton (9) reports 50% germination of Umbrella Pine in 101 days after two months stratification at 10 degrees C. Stratification gave no important difference in the rate nor the percentage of germination obtained as compared with no stratification. The optimum growing temperature in the greenhouse is 65-70 degrees F.

Barton (8) finds low temperature stratification advantageous to old seeds of low vitality. Work was done on Southern Pine seeds.

Johnstone and Clare (17). Seeds of Pinus torreyana, coulteri, sabiniana, cembroides after ripened more quickly and yielded a higher percentage of germination after exposure to the temperature of melting ice for optimum periods than without such treatments.

Seeds which store their food as oil often require low temperature treatment to break the dormancy or to hasten the germination. During the exposure of such seeds to low temperatures, preferably above 0 degrees C., the oils are changed to sugar while the rate of respiration is low. After the chilled seeds are transferred to a higher temperature and the other usual conditions for germination, respiration is accelerated, not only because of the influence of the higher temperature but also due to the higher percentage of readily respirable sugar.

Chemical Stimulation.

Snow (20) - Soaking in solution of sulphuric acid and chloroform gave best results for the Sugar Pine.

Toumey and Durland (21) - Soaking of the seed for a limited period prior to sowing reduced the germination energy period in most species of conifers. As a rule soaking for a longer period than 10 days caused a rapid falling off in germination. Only in a few species did any of the seeds remain viable after soaking for 30 days. In certain wet land species, however, soaking for 15 to 20 days increased the percentage of germination obtained.

Howard (15) Treatment with ether will overcome dormancy in certain herbaceous perennials.

Appleman (6) was able to shorten the rest period in the potato tuber by the use of hydrogen peroxide.

Vacha and Harvey (23) were able to hasten the germination in seeds of Buckthorn, Highbush Cranberry, Snowberry, and Tatarian Honeysuckle by the use of Ether, Chloroform, Ethylene, and Propylene.

Properties of treatments used in seed germination experiments

Ether. Treatment with ether has been found to overcome dormancy in seeds as well as in certain herbaceous perennials.

Chloroform. Has a number of properties in common with ether.

<u>Hydrogen Peroxide</u> - An oxidizing agent which has been found to shorten the rest period in the potato tuber.

<u>Stratification</u> - It is well known that storing of seeds which have a rest period in a moist medium at cool temperatures often considerably shortens the rest period. The time of treatment and temperature varies for the individual seeds.

<u>Experiments and Results</u>

Two lots of seeds were used. One, of the crop of 1930, was obtained from Conyer B. Fleu, seedsman of Philadelphia. The other lot, of the crop of 1931, was obtained directly from a Japanese seedsman.

The seeds placed in stratification were mixed with moist sand and German sphagnum peat and kept at a temperature of 38 to 40 degrees F. The seeds of the ice treatment were stored dry in a cloth container laid on ice, temperature about 32 degrees.

Treatment of seeds by chemicals before planting was done in all cases by soaking the seeds in the liquid for a period of 24 hours and then planting.

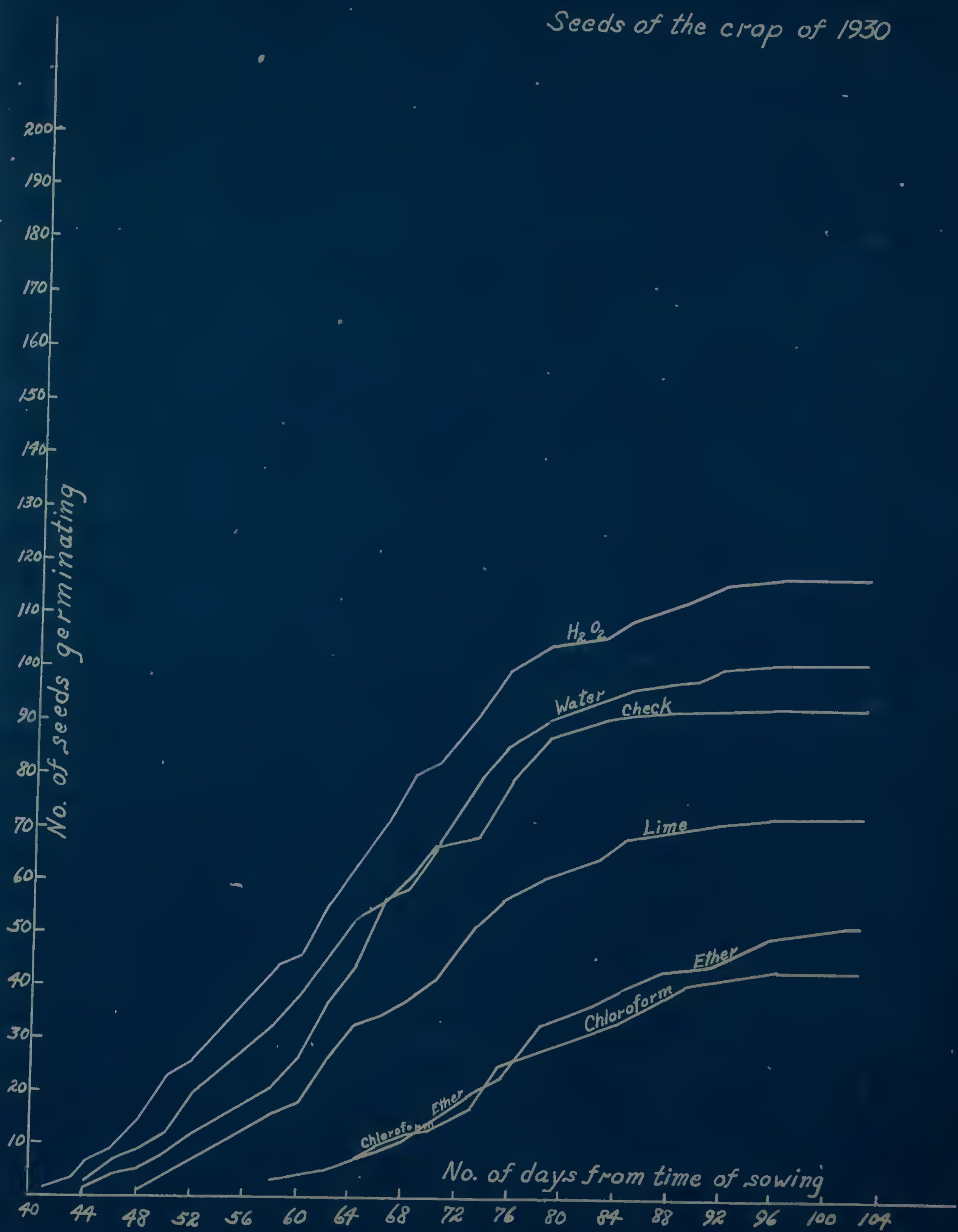
The various treatments were planted broadcast in 10 by 12 inch flats with 500 seeds for each treatment. The flats were kept in a warm house (70 degrees). As the seedlings made their appearance they were noted and a record of the germination was kept.

The seeds of the 1930 crop arrived and the first plantings were made November 1, 1931. The seeds of the 1931 crop arrived and the first planting was made January 7, 1932.

Cutting tests were made of typical samples of the two lots of seed. The 1930 crop had 77% solid seeds while the crop of 1931 had 91% solid seeds.

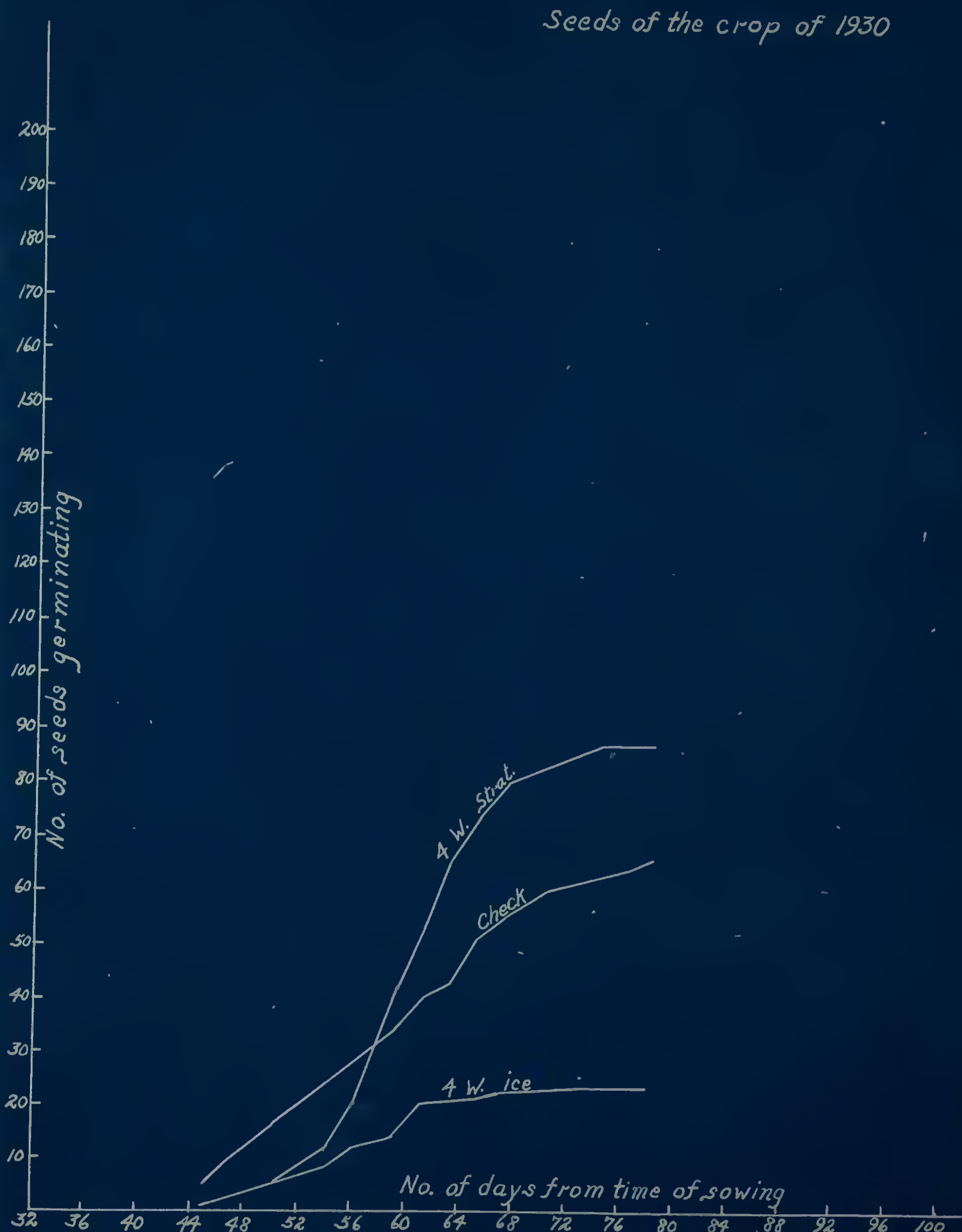
The following grafts show the number and the rate of germination for the various treatments.

GERMINATION TABLE No. 1.

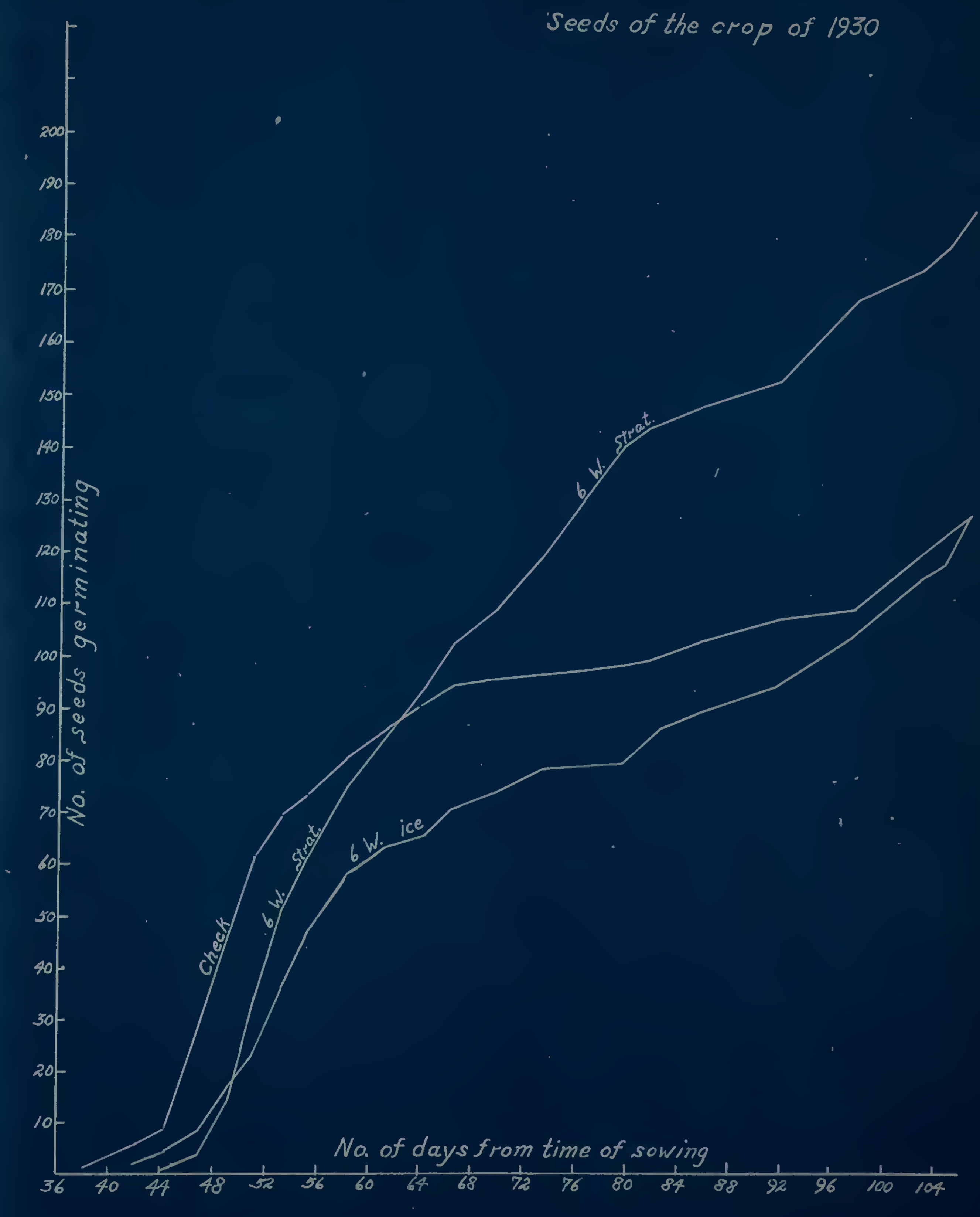


GERMINATION TABLE
No. 2.
Seeds of the crop of 1930
No. of seeds germinating
No. of days from time of sowing
2 W. Strat.
2 W. ice
Check
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
28
32
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96

GERMINATION TABLE No. 3.

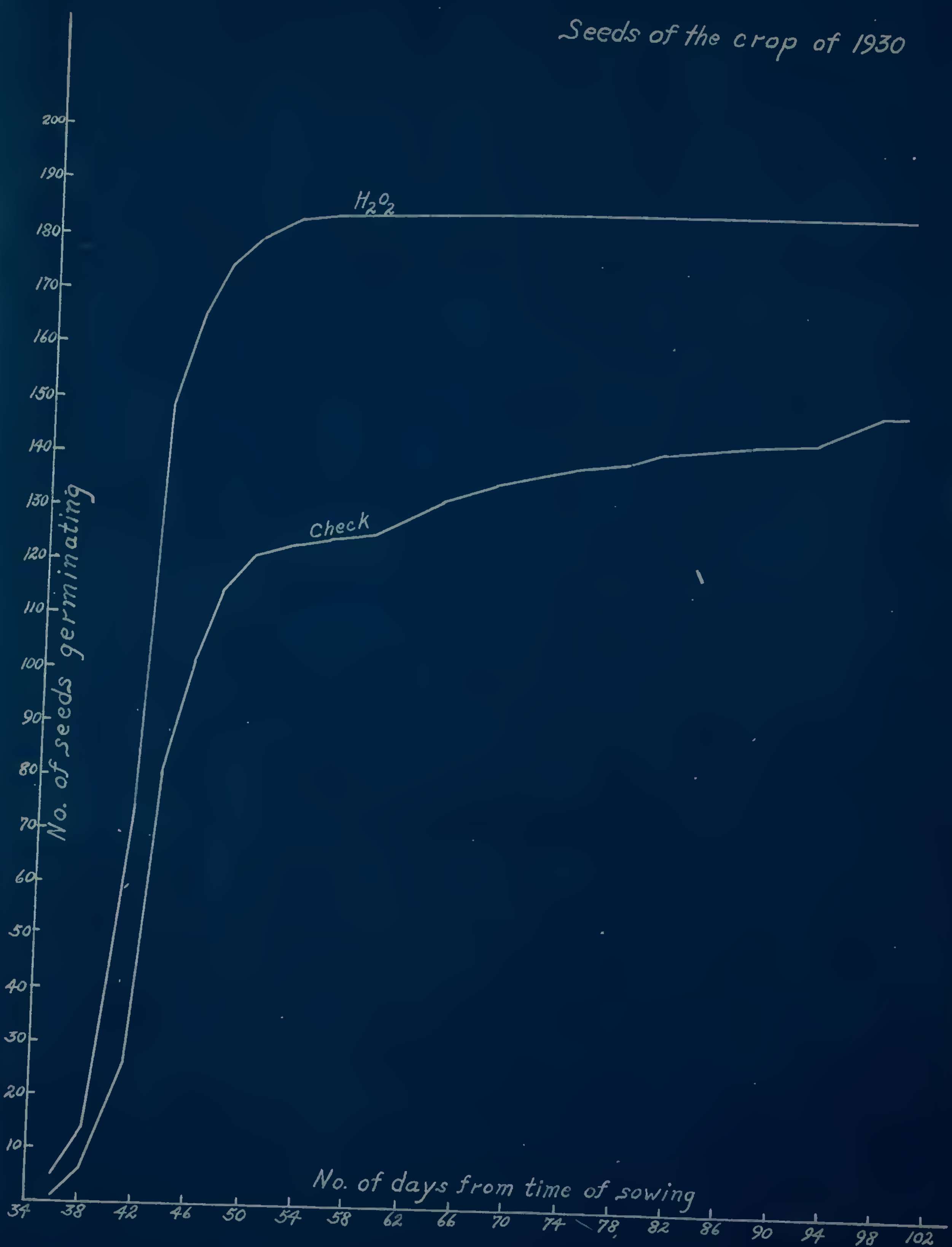


Germination Table No. 4.



GERMINATION TABLE
No. 5.
Seeds of the crop of 1930
No. of seeds germinating
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
9 W. Strat.
9 W. ice
9 W. ice
Check
No. of days from time of sowing
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
104

GERMINATION TABLE No. 6.



Germination Table No. 7.

Seeds of Crop of 1931

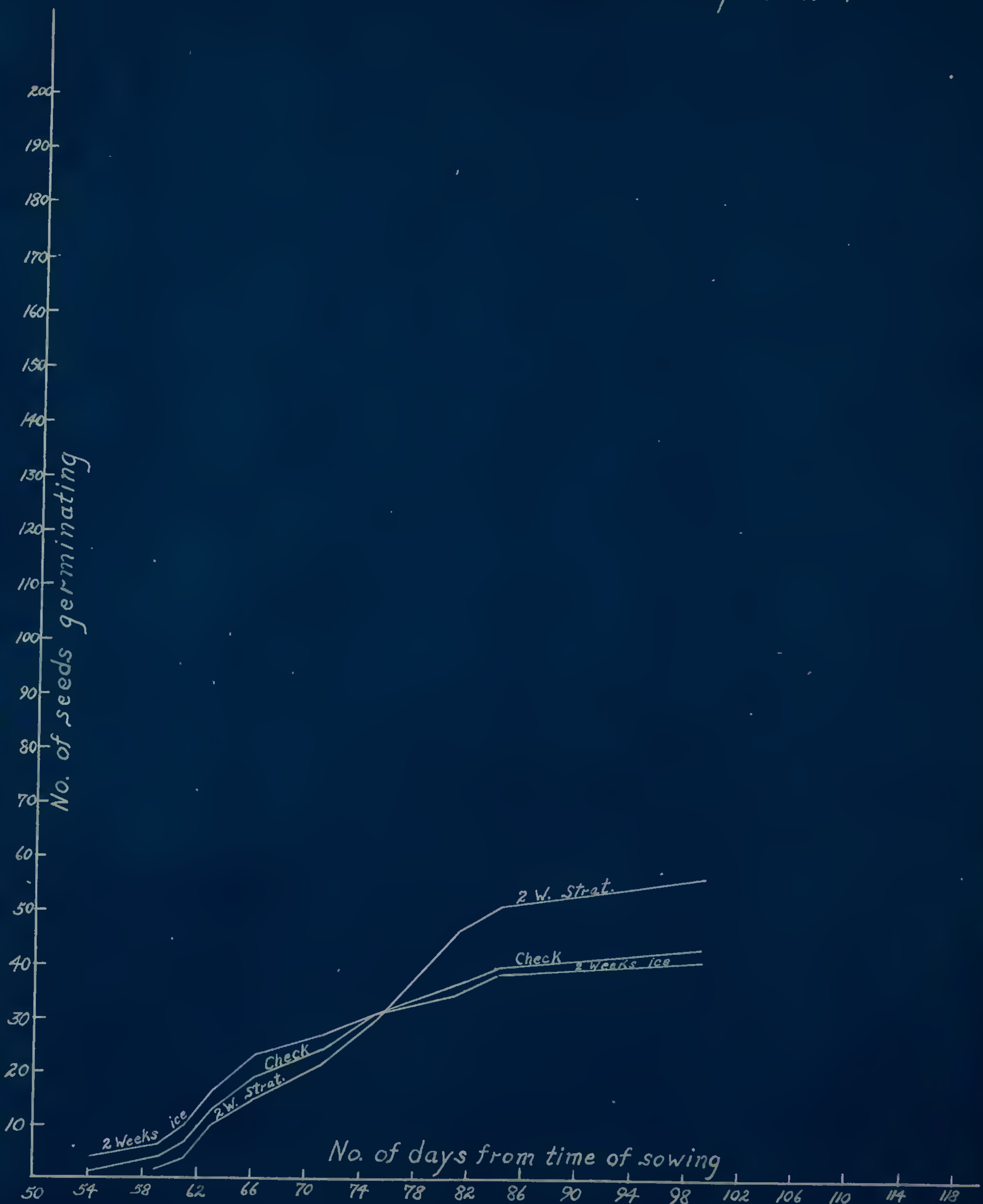


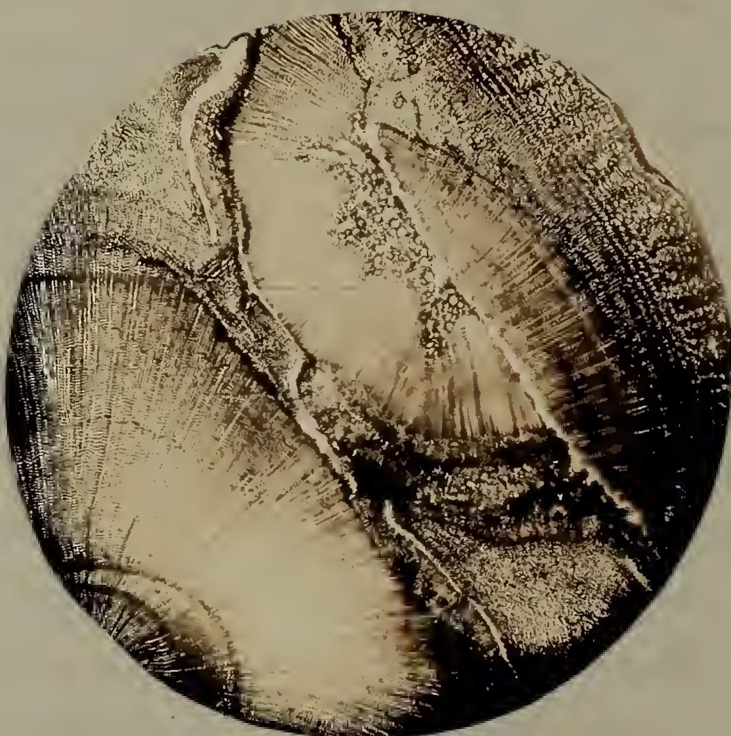
Table of Germination

Treatment of seeds	Check	Treatment
Hydrogen peroxide 12/14/31	40	49
6 Weeks stratification	33	49
2 Weeks stratification	29	43
6 Weeks ice	33	33
2 Weeks ice	29	32
Hydrogen peroxide 11/1/31	23	31
9 Weeks stratification	22	28
Water	23	27
2 Weeks ice	22	24
4 Weeks stratification	17	23
Ether	23	14
Chloroform	23	11
4 Weeks ice	17	6

Actual percentage of germination at the end of 3 1/2 months

A longitudinal section of the base of a cutting showing root development and origin.

A cross-section of a veneer graft at the end of twelve weeks.



A cross-section of a side graft at the end of seven weeks.

Discussion of Results

Experiments on cuttings.

From the results of work on cuttings everything seems to point to but one season of the year when cuttings may be taken successfully. That this time should vary two or even three weeks from one year to the next is reasonable because of the advancement or retardation of the season. The success of rooting depends on the maturation of the growth. In an average year the first of August would probably give the best results. Growth should apparently be matured enough so that the new stems have turned from the green of the succulent growth to the brown color of the matured growth, but it should not be entirely hardened.

Cuttings made with a basal cut at the node will give a much larger percentage of rooting than cuttings made by an internode cut. This holds true for most cutting material.

Cuttings of rather vigorous growth gave plants of more vigorous growth after rooting than when smaller growth was used for cuttings.

As to media, the pure peat showed up very poorly, the probable reason being that it is hard to keep the medium dry enough and at the same time keep a humid atmosphere around the upper part of the cutting. The mixture of $\frac{1}{4}$ peat and $\frac{3}{4}$ sand was, without question, the best medium of the three tried for the rooting of cuttings.

Of the two chemical treatments given, the potassium permanganate treatment was superior to acetic acid treatment and check plots. In only one case was a cutting rooted which had been treated with acetic acid. The combination of the peat mixture medium and the potassium permanganate treatment was superior to all other lots.

<u>Experiments on grafting</u>. Sciadopitys did not unite with Thuja occidentalis, Chamaecyparis pisifera, and Cryptomeria japonica elegans. It does apparently unite with Cryptomeria japonica. The union of tissue is not made very rapidly so the top of the stock should not be cut back until at least six months or more. Cross-sections of graft unions on pages 39 and 40, taken at the end of 12 and 7 weeks respectively, shows little union except of phloem or bark tissue and as yet not a union of cambium layers. The grafts making only a small growth, at least the first year, the advantage of time as compared to cuttings is doubtful. It will take at least another season's growth to determine the rapidity of growth.

Cryptomeria japonica is of doubtful hardiness in the North so that it would be wise to get the scion established on its own roots as soon as possible. This would be accomplished by setting the finished graft deep in the ground so that the scion might throw out roots.

As to the type of graft used, either the veneer or side graft, there is apparently no great difference in the taking of the grafts of the two types. The side graft is much neater appearing and would tend to grow over quicker than the veneer but as a rule a smaller cut surface on the stock and scion must be used for the graft union.

Where the scion material was scarce certainly one would be forced to graft instead of taking cuttings because of the 50% loss in taking of cuttings.

The Cutting-graft would seem a logical method of propagation if Cryptomeria japonica rooted from cuttings readily but cuttings of hardwood material do not root readily. Possibly grafts on summer cuttings would succeed very well.

Experiments on Germination. There was a marked difference in the time required for the germination of seeds of the 1930 crop and those of the 1931 crop. The first germination of the 1930 lots started usually at the end of 35 days while those of the 1931 lots started at the end of 55 days, a considerable difference in time.

The cutting tests showed a considerable drop in the number of solid seeds with the increase in age. The 1931 cut 91% while the 1930 cut 77%.

In all cases the stratification treatment in the sand and peat mixture showed a distinct advantage over the ice treatment and check plots.

The hydrogen peroxide treatment has increased somewhat the speed of germination as well as increased the percentage of germination.

Ether and Chloroform treatments have shown a distinct disadvantage as compared with the check.

The seeds in a distinct alkaline soil showed germination below that of check confirming the necessity for an acid soil.

As far as the time of stratification is concerned there was no distinct difference between the best two lots which were periods of two and six weeks. The four and nine week periods were distinctly inferior in the 1930 crop of seeds. From the results a two weeks stratification seems as advantageous as a longer period.

Summary and Conclusion

1. A stratification period of two to three weeks is advantageous for treatment of seeds before planting.

2. For seeds which have been kept in a cool dry storage there seems to be no advantage of fresh seed over seeds of one year of age.

3. Hydrogen peroxide exhibits a stimulating effect on the percentage as well as the speed of germination.

4. Cuttings taken about the first of August root better than at other seasons of the year.

5. A medium of sand and peat mixture and the treatment of cuttings with potassium permanganate are of value in the rooting of cuttings of the Umbrella Pine.

6. The Umbrella Pine can not be grafted on Thuja occidentalis, Chamaecyparis pisifera, and Cryptomeria japonica elegans. It will unite with Cryptomeria japonica.

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