SATURDAY MORNING SESSION

December 1, 1956

The Sixth session convened at 9:30 a.m., President Scanlon presiding.

PRESIDENT SCANLON: This morning we are extremely fortunate to have Dr. Lela V. Barton, of the Boyce Thompson Institute for Plant Research, Yonkers, New York, as a guest speaker. Dr. Barton has been investigating seeds for a number of years, and I am certain that many of us here this morning are familiar with many aspects of her work.

Dr. Barton presented her paper entitled, "Gathering, Stratification, and Sowing of Seeds." (Applause).

GATHERING STRATIFICATION, AND SOWING SEEDS

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A supply of good seeds is the first requirement of the plant propagator Since it is seldom possible for him to grow his own seeds, it becomes necessary for him to understand the best techniques for collecting and cleaning seeds, and some of the factors which influence their viability.

Let us consider the collection of seeds of woody plants. This subject is covered very well in the Woody-Plant Seed Manual prepared by the Forest Service of the United States Department of Agricuture, Miscellaneous Publication No 654, June 1948. Collection is usually handled by a seed collecter who must know where sufficient seed can be found of plants having desirable characteristics. He must know when the seeds are ripe enough to gather and the time period over which it is safe to harvest. He must also know whether the seeds can be collected most easily from the plants, from the ground, or from animal hoards.

The source of the seed has come to be recognized as of prime importance — next to the selection of the species itself. Earlier it was thought that any viable seed lot of a given species would serve the purpose but as large plantings developed in Europe, it was noted that trees from seeds of foreign origin were inferior in many ways to those grown from local seeds. Europeans have been aware of this situation for a long time, but it has been ignored by the United States until rather recently, partly due to the fact that unsatisfactory results from using seeds of improper origin have not been so prevalent in the United States. However, the safest procedure is to use seeds of local origin wherever possible and to restrict the use of other seeds to those which come from regions with similar climate and soils which prevail at the planting site.

Fully mature (ripe) seeds are usually considered superior to immature ones in viability and vigor as well as in keeping quality. It is usually easy to distinguish fully ripe seeds, but because of the possibility of their falling from the plant or being eaten by animals after they are fully mature, it becomes necessary to know the earliest stage of ripening consistent with good, viable seeds This makes it very difficult for inexperienced collectors, especially since the exact time for gathering seeds must be determined for each species in each locality each year. Guides to cone ripeness based on their specific gravity measured by their flotation in a test liquid are available for a few pines. To complicate matters, ripening of seeds is apt to be uneven, especially in some of the fruits such as cherry and plum. This necessitates going over the plants more than once to finish the seed collection. Although it is usually assumed that the best quality seeds are obtained from well-ripened fruit, some exceptions to this are claimed. It has been reported, for example, that the normally dormant seeds such as cotoneaster, eastern redbud, and arrowwood viburnum show good germination the first spring if the fruits are collected in late summer while still slightly green and the seed sown immediately This may be related to a hard coat effect, as we shall see in the discussion on stratification to be presented below.

Extraction and cleaning of the seeds, especially those enclosed in cones or fleshy fruits, is very important to subsequent germination. Inadequate cleaning can reduce germination by mechanical restriction or by increased rooting, the latter especially in seeds improperly cleaned of fleshy fruits.

STRATIFICATION

"Stratification" is a term which applied originally to the practice of placing alternate layers of seeds and soil or some other medium for exposure to low temperature for the purpose of breaking dormancy. The term has been carried over to apply to any low-temperature pretreatment method for breaking dormancy. For example the seeds may be mixed with the medium, such as granulated peat moss, and placed at controlled temperature instead of out-of-doors for definite periods of time preceding sowing, or the exposure to low temperature may follow regular soil plantings.

"Dormancy' is a term which has not been clearly defined in the literature. Primary dormancy present in the seed at maturity presumably has its origin during the development of the embryo and its surrounding structures while in contact with the mother plant In certain instances, conditions which are usually favorable for germination and growth, i.e, a moist medium and a warm temperature, are the conditions which prevent germination and actually may induce a type of dormancy known as secondary dormancy. Secondary dormancy has also been known to be imposed by unfavorable germination temperatures or the presence of an excess of carbon dioxide. Since our main consideration in this paper will be primary dormancy, we may use the term as signifying the failure of viable seeds to germinate when they are placed under conditions of moisture and temperature which would ordinarily bring about sprouting. This is in contrast to the so-called dormancy of the dry, resting seed. The term, "after-ripening" will be used in its broadest sense, that of preparation of the seed for the resumption of growth.

It should be kept in mind that not all germination failures are due to seed dormancy. There may be loss of viability due to age or improper storage conditions or the seeds may be devoid of embryos. This latter condition is especially characteristic of some of the coniferous forms and of such seeds as *Liriodendron tulipifera*. It would be helpful to know the source and history of the seed lot to be tested and to cut a few of the seeds to be sure they are not empty.

Dormancy, characteristic of many types of seeds, has both good and bad features It is of definite advantage to the continuance of the species in that germination under conditions unfavorable for seedling survival is prevented. This is true for many temperature-zone forms whose seeds mature in the autumn. If germination took place immediately, the young seedlings would not be able to withstand the vigorous winter weather and would all be killed. This disadvantages of dormancy are chiefly from the point of view of the gardener and nurseryman. Dormant seeds require special, and generally time-consuming, treatment if a good stand of seedlings is to be secured.

Impermeable Coats: It has long been known that certain seeds, especially of the family Leguminosae, possess coats which prevent the absorption of the water necessary for germination. Among the known methods for making the coats permeable are shaking or mechanical scarification, soaking in concentrated sulphuric acid or alcohol, and hot water of special temperature treatments. The honey locust, *Gleditsia triacanthos,* may serve as an example of seeds with impermeable coats. The effectiveness of mechanical filing of the coats of these seeds is well known. Usually, in such instances no other type of dormancy is involved so that once the coat is made permeable, germination proceeds without further difficulty. There are, however, certain forms which combine an impermeable or hard seed coat with a dormant embryo. These will be discussed later.

Seeds Favorably Affected by Low Temperature Pretreatment (Stratification): The changes which take place during after-ripening of the seed at low temperature may involve actual growth and development of the embryo itself, as in the case of the American holly, *Ilex opaca*. Changes also may, and usually do, include an increasing acidity and altered enzyme activity within the tissues of the embryo. Also there may be chemical changes within the endosperm or stored food of the seed, as well as chemical or physical changes within the seed coats during this after-ripening period. Endosperm in an insoluble form, such as hemi-cellulose, within the seed may become chemically changed in the presence of moisture at low temperature so that it is available for use by the embryo.

Even if the embryo seems fully developed and has attained considerable size while the seed is still attached to the parent plant, it may still grow in size before germination will proceed. This is true of at least one of the species of ash, *Fraxinus excelsior* Seeds were examined on March 19th after having been planted in soil the preceding September and kept over winter in a board-covered cold frame, a mulched and board-covered frame and a 70° F. greenhouse. In all three of the soil conditions the embryos grew to the full length of the seed. From the appearance of these embryos one would expect that seedlings would be produced under the three conditions. However, this is not the case. By June 10th, those seeds which had been subjected to the low temperatures of winter at Yonkers, N.Y. produced good seedling stands while no seedlings appeared in the greenhouse flat. Obviously, growth of the embryo alone does not always bring about the changes necessary for germination. Additional changes in the endosperm or seed coats or both occurring at low temperatures, but not at 70° F., must have enabled the embryo to overcome the mechanical resistance of the coats and thus germinate.

In many instances there are no observable differences in appearance between an after-ripened and a dormant embryo. Upon transfer to a higher temperature, however, after-ripened embryos begin growth immediately while the control untreated embryos do not change in size. The external appearance of the intact seed which has been after-ripened certainly gives no clue to its germination capacity and yet a planting of these seeds in the greenhouse reveals the after-ripend lot without question. This is shown for one of the roses (*Rosa rubiginosa*) in Fig. 1. These seeds are more specific in their temperature requirement for after-ripening than most others, since 41°F. was the only effective temperature used. Also, these seeds have a deeper dormancy than those of some other rose species; *Rosa multiflora*, for example, which requires only 6 weeks instead of 6 months for after-ripening. Rosaceous forms,

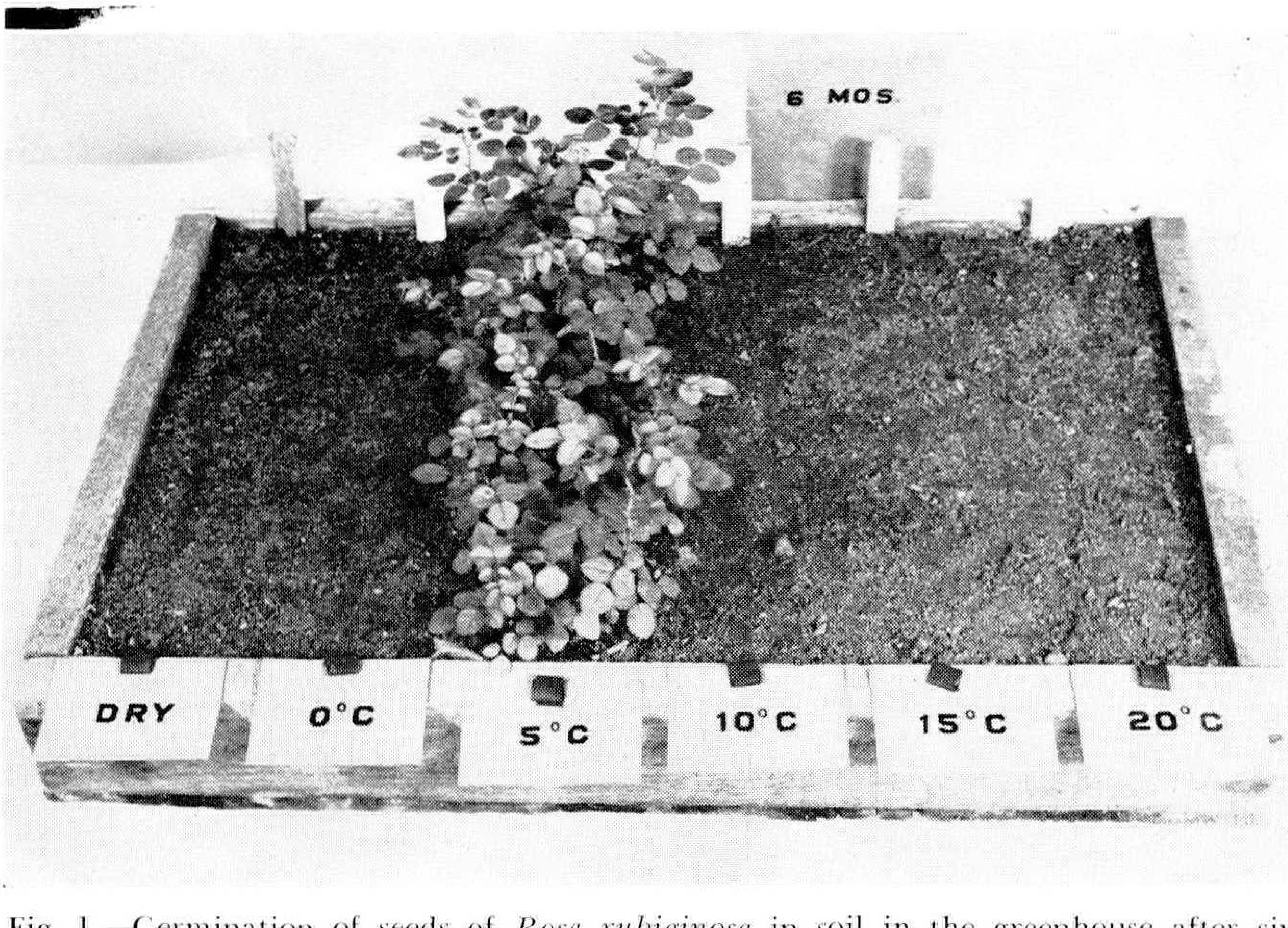

Fig. 1.—Germination of seeds of *Rosa rubiginosa* in soil in the greenhouse after six months in moist sand at the designated temperatures. A control lot of seeds was held dry before planting.

including fruits such as apple, pear, cherry and peach, are well known for their production of dormant embryos

The conifers vary greatly in their need for after-ripening. In the genus *Pinus* are to be found examples of different degrees of dormancy, ranging from the very dormant *Pinus koraiensis* which fails to germinate seventy days after planting in the greenhous to the less dormant *Pinus resinosa* which gives 67 per cent germination in twenty-four days. Low-temperature pretreatment is essential in the first instance, but can be beneficial in the second instance also in the hastening of germination so that a prompt, complete stand of seedlings is obtained. A uniform seedling stand is very desirable from the point of view of cultivation, disease resistance, and response to ecological factors, both favorable and unfavorable. *Pinus rigida* occupies an intermediate position as far as intensity of seed dormancy is concerned, as is shown in Fig. 2. Here it is seen that one month at 41° F gave as good results as two or three months. Seeds planted in the soil in the greenhouse after one month at 41° F. gave 87 per cent germination after twelve days and 95 per cent after eighteen days, and when the experiment was extended to forty days the percentage germination rached 99 This is in sharp contrast to the untreated seeds, of which only 3 per cent had germinated after twelve days and which reached only 33 per cent after thirty days. Very good germination of this species can also be obtained after one, two, or three months at 34° or 50° F.

Germination of seeds of the spice bush, *Benzoin aestivale,* is increased by stratification. The same advantage of low-temperature pretreatment of seeds is obtained with the barberry, *Berberis vulgaris.*

These examples will probably suffice to demonstrate the general effectiveness of low-temperature pretreatment We shall now consider some seeds which possess both an impermeable coat and a dormant embryo.

Germination of Seeds Possessing Both Hard Coats and Dormant Embryos: A background of the knowledge that some seeds fail to germinate because of an impermeable seed coat and that others fail because their embryos are dormant made possible the assumption that there must be seeds possessing both of these hindrances to germination. Consequently some of the especially difficult forms were tested with this in mind Several of them, including some of those which had been listed as requiring two years for germination were found to fall in this class. These species have offered great difficulties to practical growers and to scientists. Since after-ripening proceeds at low temperature only if the seed has been able to absorb water, it follows that a coat treatment must be given before low temperature stratification. This may be done by soaking in concentrated sulphuric acid. Sulphuric acid must be handled with extreme care to prevent injury to body or clothing Furthermore, the exact time of treatment must be known for each kind of seed. Too long a period of soaking eats through the coats and kills the embryo. Too short a period is of no value since the coats remain impermeable These facts make the application of the method difficult for the ordinary gardener or nurseryman Is there a simpler and safe procedure?

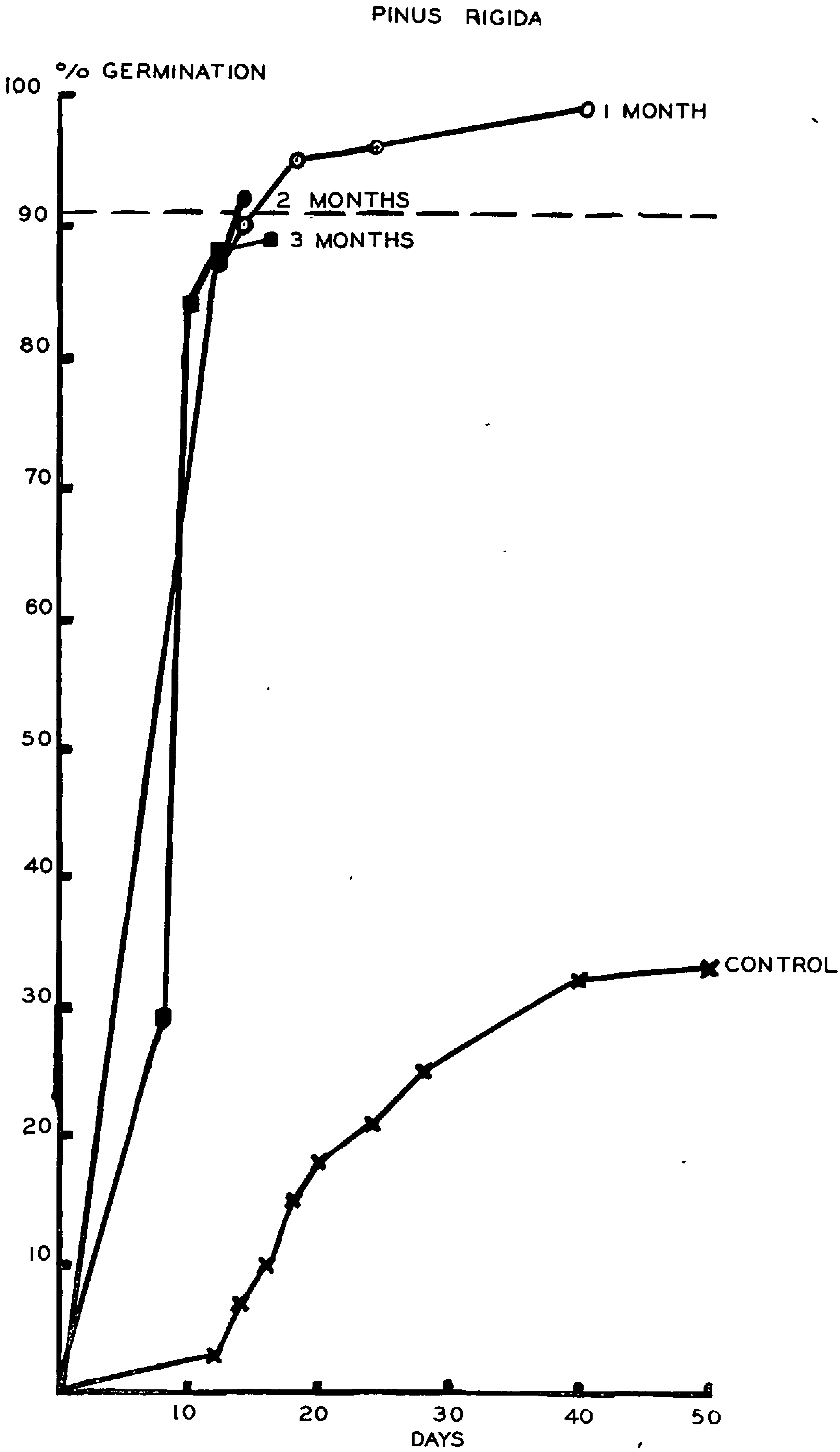

Fig 2—The effect of moist pretreatment of seeds of *Pinus rigida* for 1, 2, or 3 months at 5°C on germination in soil in the greenhouse

It has been shown now, in several cases, that a period at high temperatures (68° to 77° F.) in a moist medium causes the disintegration of the seed coats making them permeable. No germination was obtained with Crataegus after 9 months pretreatment at 41° F., but a combination of 4 months at 80° F. and 5 months at 41° F. brought about excellent seedling production in the soil. It should be noted, however, that not all hawthorn species have impermeable coats. Both high and low temperature treatments may be given at controlled temperatures, but this is not at all necessary. Practically, late spring or summer planting out-of-doors is the solution. This is shown in the Fig. 3 for seeds of *Tilia americana* where the effect of planting time is noted. Seedling production in the spring from seeds planted in June, July, and September and wintered in open, mulched, and board-covered frames is pictured. The best seedlings were produced from the June planting, and very few from the September planting.

Other species, whose seeds are known to respond in a similar fashion are *Arctostaphylos Uva-ursi, Cotoneaster sp., Halesia carolina, Symphoricarpos sp.,* and *Taxus cuspidata.*

Epicotyl Dormancy: Certain seeds produce roots readily when exposed to ordinary germination temperatures. The root systems develop until the stored food supply in the seed is exhausted, but no shoots are produced if the seedlings are kept continuously at these temperatures. The main problem in the growing of plants from these seeds has proved to be the forcing of the dormant shoot bud after the root has already started to grow. This type of dormancy has been

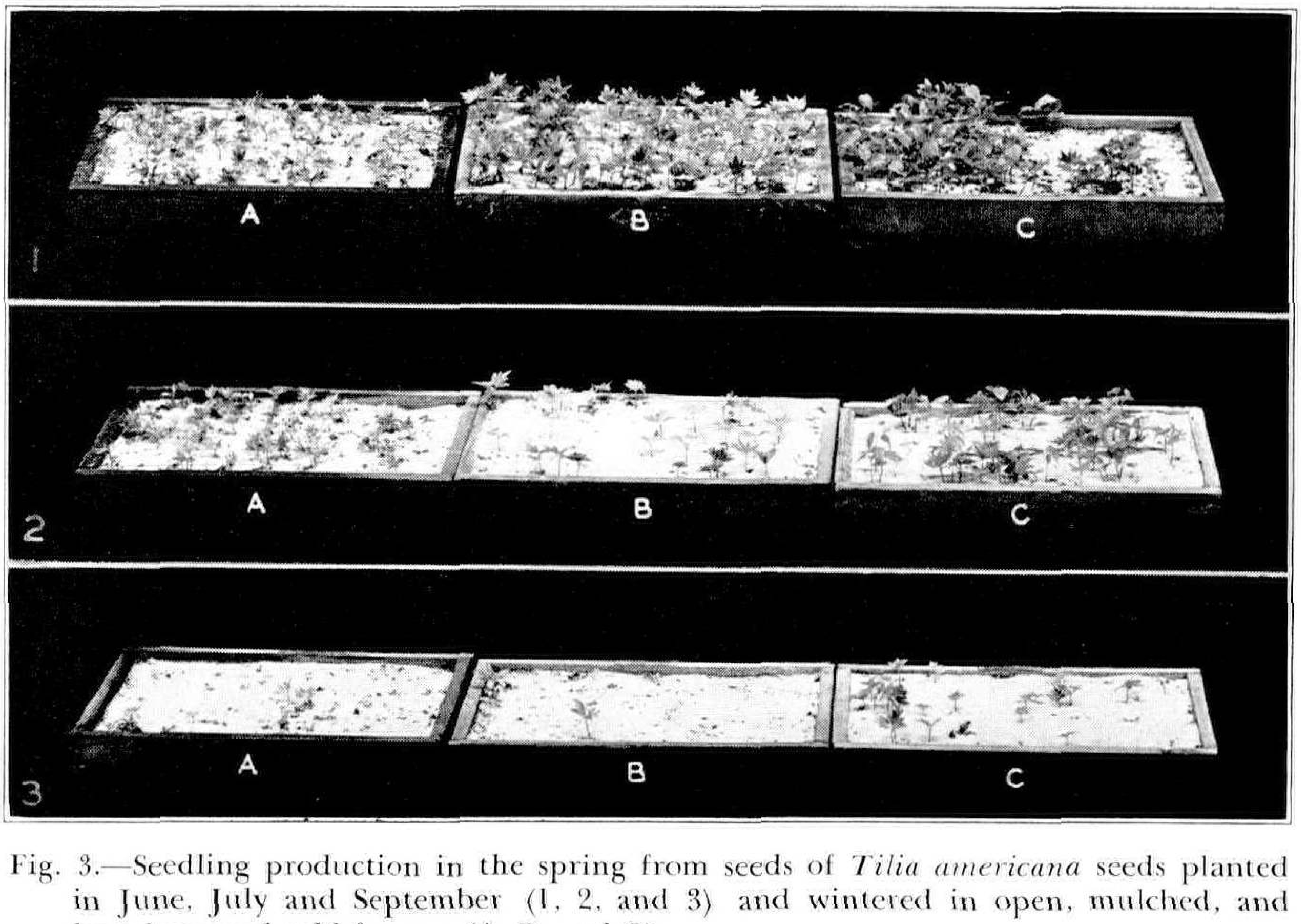

Fig. 3.—Seedling production in the spring from seeds of *Tilia americana* seeds planted in June, July and September (1, 2, and 3) and wintered in open, mulched, and board-covered cold frames (A, B, and C).

called "epicotyl dormancy" and was first reported in 1933 for seeds of the tree peony, *Paeonia suffruiticosa.* The increasing popularity of this flower coupled with the difficulties in rooting cuttings have augmented the need for adequate germination methods.

Since the roots exhibit no dormancy they may be produced in any moist medium at ordinary temperatures. After the roots have started to grow seedlings must be given a period at low temperature to after-ripen the shoot. This is accomplished by planting the germinated seeds in soil in pots and placing the pots in a cold room for two to three month. The soil must, of course, be kept moist throughout the treatment. At the end of the period, the pots should be transferred to a greenhouse or other warm place where the green shoots appear within a few days. If treatment at low temperature is prolonged the shoots start to grow and are injured unless the light requirement is provided in the cold room.

Figure 4 illustrates these effects, showing the growth of green shoots in the greenhouse after low-temperature pretreatment of the germinated seeds. No green shoots were produced in the greenhouse without low-temperature pretreatment.

Since these seeds require a high temperature for root production followed by a low temperature to after-ripen the bud which forms the shoot, the practical way of obtaining seedlings is spring or early summer planting. It will be recalled that this method may be used for seeds in the preceding category also, i.e. seeds with a combination of a hard coat and a dormant embryo. The effect of the initial period at high temperature is different, however, for the two classes. In one instance it favors the growth of the root system necessary before the epicotyl will after-ripen at low temperature and in the other it permits the microorganisms of the soil to make the seed coats permeable.

Fig. 4.—Greenhouse production of green shoots of the tree peony, *Paeonia suffruticosa,* from germinated seeds kept for two and one-half months at 1°, 5°, 10° or 15° C. The control pot was kept in the greenhouse for the entire period.

It should be noted that this same type of dormancy is exhibited by seeds of the herbaceous peony the so-called two-year lilies (such as *Lilium auratum, L. canadense, L. japonicum, L. rubellum, L. superbum,* and *L szovitsianum*) and several species of *Vibrunum.*

A Combination of Root and Epicotyl Dormancy: From the foregoing description of the types of dormancy, one might expect to find seeds with a combination of root and epicotyl dormancy. This would be distinct from the ordinary type of dormancy where, once the growth of the radicle is initiated, the whole green plant follows quickly. It would also be different from the epicotyl dormancy type where the production of the root at high temperatures is a prerequisite for low-temperature treatment to form the shoot. Seeds of several forms have been shown to have this "double dormancy" To bring about seedling production, it would appear that these seeds would need a period at low temperature to after-ripen the root, followed by a period at high temperature to bring about actual sprouting and growth of the root, a second period at low temperature to after-ripen the epicotyl, and a second period at high temperature to grow the green shoot. This is exactly what is required

The results of experiments with seeds of *Trillium grandiflorum* have demonstrated complete double dormancy. Only an occasional root is produced without low-temperature pretreatment and a separate period at low temperature is necessary to after-ripen the shoot. Lily-of-the-Valley, *Convallaria majalis,* seeds respond to the same sort of treatment but differ from *Trillium* in that the roots are only partially dormant. This is to say, some root production takes place at ordinary temperatures without previous low-temperature treatment, but the percentage is increased by such treatment. For example root production from seeds of lily-of-the-valley can be increased by low-temperature pretreatment from 16 to 82 per cent. A further complication in the germination behavior of these seeds is found in a special type of epicotyl dormancy. In the ordinary type as exhibited by the tree peony, the dormancy of the epicotyl or the bud which forms it may be broken at any time between the first appearance of the radicle and the time of the maximum development of the root system from the food stored in the seed. To break epicotyl dormancy in lily-of-the-valley, however, the low temperature must be given, not merely after root production, but after the shoot has developed to a certain stage. Low temperature is ineffective if applied before this certain stage of development is reached.

Dwarfs from Nonafter ripened Embryos. At the beginnig of our discussion of dormancy, we dealt with the after-ripening of seeds with dormant embryos. After a period in a moist medium at temperatures of 41° to 50° F. usually, such seeds germinate to form normal plants. Studies of the physiological behavior of embryos, which have been freed of the seed coats and all enveloping structures, have shown that it is possible to obtain some growth without low-temperature pretreatment. The resultant plants, however, do not grow in a normal manner but develop a characteristic dwarfed appearance The stems fail to elongate and to produce internodes of normal length. The nodes appear to be superimposed one upon the other. Seedlings produced from non-after-ripened embryos may remain dwarfed indefinitely, or may start to grow normally after a certain time has elapsed. The growth can be made normal upon exposure to low temperatures at any time in the seedling stage. Also it is known that better growth of such seedlings takes place in the long days of summer than in the short days of winter. Grafting experiments have failed to reveal the mechanism of dwarfing.

More reecntly, it has been demonstrated that lanolin preparations or aqueous solutions of gibberellic acid promote the growth of physiologic dwarfs produced from nonafter-ripened embryos of the crab apple, *Malus Arnoldiana* (Fig. 5). Such growth is characterized by the extension of internodes, resulting in the elimination of the dwarfed condition. The number of leaves and nodes were not affected by the chemical under the conditions of the present tests. This is the first chemical shown to induce extended growth of physiologic dwarfs, and may represent a forward stride in the elucidation of the dormancy mechanism, a problem which has challenged many workers for many years.

We have not spoken of the sowing of seeds, except indirectly. Since all of our work has been done on an experimental basis, we have had no experience in the handling of large lots of seeds.

Fig. 5—Use of gibberellic acid to promote the growth of physiologic dwarfs produced from non-after-ripened embryos of the crab apple, *Malus arnoldiana*.

It has been a pleasure for me to present this outline of the different types of dormancy, and I hope it will be of some help to you.

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PRESIDENT SCANLON. Thank you, Dr. Barton. The discussion was excellent. I am certain there will be many questions.

DR. SNYDER (Rutgers University, New Brunswick, N.J): What was the concentration of gibberellic acid used on crab apple dwarf seedlings?

DR. BARTON: In solution we put one micogram on each seedling, but in the lanolin mixture we put a small drop of lanolin which was made by mixing five milligrams of lanolin in five grams of lanolin.

MR. JACK SIEBENTHALER (The Sienbenthaler Co., Dayton, Ohio): How permanent is the effect of gibberellic aid on elongation?

DR. BARTON: A lot of us want to know the answer to that one. With the dwarf embryos, the gibberellic acid is finally just used up and the plant will form another little dwarf at the top. These dwarf seedlings I am speaking of are not permanent dwarfs, they are only physiological dwarfs. If they are given a low temperature, they will grow out An amazing thing is that sometimes they grow out without any apparent reason.

MR. CARL KERN (Wyoming Nurseries, Cincinnati, Ohio): Have you done any work with maleic hydrazide to effect dwarfing?

DR. BARTON: Some work with maleic hydrazide has been done at the Boyce Thompson Institute, however, it was not with the view of dwarfing plants.

MR. CONSTANT DE GROOT (The Sheridan Nursery, Toronto, Ontario): We have had germination of seed of *Cotoneaster Wardii* in one year. Is this an exception?

DR. BARTON: We have not tried all of the cotoneasters but I think it is likely an exception. The three species of hawthorne I mentioned earlier require a high temperature prior to germination, but not all species of hawthorne require this.

MR. CASE HOOGENDOORN (Hoogendoorn Nurseries, Newport, R.I.): Have you found any chemicals which will hasten the germination of umbrella pine seed?

DR. BARTON: No, we haven't tried chemicals on it. About 50% germination is our average on it.

MR. A. M. SHAMMARELLO (A. M. Sharmmello & Son Nursery, Cleveland, Ohio): Will you discuss the germination of American Holly (*Ilex opaca*) seed?

DR BARTON: I wish you would ask me something about seeds we have had good luck with. We have tried chemicals, cold and warm temperatures, etc. So far the best treatment is to plant outside in the fall. A few seeds germinate the first year, more the second, and still more the third. Dr Nelson at the Brooklyn Botanic Garden has been studying the dormancy of holly seed by excising the embryos, that is removal of the embryo from the seel

MR. JAMES S WELLS (James S. Wells Nursery, Red Bank, N.J.) : I understand that isolated trees often do not produce viable seed. Do you have any information showing a difference in viability of *Cornus florida* seed depending upon where it is gathered?

DR. BARTON: I have no information on that point.

MR. LESLIE HANCOCK (Woodland Nurseries, Cooksville, Ontario) : Have you been able to correlate your scientific findings with the natural climatic conditions under which the plant grows in nature?

DR. BARTON: Well, I think for the low temperature pretreatment. the seeds that you most often think of as responding to that treatment are temperate zone plans. They are the plants that would normally have a cold period in the winter. However, there is more variation in the requirement for germination with different localities than you would expect. I will illustrate with southern pines. You wouldn't expect the Lombardy and the commercial southern pines to respond to treatment with low temperature, but they do respond much the same way as the *Pinus rigidida*. They will germinnate but they will germinate a lot better after low temperature treatment

In general, with the tropical seeds you are more apt to find seeds that will not tolerate drying out. They lose their viability in drying out. That is not so characteristic of temperate zone.

MR. WILLIAM FLEMER, III (Princeton Nurseries, Princeton, N.J.) : I believe I have read somewhere that trees which have a wide, natural distribution such as, red maple which grows in Alabama and as far as north as Nova Scotia, exhibit no embryo dormancy in the southern part but partial embryo dormancy in the northern part. Have you any findings on the geographic origin of the seeds as related to dormancy?

DR. BARTON: I mentioned in the first part of the talk the effect of obtaining seeds of local origin I think it has been definitely established that the same species which has acclimated itself to a new region also changes its characteristics

DR STUART NELSON (Central Experimental Farms, Ottawa, Ontario) : Recently, the Forestry Branch has recommended a 24-hour soak in water or sulfuric acid treatment for Colorado blue spruce seeds. The cold treatment has been eliminated from the recommendations. Will you comment on this recommendation?

DR BARTON: Since this has been reported in the literature, we have tried soaking seeds at a range of temperatures and for various periods of time. We have not been successful with such treatments.

MR. THOMAS S PINNEY (Evergreen Nursery Co., Sturegon Bay, Wisconsin) . It has been reported that cold treatment without stratification will suffice for many pines and some spruce. Do you agree with this statement?

DR. BARTON: No. As far as dry storage is concerned, the viability of the seed will be maintained but dormancy will not be overcome.

MR PINNEY: What is your opinion of indoor versus natural stratification out-of-doors?

DR. BARTON: If you have sufficient cold weather out doors, stratification is just as good as indoors. The only exception to that would be if seed require only one month of low temperature, germination may occur and the seedlings killed by cold weather.

MR. C. H. HENNING (Niagara Falls Park Commission, Niagara Falls, Ontario): With alpines and conifers, does a snow cover have any influence on germination?

DR. BARTON: Snow cover is very good because it keeps the ground from freezing and thawing, thereby giving the seeds the low temperature needed to insure germination.

PRESIDENT SCANLON: Thank you, Doctor Barton, for coming to Cleveland to tell our members of your interesting and useful work on the problems of dormancy in seeds We hope that the meeting has been of interest to you

I am sorry to announce that our next speaker, Dr. Wendall Camp of the University of Connecticut, has been unable to come to our meeting today. Dr. Camp is now Head of the Department of Botany at Connecticut. He has had an illustrious career in botany and horticulture and is eminently qualified on the subject of Soil Mirco-Organisms. Louis Vanderbrook, our Vice-President and Program Chairman, is well acquainted with Dr. Camp and has graciously consented to read his paper.

Mr Louis Vanderbrook read Dr. Camp's paper, entitled "Mirco-organisms in Soils and Their Action on Plants." (Applause).

MICRO-ORGANISMS IN SOILS AND THEIR ACTION ON PLANTS

DR. WENDELL H CAMP
Head, Department of Botany
University of Connecticut, Storrs, Connecticut

When your amiable Vice-President some time ago asked me to talk to you about certain items which he had heard me discuss previously I agreed to do so with the understanding that I would not be restricted by the title, but would be permitted to explore certain other things pertaining to the general field of plant propagation and nursery production which would lead into my general topic.

In certain circles there is a growing feeling that the responsibility of the plant propagator ends when he has produced roots on the base of a cutting, gotten the seedling out of its seeds coats, or achieved some sort of union between stock and scion. It is encouraging to note from the program before me that this group still feels it important to get the material established in the field for, when one considers the whole problem, a plant cannot be said to have been successfully propagated until