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MODERATOR DUGAN: Our next speaker is a seed technologist at the New York State Agricultural Experiment Station and has operated an experimental nursery for testing seed quality and sources for the past twenty years. Mr. C. E. Heit.

THE IMPORTANCE OF QUALITY, GERMINATIVE CHARACTERISTICS AND SOURCE FOR SUCCESSFUL SEED PROPAGATION AND PLANT PRODUCTION

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The importance of seed quality and germinative characteristics can not be stressed too strongly if the nurseryman or plant propagator desires the most success in his plant production program. For many years nurseryman thought that tree seed could not be tested accurately in the laboratory for germination as other kinds of seeds. Some seed dealers and collectors have also clung to this belief too long and have even passed such information to the seed buyer through their catalogues, correspondence or conversations.

To-day the seed laboratory which is properly equipped with modern, automatic light germinators and manned with experienced, ingenious seed analysts can test any kind of tree and shrub seed, no matter how dormant or how difficult they are to germinate. Our New York laboratory tests hundreds of tree and shrub seed yearly now on a service basis for nurserymen, seed dealers, collectors and private planters. Our seed testing service is maintained for residents of New York State but we also test tree seed for persons from other States especially when

they do not have proper testing facilities in their respective States.

Most coniferous tree seed can be tested within 10-30 days. With modern automatic artificial light germinators as exhibited in Figure #1 most pines, spruces, firs, and cedars can be tested promptly without any stratification or prechilling treatment. Both artificial light and alternating temperatures stimulate many of these dormant seed to germinate rapidly. Many hardwood and shrub species can also be tested for germination in the laboratory without special treatment such as the elms, spring seeded maples, catalpa, black locust, common lilac and tree of heaven.

Extremely dormant seed such as apple, peach, cherry, white ash, bittersweet, barberry, basswood, redbud, and certain conifer

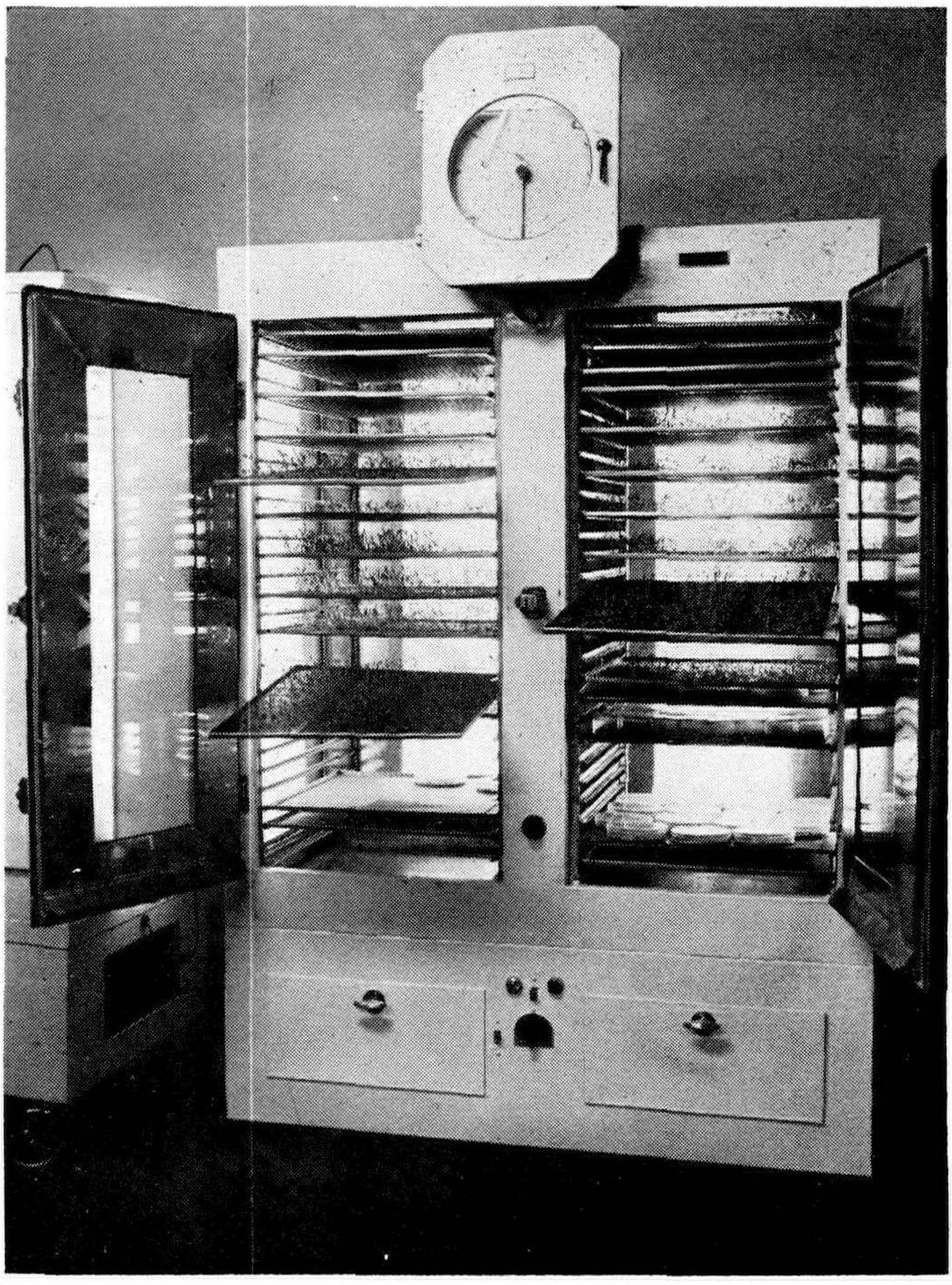

Figure 1. Automatic artificial light germinator with doors open showing conifer seed germinating on top of moist blotters on trays after 10 days. Most of these pines and spruces have completed their germination.

species can be tested by the embryo excision method within 5 to 20 days. The embryos are removed and placed in dishes under optimum temperature and light conditions in large dishes. These excised embryos will show varying degrees and different types of growth and behavior. The performance of peach embryos of varying germination and vitality is shown in Figure #2. Staining tests with chemicals such as tetrazolium chloride can be used for detecting approximate planting value with those extreme dormant seed where embryos can not be removed readily. Thus the seed analyst can determine actual planting value of all tree and shrub seed within a reasonable length of time. No propagator or nurseryman should sow any seed lot without learning the germination percentage or its approximate tree planting value.

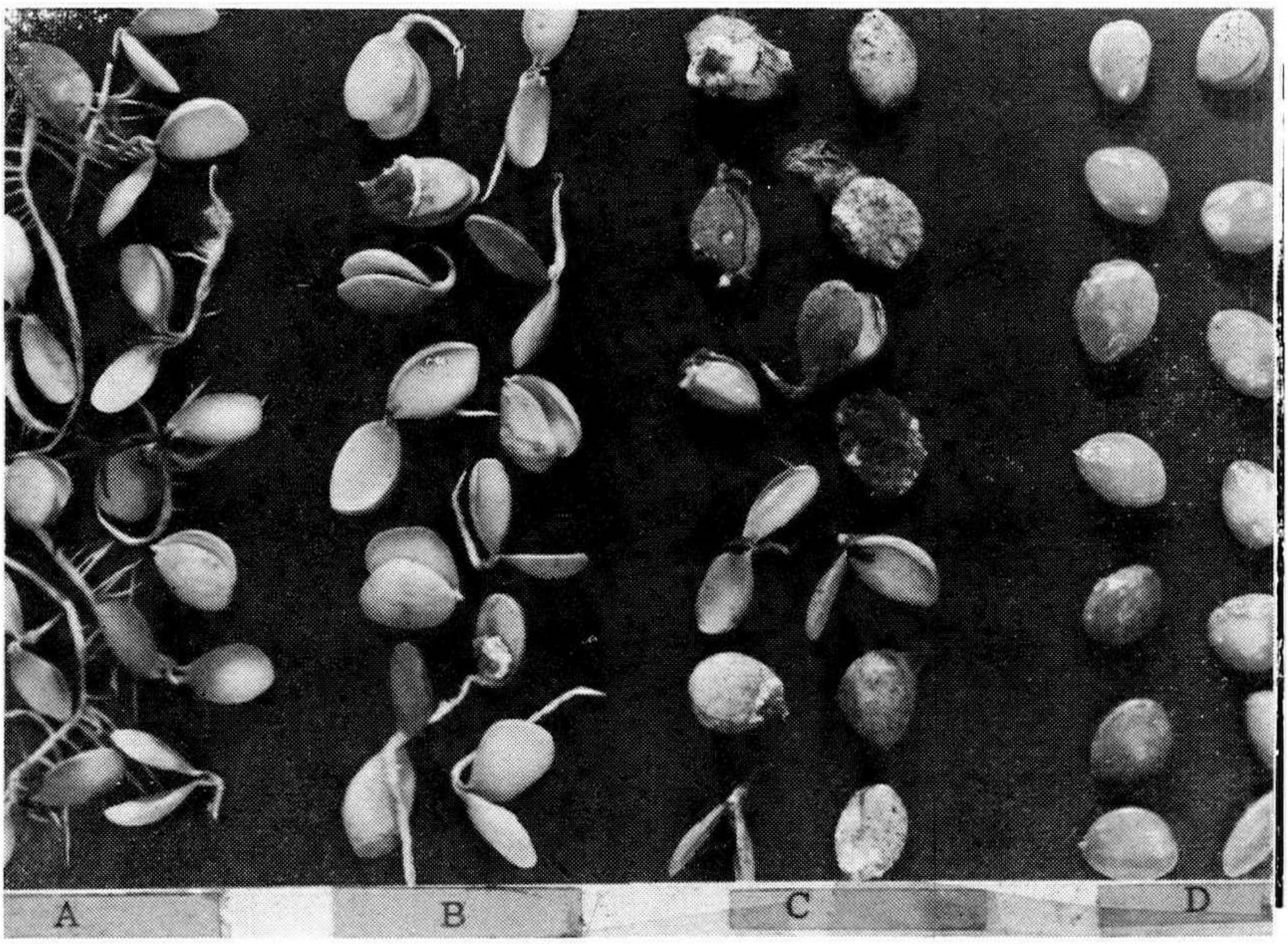

Figure 2. Embryo excision method for testing 4 peach stocks showing comparative strength and planting value. A-strong seed, vigorous growth; B-good reliable seed. fair vigor; C-old seed, weak doubtful value; D-dead seed, no activity. Actual germination of these stocks when empty and bad seed were taken into consideration were 80%, 52%, 18% and 0% respectively.

At present we have standard testing procedures for testing over 100 tree and shrub species which were adopted in June 1964 at the annual meeting of the Association of Official Seed Analysts held in Rochester, N.Y. These rules for testing tree and shrub seed will become effective in July 1965. Each official seed laboratory in your respective states will have these methods to follow when you submit samples to them for testing purposes. A memo summary of "Thirty Years Testing of Tree

and Shrub Seed" compiled by the writer may be received upon request. It also lists certain other reprints on seed source studies which are available upon request.

There are two factors which affect seed quality as it is purchased or sown in the nursery, namely purity and germination. The best seed must be properly cleaned, free from inert matter, chaff, stems, cone scales, weeds and other crop seed. Your tree seed must be also true to name or labeling. Another reason for submitting your seed to a laboratory for a test is to check proper labeling. Many tree seed can be identified by laboratory seed germinative characteristics and response. This information will detect mislabeled seeds and protect the user from planting the wrong kind of seed. In the last few years our laboratory has found the following species misnamed as to kind when submitted to us for testing.

1. Black Hills Spruce	Found to be:	Colorado Blue Spruce
2. Balkan Pine	"	Austrian Pine
3. Chinese Pine	"	Japanese Red Pine
4. Jack Pine	"	Shortleaf Pine
5. Japanese Black Pine	"	Japanese Red Pine
6. Scotch Pine	"	Aleppo Pine
7. Scotch Pine	"	Monterey Pine
8. Douglas Fir (Blue from Colorado)	"	Caesia or viridis Douglas Fir or Montana or British Columbia
9. Coral Berry	"	Honysuckle
10. White Mulberry	"	Lonicera Species

HOLD DEALER RESPONSIBLE

The seed dealer or seed collector should be held responsible for the quality of seed he sells. Each propagator should request germination percentage and complete labeling as to source information when purchasing seed from any dealer. Too many nurserymen have purchased tree seed blindly in the past, paid for the seeds, planted them in the nursery with partial or total failures because no germination tests were made prior to sowing and old, weak or dead seed was sold to them.

New York State has provisions in its seed law to protect the buyer of tree seeds, as it does for all other kinds of seeds. There are a few other states which have tree and shrub seed provisions in their laws, namely Georgia, Massachusetts, Pennsylvania and Michigan. Maryland and other States are taking steps to do likewise. It appears advisable and necessary for more States to enact labeling laws so that nurserymen will be protected in purchasing tree seed of good quality and true to name. The basic requirements of these labeling laws are:

1. Name and address of vendor
2. Kind of seed and variety
3. The percentage by weight of pure seeds

4. The percentage of germination
5. Year of collection
6. The specific locality; (U.S. - state and county or nearest political unit in case of foreign countries) in which seeds were collected.

Of course certified tree seed is the final answer and ultimate goal for highest quality tree seed. New York has provisions in its seed law for certification of tree seed and has adopted standards for five conifer species. All nurserymen should promote the establishment of certified tree seed standards in their respective areas.

NEED FOR BETTER TREE SEED CONTROL

Did you know that old, weak, dead and even misnamed tree seed can be shipped into the U.S. to-day? We need some type of Federal Control on imports. Specific cases of dead, misnamed seed involving transactions of several hundred dollars being allowed to enter this country were shown on slides. Seed dealers and private buyers have not protection at present against such situations. Some organizations are promoting the amendment of the Federal Seed Act to correct this situation. Your Society might wish to cooperate with them.

Too much weak, unfit, dead tree seed is being sold in the U.S. to both small and large growers and your Society has an opportunity to improve the situation both individually and as an organization. Our New York laboratory has tested tree seed samples nearly every year which were purchased by State inspectors from various U.S. seed dealers. In 1960, 99 samples were purchased from 9 different tree seed dealers. Two dealers has this record, 7 of 20 samples were found unfit or dead; 5 of 10 samples unfit, dead or mislabeled. A total of 15% of samples received by mail were found to be unfit.

Our tests from samples purchased by State Inspctors in 1964 show little if any improvement. Samples were purchased from 10 - 12 seedsmen or dealers and one or more samples of Austrian pine, Japanese black pine, Swiss stone pine, Norway spruce, White spruce, Engelmann spruce, Black Hills spruce, Sitka spruce, Red spruce, Cryptomeria, Orange, Ginkgo, Chinese elm, Oriental arborvitae and others were found to be unfit or worthless for planting purposes. Dealers who sold this dead and unfit sed were located as follows: 4 in California, 3 in Pennsylvania, one each in Massachusetts and Michigan. Several samples were found to be mislabeled as to kind. One group of 25 inspection samples from U.S. dealers showed 10 lots either dead or so low in germination to be unfit for planting and 4 of this group were found to be mislabeled or misrepresented as to species. The quality of tree seed being sold in the future to nurserymen can be improved by individual and united action by our Society. We have presented the facts as they exist to-day. We do not wish to infer that all tree seed being sold is low quality, much tree seed being sold to-day is good to excellent quality.

Some dealers are very careful to distribute only the best quality seed obtainable.

GERMINATIVE CHARACTERISTICS

For success in growing excellent field stands of seedlings. both total germination percentage and vitality of each seed stock is important. Laboratory tests will reveal both of these characteristics. Old seeds of weakened vitality are readily distinguished from strong, healthy seeds in a performance test. These slow germinating, weak, abnormal seedlings have no nursery field value. Extraction injuries and other mechanical seed injuries can be detected in laboratory tests. The grower must beware about sowing old, weakened or injured seed as these weak seedlings do not withstand the rigors of unfavorable field conditions as compared to strong, vigorous seed.

Varying degrees of dormancy can be measured by laboratory tests and the propagator must know the exact dormant nature of each seed kind and variety to have complete success. Some seed need fall sowing or special treatment for maximum germination. Others should not be fall sown as they might pre-germinate and be killed during the winter. The most dormant conifer species such as Balkan pine, White pine, most of the firs, Japanese larch and hemlock should be fall sown for optimum

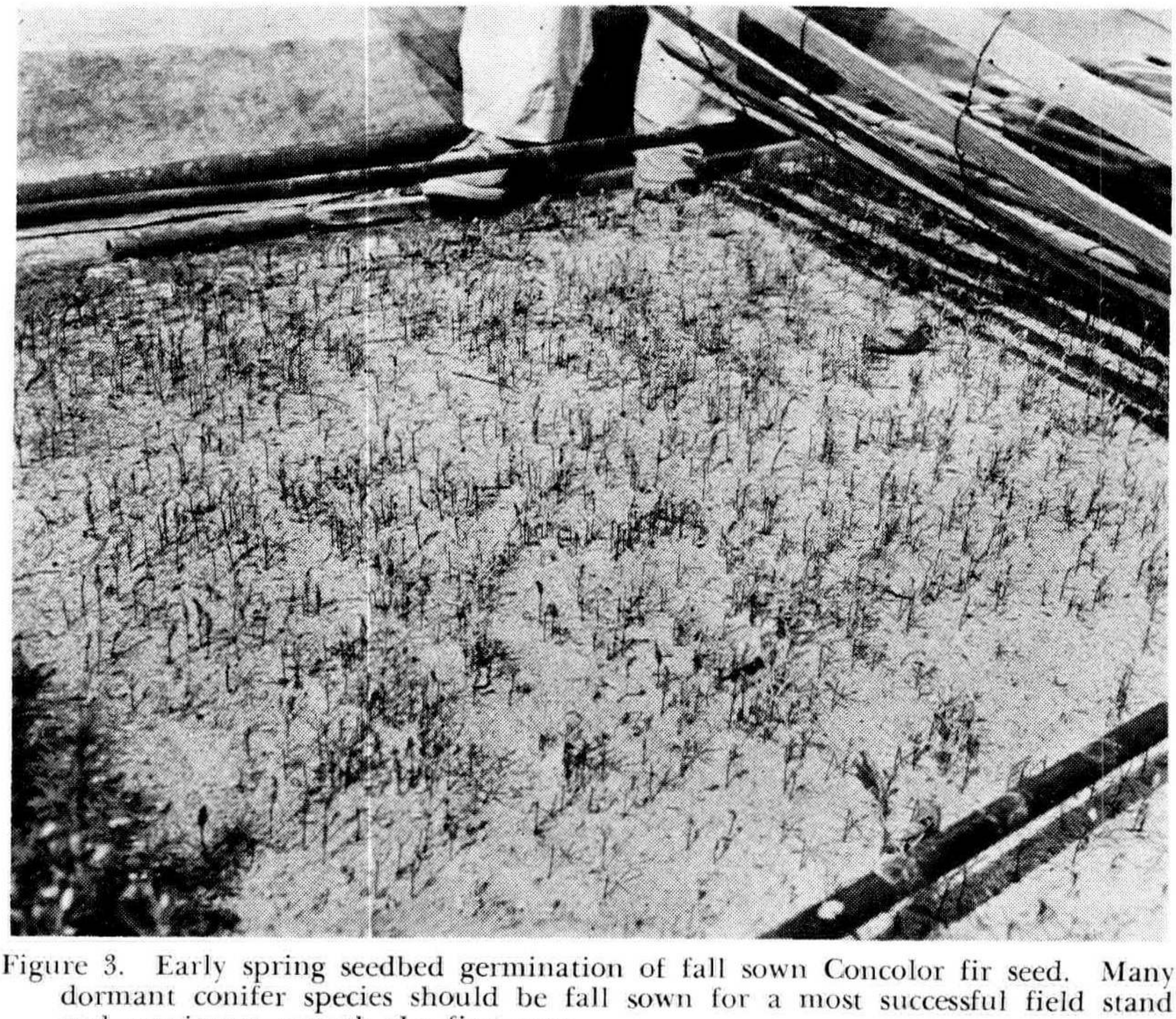

Figure 3. Early spring seedbed germination of fall sown Concolor fir seed. Many dormant conifer species should be fall sown for a most successful field stand and maximum growth the first year.

maximum germination in the spring. Note excellent germination in very early spring of fall sown concolor fir seed in Figure #3.. Fall sown seed of these dormant species will insure complete, maximum germination of all viable seed the following spring, it will insure rapid growth and establishment of the seedlings before damping off conditions become critical and it will result in larger, more vigorous seedlings by the end of the first year. The writer has grown 2 year seedlings from fall sown seed as large as 3 year seedlings from spring sown seed with the same species. Small propagators who grow a few conifer seedings might be interested in securing a reprint of a recent article published by the writer for the small nurseryman entitled "Tips on growing healthy, vigorous conifer seedlings and transplants" which can be secured upon request.

CONTROL SEEDBED DENSITY

Seedbed density must be controlled in order to produce the most healthy, vigorous seedlings and transplants. By knowing the germination percentage and the number of seeds per pound or ounce, the seedling rate can be regulated so as to give optimum seedbed density. This will result in fewer failures and over-crowded seedbeds both of which occur without careful attention to these two factors. A good example of careful attention and accurate calculation of these two factors resulted in op-

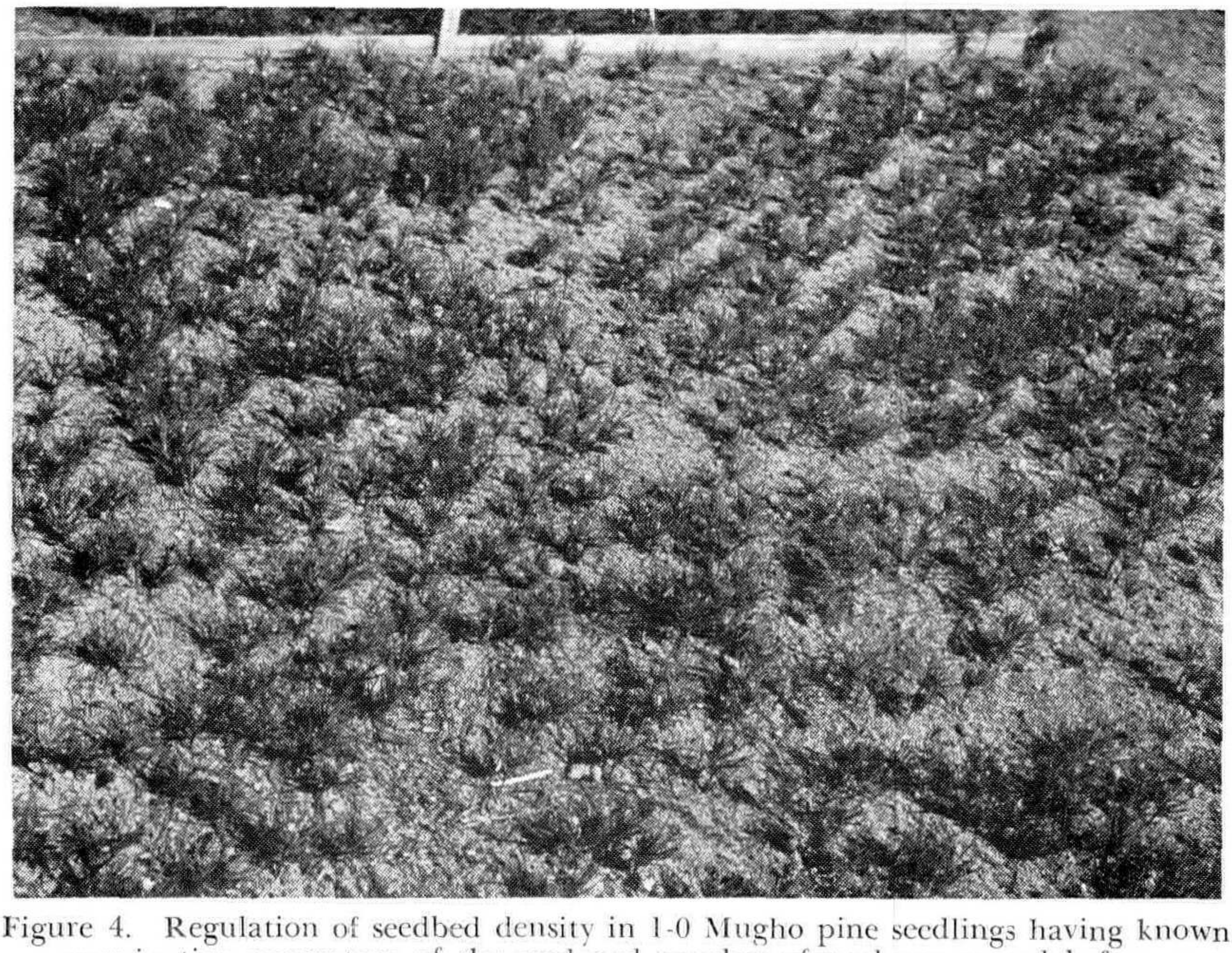

Figure 4. Regulation of seedbed density in 1-0 Mugho pine seedlings having known germination percentage of the seed and number of seed per pound before sowing seedbeds. Both these factors must be considered so as to secure ideal density for maximum head development in 2-0 seedlings.

timum seedbed density in 1 year Mugo pine seedlings as shown in Figure #4. These seedlings are not too dense for maximum growth as to allow the buds to break and develop a good head as 2-0 stock and eventually a lower branching, more spreading Mugho pine field grown specimen.

The ideal seedbed density will vary depending on the species, length of time left in the seedbeds and possible use of seedlings. Most nurserymen sow their seeds too thickly as the writer has observed with evergreen seedlings growing as high as 150-300 per square foot. These seedlings are so "spindly," similar to "hair on a dog" and they have no value as they never will recover the transplanting shock so as to develop into sturdy, healthy plants. A well-balanced seedling should be the ultimate goal of every propagator ,that is proper root-top ratio and this characteristic can only be obtained by proper regulation of seedbed density. The writer has grown strong, healthy 1 year Scotch pine seedlings 2 - 4 inches in height at a density of 100 per square foot and transplanted them with excellent results. However, for good sturdy 2 year Scotch pine seedlings this density must be reduced to 45-60 per square foot and for good 3 year seedlings this figure must be reduced to 25-30 per square foot. Firs and spruces may be grown at a little higher density and hardwood species usually must be grown at a lower density for best results.

The seed per pound or ounce must be determined for each seed lot and used in calculated sowing rates along with germination percentage. Average seed per pound rates published by species in catalogues or textbooks should not be used because of extreme variation with individual seed lots within the same species. Seeds per pound will vary within a species due to many factors, such as seed source, age of tree, cone size, condition of tree, percent of empty seed present and many other factors. For example, Scotch pine seed per pound will vary from around 32,000 in some Spanish sources to as high as 104,000 in the North Baltic sources of Finland or over 3 times as many. Similar seed count variations exist in other species, although they may not be as great. Thus never neglect the seed per pound figure for the seed lot you are presently sowing.

IMPORTANCE OF SEED SOURCE

The writer has conducted seed source studies on many species during the last 20 years such as Austrian pine, Mugho pine, Scotch pine, Colorado blue spruce, Engelman spruce, Norway spruce, Concolor fir, Douglas fir and others, both in the laboratory and in the nursery. Variation in seed germination in the laboratory from different geographical sources has intrigued the writer immensely and certain species and strains can be identified by their germinative characteristics. Species showing variation in germinative response due to geographical location have been Douglas fir, Ponderosa pine, Concolor fir, Lodgepole pine, Scotch pine, White pine and possibly others. Seed

sources of some of these species vary in rate of growth, winter hardiness, type of development, needle length and color in both summer and off-coloring or adverse yellowing in the winter. The propagator must select the optimum seed source for the intended use of his planting stock, for the characteristics needed for its eventual planting site or for his personal and customer preference for the ideal type of each species. These facts must be determined before selecting the correct seed source and the propagator must have learned the characteristics of the many sources available before he purchases his seed for sowing in the nursey.

In Mugho pine one must be certain to secure seeds from the true dwarf, compact trees of the high Tyrol Mountains of Central Europe. Open market seeds without authentic certification have been collected from fast growing rangy mountain pines found on the sand dunes along Denmark and Germany.

SCOTCH PINE SOURCE STUDIES

Detailed studies covering 20 years or more on over 200 known seed sources of Scotch pine can not be presented here. Memos or reprints are available upon request. Studies have shown that all Nurserymen, Christmas Tree Growers and Propagators should learn the specific characteristics of various geographical sources. Observations have been compiled on seed sources from Austria, Belgium, France, England, Germany, Greece, Italy, Norway, Poland, Scotland, Spain, Sweden, Switzerland, Turkey, Yugoslavia and many growers strains from the U.S. Growth habits, needle and branch characteristics and winter coloration have varied tremendously in 1 and 2 year seedlings and in 3 and 4 year transplants. Various seed source series have been tested in nursery rows year after year as shown in Figure #5 with comparative results recorded. Four year old transplants from different sources growing side by side have varied in total height from 1 to 3 feet, in needle length from 2 to 4 inches and in winter coloration from golden yellow to blue-green. What kind of a Scotch pine do you wish to grow for yourself or your customers? What is going to be the use of your planting stock? Do you want a slow growing pine, or a fast growing tree? Do you want a "golden" Scotch pine or a green Christmas Tree? Do you want a short needle, medium length needle or a long needled source? It is more important that you know the source you are sowing.

In general summary we might state these facts.

1. Sources from a single country have been found to vary widely, especially as to growth rate and needle length.
2. All sources tested from five Spanish provinces namely Burgos, Cuenca, Guadalajara, Guadarrama and Soria, at two or more elevations, have performed fairly uniformly with slight variations in rate of growth and winter coloration. These sources have shown short to medium length needle, slow to medium growth rate and excellent winter color.

Figure 5. A planting of Scotch Pine 3 and 4 year old transplants numbering 50 different seed sources being tested side by side for growth rate, branch angle, needle length, bud formation and winter needle coloration. Note extreme variations in growth rate and needle length.

3. French sources have shown wide variation in growth rate but usually good winter color and short to medium length needle.
4. England and Scotland sources have shown good needle color with mostly medium length needle and medium growth rate. Secondary height growth sometimes has developed in these sources.
5. Sources from Greece and Turkey have not been tested as long as many others but have shown most encouraging results and most favorable Christmas tree characteristics to date, especially when all factors are taken into consideration. Turkish strains have had to date excellent green color and Greece sources have shown particularly excellent general form as transplants.
6. Many foreign sources have shown moderate to severe winter needle yellowing or extreme rapid growth and long needle development. In this general category have been sources from Austria, Belgium, Northern Germany, Poland, Italy, Switzerland, Norway, Sweden and Yugoslavia.
7. There is no correlation between rate of growth and length of needle as far as winter coloration or yellowing is concerned. The slow growing Highland French strains and the Sweden sources have shown nearly identical rates of growth and needle length yet they were at the two extremes of blue-green to golden yellow as to winter coloration.

DOUGLAS FIR SOURCE STUDIES

We know of no other coniferous tree in which seed source of your planting stock is so important or critical. The seed of this species is collected from far north in British Columbia, Canada to as far south as Northern Mexico. It is also distributed East and West from the Eastern base of the Rocky Mountains in Montana and Colorado to the Pacific Coastal area in Washington and Oregon. There are three recognized strains or races of this fir, namely *viridis, caesia* and *glauca* and geographical mixtures of them.

Several factors must be considered in selecting seed for production of seedlings, transplants, or finished landscape planting stock. Do you wish a fast growing douglas fir or a slower, more compact type of growth? Do you wish uniform green foliage, a grey green type, a blue grey foliage or the most uniform bluish foliage? You no doubt wish a winter hardy tree but many sources are not winter hardy in the Northern U.S. and our Northeast region. How about length of needle or type of needle development? Have you grown different sources in your nursery of known origin to learn which characteristics you, your landscape buyers or private customers perfer? We suggest you do this or at least learn the characteristic performances of the various geographical sources. Enough information is now available on over 100 different seed sources so that if a propagator knows the color, type of tree development and growth rate desired, several sources can be recommended for his needs.

Findings and observations on a 15 year study of Douglas fir seed sources can not be presented here but a memo summary is available upon request. New sources are under test at the present time. Many of the field failures with this species in past years can be traced directly to the wrong seed source. Most of the West Coast *viridis* strains are not winter hardy in the North Central or Northeastern U.S. Some of the inland *viridis* or *caesia* strains from the Wyoming, Idaho, Montana area are terrifically slow growing and not suitable at all for Christmas tree production or for other uses. However, these sources might be ideal for certain ornamental uses, tub culture or foundation planting. Other inland *viridis* and *caesia* sources have been found to be winter hardy, fast growing and excellent for Christmas Tree planting.

The blue *glauca* sources from the large Rocky Mountain region in British Columbia to Southern Arizona and New Mexico were all found to be winter hardy but varied in rate of growth, needle color and other characteristics as shown in Figure #6. These two sources shown here have both produced excellent plant specimens and yet note the difference in growth rate, a typical performance year after year. Other two year old seedlings from various sources have varied in height growth from 2 - 3 inches to as much as 12-18 inches and from a uniform blue

to blue grey to uniform green in needle coloration and from 100% winter killed to 100% winter hardy. The nurseryman or grower must order more than "just douglas fir seed" to have best success with this species.

Briefly, we can summarize by stating that in order to be most succesful in seed propagation and plant production all propagators, both large or small, must sow tested seed of known, strong germination percentage, true to name as labeled, and of known, authentic seed source to fulfill the requirements for the intended use or purpose for which the stock is to be grown.

Figure 6. Two Douglas Fir seed sources as 2 year seedlings showing extreme variation in height growth. Foreground — Manti-Lasal Forest, Utah 9,000′ elevation 3-6 inches. Background — Coconino National Forest, Arizona, 7,000′ elevation 10-16 inches. Several sources from Montana and Wyoming were slower growing than the Manti-Lasal source.

MODERATOR DUGAN : Our next speaker is Dr. Pridham from the faculty of Cornell University, Department of Floriculture and Ornamental Horticulture.