In summary, the germination problems with Viburnum seed appear to be due to a number of factors. There is considerable variation between species, variation between individual plant seed sources, variation due to environmental effects, as well as variation due to the time seed is collected. In this study, as in others, it was found that the use of short periods in the warm and cold temperature treatments resulted in low germination percentages; however, the fact that a small percentage of seed did germinate, indicates a variation that exists even within individual seed from the same plant.

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MODERATOR LEACH: Thank you, Dr. Reisch.

The subject of Stimulating Germination by Chemical and Mechanical Means has been divided into two discussions, the first by Thomas S. Pinney, Jr., of Evergreen Nursery Company, Sturgeon Bay, Wisconsin, who is going to talk to us about Commonly Propagated Ornamentals.

STIMULATING GERMINATION OF SEED BY CHEMICAL AND MECHANICAL MEANS

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There have been a number of techniques developed to overcome the problem of rest or internal dormancy of various seeds. Chemical and mechanical treatments may be helpful in overcoming internal dormancy that is caused by: (1) seed coat (i.e.) *Gleditsia, Gymnocladus* (2) hard endosperm which acts as a seed coat (i.e.) *Tila* and (3) when seed coat is one of the factors which contribute to the in-

ternal dormancy of the seed (i.e.) *Cotoneaster, Viburnum, Malus* and *Crataegus.*

There are several chemicals which may be used to overcome the seed coat or endosperm internal dormancy in the seed. There has been considerable work done using a chemical such as sulphuric acid to break down the hard seed coat or endosperm. An acid resistant type of container such as a wooden barrel or plastic container is used. Usually the seeds are placed in some type of basket that is acid resistant so the seeds may be lifted easily out of the chemical at the proper time.

Generally 95% sulphuric acid commercial grade 1.84 (specific gravity) is used and the temperature of the acid should be maintained between 60-80 degrees F. The higher the temperature, the faster the reaction. The seeds remain in the acid from 15-60 minutes. The difficulty in this method is to determine the optimum length of time the seeds should stay in the acid. Under-treated seed coats will still be quite glossy while an over-treatment may deeply pit and even expose the endosperm or the embryo resulting in permanent damage of the seed. When the seeds are treated for the optimum length of time. they will appear dull. A cutting test will help you determine how much of the seed coat remains. Usually as much of the seed coat as possible is removed without exposing the endosperm or embryo.

A supply of water is necessary for rinsing the acid from the seed and also it should be located some place where the water used for rinsing the acid from the seed can safely run off.

There is an additional complication since the seed coats vary within the same batch and from year to year. This means that seeds might be treated for 15 minutes one year and may require 25 the next or the reverse may be true. Occasionally other acids such as nitric acid have been used, but most of the work has been done with sulphuric acid.

Another method that is considerably simpler to use is soaking the seed in water. The seeds are placed into water that is between 170-210 degrees F and allowed to soak for 12 hours as the water gradually cools. The theory is that as the temperature cools it will reach a point of optimum temperature for overcoming the internal dormancy caused by the seed coat. This method has been suggested for use on Eastern Red Cedar where there is a wax coating over the seed coat which inhibits the passage of water into the seed. P. O. Rudolph in 1950 (Cold Soaking — A Short Cut Substitute for Stratification? *Journal of Forestry* Vol. 48 pp. 31-32) attempted to use cold water at 41 degrees F. as a substitute for cool stratification.

One serious problem with the water soak is that the seeds become sticky, hold together and often times swell so that you are unable to put them through the regular mechanical seeding apparatus. This means that they have to be sown by hand and you have no real way of calibrating your seeding operation for replication from year to year.

There have been a great number of mechanical devices used for the scarification of seeds. Dr. Chadwick at Ohio State University

has felt that one of the better types of scarifiers is the Ames Scarifier. Generally these machines consist of some abrasive type of material and a rotation of a drum or agitator which causes the seed to rub against the scarifying material, thus mechanically wearing down the seed coat. There are a number of advantages to this method in that it is quite simple and there is no need to work with dangerous materials such as acids or controlled temperatures. However, the seeds must be watched carefully so as not to injure the endosperm or the embryo by excessive abrasion and this method usually fails when the seeds have a soft or fleshy seed coat since this would gum up the abrasive material. The seeds are also more susceptible to pathogenic organisms than untreated ones.

It has been my experience in our particular nursery which specializes in propagation of common ornamentals by seed, that the methods I have previously discussed are not too practical in our particular nursery. We have never experienced a great deal of difficulty in germinating the common coniferous seed that we grow when a few simple practices are followed.

We plant as much of our coniferous seed in the fall as possible. Sometimes this is difficult, since securing seed before freeze-up is not always possible, especially when some species are obtained from foreign countries. When we are not able to plant in the fall we do store the seed in a damp common cold storage in polyethylene bags that are placed in tightly covered steel barrels to protect them from rodents.

We find that in most cases the conifer seeds do not need the high moisture used in normal cool stratification methods. Some coniferous seeds are difficult to store and may be better stored in a tightly sealed container in this same cool, damp environment. These stored seeds may then be planted in the spring or early summer with still very good germination.

The seeds of deciduous plants are a little more difficult to work with commercially, but we still follow a few very simple rules and it seems to have worked out quite well for us. We never plant a fleshy fruit, and we always clean our seeds with a machine designed for this purpose. The seed cleaner is made by the Dybvig Nursery Company at Colton, S.D. and we purchased it in 1954 for $275.00. It has proved to be very successful and the pulp is cleaned from the seed by maceration using water. The machine is powered by any belt power from a tractor or small implement. On some seeds such as Red Cedar we have also used this machine to attempt to remove the wax coating using warm water.

Since we plant all of our deciduous seeds without any pre-treatment other than might be given it with the cleaning machine, we realize that some of the seed such as Viburnums and Cotoneasters will not germinate until the second year. We feel that since many of our evergreens in the seed bed areas are there for three full years anyway, that the delay of the germination of the deciduous seed until the second year is not really a serious problem. The deciduous liners are usually sold as one and two year olds.

We have found that mechanical, chemical and stratification methods hastening germination can become quite complicated, time consuming and not conducive to mass production methods. It creates problems in calibrating our seeder and thus we are unable to accurately sow the seed. We practice a very simple method — plant the seeds and allow Mother Nature to do her work in the normal way. Since we have to assemble a tremendous amount of equipment each time we want to make seed beds, this allows us to plant all of our seed at one time and to make the best use of mass production methods. Also, we have attempted to do some stratification in storage and have found that so often these seeds are ready to be planted exactly when we are busiest in the spring of the year.

In conclusion I realize that my viewpoint is strictly from the commercial angle and I certainly feel that continued research must be done in hastening the germination of seed since sometimes nurserymen are caught short and would like to produce seedlings in shorter periods of time. We should have this information available to us for use for such an emergency basis. Also, the universities and other research institutes are helped a great deal by these various methods of hastening germination. For those that are interested there are two very excellent references in the field of seed dormancy. (1) Woody Plant Seed Manual, 1948, Prepared by the Forest Service, USDA Miscellaneous Publication No. 654. (2) A reference sheet prepared by Dr. L. C. Chadwick, Ohio State University.

I feel that most nurserymen still rely upon Mother Nature to take care of the dormancy problems in seed propagation. No doubt as the nursery industry becomes more and more specialized and more and more advanced, these techniques of hastening seed germination may become part of our commercial practices.

MODERATOR LEACH: The other half of the subject Stimulation of Germination by Chemical and Mechanical Means as applied to Exotic Plant Materials is to be discussed by Alfred J. Fordham, Arnold Arboretum.

METHODS OF TREATING SEEDS AT THE ARNOLD ARBORETUM

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The USDA Woody-Plant Seed Manual and Contributions from the Boyce Thompson Institute are invaluable sources of information for those concerned with germinating seeds of trees and shrubs. However, when it comes to many woody ornamental plants and the more remote botanical garden subjects, information as to germination becomes hard or impossible to find. No doubt, at times in the past, people have known how some kinds of seeds perform but much was unknown and little recorded for the information of others. Among that which is written it is not uncommon to find erroneous informa-