Recent Developments in Seed Technology and Obstacles to be Overcome

Franklin T. Bonner[1]

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Abstract - Four developments in tree seed technology are identified: (1) seed moisture in recalcitrant seeds during storage; (2) precise control of moisture during stratification; (3) spin-offs from the use of precision seeders; and (4) declining support for seed research in North America. Five obstacles to better seed utilization for nurseries are also identified as targets for improvements. They are: (1) storage of recalcitrant seeds; (2) control of moisture during stratification; (3) complex dormancy of shrubs and minor hardwoods; (4) seed cleaning and conditioning; and (5) communication. Possible solutions for these obstacles are presented.

DEVELOPMENTS

An overview of recent developments in seed technology may sound like a daunting task, but it gives me the freedom to establish my own definition of "recent" and "development". I would like to highlight four recent or emerging developments: (I) seed moisture in recalcitrant seeds during storage; (2) precise control of moisture during stratification; (3) spin-offs from the use of precision seeders; and (4) declining support for seed research in North America.

Moisture in recalcitrant seeds

Long-term storage of seeds of recalcitrant species is a difficult, if not impossible, process. A solution first proposed more than 20 years ago for southern red oaks (Bonner 1973) called for storage at maximum acorn moisture content, temperatures just above freezing, and in non-sealed containers that allowed air exchange with the surrounding atmosphere. This method doesn't help much with southern white oaks, but it does permit storage of many red oaks for 3 years with only moderate losses in viability (Bonner and Vozzo 1987).

Additional tests through the years have not improved this method, but now there are new possibilities.

The new development is to reduce seed moisture content below the maximum, perhaps 5 percent. This step appears to help aeration, reduce the incidence of fungi and molds, and reduce early germination in storage. By reducing moisture content European foresters are getting 3 to 5 years of good storage of northern red oak and English oak (a white oak) acorns with only a minimum of germination in storage. In the United States, at least one southern seed dealer is also reducing moisture of his stored acorns, and others may also be doing the same. How much the moisture content should be lowered is not precisely known, but a good rule of thumb is to not have any free moisture on the pericarps of the acorns. Seed vigor, at least in oaks, may be slightly impaired, but the trade-off can be worth it. Experience with other recalcitrant seeds is lacking, so this method is suggested for oaks only at this point.

Precise control of moisture during stratification
Seed researchers in the Pacific Northwest made the first improvements by changing our understanding of seed moisture content and its function during and after stratification (Edwards 1986). In Europe the concept was adapted to focus on precise control of seed moisture during stratification. Optimum moisture level was found to vary by species (Muller 1993). European beech (*Fagus sylvatica* L.) requires 30 percent, European ash (*Fraxinus excelsior* L.) 55 to 60 percent, and cherry (*Prunus avium* L.) 27 to 30 percent. New equipment has been developed to maintain control of moisture on an operational scale for nurseries. Improved oxygen supply is the supposed benefit, but this has not yet been confirmed by research. At the end of stratification, seeds can be sown, or redried to below 10 percent moisture and stored for up to 6 years (Muller 1993).

Spin-offs from precision seeding
You may be surprised to find precision seeding listed as a recent development in seed technology, but it is a significant development that has forced nursery managers (and seed dealers) to upgrade their seed lots for bareroot production. Precision seeders require clean, filled, sized, germinable seeds to make the investment in equipment worthwhile. This need has led to increased use of aspirators, gravity tables, air-screen cleaners, and the newer flat-screen cleaners. Similar problems for container operations in Sweden led to development of the Incubation-Drying-Separation (IDS) technique more than a decade ago in Sweden (Simak 1984).

Once nursery managers used these upgraded seed lots, they were convinced. Seed sizing is now being used for acorns in many places, and new hardwood sowers have been developed (usually in the nursery shops) to take advantage of these improved seed lots. With access to new brush machines that provide good control for dewinging hardwoods (Karrfalt 1992), more nursery managers are dewinging their yellow-poplar (*Liriodendron tulipifera* L.) seeds, and some are asking about dewinging ash. These changes reflect a welcome trend in seed management in nurseries; managers are no longer content to accept and plant seed lots with 30 or 40 percent empty seeds.

Declining support for seed research
When government agencies are downsized, and research budgets are cut, decisions must be made about what program stays and what goes. Some people may not like the results of these decisions, but we must recognize the reality of the situation. Tree seed research isn't faring so well in North America these days. The USDA Forest Service is closing out its tree seed research program, and the Canadian Forestry Service has made massive cuts in theirs. Most universities are not interested in applied seed technology research anymore that the nursery industry still needs; they want cutting-edge, sophisticated research programs based on gene transfer or DNA cloning.

While interest in North America is waning, interest in tree seed research is alive and well in Europe. At the Fifth International Workshop on Seeds held at the University of Reading in England in September 1995, seven papers and twice that many posters dealt with tree seeds. Some were on storage problems of recalcitrant species, but most dealt with treatments to overcome dormancy in hardwoods. Why is there so much interest in tree seeds among these

university researchers, many of whom do not have forestry backgrounds? The European Economic Community (EEC) is supporting their research with grant money because Europeans are afraid their natural forest gene pools are disappearing. One British forester told me that seed dealers who have Scots pine (*Pinus sylvestris* L.) seeds from the old native stands in England can get five to six times the price of improved orchard seed. North Americans may not wish for these extremes, but we can look at this EEC research funding with a little bit of envy.

OBSTACLES

Now let's shift gears and look at what I consider to be five serious obstacles to better utilization of seed supplies in nurseries. They are: (I) storage of recalcitrant seeds, particularly acorns; (2) control of moisture during stratification; (3) complex dormancy of shrubs and minor hardwoods; (4) seed cleaning and conditioning; and (5) communication. Despite some improvements, storage and moisture control are also listed as obstacles.

Storage of recalcitrant seeds

With more and more planting of oaks in the South and East, storage of seeds takes on greater significance. The root of the problem, of course, is the physiology of the seeds: they simply cannot be dried, which greatly reduces the options for storage. And there is no "silver bullet" for this problem. It is extremely unlikely (but not impossible) that additional seed research will discover a way to overcome these recalcitrant characteristics; they must be accepted. Many of the best researchers in the world consider storage of recalcitrant seeds to be the most challenging problem in seed science today.

There are at least two ideas worth exploring. One is to reduce seed moisture contents below the maximum during storage, perhaps 5 percent. We need more research, however, because we do not know the applicability or the limits to this concept for individual species. The second idea is related to the first. If we decrease acorn moisture contents, we might be able to drop the storage temperature below freezing, thus slowing metabolism even further. We know that acorns can be stored successfully a couple of degrees below freezing, but results are usually no better than storage at a couple of degrees above freezing. Long-term storage trials with acorns of southern oaks at subfreezing temperatures failed in the past (Bonner and Vozzo 1987), but survival below freezing may be a function of acorn moisture content and time of exposure. This past winter provided many examples of acorns surviving 36 to 48 hours of sub-freezing temperatures, some as low as -10 OC while fully exposed on top of the ground. Could we possibly freeze acorns for a week or so, then move them to higher temperatures for recovery, then freeze them again? This strategy may sound like excessive handling of the seeds, but it should be investigated.

Control of moisture during stratification

While control of moisture during stratification was listed as a new development, it can also be listed as an obstacle because we have experience with only a handful of species. Both excessive and insufficient moisture during stratification can cause problems and reduce the effectiveness of treatment. Some southern and midwestern state nurseries are growing 30 to 40 different woody plants, most of which could benefit

greatly from pretreatments that would provide better and more uniform emergence. Precise control of moisture during stratification could be the answer for some species, but someone will have to do the research. The stratification-redry results of Edwards (1986) have made the first improvements in our concept of stratification moisture. In Europe the concept was refined to allow precise control of seed moisture during stratification of European beech (Muller 1993), even to the point where new equipment has been developed on an operational scale for nurseries. Another tantalizing question is: Is this the same effect we get in seed priming? The rotating drums being used for controlled stratification of beech in Europe appear similar to equipment used in priming of vegetable seeds in this country. Moisture control should be an emerging research issue for all regions.

Complex dormancy of shrubs and minor hardwood

As public concerns for the environment grows nurseries are now called upon to grow an increasing number of species. Most of these new species, both shrubs like serviceberry and trees like arrowwood, have not been widely grown before in forest nurseries, and many of them have rather complex dormancies that confound the goal of rapid and uniform germination. Like the recalcitrant seed problem, there are no quick fixes. These dormancy mechanisms have evolved for good reasons, and there are no magic switches that turn them off. There are, however, some possible solutions. One is to look again at warm or alternating warm/cold stratification temperatures. Variations of these techniques have been used with some success for years on deeply-dormant species in northern latitudes; some examples are: plums (*Prunus* spp.) (Tylkowski 1985), hollies (*Ilex* spp.) (Bonner flex, in press), junipers (*Juniperus* spp.) (Bonner *Juniperus*, in press), and some species of dogwoods (Brinkman 1974). Tests on similar methods in our laboratory have yielded no decisive results on black cherry (*Prunus serotina* Ehrh.), eastern redcedar (*Juniperus virginiana* L.), Rocky Mountain juniper (*J scopulorum* Sarg.) (unpublished data), and white ash (*Fraxinus americana* L.) (Bonner 1975). A more systematic approach that could more closely match the environment of a southern nursery bed might help.

There is another point to consider about these seeds. Most agricultural seeds must dry at maturity for all of the enzymes that are essential for germination and normal growth to be formed, and tree seeds such as loblolly pine and sycamore probably have similar requirements. Those species that have complex dormancies are shed from the trees in moist fruits (drupes, fruits, or fleshy cones in these cases), and they do not achieve a dry maturity on the tree as seeds in dry fruits do. Could it be that they need a warm, drying period before they are fully mature? When they are fully mature, are they as dormant as they were before? The relationship of moisture to dormancy is an area where more seed research is desperately needed.

There is another option available to nurseries for these deeply-dormant seeds: stratify a year ahead. A grower can collect in the fall, place the seeds in cold stratification, and sow in the spring 15-18 months later. This step may sound drastic, but it could be possible with species like basswood, sassafras, haws, viburnums, or hollies. And if these drastic measures do not work, there's always vegetative propagation.

Seed cleaning and conditioning

There's not much new research in seed cleaning and conditioning. Some new equipment appears or old equipment is modified, but growers and researchers continue to use the existing methods and equipment. The condition of some hardwood seed lots that I have observed through the years has been appalling! A common theme has been that only a small amount of seed has been collected, and "the nurseryman doesn't want to waste any by trying to remove trash and empty seeds." Or, a grower may say "we've never grown this stuff before and don't have any idea how to clean it." Most nurseries are doing a great job these days, but we have a way to go.

Communication

No matter how hard researchers try, we don't do as good a job as we should in technology transfer. It's hard to blame the nursery managers. Who has the time to read all of the journals? The nursery conferences and regional training sessions that Tom Landis and Clark Lantz have arranged are really good, but they can't cover all everything. Another factor is that new nurserymen keep coming on the job, and few of them, if any, are getting training in seed and nursery management in forestry schools. Therefore, some training must be given repeatedly, at regular intervals, an approach that we don't always take. Maybe electronic information services are part of the answer. The revised edition of USDA's "Seeds of woody plants in the United States" will be made available on the Internet. A grower with the proper connections can go online and download individual genus chapters without buying the book! In the same way, future updates can be done genus by genus as information becomes available without having to print the whole book. Electronic information retrieval will never replace these Nursery Association meetings, but it does offer a quick, inexpensive way to get (and give) the latest results and advice. Furthermore, there would be no geographic limitations; the seed experts in Denmark would be just as close to you as those in Starkville, Macon, Corvallis, or Victoria. Just think about it; the potential is enormous!

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[1]*Supervisory Plant Physiologist, USDA Forest Service, Southern Research Station, Mississippi State, MS.*

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