OPTIMIZING NURSERY GERMINATION BY FLUID DRILLING AND OTHER TECHNIQUES

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Abstract.--Fluid drilling techniques allow partial germination of seeds before sowing, separation of those that have failed to germinate, and then sowing viable seeds through a seed-gel mixture. Although research has been primarily with vegetable seeds, preliminary work indicates considerable potential in forestry. Other techniques are available to help optimize germination on nursery beds. Lengthening the period of stratification can greatly speed germination, make it more uniform, and reduce inter-seedling competition that will lessen the proportion of cull seedlings. Stratifying dormant seeds such as loblolly pine for 60 instead of 30 days will markedly improve the speed as well as total germination under the less than optimum conditions encountered on nursery beds. Individual seedlots vary in their response to stratification and comparative germination tests should be used to determine stratification requirements.

INTRODUCTION

It is well known, particularly among nurserymen, that seeds do not germinate and develop as well in the field as standard laboratory germination tests indicate. This is due partly to unfavorable climatic and soil conditions during and following sowing, as well as to the presence of soil pathogens. Numerous attempts have been made to develop vigor or stress tests that would allow nurserymen to be able to predict field performance more accurately. However, these efforts generally have been unsuccessful, and germination tests remain the best means of estimating nursery performance.

The problems of poorer than expected germination, inaccurate spacing, and staggered germination increase the percentage of cull or inferior seedlings and can significantly increase seedling costs. Ideally, (1) every seed sown should result in a seedling, (2) germination should be prompt and uniform, and (3) each seed should be accurately spaced within the nursery bed. Fluid drilling, a relatively new technique, offers the potential of meeting these objectives. It involves "pregermination", in which seeds have barely begun the germination process--radicle emergence is only 1 to 2 mm. This allows for removal of nonviable seeds from the lot.

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Seed stratification is also being used to increase seed performance in the field. Varying the lengths of stratification gives the nurseryman another means of optimizing nursery germination.

FLUID DRILLING

Work done in England at the National Vegetable Research Station (Currah et al. 1974) has established the distinct advantages of using pregerminated seeds over ungerminated seeds. These advantages are obtained by a fluid drilling technique in which seeds are pregerminated under optimum conditions. Seeds that failed to germinate are then separated out and the pregerminated seeds are sown in a seed-gel mixture. Research to date with fluid drilling techniques has been primarily limited to vegetable seeds but is now in progress with southern pine seeds. Although the results to date are preliminary, they do indicate the potential for the techniques in forestry.

Pregermination.--Some of the causes for problems in nurseries are related to poor or slow germination. Fluid drilling offers the potential of sowing partially germinated seeds. No allowances have to be made for poor viability or inconsistencies between laboratory and nursery performance, since only seeds that have already begun the germination process will be sown. Seeds are pregerminated in aerated water with optimum temperature and light conditions.

Earlier work (Barnett 1971) with aerated water soaks as a means of stimulating germination has shown that germination of southern pine seeds in water is feasible. Even at low temperatures (about 40°F), germination will eventually occur, but it is more prompt at higher temperatures (70°F). The stratification and pregermination processes can both be done in aerated water. However, the most prompt and uniform pregermination is accomplished when stratification is done before and separately from pregermination. Our tests have shown that pregermination is more efficiently done when dormant seeds such as loblolly are already stratified. We do not have sufficient data at the present time to identify the optimum temperature and light regimes for this technqiue.

Pregermination can be done with equipment as simple as an aquarium tank and aerator; however, more sophisticiated and reliable equipment is now commercially available from Fluid Drilling Limited® 2/. A variety of pregermination units are available that aerate the water and maintain temperatures from near freezing to about 95°F. After germination, the development of the seeds must be arrested until it is convenient to sow them. This can be done by cooling them to near 32°F and maintaining this temperature during storage for up to 2 weeks (Currah 1978).

2/ Use of trade names does not imply endorsement by the U.S. Department of Agriculture. They are used solely to identify materials.

Sorting of pregerminated seeds.--An important part of the fluid drilling technique is separation of partially germinated from ungerminated seeds. Ungerminated seeds are removed from the seedlot with a solution of a proper specific gravity. The germinated seeds float, whereas the ungerminated ones sink. Taylor et al. (1978) developed a density sorting method using a sucrose solution of an appropriate specific gravity. Sorting of pregerminated from ungerminated seeds is particularly important in seedlots of low viability. In high quality lots, separation may not be necessary or desirable because the separation process is not completely accurate. In the example shown in figure 1, separation is only about 80 percent complete with a solution of 1.12 specific gravity. However, if the settled seeds are returned to the solution, the proportion of separation will increase.

Gel seed carrier for planting.--Pregerminated seeds should have an exposed radicle of only 2 to 3 mm in length, but even then the seeds are subject to damage. For protection, the pregerminated seeds are normally suspended in a viscous gel that is thick enough to protect them and provide a means of transporting and metering a given quantity of seeds. Fluid Drilling Limited® has a portable mixer that efficiently mixes a carrier powder and cold water to form a viscous gel. By mixing a known number of seeds into a quantity of gel, the seed density (number of seeds per planted area) can be determined by the rate of gel application.

The seed-gel mixture has generally been applied with a planter consisting of a single large holding tank and a number of peristaltic pumps, one pump per row. Each pump would extrude a quantity of gel determined by the travel speed of the planter. Using this type of apparatus, the seed density can be controlled with reasonable accuracy, but the resulting spacing of the seeds is random. Searcy and Roth (1981) have developed a prototype precision metering system that holds considerable promise for accurate spacing of pregerminated seeds.

Potential applications.--Although the use of pregerminated seeds in forest seedling production has not been reported, the application of this technique could result in cost reductions in both seedbed and containerized seedling operations. Reductions should occur in the number of cull plants and in the labor requirement for seedling production. Use of optimum germination conditions and the ability to eliminate nonviable seeds will allow maximum yield from the seedlot. Pregermination will result in earlier emergence of the seedlings and allow them to develop over a variety of temperatures, including those at which seeds may not normally germinate. This uniform seedling development should also reduce the number of cull plants due to less inter-plant competition. These benefits are being used in vegetable production and they should be further investigated for forest practices.

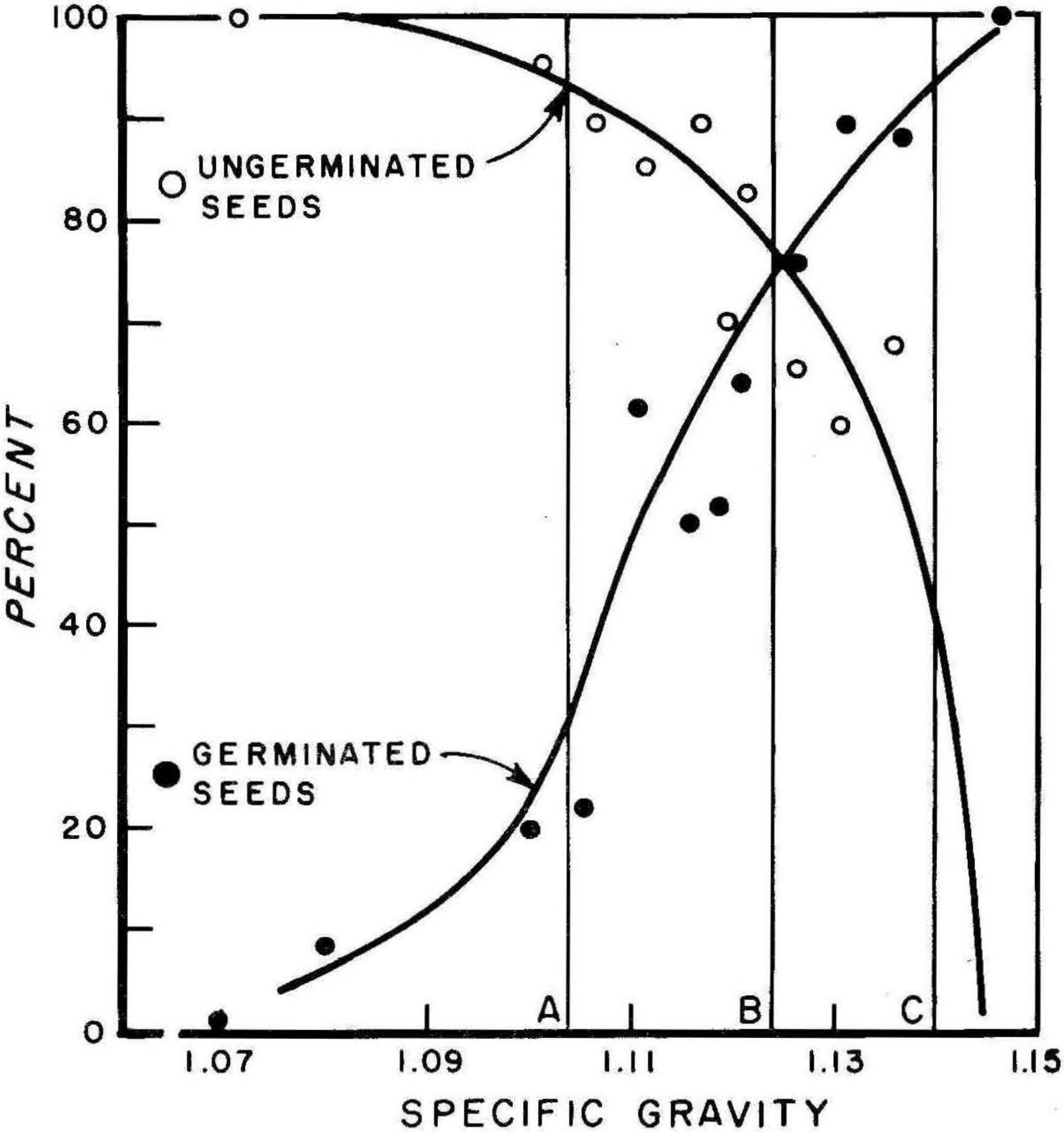

Figure 1.--Separation of germinated from ungerminated seeds by specific gravity solutions.

CURRENT WAYS TO OPTIMIZE GERMINATION

Although fluid drilling techniques offer considerable potential in maximizing seed germination and development under field conditions, some techniques are already available that merit special consideration. Lengthening the period of seed stratification can have a great influence on germination under adverse nursery conditions and can reduce the variability in seedling development that results in cull seedlings.

Stratification effects on germination.--Stratification of dormant-seeded species such as loblolly pine is necessary to obtain prompt and complete germination. The amount of stratification required by a seedlot varies by the dormancy of the species and the need for uniformity of germination. Loblolly pine is generally considered the most dormant of the southern pines and increasing lengths of stratification result in faster and more uniform germination. Normally only 30-day stratification is used with loblolly pine, but the positive response to stratification increases with 45 or 60 days of treatment (figure 2). It is also important to note that this response curve was developed under ideal laboratory conditions.

Overcoming adverse germination conditions.--Response to 30-day stratification can differ greatly when evaluation is under less than the optimum conditions of the testing laboratory. McLemore (1969) evaluated the effects of long periods of stratification under simulated field conditions and under standard laboratory conditions. Longer periods of stratification were required to obtain prompt and complete germination of loblolly pine seeds under less optimum conditions (table 1). Thirty days of stratification resulted in slow and incomplete germination under conditions of lower temperature and shorter photoperiods. Lengthening seed stratification periods will greatly improve the completeness and uniformity of germination in nursery beds during early spring and later at higher temperatures (Barnett 1979). Stratification becomes very important in environments where temperature and other stresses cannot be controlled. Recent research indicates that with stratification, pine seeds can withstand fluctuating exposures to temperature extremes (>85°F) without adverse effect (Dunlap and Barnett 1982a). It is also interesting to note that differences in germination and seedling development due to variations in size can be lessened by increasing the length of stratification (Dunlap and Barnett 1982b). The larger seeds of a lot are generally less dormant than those of the small and medium size classes.

Species requirements.--The need for stratification varies with species, primarily because of the different levels of dormancy among species (Barnett 1976). Shortleaf and slash pines are less dormant than loblolly but may also benefit from stratification for 30 days. Longleaf usually germinates well without treatment.

Not only does the need for stratification vary by species, but it also differs from one seedlot to another. To confuse matters even more, dormancy of a particular seedlot may increase in storage (Barnett and McGilvray 1971). However, there are tests to determine if and how much stratification is needed for a particular lot of seed.

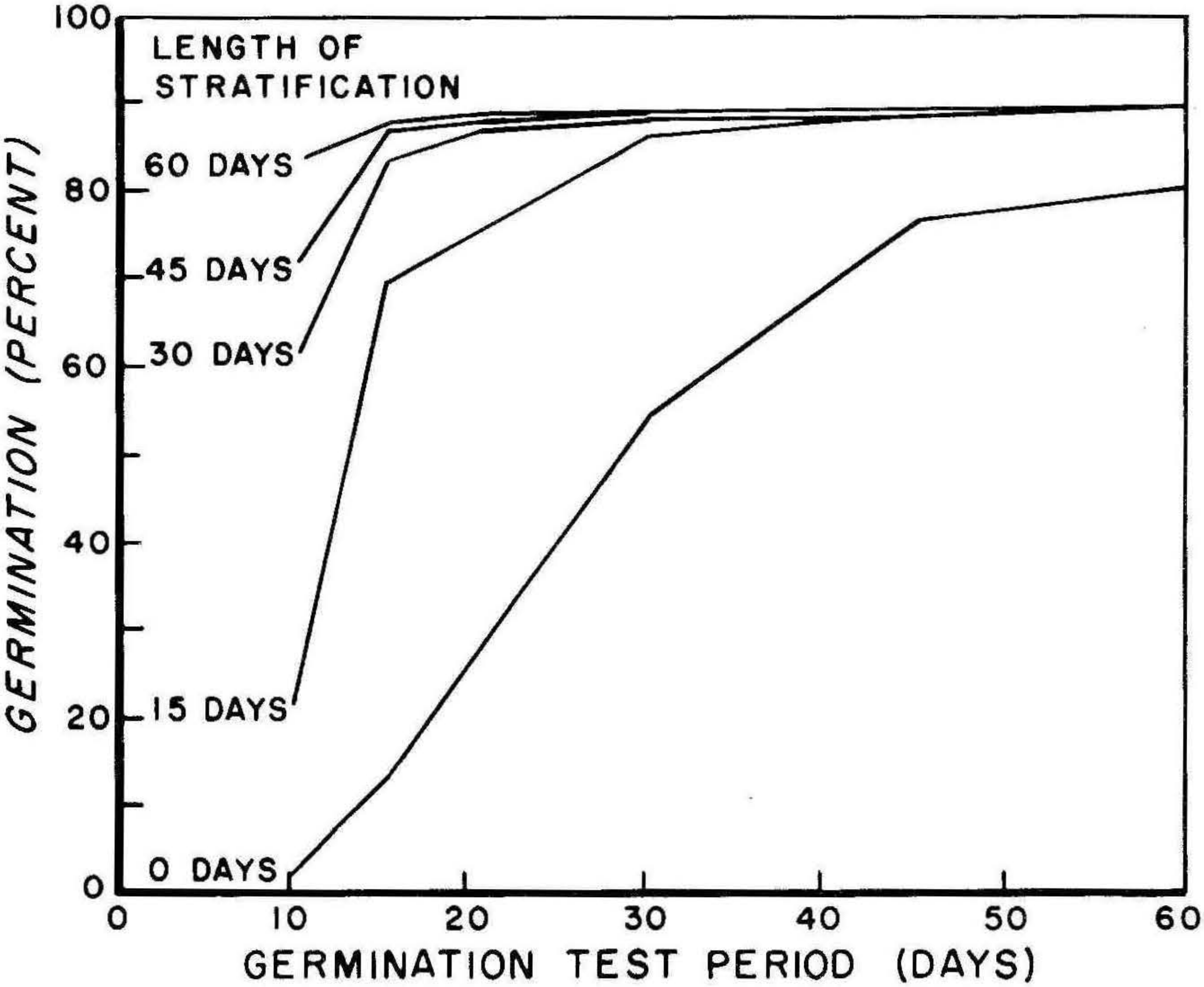

Figure 2.--Benefits of cold stratification for speeding germination of loblolly pine (Pinus taeda). Adapted from McLemore and Czabator (1961).

Table 1.--Effect of length and method of stratification in two testing environments a/

Days of stratification	Stratified in refrigerator at 34°F		Stratified outdoors	
	Germination percent	Germination value	Germination percent	Germination value
	Tested at 60°F with 11-hour photoperiod			
0	< 1	0.0	< 1	0.0
30	68	7.1	59	6.0
60	95	17.3	91	11.4
113	99	24.0	98	19.6
	Tested at 72°F with 16-hour photoperiod			
0	96	20.8	96	20.8
30	99	37.6	98	41.8
60	99	47.1	99	47.0
113	100	50.3	99	56.3

a/ Adapted from McLemore (1969). Germination values represent the speed as well as completeness of germination (Czabator 1962).

Comparative tests.--The easiest way to establish the response of a seedlot to stratification is by comparative germination tests. It is highly desirable to test seed, both before and after stratification, for different lengths of time. For example, loblolly and shortleaf seeds should be tested with and without stratification for both 30 and 60 days. Slash seeds should require testing only with and without 30-day stratification. Since the testing will be done under nearly optimal conditions, you may not note appreciable differences in response between 30 and 60 days of stratification. However, go with the longer period of stratification unless it is detrimental to viability; your nursery performance will improve greatly. Stratification may adversely affect germination of some lots, particularly weak ones; therefore the comparative tests are helpful for evaluation of treatment responses.

SUMMARY

Fluid drilling techniques, developed for vegetable crops, offer the potential for improving seed and seedling performance in nurseries. Seeds go through a pregermination step and ungerminated ones are removed. The germinated seeds can then be drilled on the nursery bed through a seed-gel mixture. These techniques are still under development for forest seeds.

Proven techniques to improve seed performance include stratification. Lengthening the period of stratification from 30 to 60 days can greatly speed germination, make it very uniform, and therefore reduce the inter-seedling competition that increases the proportion of cull seedlings. Nurserymen and others that use seed should establish the responses of individual seedlots to stratification by use of comparative germination tests. Test seeds both with and without stratification for different lengths of time. Use the longer periods of stratification unless they are detrimental to germination, and your performance in nurseries will greatly improve.

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